Dental Public Health Implications of Novelty Sweets Consumption in Children

Ayman Ali Aljawad

BDS (King Abdulaziz University, Saudi Arabia)

Master of Clinical Dentistry in Prosthodontics (Cardiff University, UK)

A thesis submitted to Cardiff University in accordance with the requirements for the degree of Doctor of Philosophy

April 2016

School of Dentistry

Cardiff University

Dedication and acknowledgments

I would like to thank my supervisors **Professor Jeremy Rees, Mrs. Maria Morgan, Dr. Ruth Fairchild and Professor Alan Gilmour** for their invaluable advice, guidance, generous support and substantial encouragement throughout this study.

I am very grateful for the **Ministry of Education, Saudi Arabia** for sponsoring me during the master and PhD studies.

I would like also to thank the **Food and Nutrition department at Cardiff Metropolitan University** for giving the opportunity to utilise the department's facilities during the focus group and sensory works.

A sincere thanks to the medical statistician **Dr. Damian Farnell, Dr. Ilona Johnson, Mrs. Wendy Rowe and Mr. Paul Milward** for their help and assistance during the various stages of this study. I would like to express my thanks to **Mrs. Rachel Rees** for her amazing help during the focus group and sensory work.

I would like also to thank the Health Indices Analyst **Mr. Hugo Cosh** for his great help in the process of analysing the Welsh Index of Multiple deprivation (WIMD).

Special thanks go to **GSK** (**G**laxo**S**mith**K**line) for providing toothbrushes and toothpastes given to the children attended the open days at Cardiff Metropolitan University.

Sincere thanks to my colleagues, **Ali Alabdullah, Yousif Alothman, Kadija Albaik, Abeer Almowallad and Supachai Chuenjitongsa** for their excellent help and support.

Finally, a special thanks to my family and friends, especially **my mother, brothers and sisters and my wife** who have encouraged and supported me throughout my career.

Table of Contents

1 ABSTRACT ---------- XI

2 INTRODUCTION ---------- 13

3 LITERATURE REVIEW ---------- 17

3.1 Sweet consumption in the UK ---------- 17

3.1.1 Novelty sweets ---------- 17

3.2 Children's eating habits ---------- 19

3.2.1 Role of food preferences on children's eating habits ---------- 19

3.2.1.1 Food preferences in children ---------- 20

3.2.1.1.1 Sweet preferences in children ---------- 21

3.2.1.1.2 Sour preferences in children ---------- 22

3.2.1.2 Methods for assessment of sensory taste thresholds ---------- 23

3.2.2 Role of food availability and accessibility on children's eating habits ---- 27

3.2.2.1 Role of availability and accessibility of food at home ---------- 27

3.2.2.2 Role of food availability and accessibility outside the home ---------- 28

3.2.2.2.1 Fast food restaurants ---------- 28

3.2.2.2.2 Schools ---------- 29

3.2.2.2.3 The school fringe ---------- 30

3.2.2.2.4 Vending machines ---------- 31

3.2.3 Role of parents on children's eating habits ---------- 31

3.2.3.1 Role of parent's attitude towards food ---------- 31

3.2.3.2 Use of sweets as a reward ---------- 32

3.2.3.3 Role of parent's pattern on children's eating habits ---------- 33

3.2.4 Influence of peers on children's eating habits ---------- 34

3.2.5 Role of socioeconomic status, ethnicity and culture on children's eating habits 34

3.3 Children as vulnerable consumers ---------- 35

3.3.1 Children's purchasing behaviour ---------- 36

3.3.2 Styles of parents' communication during shopping ---------- 37

3.3.3 Factors affecting children's sweet buying behaviour ------------------------- 37
3.3.3.1 Pricing -- 38
3.3.3.2 Packaging colour scheme --- 39
3.3.3.3 Shelf location --- 41
3.3.3.4 Media -- 43
3.3.3.4.1 Promoted products to children on television -------------------------- 44
3.3.3.4.2 Other types of media -- 46

3.4 Public health concerns of novelty sweets in children ----------------------- 46
3.4.1 Concerns about novelty sweets and obesity ---------------------------------- 47
3.4.2 Dental health implications of novelty sweets in children -------------------- 51
3.4.2.1 Dental caries --- 51
3.4.2.1.1 Pathogenesis --- 54
3.4.2.1.2 Epidemiology of dental caries --- 57
3.4.2.1.3 Link between obesity and dental caries -------------------------------- 62
3.4.2.1.4 Concerns about sugar content of novelty sweets and dental caries 63
3.4.2.2 Dental erosion -- 66
3.4.2.2.1 Epidemiology of TSL in children -- 68
3.4.2.2.2 Aetiology of dental erosion -- 70
3.4.2.2.3 Concerns about novelty sweets and dental erosion ----------------- 77

3.5 Socio-economic status and oral health -- 79

3.6 Tooth structure -- 81
3.6.1 Dentine-pulp complex --- 81
3.6.2 Enamel -- 82
3.6.2.1 Chemical composition of enamel -- 82
3.6.2.1.2 Factors relevant in the erosion process -------------------------------- 84
3.6.2.1.3 Factors protecting the enamel surface ---------------------------------- 97
3.6.2.1.4 Methods used to investigate tooth surface loss ---------------------- 99

3.7 Literature review conclusions -- 104

4 MATERIALS AND METHODS, RESULTS AND DISCUSSION -------------- 107

4.1 Study structure -- 107

4.2 Assessment of the most available novelty sweets-------------------------- 110
4.2.1 Participants-- 114
4.2.2 Data recording and handling --- 114
4.2.3 Debriefing of shop manager -- 115
4.2.4 Results of assessment of novelty sweets' availability---------------------- 115
4.2.4.1.1 Price of the available novelty sweets in Cardiff--------------------- 119
4.2.4.1.2 Categories of the available novelty sweets in Cardiff ------------- 120
4.2.4.1.3 The ten most available novelty Sweets in Cardiff------------------ 121
4.2.5 Discussion of novelty sweets' availability ------------------------------------ 124

4.3 Sociological aspects of the study-- 127
4.3.1 Focus groups to inform the assessment of the sweet and sour tastes thresholds-- 127
4.3.1.1 Methodology -- 128
4.3.1.1.1 Participants of focus group discussion------------------------------- 128
4.3.1.1.2 Programme for the focus group discussions ----------------------- 129
4.3.1.1.3 Debriefing--- 130
4.3.1.1.4 Data handling--- 131
4.3.1.2 Analysis of the focus groups' discussion ------------------------------- 132
4.3.1.2.1 Familiarity of sweets amongst children ------------------------------ 133
4.3.1.2.2 The routine nature of novelty sweets consumption (when and where eaten)-- 136
4.3.1.2.3 Availability and accessibility of novelty sweets to children ------ 140
4.3.1.2.4 Children's belief about which age/gender novelty sweets are aimed at 143
4.3.1.2.5 Reasons of like and dislike of novelty sweets----------------------- 145
4.3.1.3 Discussion of focus group work-- 152
4.3.1.4 Using findings from the focus group discussion to design a questionnaire --- 159
4.3.2 Testing sour and sweet absolute and recognition thresholds------------ 161
4.3.2.1 Methodology -- 162

4.3.2.1.1 Participants of testing sweet and sour thresholds and questionnaire completion -- 162
4.3.2.1.2 Preparation of sweet and sour solutions ---------------------------- 164
4.3.2.1.3 Program of the visit --- 167
4.3.2.1.4 Data handling -- 170
4.3.2.2 Results of sensory testing and questionnaire ------------------------- 172
4.3.2.2.1 Perception of absolute and recognition thresholds --------------- 173
4.3.2.2.2 Comparison of taste thresholds' perception and age ------------- 176
4.3.2.2.3 Comparison of taste thresholds' perception and gender --------- 180
4.3.2.2.4 Comparison of liking of novelty sweets and gender -------------- 184
4.3.2.2.5 Comparison of taste thresholds' perception and frequency of novelty sweets' consumption --- 186
4.3.2.2.6 Comparison of taste thresholds' perception and liking novelty sweets 192
4.3.2.2.7 Comparison of novelty sweets and liking of other food types -- 198
4.3.2.3 Discussion of sensory work and questionnaire ----------------------- 202

4.4 Oral science aspects of the study -- 209
4.4.1 Preparation of the ten most available sweets ------------------------------- 210
4.4.2 Preparation of enamel samples -- 213
4.4.3 pH -- 217
4.4.3.1 Methodology -- 217
4.4.3.2 pH results --- 219
4.4.4 Neutralisable acidity -- 221
4.4.4.1 Methodology -- 221
4.4.4.2 Neutralisable acidity results -- 222
4.4.5 Contact angle measurement (wettability) ------------------------------------ 226
4.4.5.1 Methodology -- 226
4.4.5.2 Contact angle (wettability) results -- 229
4.4.6 Novelty sweet viscosity -- 232
4.4.6.1 Methodology -- 232
4.4.6.2 Viscosity results --- 235
4.4.7 Sugar content measurement using a refractometer ----------------------- 238
4.4.7.1 Methodology -- 238

4.4.7.2 Sugar content results ---- 240
4.4.8 Enamel erosion tests ---- 243
4.4.8.1 Saliva collection ---- 243
4.4.8.2 Preparation of enamel specimens ---- 246
4.4.8.3 Surface enamel loss ---- 248
4.4.8.3.1 Methodology ---- 248
4.4.8.3.2 Results of surface erosion test ---- 250
4.4.8.4 Subsurface enamel loss ---- 256
4.4.8.4.1 Methodology ---- 256
4.4.8.4.2 Results of subsurface erosion test ---- 259
4.4.9 Discussion of oral science aspects ---- 266
4.4.9.1 pH values ---- 266
4.4.9.2 Neutralisable acidity ---- 267
4.4.9.3 Viscosity and contact angle ---- 269
4.4.9.4 Sugar content ---- 270
4.4.9.5 Enamel erosion tests ---- 271

5 OVERALL DISCUSSION OF THIS STUDY ---- 276

6 CONCLUSIONS AND RECOMMENDATIONS ---- 285

6.1 Conclusions ---- 285

6.2 Recommendations ---- 287
6.2.1 Clinical recommendations ---- 287
6.2.2 Public health recommendations ---- 288
6.2.3 Recommendations for future work ---- 291

7 REFERENCES ---- 293

8 APPENDICES ---- 350

8.1 Appendix 1. Search strategy ---- 350

8.2 Appendix 2. Data collection sheet for scoping visits ---- 356

8.3 Appendix 3. Ethical approval for scoping visits ----------------------------- 357

8.4 Appendix 4. Participant information sheet for scoping visits ----------- 358

8.5 Appendix 5. Consent form for scoping visits --------------------------------- 361

8.6 Appendix 6. Thank you note for scoping visits ------------------------------ 363

8.7 Appendix 7. Ethical approval for focus group work, Cardiff University 364

8.8 Appendix 8. Ethical approval for focus group work, Cardiff Metropolitan University --- 365

8.9 Appendix 9. Parents letter for focus group work ---------------------------- 366

8.10 Appendix 10. Participant information sheet for focus group work -- 368

8.11 Appendix 11. Consent form for focus group work ----------------------- 371

8.12 Appendix 12. Dental Health talk for participating children ------------ 373

8.13 Appendix 13. Thank you note for focus group discussion------------- 378

8.14 Appendix 14. The compositional structure of themes ------------------ 379

8.15 Appendix 15. Questionnaire for sensory testing ------------------------- 399

8.16 Appendix 16. Ethical approval for sensory testing, Cardiff University 403

8.17 Appendix 17. Ethical approval for sensory testing, Cardiff Metropolitan University --- 404

8.18 Appendix 18. Participant information sheet for sensory testing ----- 405

8.19 Appendix 19. Consent form for sensory testing -------------------------- 409

8.20 Appendix 20. Sensory taste tables for sweet and sour thresholds - 411

8.21 Appendix 21. Thank you note for sensory testing ----------------------- 413

8.22 Appendix 22. Raw data of sensory testing and questionnaire-------- 414

8.23 Appendix 23. Ethical approval to obtain human extracted teeth---- 427

8.24 Appendix 24. Raw data of pH at body temperature ---------------------- 430

8.25 Appendix 25. Raw data of pH at room temperature---------------------- 432

8.26 Appendix 26. Raw data of neutralisable acidity at room temperature 434

8.27 Appendix 27. Raw data of Neutralisable acidity at body temperature 436

8.28 Appendix 28. Raw data of contact angle------------------------------------ 438

8.29 Appendix 29. Raw data of viscosity --- 441

8.30 Appendix 30. Raw data of sugar content ------------------------------------ 442

8.31 Appendix 31. Raw data of surface enamel loss with saliva------------ 443

8.32 Appendix 32. Raw data of surface enamel loss without saliva ------- 454

8.33 Appendix 33. Raw data of subsurface enamel loss without and with saliva 465

1 Abstract

Statement of problem: The expansion of the novelty sweets market in the UK has major potential public health implications for children and young adults as they may cause dental erosion, dental caries and obesity.

Aims and objective: To investigate the potential dental public health implications of novelty sweet consumption in children. The objectives of this study were to determine the available novelty sweets available to UK consumers, to determine the erosive potential of the most available novelty sweets, to establish the sensory thresholds in children and to determine any potential link between high sensory threshold individuals and their consumption of novelty sweets.

Methodology: A list of the most commonly available novelty sweets was created by undertaking scoping visits of shops in the Cardiff area. Children's use and knowledge of the ten most available novelty sweets were undertaken using focus groups, amongst 11-16 year old children. The focus groups informed the design of a questionnaire. The questionnaire was distributed to 46 children aged 11-16 years during a sensory analysis assessment involving sensory taste thresholds for sweet and sour, assessed using the intensity ranking method. The pH of the ten most available novelty sweets was assessed using an electronic pH meter; the neutralisable acidity was measured by titration against 0.1M sodium hydroxide; an erosion test was conducted on human teeth using a surfometer; contact angles were measured using a Dynamic Contact Angle Analyser; the viscosity was measured using a rotational viscometer and sugar content of the sweets was measured using a refractometer.

Results: A wide range of novelty sweets were available, accessible to children in 73% of shops with an average price of 96p. The children were all familiar with novelty sweets, they reported buying and consuming them regularly. The majority of children (65%) required higher amounts of sugar and citric acid than the absolute taste threshold to recognise the sweet and sour tastes. There was an inverse relationship between the preference of the novelty sweets and perception of sweet and sour sensory thresholds ($p<0.05$). The pH of eight of the ten novelty sweets was significantly lower than the orange juice ($p<0.05$). The neutralisable acidity of seven of the sweets was significantly higher than the orange juice ($p<0.05$). The erosive potential of six novelty sweets was significantly higher than the erosive potential of the orange juice ($p<0.05$). Delayed ultrasonication by 1 h, reduced the amount of subsurface enamel loss by 0.52-1.45μm in presence of saliva. Some of the acidic solutions had low contact angles, lower viscosity and higher sugar content than orange juice.

Conclusions: A wide range of acidic and free sugar sweetened novelty sweets were easily accessible and affordable to children. Children reported consuming these sweets regularly. The high sensory taste thresholds perception for sweet and sour in children may potentially affect their consumption of novelty sweets. Those personnel involved in delivering dental and wider health education or health promotion need to be aware of and able to advise on current trends in sweet confectionary. The potential effects of these novelty sweets on both general and dental health require further investigation.

Introduction

2 Introduction

The Declaration of Human Rights of the Child adopted by United Nations in 1989 stated that *"The child is recognized, universally, as a human being who must be able to develop physically, mentally, socially, morally, and spiritually, with freedom and dignity"* (Unicef UK 2014 p.5). Furthermore, the common law of Wales and England states that parents are the main responsible people in protecting the child (Unicef UK 2007). This responsibility includes making the best decisions in the interest of the children until they reach the age of consent. The British Nutrition Foundation (2013) provided dietary guidelines, which included providing a diet that meets all the nutritional requirements for children, avoiding any diet related diseases such as obesity and dental caries and the prevention of any food-borne transmitted diseases such as food poisoning. However, there are wide ranges of environmental, familial, social and cultural roles, which modify the parent and child's behaviour in the process of food selection and consumption (Patrick and Nicklas 2005). These factors include the child's food preferences, the parent's attitudes towards food, the influence of peers, availability and accessibility of food inside and outside the home, socioeconomic status and interaction with the media, which often target children as a vulnerable consumer.

Many studies and surveys have shown that diet is one of the major aetiological factors in the development of obesity, dental erosion and dental caries amongst children (Asher and Read 1987; Dugmore and Rock 2004a; Rees 2004; Moynihan 2005; Rees et al. 2006; Arnadottir et al. 2010; Hooley 2012). It has been found that there is a strong relationship between eating food with a high "free" sugar content and dental caries (Burt and Pai 2001; Harris et al. 2004; Ruxton et al. 2010). The term "free" sugars refers to all mono and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, fruit juices and syrups (Scientific Advisory Committee on Nutrition 2015). It is recommended that the average consumption of free sugar does not exceed 5% of the total dietary energy of age group of 2 years and upward (Scientific Advisory Committee on Nutrition 2015). Free sugars are different than the other types of sugar which are termed milk-sugars. Milk-sugars are sugars present naturally in milk and milk products (i.e. lactose) (Scientific Advisory Committee on Nutrition 2015).

Epidemiological and laboratory based studies have highlighted that frequent consumption of acidic foods and/or drinks can lead to the development of dental erosion (Al-Majed et al. 2002; Davies et al. 2008; Ehlen et al. 2008; Bartlett et al. 2011; Lussi and Carvalho 2015).

The National Children's Dental Survey showed that dental erosion and dental caries are common diseases in children (Department of Health 2013). In addition, it has been found that the prevalence of childhood overweight and obesity is still high amongst children although a stability plateau was reported in the last decade (Health and Social Care Information Centre 2014a; Jaarsveld and Gulliford 2015; Parliament UK 2016). A systematic review by Te Marenga *et al.* (2013) suggested that consumption of high calorie food, such as high free sugar products is detrimental to body weight.

Novelty sweets are of particular concern because they contain high levels of both sugar and acids. Furthermore, their unusual product design facilitates regular frequency of consumption as many are available in re-sealable packages. Consequently, they have the potential to cause dental erosion (Bartlett et al. 2011;

Fung and Brearley Messer 2013), dental caries (Burt and Pai 2001; Harris 2004; Ruxton et al. 2010) and obesity (Malik et al. 2006; Hu and Malik 2010; Te Marenga 2013). It has been suggested that it is important to address sweet consumption as a part of an overall prevention program to control the public health implications of such types of food (Asher and Read 1987; Arnadottir et al. 2010). One of the most commonly available types of sweets in the market are novelty sweets which are characterised by being in re-sealable packages, being both sweet and sour or/and combined with a toy element (Stewart et al. 2013). The marketing of novelty sweets is mainly directed towards children who are the top consumers of sweet confectionary in the UK (Mintel 2012).

To date, studies on the dental public health implications of novelty sweets are limited (Beeley 2005; Gambon et al. 2007; Davies et al. 2008; Robyn et al. 2008; Gambon 2009; Wagoner et al. 2009). Aspects which have not been investigated before include: the types of novelty sweets available to children in the UK, their prices, where and how they are displayed in shops, their potential erosive effect on teeth, children's preference for novelty sweets and sensory taste thresholds for sweet and sour in children. All these factors may influence children's consumption of novelty sweets. Therefore, this study was conducted to explore these gaps in knowledge.

Literature review

3 Literature review

The literature search was undertaken using the search strategy presented in Appendix 1.

3.1 Sweet consumption in the UK

The UK is one of the world's major consumers of confectionary. The available data suggests that there has been a continued growth of chocolate and sugar confectionary consumption in the UK and the market sector was worth £5.41 billion in 2011 (Mintel 2012). For example, sales of chocolate confectionary accounted for 74% of the total confectionary spends in the UK in 2011 and the sugar confectionary spends were worth 26%. One aspect of the recent market growth of confectionary is due to the increase in the production of sweet types in re-sealable packages and novelty sweets. According to the UK confectionary report for 2012, the overall growth in sugar confectionary in the UK was 8.5% in 2011 (Market Intelligence 2012).

3.1.1 Novelty sweets

Novelty is defined by Oxford English Dictionary as *"The quality of being new, original, or unusual"*. Over the last decade sour and novelty sweets have continued to gain in popularity in the UK (West 2006; Milan 2008; Stewart et al. 2013). Sour sweets were first introduced in the late 1970s by a Canadian confectionary distributer, Frank Galatolie. He modified traditional gum based sweets by adding a sour flavoured coating which contained a mixture of simple organic acids such as citric, malic and tartaric acids, to the surface of the sweet. A product using this approach and known as ‘Sour Patch Kids’ was introduced to the US market in 1985 and this appears to be the first recorded sour sweet. This product was also introduced to the UK market as ‘Maynards sour patch kids’ in the last decade (Davies et al. 2008).

This sector of the confectionary market has evolved rapidly since 1985 and has been referred to by many authors as ‘novelty sweets’ and these products seem to be specifically targeted at young children (Mintel 2012). These sweets are a heterogeneous group but are usually brightly coloured, they resemble or can be used as toys and are sold at pocket money prices. Examples of some commonly available novelty sweets are shown in Figure 1.

Stewart *et al.* (2013) have classified these novelty sweets into three broad groups:

1. Those that combine a sweet with a toy, for example, ‘Wrist Licker’ and ‘Hose Nose’
2. Re-sealable lollipops such as ‘Flic n Lic’
3. Liquids and sprays such as ‘Juicy Pop’ and ‘Brain Licker’

Figure 1. Examples of some novelty sweets.

Although concerns have been raised about the safety of novelty lines (e.g. the choking hazard posed by small parts) little attention has been paid to their potential impact on oral and general health (Beeley 2005; Davies et al. 2008; Robyn et al. 2008; Gambon 2009; Wagoner et al. 2009; Stewart et al. 2013). In addition, the Food Standards Agency has previously released a warning of the risk of oral and circumoral chemical burn as a result of prolonged exposure of highly acidic novelty sweets (Food Standards Agency 2003), which caused reformulation of these sweets (Stewart et al., 2013).

3.2 Children's eating habits

3.2.1 Role of food preferences on children's eating habits

Childhood is the time when people develop their food preferences, the highest number of preferred foods is established by the age of 8 years (Skinner et al. 2002). There are many factors which influence a child's development of food preference. These factors include the innate mechanism which is genetically determined, food exposure and social factors (Harris 2008). Children's preference of any new food is formed and modified by two important factors, the quantity of the experience such as the repeated exposure to a new food and quality of the exposure such as the social presentation of food (Birch 1980). Both number of exposures (quantity) and the method of presentation (quality) should work together to get the best result. It is clearly observed that children do not like to try new foods and this well-researched phenomenon is called neophobia (Rozin 1976; Cooke et al. 2004). Studies have shown that if this phenomenon were more apparent in children, they would be more likely to refuse eating fruits and vegetables. However, frequent exposure to fruits and vegetables at home and in school will strengthen the liking of such types of food (Cashdan 1998; Cooke et al. 2003; Reverdy et al. 2008). For consumption of new foods, it has been suggested that the number of exposures needed for the child to accept the food ranges between 10-15 times in a discrete period of time (Marshall et al. 2006).

3.2.1.1 Food preferences in children

Food selection is guided mainly by the taste of the food (Harris 2008). Food taste is complex and includes the chemical senses of taste, odour and the oral acuity of food texture. Sensory perception affects food preference as well as eating habits (Frank and Vanderklaauw 1994; Reed et al. 2006). For example, it has been found that the major factor predicting soft drink consumption in school-aged children in the US was the taste preference with a direct relation between the taste preference and frequency of consumption (Grimm et al. 2004).

In children, the effect of sensory perception is more intense than in adults (Birch 1992). It was also suggested by Ricketts (1997) and Ludwig *et al.* (2001) that food preference is one of the important determinants of the development of obesity in industrialized countries. It has been suggested by many authors that children's food choices are determined by their sweet taste preference (Pangborn and Giovanni 1984; Liem and Mennella 2002, 2003; Perez-Rodrigo et al. 2003). A study by Alleson *et al.* (2009) which assessed the sensory taste threshold in 8,900 children revealed that girls are more sensitive to sweet by a 10% concentration and in sour by a 20% concentration, compared to boys. In addition, it was also found that girls preferred foods with lower taste strengths, than boys.

3.2.1.1.1 Sweet preferences in children

In general, humans have an innate preference for sweet tasting foods. This innate preference is partially inherited; this genetic variation may affect the level of sweet consumption (Keskitalo et al. 2007).

In children, the preferred food is either familiar to them or sweet (Birch 1992). In addition, taste is the only determinant of food preference in children. In adults, taste alone is not the absolute deciding factor of food selection and consumption. There are other factors to be considered such as perceived nutritional beliefs, product safety, price, convenience and prestige. Moreover, there are strong effects of demographic, sociocultural and economic factors that may affect the food selection and consumption (Schiffman 1993; Nestle et al. 1998).

The most significant example of food dislike in children is the dislike of bitter flavours. The acquired preference of some children’s unpleasant foods such as coffee and beer in adulthood is an example of how the food preference can be learned and modified by age. Studies have also shown that there is a gradual decrease in sweet preference throughout adolescence into adulthood (Desor and Beauchamp 1987; Drewnowski 1997).

With regards to the preference of sweetened dairy products, studies have suggested that their fat content potentiates the sensory response. The high sensory response is achieved when 20% of fat is mixed with 9% of sucrose in the form of a mixture of milk, sugar and cream (Drewnowski et al. 2012). The preference to such a mixture has been suggested to be related to both the child's and parent's body weight, which might suggest possible familial and genetic factors in sensory responses (Fisher and Birch 1995).

In addition, the pleasure of food may be mediated by brain neurotransmitters or peptides. The pleasure of a sweet flavour is suggested to be mediated by opiates (Drewnowski 1997). It increases by opiate agonist and decreases by opiate antagonists such as naloxone and naltrexone, which reduce sweet food intake by lowering their preference. In addition, endogenous opiate has been suggested to be involved in obesity, bulimia nervosa and in binge-eating syndrome (Drewnowski 1997). The latter is characterised by repeated eating cycles of sweet and high-fat foods indicating an "addiction to sugar". Opiate blockage might therefore be the treatment of choice in managing such conditions (Drewnowski et al. 1995; McElroy et al. 2012).

3.2.1.1.2 Sour preferences in children

Over the last four decades, many researchers have investigated children's sensory taste thresholds. However, these investigations were focused mainly on sweet, salt and, more recently, bitter tastes with little focus on the sour taste (Birch 1999). It has been suggested that some children have a preference for sour taste with no clear understanding of the reason behind it (Liem et al. 2004a). A study by Liem and Mennella (2003) found that 35% of children aged 4-9 years preferred a high level of sour taste in gelatine. Those children were significantly less food neophobic (willing to try new foods) and also generalised their liking of the strong sour to other types of food such as candies (sweets) and lemons. It was also found that 92% (n=24) of children were able to rank the sour taste from the highest sour to the least.

The basis of these sour taste preferences remains unknown. One hypothesis is that children who have a preference for high concentrations of citric acid in foods, rate this as less sour compared with those who do not prefer these concentrations of citric acid (Liem and Mennella 2002). It has been suggested that a high salivary flow (Dawes 1987; Spielman 1990; Liem and Mennella 2003), high saliva pH (Norris et al. 1984) and buffering capacity (Christensen et al. 1987) may increase the sour taste threshold.

It has also been suggested that a preference for sour taste in children is related to the desire for adventure and to the preference for unfamiliar foods or stimulation of other senses such as vision (Gunnar et al. 1997; Davis et al. 1999; Liem et al. 2004b).

Based on what has been established with regards to sweet and sour taste preferences in children and its effect on level of consumption, children's liking of novelty sweets and the sensory thresholds of sweet and sour in children were assessed in the present study. Thresholds of sweet and sour may also help to predict the development of a "sweet tooth" or "sour tooth", (Reed and McDaniel 2006; Sijtsema et al. 2012) which could affect the level of consumption of novelty sweets in children.

3.2.1.2 Methods for assessment of sensory taste thresholds

Taste is defined as the sensation when a particular substance reacts chemically with taste receptors. These receptors are located on taste buds; mainly on the tongue and soft palate. Both taste and smell stimulate the sensory innervation of the oral cavity through the trigeminal nerve to determine the flavours of foods and drinks (Spielman 1990; Hadley et al. 2004).

There are five basic tastes that trigger the taste sensation in humans; sweet, salt, sour, bitter and umami. The taste buds are able to differentiate between different tastes by detecting the interaction between different molecules (Purves et al. 2001). Sweet, umami and bitter taste can be perceived by the binding of molecules to G protein-coupled receptors (Stuck 2010). Whilst the salty and sour tastes can be perceived when alkali metal or hydrogen ions react with the taste buds (Purves et al. 2001; Caicedo et al. 2003).

There are other factors considered as part of perception of the taste sensation. These factors include smell (detected by olfactory epithelium), texture (detected by mechanoreceptors), and temperature (detected by thermoreceptors) (Hadley et al. 2004; Asahina and Benton 2007; Stuck 2010).

The sweet sensation is perceived by the presence of sugar. Two types of sweet receptors (heterodimer and homodimer) have to be stimulated for the brain to detect sweetness (Mennella and Bobowski 2015). The sour taste sensation is perceived as the acidity of foods and drinks. The sour taste is detected by small cells located in the taste buds which express a specific protein (PKD2L1) (Plattig et al. 1980; Stuck 2010). The sour sensation is perceived when taste receptors are coupled to G protein gustducin (Nakata et al. 1995). The saltiness sensation is perceived by the presence of sodium ion which activates the sodium chloride salt receptors (Hill and Mistretta 1990). Bitterness is usually perceived as an unpleasant and sharp sensation, although sometimes is a desirable sensation such as in coffee and citrus peel (Nakamura et al. 2002; Caicedo et al. 2003; Mennella and Bobowski 2015). Umami is an appetitive taste usually described as a savoury or meaty taste. Umami taste is perceived when glutamate binds to G protein coupled glutamate receptors (Bellisle 1999; Kurihara 2009, 2015).

Sensory taste involves the use of senses in the form of a physiological response. There are what are called sensory characteristics of any type of food and drink which include colour and appearance, texture, aroma and flavour, the latter produced by aroma and taste (Leon et al. 1999; Murray et al. 2001). In sensory testing procedures all the sensory characteristics need to be considered to assess the sensory threshold in a reliable manner. Taste requirements include that the molecules must be soluble in saliva and can bind to the taste receptors distributed throughout the oronasal cavity (Hadley et al. 2004).

There are different levels of sensory threshold. Subthreshold level is the concentration of taste compound at a level which is undetectable. Absolute, detection or stimulus threshold is the level at which an individual perceives a difference between the water and the next solution but the taste is not identified. Recognition threshold, on the other hand, is the level at which the individual perceives and recognises the taste of the solutions (Liem and Mennella 2003; Popper and Kroll 2003; Liem et al. 2004a).

The method of measuring the sensory taste sensitivity is called a rank order test (Leon et al. 1999). There are two main types of rank order test, the preference ranking method to rank the food or drink from the most preferred to the least (Keskitalo et al. 2007) and the intensity ranking method to assess the ability of the participant to recognise single taste with different intensity (Liem and Mennella

2003). The intensity ranking method can be performed either in a structured or unstructured format (Popper and Kroll 2003). In the structured method, the participant is given one or more tastes (e.g. salt, sweet, sour) in groups with different concentrations in ascending order for the participant to identify the stimulus and recognition thresholds. In the unstructured method, the participant is given the taste solutions in groups but with a random order for the participant to rank them based on the intensity of the taste (Leon et al. 1999; Liem and Mennella 2003; Popper and Kroll 2003; Chambers 2005).

The British Standards Institute (2011) has developed a validated methodology for threshold testing of individuals using the intensity ranking method, with specific materials and concentrations, which are diluted up to 12 times to produce solutions for each type of taste (Table 1).

Table 1. Reference materials of the tastes and maximum concentrations for the sensory threshold test in children (British Standards Institute 2011).

Taste	Reference material	Maximum concentration (g/l)
Sour	Citric acid	1.50
Bitter	Caffeine	0.54
Salty	Sodium chloride	4.00
Sweet	Sucrose (table sugar)	10.00
Umami	Monosodium glutamate monohydrate	2.00
Metallic	Iron (II) sulfate heptahydrate	0.012

It is important to control the test conditions to obtain reliable and relevant results (Chambers 2005). The British Standards for sensory panels provide general rules to obtain a high level of reliability of the sensory test (British Standards Institute 2011) which will be used in the sensory testing part of this study. These rules include:

1- Citric acid and caffeine should be dissolved in hot water (80° C).
2- All solutions should be used within 48 h.
3- All solutions should be stored chilled until use.
4- The participant should be provided with enough volume of solution (about 15 ml)
5- Take about 30 seconds to evaluate the taste intensity.
6- Between each type of taste group, participants should rinse the mouth with water at the same temperature as the test solutions.
7- Participants should follow the sequence of the concentrations without going back to the previous concentration.
8- To avoid sensory fatigue, no more than 3 taste series should be tested in the same session.
9- The series should be always presented in ascending not descending order.

3.2.2 Role of food availability and accessibility on children's eating habits

3.2.2.1 Role of availability and accessibility of food at home

It is not only the child's taste preference that determines their eating habits, but also the availability of food types and their accessibility (Birch et al. 2007). Regardless of the preference of food type, children are usually directed to eat the available and accessible food choices at home (Birch and Marlin 1982). For example, a qualitative study by Holsten (2010) reported that children's dietary intake of fruits, low-fat dairy and sugar-sweetened beverages were correlated with their availability at home regardless of the children's food preference.

It has been found that the children in families who do not prepare food every day tend to ask for sweet foods continuously because they do not eat enough food and depend on sweets as the main source of energy (Baranowski et al. 1999).

3.2.2.2 Role of food availability and accessibility outside the home

Eating outside the home is usually associated with eating foods high in calories. It has been shown that children aged between 12-18 years old consume the highest percentage of "junk" food and sweets eaten outside the home (Nielsen et al. 2002).

The amount of high calorific food consumed by children outside the home has increased particularly during the last few decades (Nielsen et al. 2002). There is a strong relationship between the food consumed outside the home and diet related diseases, bearing in mind other contributory factors such as a sedentary life-style and lack of physical activity (French et al. 2001).

3.2.2.2.1 Fast food restaurants

In fast food restaurants, there is a significant possibility of eating more as a result of the availability of promotional "big kid's" meals and some of them are also promoted with toys. The availability of such type of meals promotes the over-consumption of an energy-dense food which is against the recommendation of obesity prevention (Livingstone and Pourshahidi 2014; Mattes 2014; Berg and Forslund 2015). US data has also shown that the consumption of fast food by children has increased by about 300% between 1977 and 1996 (St-Onge et al. 2003). It has been found the average energy density in the fast food meals was 65% more than the average British diet (670 kilojoule /100g) and twice the recommended energy density of the healthy diet (Prentice and Jebb 2003). In the UK, the food portion size has been extended recently including food sold in fast food restaurants (Church 2008; Livingstone and Pourshahidi 2014).

3.2.2.2.2 Schools

In the UK, one of the aims of the National School Fruit Scheme is to provide school children with a healthy diet outside the home by giving them fruit as a snack between meals (Wells and Nelson 2005). However, it is almost impossible to control the quality of food in the lunch boxes that are brought with children to school. In Manchester, for example, dental health inspectors have performed periodic checks of the lunch boxes of children aged 7-11 years old at school. These check-ups have shown that most of the food boxes contained chocolate, crisps and fizzy drinks. Interviews with their parents have shown a loss of control of parents over their children in deciding what to eat, or the forgiving nature of parents and the fact that some parents do not pay much attention to how their children spend their pocket money (Roberts et al. 2003).

3.2.2.2.3 The school fringe

A large number of students get to and from school by walking. For example, in England 43% of students aged 5-16 were get to and from school by walking (National Statistics 2013). Sinclair and Winkler (2009) and Crawford *et al.* (2012) defined the school fringe as the area in close proximity to schools where children purchase items before school, at lunchtime and after school. Sinclair and Winkler (2009) found that 80% (n=260) of schoolchildren bought something from the school fringe at least once a week with an average of once per day. They also discovered that the quality of food bought by schoolchildren from the school fringe in London was composed of 23% fat, 25% total carbohydrate (including sugar) and 22% total sugar (the remainder being protein and salt). Crawford *et al.* (2012) and Caraher *et al.* (2014) found that the calorific contents of the available food in shops around high schools was 1323 kcals per portion which was double the recommended amount to be consumed by children (Scientific Advisory Committee on Nutrition 2015). Furthermore, it was also found that shops around school used targeted marketing and promotional strategies to attract children such as offers and deals (Story and French 2004; Harris and Graff 2011). It was found to be not only the small independent businesses that attracted large group of children, but also the popular chain and franchised businesses (Crawford et al. 2012).

Therefore, what is available and accessible to children in shops within walking distance around schools may significantly affect children's eating habits on a regular basis with a negative impact on general and oral health. Particularly, if children are walking to school without having eaten breakfast which is true for about 46% of children (Sinclair and Winkler 2009).

3.2.2.2.4 Vending machines

Foods available from vending machines are often from the unhealthy food groups such as sweets and soft drinks. A study by Maliderou *et al.* (2006) reported that there was a significant direct relationship between the high socioeconomic status of children in London and accessibility to vending machines and dental health. However, other studies have shown that there is no clear negative effect of consumption of confectionary purchased from vending machines on school children with regards to BMI or undesirable dietary lifestyle (Forshee et al. 2005). The availability and accessibility of soft drinks and sweets in vending machines at schools may influence food choices of children of such types of food outside the home (Rovner et al. 2011). Moreover, recently, Healthy Schools initiatives have been successful in changing the nature of food drinks in vending machines. In Wales, for example, sweetened soft drinks and confectionary are no longer allowed (Welsh Government 2012).

3.2.3 Role of parents on children's eating habits

3.2.3.1 Role of parent's attitude towards food

Children develop their eating habits by watching others. Research has found many common features between children's and their parents' diets. Children's consumption of fruit and vegetables, spicy food and sweet foods is strongly related to their parent's attitude towards these types of food (Cooke et al. 2004).

This is a critical period in the development of a child's eating habits. Children follow the beliefs, knowledge and attitude of their parents towards food from as early as two years of age. Furthermore, maternal food preferences affect the availability of food to children. It has been shown that mothers affect children more than fathers in this context (Skinner et al. 2002). Gibson *et al.* (1998) reported that a mother's preference for confectionary is one of the main predictors of high consumption of confectionary by their offspring. Furthermore, it has been found that there is a direct relationship between parental dietary belief and behaviour, and children experiencing oral diseases (Poutanen et al. 2006; Fisher-Owens et al. 2007; Hooley 2012) and obesity (Bruss et al. 2003; Lindsay et al. 2006).

However, the parent's influence cannot be separated from the other factors affecting a child's eating habits. Most of the other factors such as food preference, availability and accessibility are linked with this factor (Casey and Rozin 1989; Birch 2001; Story et al. 2002).

3.2.3.2 Use of sweets as a reward

Families use sweets as treats and rewards on specific occasions such as at Easter, Christmas, Eid and as a reward for children following performance of a specific behaviour which reinforces the sweet as a preferred food. Birch *et al.* (1980) found that the majority of preferred foods are those used as a reward for performance of a specific behaviour or as a part of encouragement by parents. Such use of food is called an instrumental consumption. However, a study by Wardle *et al.* (2003) showed that there is a negative effect of using instrumental consumption of food on children's preference with no positive effect on the targeted behaviour. Furthermore, a study done by Maimaran and Fishback (2014) found that the reward strategy did not significantly increase the food liking in primary school children, but the repeated exposure of food (for 2 weeks) was significantly effective.

3.2.3.3 Role of parent's pattern on children's eating habits

Parents tend to have three predominant styles, namely authoritarian, permissive and authoritative which were first described by Baumrind (1973). The authoritarian style of communication is characterised by the restriction of some foods only allowing children to eat a specific type of food and forcing them to eat only selected types of food (De Bourdeaudhuij and Van Oost 2000). In the permissive style, children can eat whatever they want and the only control is the availability of food (De Bourdeaudhuij and Van Oost 2000). The last style is the authoritative way by which the parents allow the children to eat the food they selected with some possibility of eating the other type of food that children may choose (Fisher and Birch 2000). The last style is often considered as a balanced way of managing the child's preference and limiting unhealthy foods. It is usually associated with the consumption of greater amount of fruits and vegetables and lesser amount of sweets and soft drinks. The permissive style is not surprisingly associated with a high intake of sweets, snacks and soft drinks and lesser amount of fruits and vegetables (Cooke et al. 2004).

The authoritarian approach is the enforcement of children by parents to eat specific types of food or restricting children from eating specific types of food. Research has found that restricting children to eat specific types of food results in higher consumption of that type of food by children. While enforcement of children to eat specific type of food results in dislike of that type of food (Fisher and Birch 2000). In reality, this result is against the belief of about 40% of parents who believe that the restricted type of food will be consumed less by children (Casey and Rozin 1989).

3.2.4 Influence of peers on children's eating habits

More children accept the food given to them if their mother or friendly adult was the source of the food (Happer 1975; Savage et al. 2007). Food like and dislike in children are suggested to be influenced by observing others including parents and peers in a form of observational learning (Happer 1975; Cashdan 1998).

Peers and friends also can strongly influence children's eating behaviour (Oliver and Thelen 1996; Marshall et al. 2007; Salvy et al. 2012). One study reported that 19% of children preferred food that their friends also preferred (Birch 1980). This influence of friends was seen more in girls than in boys. A study by Kelly *et al.* (2006) has also shown that 60% of parents believe that there is a strong peer pressure influencing the consumption of junk food and sweets by their children.

3.2.5 Role of socioeconomic status, ethnicity and culture on children's eating habits

Family educational level and income are considered very important determinants of children's eating patterns. Studies have shown that the higher the educational level of the parents, the higher the quality of their food and their children's food and it is more related to the mother than the father's education (Xie et al. 2003). Vereecken *et al.* (2004) reported that the level of a mothers' education is a significant predicator of children's consumption of fruits and vegetables, but not soft drinks.

Household income also determines the affordability of specific types of food; studies have shown that families with low incomes eat more meat, potato, fats and sugar and less fruit and vegetables. In contrast, families with high incomes eat more unsaturated fats (James et al. 1997). British children from lower socioeconomic groups also tend to get most of their energy from fat and snacks compared with children from higher socioeconomic groups (Ruxton and Kirk 1996). There is a strong link between low socioeconomic level and low quality diet (Public Health England 2012). There is an inverse relationship between food quality and cost, which makes confectionary more affordable for low-income groups than high quality food such, as fish, meat and fruit. This may explain the strong relationship between obesity and poverty rate and lower levels of education (Drewnowski and Specter 2004).

Families from different cultural and ethnic background show differences in the types of food and ways of food preparation. For example, Indian and Mexican families tend to eat more spicy food and less fruits and vegetables. Furthermore, Asian families eat less dairy products, while Europeans eat food with less carbohydrate compared with African families (Prescott 1998; Xie et al. 2003). However, sweetness is an innate taste in all cultures (Ventura and Mennella 2011; Drewnowski et al. 2012).

3.3 Children as vulnerable consumers

Children are especially vulnerable to marketing strategies employed by the confectionary industry as they strongly influence household purchases and children also have the potential to become ‘life-time’ consumers (Valkenburg 2000).

Children are important customers in the market place especially in sweet confectionary and toys (Mintel 2012). It has been reported that children are targeted by sweet advertisements from as early as 2 years old (Zimmerman et al. 2007; Brown et al. 2011). It has been also found that children (7 years old and upward) become more demanding in purchasing sweets as their understanding of the market becomes wider and more sophisticated (John 1999). It has also been shown that children become more aware about what is available in the market and become more analytical in choosing these products (John 1999). Research in marketing shows that in order to target children, more focus is paid on developing child-friendly facilities with colourful decorations, playful displays and even making credit cards for them (Valkenburg 2000).

3.3.1 Children's purchasing behaviour

Studies have observed that when family numbers increase, children become more important in the decision making process within the family with a more open relationship between parents and their children (Turow 2003).

In 2006, data showed that children influence 43% of total purchases made by parents in the US. Mothers spend 30% more if they shop with their children and fathers spend 70% more if they shop with their children (Cairns et al. 2009). In the UK, 84% of parents said that their children influence their food purchases and consumption decisions (Dougherty et al. 2006). Studies have shown that parents become more forgiving with children when they choose to buy high caloric foods (Roberts et al. 2003). In addition, more than 48% of parents cannot resist their children's buying requests which are mainly related to sweet confectionary and toys (Dougherty et al. 2006).

3.3.2 Styles of parents' communication during shopping

Parents' management and response during shopping also significantly affect children's future shopping behaviour (Carlson et al. 1990). Children aged 7 years and upward are able to analyse their parent's reaction to develop their own buying strategy and food selection (John 1999). There are two styles of parent's communication with children when shopping. The socio-oriented style and concept-oriented style (Caruana 2003). The socio-oriented style is characterised by encouraging children to learn how to adapt their strategy to people and improve agreement and compliance to be more able to socialise (Marquis 2004). By using this type of communication, the liking and acceptance of children by other people would be higher. In addition, parents can monitor and control the purchases of their children easily.

The concept-oriented style is based on building the children's own ideas before making their decision. In this style, children discuss, analyse and think about alternatives before they decide what to buy which improve their awareness about available products and their buying skills (Caruana 2003).

3.3.3 Factors affecting children's sweet buying behaviour

Market research has been undertaken to help manufacturers to address the individual and environmental factors that may affect children's eating habits. In child-targeted marketing certain criteria are applied to attract children to specific products. Those criteria include the colour scheme of the package, the shape and colour of the product itself, the presence of branding character, shelf location and pricing (Birch and Fisher 1998; Mela 1999; Wansink 2004; Andreyeva et al. 2010; Elliott et al. 2013).

3.3.3.1 Pricing

Price of food was found to be one of the main factors which determines the food choices (Andreyeva et al. 2010). It has been found that price can strongly affect the food choices to be either healthy or unhealthy particularly in young people (Powell and Chaloupka 2009; Andreyeva et al. 2010). In 2015, the national average weekly pocket money for children was £6.20 in the UK with children in Wales receiving £5.94 per week in comparison to £7.65 for the children in London. The majority (94%) of children receive their weekly pocket money from their parents or guardians while 36% of children also get pocket money from grandparents and 11% get pocket money from other relatives and family friends. The weekly pocket money for children in 1987 was £1.10, when the average price of a bar of chocolate was 22p and children were able to buy only 5 bars of chocolate per week. With the steady increase of weekly pocket money which increased by 579% over the last 25 years, children can now buy about 10 bars of chocolate per week with the average price of a chocolate bar being about 60p (Lloyds Banking Group-Halifax 2015).

The average weekly pocket money also increases with age. In 2015, data showed that children of 8 years old received an average of £4.20 in comparison with £5.78 and £8.17 by age 11 and 15 respectively (Lloyds Banking Group-Halifax 2015). In addition, studies have shown that children aged from 8-16 years spend more on sweets and snacks in the 1990s in comparison to the 1980s following the increase in the average weekly pocket money (Donkin et al. 1993). The trend for the increase in average weekly pocket money for UK children between 1987 and 2015 is shown in Figure 2 below.

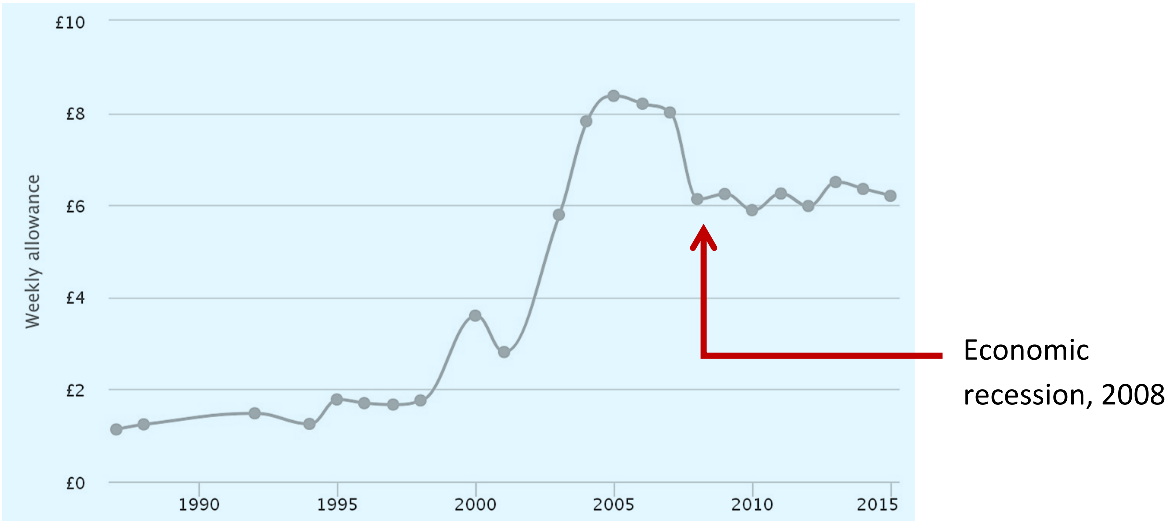


Figure 2. UK children average weekly pocket money from 1987 to 2015 (Lloyds Banking Group-Halifax 2015).

3.3.3.2 Packaging colour scheme

There is a strong link between food packaging, food acceptance and taste perception (Gelperowic 1994). In child-targeted marketing, manufacturers put a great deal of effort into designing fun packaging by selecting bright colours, shapes and brand characters that will attract children (Gelperowic 1994). Since 1993, there has been an increase in the number of products which are designed specifically to target children (Van Landuyt et al. 2008). Packages work as a silent message which influence a child's purchasing decision and children readily transmit that message to their parents. It has been found that there is a strong link between colour and memory (Spence et al. 2006). Marketing research has also found that visual effects are the main trigger that children respond to. Child-attractive visual signals are important in marketing because children are less able than adults to interpret written words (Neeley and Schumann 2004). The colour of the package also familiarises children with products so that they become part of the environment and considered as a normal feature. Therefore, package colour becomes part of the child's memory collection and will serve as a key for visual memory (Liem and Mennella 2002).

In marketing, it is rare to change the basic colour of any successful product to avoid any disruption to the child's visual memory (McNeal 2003). There is also a strong relationship between a child's favourite colour and food selection (Marshall et al. 2006). Furthermore, a US study by Walsh *et al.* (1990) found that red was the favourite colour of most children followed by green, orange and yellow. However, a more recent UK study by Marshall *et al.* (2006) found that pink (24%), purple (11.4%), yellow and blue (both 9%) are the most favourite colours. It was also found that the most commonly available colours amongst child targeted food products were pink (50%) followed by purple (15%) and yellow (15%). A study by Liem *et al.* (2004b) investigated the link between liking sour sweets and liking bright colours. They found that 85% of children aged 4-9 years who prefer the sour sweets liked the bright colours of the sweets.

Children use colours to evaluate the composition of packages as something good or bad (Carruth et al. 2000). In addition, bright colours are also used frequently in child-targeted packages to maximise the effect of colour. Children do not only respond to visual signals related to the packages, but they also give attention to the colour and shape of the product itself as the next level of analysis (Liem and Zandstra 2009). In addition, the strongest keys for children to retrieve any visual objects from the memory are their shape and size in addition to colour (Berry and

McMullen 2008). Children usually respond better to certain shapes of sweets such as honeycombs, wavy squares, marshmallows, round shapes and coloured loops.

Manufacturers usually choose attractive colours, shapes and textures in sweet confectionary to encourage children to buy sweets (Hutchings 2003). Recently, nutritionists have recommended providing healthy food to children in friendly packages to attract them by using the child-friendly colours and shapes (Robinson et al. 2007; Berry and McMullen 2008; De Droog et al. 2010).

3.3.3.3 Shelf location

One of the main aspects of child-targeted marketing is a products' location in shops. It has been found that the use of physical engagement is a highly successful aspect of marketing (McNeal 2003). It is part of the visual interaction in triggering children to purchase. When children can reach the product, they interact better with its characteristics such as the texture and quantity. Therefore, as a part of the expansion of the associative memory of children, products are placed on child reachable shelves (Pheasant and Haslegrave 2006). It has been found that products with high sugar contents are displayed in more accessible and noticeable areas in stores. Table 2 below shows a list of the average length and reach of children based on age and gender. It has been reported that between 1971 (when the average measurements were taken by Pheasant and Haslegrave) and 1999, the UK children's dimensions increased by 0.2-3% (Smith and Norris 2004). The additional increase of the UK children (between 1971 and 1999) in comparison to the figures of Pheasant and Haslegrave (2006) is presented in Table 3.

These measurements are used to design displays which are child friendly. Therefore, the location of the most available novelty sweets will be noted as a part of this study to assess the accessibility of these types of sweets to different age groups of children.

Table 2. The average height and reach in inches of boys and girls at different ages (Pheasant and Haslegrave 2006).

Age	Girls		Boys	
	Height	Reach	Height	Reach
4	42	54.6	42	54.6
5	44	57.2	44	57.2
6	46	59.8	47	61.1
7	48	62.4	48	63.7
8	51	66.3	51	66.3
9	53	68.9	53	68.9
10	55.5	72.2	55.3	71.8
11	58.5	76.1	57.3	74.7
12	60.5	78.7	59	76.7
13	62	79.9	61.2	78.9
14	64.5	82.2	63.3	81.8
15	66.5	84.1	65.3	84.7
16	68.5	86.7	67.5	86.3

Table 3. The additional increase of the UK children's dimensions between 1971 and 1999 (Smith and Norris 2004).

Age	Boys (%)	Girls (%)
2	-2.2	1.2
3	0.2	1.3
4	0.9	0.5
5	1.1	1.8
6	1.6	1.9
7	1.6	1.7
8	2.4	1.3
9	2.2	2.1
10	1.7	2.2
11	3.0	2.8
12	2.4	2.6
13	3.0	1.9
14	1.6	1.3
15	1.8	0.9
16	1.2	1.1

3.3.3.4 Media

Media consumption encourages children to push their parents to buy heavily advertised products (Fiates et al. 2008). Generally, all children affect their parent's decisions on food purchasing (Roberts et al. 2003) such as children who are trolley loaders and grabbers. However, there are individual differences between children. Mothers are more likely to be influenced by their children's power and girls are more successful than boys in exerting their power (Wilson and Wood 2004). Children who watch television for longer periods try to exert more pressure than children who watch television for less time (Tilston et al. 1990; Vereecken et al. 2006; Harris et al. 2009).

In the last three decades, eating in a traditional way has been replaced by eating while watching television (Neumark-Sztainer 2000; Francis and Birch 2006; Olafsdottir et al. 2014). Studies have shown a significant relationship between advertisements children watch on television and what they choose to eat (Marquis et al. 2005; Chamberlain et al. 2006). The main timing for advertising products to children is during children's viewing time i.e. weekdays after schools and weekend day morning.

3.3.3.4.1 Promoted products to children on television

The most advertised types of food on television are chocolate, sweets, soft drinks and other high calorie foods. A study by Chestnutt and Ashraf (2002) found that 62.5% of the advertisement, during 250 hours of children programming in the UK were about food. Another study by Neville *et al.* (2005) found that advertisements about confectionary were three times higher than anything else. Furthermore, another study by Lemos (2004) showed that the highly advertised products were sweets with 35% of the total advertised time.

With regards to the types of advertised food on TV in the UK, a study by Dibb and Godon (2001) reported that advertisements about unhealthy food and drinks constituted 90-99% of the total advertisements during children viewing times. An older survey by Donkin *et al.* (1993) showed that about half of the food requested by children had added sugar such as breakfast cereals, sweets, chocolate, biscuits and cakes and 51% of them had been advertised within the last 6 months, indicating TV advertising has long influenced children's purchase intentions.

In addition, watching television is often associated with eating food with high calories such as soft drinks and sweets and fewer fruits and vegetables (Woodward et al. 1997; Coon et al. 2001; Robinson 2001). A study by Halford *et al.* (2007) showed that in younger children, food advertisements caused the over-consumption of food which is usually a high calorific food. One study reported that the average number of hours of television watching by children (11, 13 and 15 years old) in the UK is three hours per day (Vereecken et al. 2006). In the UK, the average number of hours of advertising products to children (between May 2004 and February 2005) was five hours with the majority of the products containing high level of fat and sugar. The advertisement of products of high sugar and fat contents to children was also confirmed by Morgan *et al.* (2009). It was suggested by Olafsdottir et al. (2014) that there is a strong influence of watching television on children's eating behaviour in terms of high consumption of high caloric food and soft drinks.

Food advertisers use approaches based on taste, health properties, appearance of the food, adventure themes, fun, price and novelty. Studies have shown that 90% of foods are advertised to children using humour appeal in the United States while 90% of food advertised to children using taste appeal in Holland (Valkenburg 2000).

In 2007, the UK government initiated rules about advertising food with high fat and sugar content towards children below the age of 16 which includes content, timing and volume (Darwin 2009). However, a study by Boyland *et al.* (2011) reported that the advertisement of unhealthy food to children was still a problem even in the presence of such regulations. Advertising food with high fat and sugar content during adults' watching time, especially during popular program slots still target children as a part of the family and through other types of media (Kelly et al. 2007; Kelly et al. 2010).

3.3.3.4.2 Other types of media

In addition to using television in promoting products to children, there are many other ways of promoting products to children such as print media, in-store advertisement and websites. In 2008, two thirds of US food companies had websites, advertisement games or brand-related contents such as wallpapers designed specifically to target children (Boyland et al. 2011). The same techniques of marketing have been found in the UK. It has been found that there is a great expansion in "below-the-line" promotion techniques to target children using branding, novel packaging and inventing new "funny" food types (Cairns et al. 2009).

3.4 Public health concerns of novelty sweets in children

There are three main public health concerns about novelty sweets namely dental erosion, dental caries and obesity.

Novelty sweets are a particular concern as they tend to be non-sharable; they are largely single item sweets the packaging of which allows resealing and, therefore, repeated consumption and increased frequency and length of tooth contact (Stewart et al; 2013). Such frequent consumption and prolonged exposure of the oral tissues to very high sugar and acidic pH products is a recognised risk factor for dental erosion, dental caries and obesity (Harris 2004; Bawa 2005; Davies et al. 2008; Te Morenga et al. 2013; Lobstein 2014; Moynihan 2014; Sovik et al. 2015).

3.4.1 Concerns about novelty sweets and obesity

Obesity is a universal problem affecting a wide range of people in many countries. In 2011, nearly 30% (2.1 billion) of the world's population with more than 40 million children under the age of 5 years old were obese or overweight (World Health Organization 2013). This has increased dramatically from 857 million obese people in 1980 to 2.1 billion in 2011 worldwide (Ng et al. 2014). The latest figures in 2012, showed that 25% of the UK population were obese, which was the fifth highest percentage amongst the Organization for Economic Cooperation and Development (OECD) countries (34 countries) (Parliament UK 2016). The percentage of obese people in the UK has almost doubled since 1995. For example, between 1995 and 2013, obesity increased from 15% to 25% of the population in England (Health and Social Care Information Centre 2014b).

According to the national surveys in the UK countries (2014/15), which include the Health Survey for England, Wales, Scotland and Northern Ireland the percentage of children (5-15 years old) with obesity and overweight ranged from 28% to 34% (Parliament UK 2016) (Table 4). The annual increase in obesity amongst the UK children was 8.1% (7.2-8.9%) between 1994 and 2003 and 0.4% (0.2 -1.1%) between 2004 and 2013 (van Jaarsveld and Gulliford 2015).

Table 4. Prevalence of obesity and overweight amongst the UK children in parentage (2014/15) (Parliament UK 2016).

		England (2014/15)	Wales (2013/14)	Scotland (2014)	Northern Ireland (2014/15)
Boys	Overweight	13	16	12	18
	Obese	19	20	16	7
	Obese or overweight	32	35	28	25
Girls	Overweight	15	15	16	25
	Obese	16	19	18	8
	Obese or overweight	31	33	34	33
Children	Overweight	14	15	14	21
	Obese	17	19	17	7
	Obese or overweight	31	34	31	28

Increasing obesity levels in children are closely linked to type 2 diabetes mellitus and metabolic syndrome in adults (Vanhala et al. 1998; Cali and Caprio 2008; Malik et al. 2010; Malik and Hu 2012). It has been found that snacks are responsible for an additional 24-32% of the daily energy intake for children which ranged from 378-612 kcal/day (1580-2560 KJ). It has been also found that sugar contributes to the high prevalence of obesity in children (St-Onge et al. 2003; Malik et al. 2006). Novelty sweets have a high sugar content and will contribute to the daily energy and calories provided by snacks.

A strong relationship exists between obesity in children and deprivation (Law et al. 2007). For example, data released by Public Health England (2014) and the House of Common Library (Parliament UK 2016) showed that the obese children in most deprived areas were more than double the obese (25%) children in least deprived areas in England (11.5%).

Obesity in children may cause morbidity or even mortality later in adulthood (Holt 2003; St-Onge et al. 2003). Between 1998 and 2003, the annual deaths attributed to obesity in the UK were the highest (8.7%) in comparison to the other EU countries (7.7%) (Banegas et al. 2003). A link has been found between obesity and the incidence of depression which is suggested to be related to the lost productivity and income and high cost of obesity-related medical care (Wyatt et al. 2006). It has also been found that there is an association between obesity, being overweight and depression amongst children, especially in girls (Erickson et al. 2000).

Furthermore, there is a suggested link between obesity and periodontal disease in young, middle age and older adults (Al-Zahrani et al. 2003; Chaffee and Weston 2010). It has been suggested that adipose tissue secretes a number of cytokines and hormones which are involved in the inflammatory process of periodontitis. Adipose tissue is considered as a reservoir of multiple biologically active mediators such as TNF-α and other types of adiponectin group. A study by Gorman *et al.* (2012) reported that the progression of periodontal disease in obese people was 41-70% higher than people without obesity with adjusted hazard ratio. Furthermore, a systematic review by Suvan *et al.* (2011) also confirmed the link between obesity and periodontal disease, but with no data about the exact magnitude of the relationship.

Obese people are at higher risk for a group of interconnected diseases that include hypertension, diabetes and heart disease (Story et al. 2002). Obesity also results in a decreased life expectancy of between 3 and 10 years and contributes to around

8% of deaths in Europe annually. In addition, the estimated indirect economic cost of obesity (loss of productivity) to the UK was approximately £15.8 billion in 2007, whilst the direct cost to the NHS was £4.2 billion (Public Health England 2007).

In adults, the body mass index (BMI) has been used as an assessment tool for obesity for more than three decades. Obesity in adults is defined as a body mass index (BMI) greater than or equal to 30 kg/m^2. Being, overweight is defined as a BMI equal or more than 25 kg/m^2 (World Health Organization 2013). The BMI is calculated by dividing the patient's weight in kg by the height in meters and the result divided by the height in metres to get the BMI in kg/m^2.

In children, there is a specific BMI cut off value used to assess their height and weight (Cole et al. 1995). These values are important to consider allowing for height gain during childhood particularly during puberty. The value of a child's height and weight is compared against the centiles of height, weight and BMI (Freeman et al. 1995). BMI centile above the 91^{st} centile suggests obesity/overweight, above 98^{th} centile suggests clinical obesity and below the 2^{nd} centile suggests undernourished.

In adults, the increase in BMI is generally slow and steady, but this is not the case in children. In childhood, there is a tendency for the BMI to raise and fall with various growth phases. It rises in infancy, falls during the preschool period and rises again during adulthood (Cole et al. 2005).

The main causes of obesity in children are thought to be genetic and environmental factors, including diet (Troiano and Flegal 1998). The genetic aspects of obesity are not fully understood yet, but are associated with differences in gene coding for hormones and neurotransmitters (Dubern and Clement 2007). The genetic factors involved in body weight regulation may affect individual responses to environmental factors such as diet and exercise (Farooqi 2006; Barness et al. 2007). Furthermore, obesity may also be seen in some very rare syndromes such as Prader-Willi syndrome, Bardet-Biedle syndrome and Cohen syndrome (Butler et al. 2015). Environmentally, several different factors may also contribute to obesity (Troiano and Flegal 1998; Barness et al. 2007) including consumption of high calorific foods, large portion sizes and the consumption of low amounts of fruits and vegetables (St-Onge et al. 2003). It has been found that high sugar intake is also a determinant of increased body weight in children (Te Morenga et al. 2013).

It has been suggested by Bellisle and Rolland (2001) that sugar containing drinks may increase the adiposity in children more than sugar containing solid food.

3.4.2 Dental health implications of novelty sweets in children

Dental health is a part of oral health which can be defined as the "standard of health of the oral and related tissues which enables an individual to eat, speak and socialise without active disease, discomfort or embarrassment and which contributes to general well-being" (Department of Health 1994).

3.4.2.1 Dental caries

Dental caries can be defined as a localised dissolution of the dental hard tissue caused by acidic by products from bacterial fermentation of dietary carbohydrates. Caries develops as a result of disturbance in the dynamic relationship between oral microorganisms, dietary carbohydrate, salivary flow, pH of the plaque and time (Figure 3).

Dental caries is a multifactorial disease which starts with a microbial shift within the bacterial biofilm. This shift is affected by the consumption of dietary sugar, salivary flow and oral hygiene. There is a strong relationship between the total intake of sugar and frequency; the British Society of Paediatric Dentistry in 1999 recommended decreasing the sugar intake by children to prevent dental disease (Paediatric Dentistry -UK 1999).

Dental caries is preventable with plaque control using a fluoride toothpaste, pits and fissure sealant and limiting sugar containing food and drinks to meal times (Marinho et al. 2003; Twetman et al. 2003; Kidd and Fejerskov 2004; Petersen and Lennon 2004).

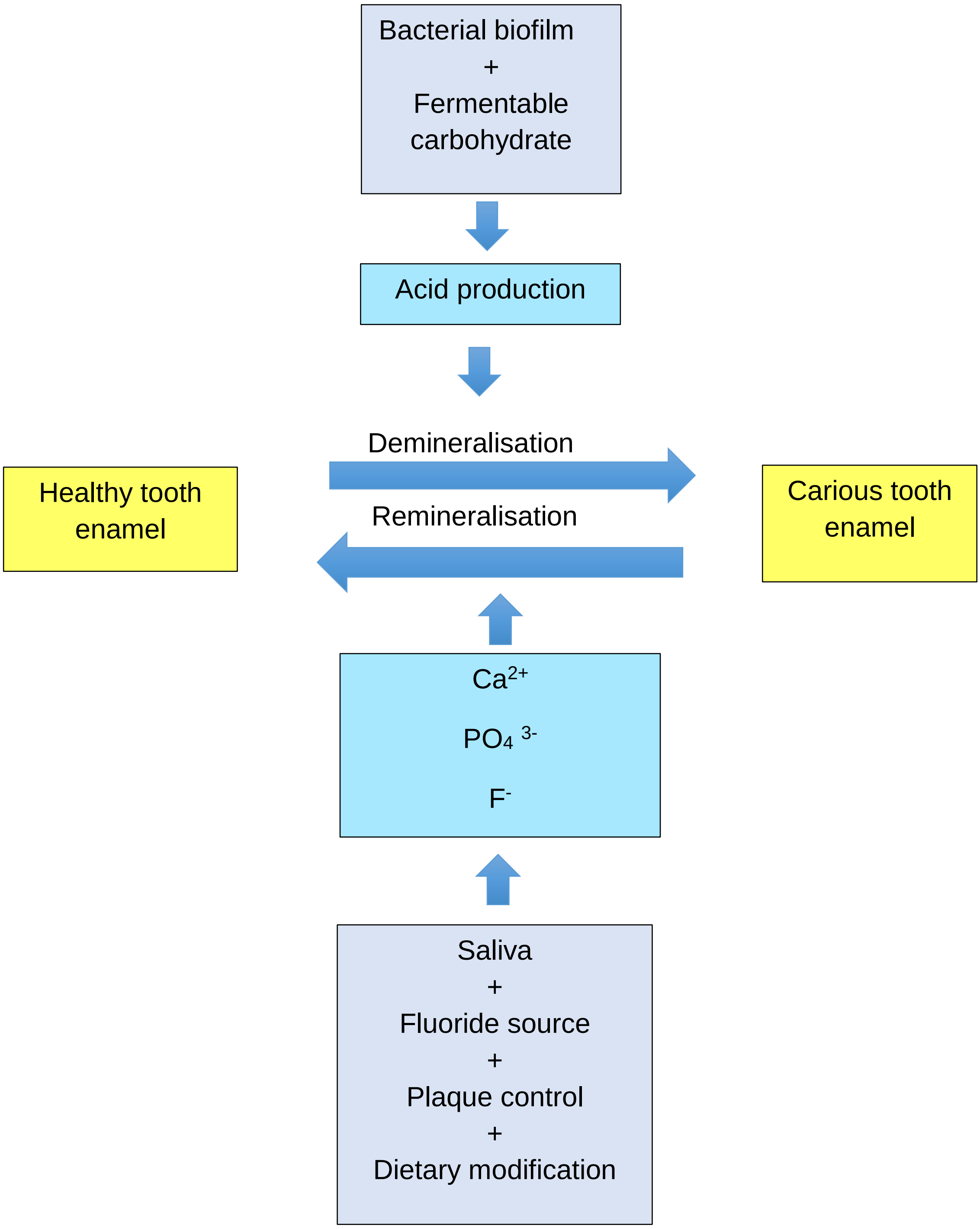


Figure 3. Pathogenesis of dental caries (baed on Selwitz et al. 2007).

3.4.2.1.1 Pathogenesis

The oral cavity is colonised by a complex microbial community (Socransky and Haffajee 2005) and there is a delicate balance between the growth of the bacteria, the host and associated diet (De Soet and De Graaff 1998). Changes in the balance of the bacterial community may result in the development of oral diseases (Xie et al. 2010).

In the first instance, bacteria must be able to adhere to the acquired pellicle on the tooth surface in order to colonise the tooth surface (De Soet and De Graaff 1998). The enamel pellicle is an acellular insoluble membranous layer originating primarily from salivary glycoproteins and is formed within a few seconds to minutes of exposure of enamel to saliva (Liljemark and Bloomquist 1996). The thickness of the enamel pellicle ranges from 0.1 to 0.3 μm (Rogers 1976; Lendenmann et al. 2000)

Miller in the late 1800s proposed that acid production from dietary carbohydrate was the main cause of dental caries and named this as the chemoparasitic theory of caries (Loesche 1986; Balakrishnan et al. 2000). Miller assumed that all oral microorganisms were cariogenic and capable of acid production via the enzymatic breakdown of dietary carbohydrates (Balakrishnan et al. 2000). In human studies, it has been shown that increased sugar consumption resulted in elevation in the number of specific bacteria such as *mutans streptococci* and *lactobacilli*, whilst restriction of sugar in the diet resulted in a reduction in the decay rate (Staat et al. 1975; Skinner and Woods 1984; Moynihan and Kelly 2014; World Health Organization 2015).

The early phase of dental caries is characterised by the invasion of the dentine by bacterial acidic by-products of *lactobacilli*, *Actinomyces* species, *Veillonella* species and *mutans streptococci* (Love and Jenkinson 2002). Munson *et al.* (2004) studied the microorganisms associated with dental caries using molecular techniques and reported that the microflora was dominated by Gram-positive bacteria, mainly *Actinomyces, Propionobacterium, Lactobacillus,* and *Streptococcus* (Munson et al. 2004).

Clarke (1924) was the first to report the involvement of streptococci with dental caries. *Mutans streptococci* (MS) have several virulent factors including the ability to synthesis extracellular and intracellular polysaccharides, acidogenicity, aciduricity and endodextranase production (Balakrishnan et al. 2000). *Mutans streptococci* colonise the mouth only after the eruption of the first tooth (Carlsson et al. 1975) and sugar consumption will increase their numbers (Staat et al. 1975). Tanzer *et al*. (2001) reported that MS plays an important role in the initiation of dental caries. In an experimental animal study, it was shown that *S. mutans* and *S. sobrinus* were highly cariogenic (Van Houte 1994)

Lactobacilli were the first microorganisms reported as being associated with dental caries due to their acidogenic and aciduric nature (Van Houte 1994). It has been proposed that the number of lactobacilli in dental plaque is generally low or negligible (Van Houte 1994). However, high carbohydrate consumption in the diet and low environmental pH levels have been implicated with increased levels of lactobacilli (De Soet and De Graaff 1998). According to the available data, it may be that lactobacilli play a more important role in caries progression rather than initiation (Van Houte 1980). Carious dentine is considered to be anaerobic and predominated by anaerobic microorganisms (Sims 1985; Loesche 1992).

The acid causes the pH to decrease below the critical pH of 5.5 and cause diffusion of calcium, phosphate and carbonate out of the tooth. Before the cavitation of tooth surface, the caries process is reversible (Larsen and Pearce 1997). The lesion clinically is called a white spot lesion due to the change in the optical properties of enamel (Kidd and Fejerskov 2004)

After four weeks of plaque accumulation, upon removal of plaque, a chalky white spot lesion may be seen by drying the tooth. This is due to the porosity and the refractive indices of air, water and enamel. The enamel has refractive index of 1.62, so when porous enamel is wet and the spaces are filled by water (refractive index of 1.33) there is less light scattering and the lesion will be less obvious because the refractive index between air and enamel is greater than between enamel and water. When cavitation occurs the carious process becomes irreversible and intervention is required (Fejerskov 2003). Histologically, there are four zones of uncavitated lesion which differs from the cavitated lesions (Kidd and Joyston-Bechal 1998)

Remineralisation can occur by uptake of calcium, phosphate and fluoride. The resulting fluoridated hydroxyapatite is also more resistant to an acidic challenge. In addition, remineralisation occurs when the pH returns to the natural level (pH of 7) which results from the salivary buffer capacity (Selwitz et al. 2007) (Figure 4).

3.4.2.1.2 Epidemiology of dental caries

3.4.2.1.2.1 Internationally

Data from World Health Organization (WHO) showed the distribution of dental caries amongst children in the world in 2003. It can be seen that although the UK has one of the lowest levels of dental caries in comparison to some developing countries such as the Caribbean or South American countries, it is still considered a major public health problem (Petersen 2003). However, dental caries has been found to be challenging to control in the developing countries. In 2003, dental caries was also reported to affect 60% to 90% of industrialised countries (Petersen et al. 2005).

3.4.2.1.2.2 Europe

DMFT is an index that represents the average number of decayed (D), missing (M) or filled (F) permanent teeth (T) while the corresponding index for deciduous teeth is dmft. The data from WHO published in 2003 showed that the average DMFT of 12 years olds in Europe was the third highest in the world with an index of 2.6. The highest average DMFT was reported in the Americas with an index of 3.6 (Petersen 2003). The Average DMFT of the six WHO regions is presented in Figure 4.

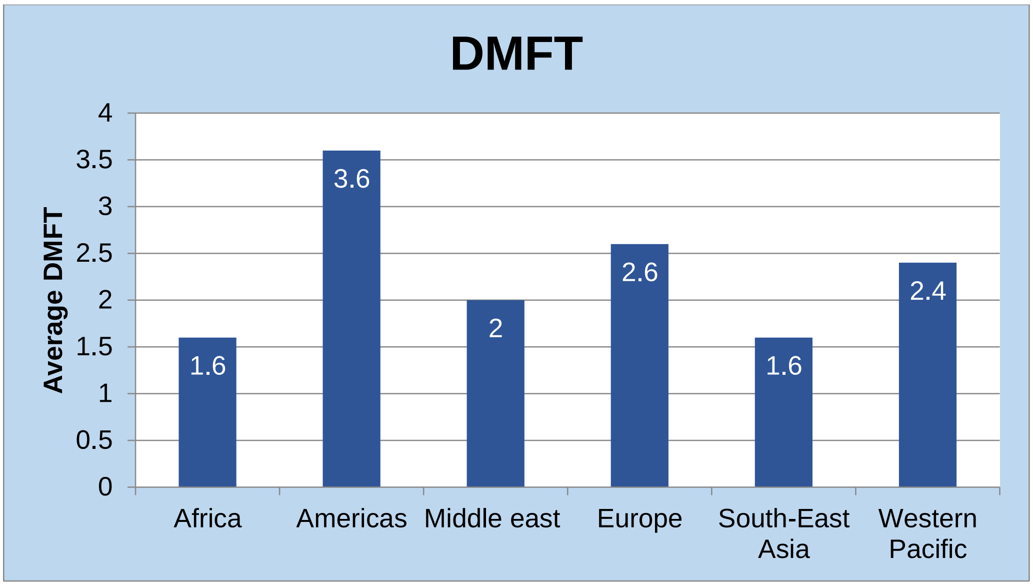


Figure 4. The average DMFT of the six WHO regions in 2003 (Petersen 2003).

3.4.2.1.2.3 UK

In the UK decennial surveys of children's teeth have been carried out since 1973 (Department of Health 2013). The Child Dental Health Survey provides information about oral health in children aged 5,8,11 and 15 years in the UK. The survey was undertaken in 1983, 1993, 2003 and 2013 (Department of Health 2013) and the findings are summarised below.

3.4.2.1.2.3.1 Primary teeth

There has been a gradual decrease in the percentage of 8 years old children with grossly decayed teeth from 70% in 1983 to 41% in 2013. The decrease in the percentage of children at 5 years old was from 50% in 1983 to 26% in 2013. The data also shows that there was decrease in the percentages of 5 years old children with dental caries involving dentine between 1983 and 2013. In 2013 there were around 31% and 46% of children at 5 and 8 years old with decay involving dentine respectively. There was a decrease in percentage of children at 5 and 8 years with filled primary teeth from 23% to 8% and from 47% to 19% respectively (Department of Health 2013) (Figure 5).

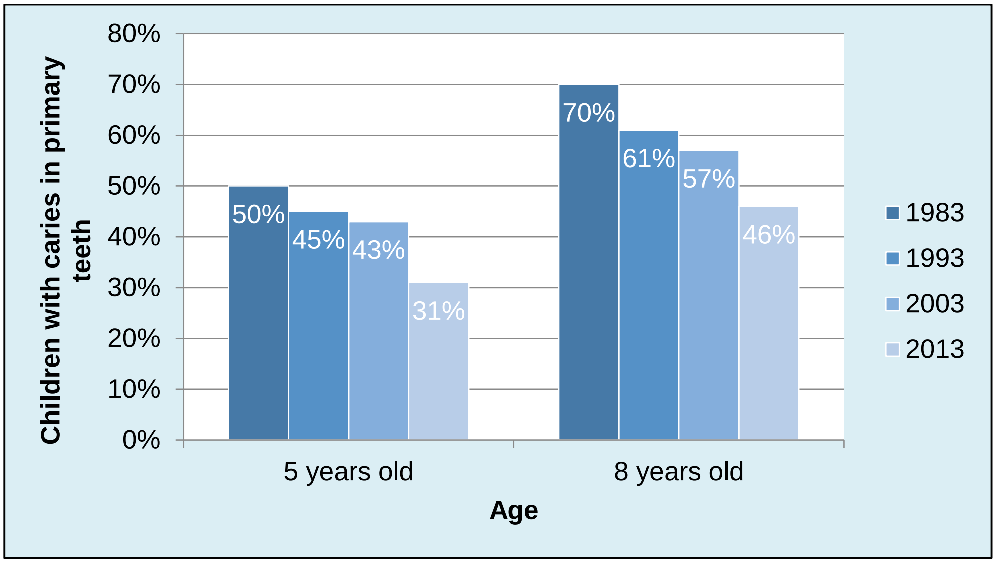


Figure 5. Percentage of children with obvious dental caries involving dentine in primary teeth only, Child dental health survey, 2013 (Department of Health 2013).

In 2013, the highest percentage of children with enamel decay in primary teeth was in Wales (42% of 5 years old children and 34% of 8 years old children) and the lowest was in Northern Ireland (27% of 5 and 8 years old children) (Figure 6).

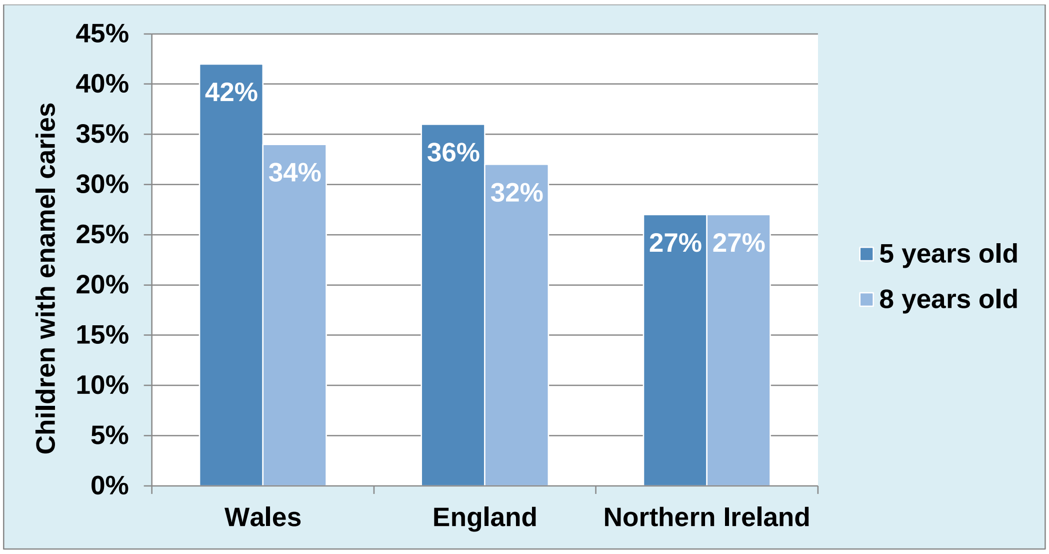


Figure 6. The percentage of the 5 and 8 years old children with enamel caries in permanent teeth in Wales, England and Northern Ireland in 2013 (Department of Health 2013).

3.4.2.1.2.3.2 Permanent teeth

The data showed a gradual decrease in the percentage of children with obvious dental caries in permanent teeth. At the age of 8, it decreased from 38% in 1983 to 13% in 2013. The percentage of children with obvious dental caries at 12 years old decreased from 81% in 1983 to 34% in 2013. At the age of 15 years there was also a decrease in the percentage of children with obvious decay from 93% to 46% (Department of Health 2013) (Figure 7).

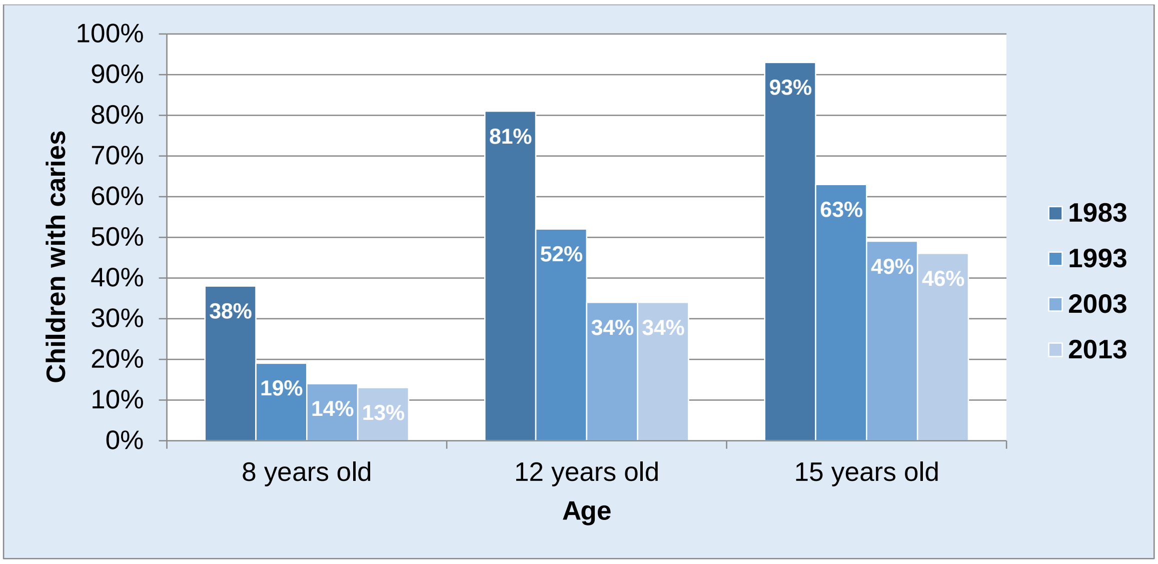


Figure 7. Caries experience in children in permanent teeth in the UK (Department of Health 2013).

In 2013, the data shows that the highest percentage of children with dental caries in permanent teeth was in Wales (55% of 12 years old children and 54% of 15 years old children) and the lowest was in Northern Ireland (35% of 12 years old children and 46% of 15 years old children) (Department of Health 2013) (Figure 8).

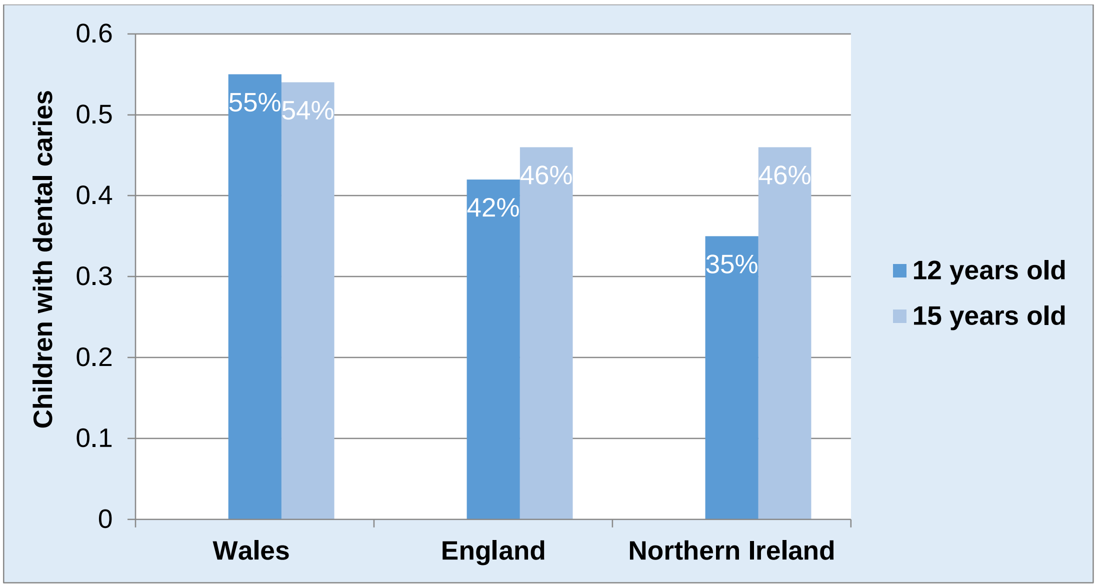


Figure 8. Prevalence of dental caries in England, Wales and Northern Ireland (National child oral health survey, 2013) (Department of Health 2013).

Encouragingly, since 1983 there has been a downward trend in dental caries experience amongst all age-groups taking part. However, the prevalence remains high for this largely preventable disease (Department of Health 2013). Worryingly, there are wide inequalities in experience with all age groups eligible for free school meals (i.e. lower income families) having greater experience of dental caries (Department of Health 2013).

3.4.2.1.3 Link between obesity and dental caries

The link between obesity and dental caries has been explained by being observed when the child consumes cariogenic food with high calories and has poor oral hygiene (Karjalainen et al. 2001; Palmer 2005; Hilgers et al. 2006; Hooley 2012). Furthermore, some authors have also reported a relationship between the BMI of children and dental caries (Hilgers et al. 2006; Hooley 2012). The development of both obesity and dental caries in children is often associated with both low socioeconomic status and some ethnicities particularly in children with a South Asian origin (Sheiham and Watt 2000; Birch 2001). Systematic reviews of Munoz *et al.* (2013) and Silva *et al.* (2013) suggested that the link between dental caries and obesity in children is related to the common aetiology including environmental factors such as the socio-economic level and dietary such as high sugar diet.

However, other researchers have suggested that the available data is inconclusive and more studies need to be conducted to assess the relationship between dental caries and obesity in children (Kantovitz et al. 2006; Werner et al. 2012). They found that there might be no significant relationship between obesity and dental caries if age, race and poverty are controlled. These markers suggest that caries and obesity are just different diseases with common risk factors and do not necessarily have a direct influence on each other (Hong et al. 2008).

3.4.2.1.4 Concerns about sugar content of novelty sweets and dental caries

Novelty sweets have a high sugar content which is considered a good substrate for cariogenic bacteria to produce acid. There is a well-documented relationship between high consumption of sugar and dental caries (Burt and Pai 2001; Harris et al. 2004). It has been found that children with frequent consumption of sugar had a higher prevalence of dental caries (Gibson and Williams 1999). Novelty sweets are re-sealable, thus the frequency of exposing teeth to sugar each day can be high.

As a part of the present study, the sugar content of the novelty sweets will be measured to assess the potential risk of dental caries and obesity in children who frequently consume the novelty sweets.

3.4.2.1.4.1 Methods for measuring the sugar content of foods and drinks

There are two main methods for measuring the sugar content of foods and drinks. These methods are High Performance Liquid Chromography (HPLC) and the index of refraction method (Agbazue et al. 2014).

3.4.2.1.4.1.1 High Performance Liquid Chromography (HPLC)

This technique is usually used to measure the sugar content during the production process of food, and medical formula. It is based on allowing a liquid to pass under low pressure through a column filled with a sorbent to separate the components of the liquid. The separation of the components results from the difference in the interaction between the components and the sorbent (Sodamade 2014; Pan et al. 2015a).

The HPLC consist of three parts, pump, liquid and detector. After separating the components of the liquid, the exact amount and percentage of each component is detected by the machine. This technique needs a long time of sample preparation and analysis plus specific columns for the analysis of sugars (Johnston and Brown 2014).

3.4.2.1.4.1.2 Refractive index method

The refractive index method is based on measuring the sugar content of a sample by the detection of the critical angle of the refraction of light. The light is concentrated in a prism surface through a lens. As a result of the light concentration in a specific area, different angles can be detected. The refractive index of the test liquid determines the amount of the incoming light to the sample (Agbazue et al. 2014). If the refractory index is below the critical angle (high sugar content), only part of the light is transmitted and detected in the eyepiece. While if the refractory index is higher than the critical angle (low sugar content) a high amount of light can be transmitted into and detected by eyepiece (Cen et al. 2012).

The amount of transmitted light is detected and presented in the eyepiece in a scale which reflects the percentage of the sugar contents in the liquid. In this technique, only a small amount of liquid (e.g. a microliter) is required in order to measure the sugar content (Pan et al. 2015b). The determination of the refractive angle is independent of vibrations and other environmental disturbances (Pan et al. 2015a).

In the present study, the sugar content of the selected novelty sweets was measured using the refractive index method.

3.4.2.2 Dental erosion

Dental erosion is one type of non-carious tooth surface loss (TSL). TSL is one of the major topics in dentistry and a subject of increasing interest in dental research. TSL can be defined as the non-carious loss of hard tooth structure resulting from attrition, abrasion, erosion or abfraction, which can be found either singly or concurrently (Addy and Shellis 2006).

There are four main types of TSL, namely attrition, abrasion, erosion and abfraction (Grippo et al. 2004). Attrition is defined as tooth wear that results from tooth to tooth contact (two body wear) and thus relates to dental occlusion (Mair et al. 1996). Abrasion is the loss of tooth structure usually in the cervical region as a result of foreign body contact (Chu et al. 2002). Erosion is the non-bacterial chemical dissolution of surface tooth structure. Abfraction is a stress-induced lesion caused by occlusal loading forces, leading to tooth flexure and mechanical microfracture of enamel in the cervical area (Grippo 1991).

TSL is considered to be a normal physiological process that occurs throughout life or a pathologic process when seen in younger people or when affecting dental health (Berry and Poole 1976; Bartlett and Dugmore 2008). The features of pathological TSL are that the surface loss may result in changes in the appearance or the integrity of teeth and may be considered to be excessive with respect to the age of the patient (D'Incau et al. 2012).

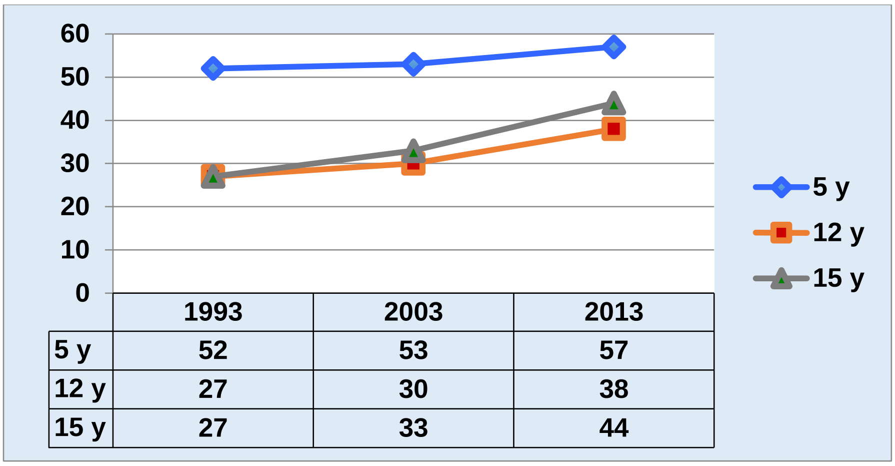
With the increased understanding and control of dental caries and periodontal disease, teeth can be retained into old age, where surface loss or wear takes place (Haugen 1992). TSL needs to be well understood in terms of its epidemiology, aetiology, diagnosis, prevention and clinical management (D'Incau et al. 2012).

Recently, some new definitions have arisen due to the increased complexity and the interaction of different causes of TSL. Abrosion is enamel loss caused by a toothbrush (abrasion) after it has been softened by acid (erosion) (Chu et al. 2002). Demastication describes the wearing of enamel by attrition (mastication) after erosion (demineralisation) (Rugg-Gunn et al. 1998). The term toothwear is a useful overarching term to describe tooth surface loss since it does not prejudice the aetiology of a particular case in which one or more of these processes may occur. For example, accelerated abrasion may take place at a surface already demineralised by erosion (Dugmore and Rock 2004a; Addy and Shellis 2006).

Dietary acids that contribute to erosion may also be involved in the aetiology of dentine hypersensitivity, aesthetic problems and discomfort caused by sharp edges (Mehta et al. 2012). In addition, progressive TSL may cause loss in occlusal vertical height, a history of frequent fracture of teeth or restorations, hypermobility or difficulty in eating and speaking. Based on the aetiology, extent, patient's concerns and symptoms of TSL, the management varies from maintenance, diet analysis and counselling, application of bonding agents, direct and indirect composite restorations to full mouth rehabilitation (Ibbetson 1999; Davies et al. 2002; Mehta et al. 2012). Prevention and controlling TSL in young patients is important to prevent any possible complications later in life (Kelleher et al. 2012). Recent epidemiological data shows a gradual increase in the percentage of affected children by TSL especially secondary school students (Bartlett et al. 1997; Bartlett et al. 1998; Arnadottir et al. 2010; Taji and Seow 2010).

3.4.2.2.1 Epidemiology of TSL in children

TSL is one of the common findings in teenagers in the UK (Al-Dlaigan et al. 2001; White et al. 2012). Recent epidemiological studies have shown increases in the prevalence of tooth surface loss among all age groups. The National Survey of Child Dental Health in 1993 was the first survey carried out to provide prevalence data on TSL in children throughout the UK followed by other surveys published in 2003 and 2013 (Department of Health 2013). The survey reported an increase in tooth surface loss (TSL) for all age-groups taking part between 2003 and 2013. There was an increase of the percentage of 5 years old children affected by TSL from 53% in 2003 with almost the same distribution in the surfaces and same level of severity to reach to 57% in 2013. Amongst the children of 12 and 15 years old, the average percentages of TSL in the lingual surfaces increased between 2003 and 2013 from 30% to 38% and from 33% to 44% respectively (Department of Health 2013) (Figure 9). The survey also reported a variation in the percentages between the UK regions. For example, more 12 and 15 year old children are affected by TSL in lingual surfaces in Northern Ireland (44% and 57%) than Wales (30 and 40%) and England (39% and 43%) (Department of Health 2013).



	1993	2003	2013
5 y	52	53	57
12 y	27	30	38
15 y	27	33	44

Figure 9. Prevalence of of TSL the lingual surfaces in children (Department of Health 2013).

The development of tooth surface loss (TSL) at an early age in the deciduous and the mixed dentition is becoming an increasing concern for the dental profession with erosion being the primary cause. Dugmore and Rock (2004b) examined 1,753 12-year-olds in the UK and found tooth erosion in 59.7% of the children and exposure of dentine in 2.7%. Moreover, more tooth erosion was found in males than females, Caucasians than Asians and in children with experience of caries, which may reflect an overall lower level of dietary and/or oral health care. Significantly more erosion was observed in teenagers in the lowest socioeconomic categories (Al-Dlaigan et al. 2001; Nunn 2001; Deshpande and Hugar 2004; Kazoullis et al. 2007; Wang et al. 2010). In addition, Al-Dlaigan *et al.* (2001) found that moderate levels of dental erosion were common in 14-year-old school children, particularly amongst low socioeconomic groups in the UK.

3.4.2.2.2 Aetiology of dental erosion

Generally, tooth surface loss is often caused by the interaction of multiple factors. Erosion may be caused by intrinsic acid which originates from the inside of the body such as gastric acids, or/and extrinsic acid which originates from outside of the body principally from the diet (Addy and Shellis 2006).

Erosion is the most common type of tooth wear (Azzopardi et al. 2004). Exposure of teeth to acids leads to surface loss of minerals, softening and with time, dissolution and complete loss (Schweizer-Hirt et al. 1978). Erosion is more linear in enamel than dentine which means that the amount of loss of minerals from the enamel can be related to the amount of acid exposure while in dentine it may or may not be the case (Hunter et al. 2000). An important factor to be considered before assessing each patient is their susceptibility to erosion (Rees 2004). Furthermore, the interaction of various factors helps explain why some patients exhibit more erosion than others, even if they are exposed to the same amount of acid. The degree and distribution of erosion seems to be strongly related to age, frequency of soft drink intake and tooth brushing technique (Dugmore and Rock 2004a; Bardolia et al. 2010).

Due to the multifactorial nature of erosion, several factors (biological, behavioural and chemical) are involved and interact with the tooth surface either to wear it away or protect it. Among the different factors, saliva and dental pellicle have a considerable effect on erosion (Amaechi et al. 1999c).

3.4.2.2.2.1 Intrinsic Sources

Intrinsic dental erosion occurs when the acid reaches the mouth either through vomiting or by regurgitation. The regurgitation may be involuntary or voluntary (self-induced). The most commonly affected areas are the palatal surfaces of the upper anterior teeth and in severe cases, the occlusal and buccal surfaces of posterior teeth (Jarvinen et al. 1988). The effect ranges from thinning of the enamel to destruction of the enamel and dentine and eventually, pulp exposure in extreme cases.

In children, this source of acid is not particularly common unless they have an underling medical problem causing reflux/vomiting such as children with Down's syndrome and children with cyclic vomiting syndrome (Bell et al. 2002; Boles et al. 2006; Green 2009). A study by Bell et al. (2002) found that children with Down's syndrome showed significantly more tooth wear (67%) than non-down's syndrome group (34%) with about 46% of tooth wear cases is in form of combined attrition and erosive tooth wear. Gastric reflux and vomiting were reported in 20% of children with Down's syndrome.

3.4.2.2.2.1.1 Gastro-oesophageal reflux disease (GORD)

Gastro-oesophageal reflux disease (GORD) is the retrograde movement of stomach acid and is usually associated with rumination, chronic alcoholism and eating disorders (Bartlett and Coward 2001a). The movement of gastric acid in GORD is slow, less forced but more prolonged.

The common factors related to reflux are the reduced lower oesophageal sphincter pressure and oesophageal motility (Bartlett et al. 2000), diet which includes onion, fatty foods, chocolate, peppermint, spicy foods and pickles can be promotors. In addition, alcohol increases GORD and irritates the oesophageal mucosa (Vitale et al. 1987; Chen et al. 2010). The posture of the person may also have an influence on GORD such as reclining (Demeester et al. 1976; Castell et al. 2004). Another factor is hard physical exercise which also may cause heartburn and nausea (Kraus et al. 1990). Furthermore, due to the increased pressure in the abdomen, pregnancy may cause GORD (Dahl et al. 1993; Ali and Egan 2007).

In 2001, a study by Bartlett and Coward (2001b) showed that gastric acid has significantly stronger erosive potential than soft drinks.

3.4.2.2.2.1.2 Eating disorders

Patients who try to control their body weight, would suffer from signs of perimolysis which is characterised by having dental erosion affecting the palatal surfaces of the maxillary teeth with an enamel bands in the gingival area (Andrews 1982; Kim et al. 2005). The main eating disorders which cause erosion are anorexia and bulimia nervosa. In these types of disorders, the patients may experience frequent vomiting cycles and vomit up to 20-30 times per day with a gastric acid of pH 1-2 (Milosevic et al. 1997). The reported percentage of bulimic patients affected by dental erosion may reach 90% (Ohrn et al. 1999). In addition, these types of eating disorders are more common amongst the females in Western societies (Szmukler 1985; Pagsberg and Wang 1994).

3.4.2.2.2.1.2.1 Anorexia nervosa

Anorexia nervosa is considered as a psychiatric disorder which may be triggered by social issues, emotional stress from relationships and concerns about the body appearance (Ashcroft and Milosevic 2007b). In severe cases of anorexia nervosa, patients ignore and resist the feeling of hunger. This style of managing eating habits by resisting hunger could be an expression of the person's success and his/her strength by controlling life. Usually, looking for being a perfect person is the main personal characteristics of people with anorexia and bulimia nervosa (Ashcroft and Milosevic 2007a). Sufferers overestimate their body size and weight which has been found to be one of the best ways to manage their beliefs and acceptance of their body (Smith and Knight 1982).

3.4.2.2.2.1.2.2 Bulimia nervosa

Depression has been found to be the most common reason behind an eating disorder. Half of the patients who are diagnosed as bulimic were suffering from depression (Beebe 1994; De Groot et al. 1995). Shame and guilt are also described by people who suffer from bulimia nervosa which is related principally to their eradication behaviour. In this type of eating disorder, there is a disturbance in the hunger response (Imfeld and Imfeld 2008). They have the ability to eat a large amount of food in a discrete time period without the feeling of hunger (Ashcroft and Milosevic 2007a).

Studies have shown that bulimic patients have mean salivary flow rates significantly lower than healthy persons (Ohrn et al. 1999). The mean bicarbonate concentration in both bulimic and anorexic patients is significantly less than in the healthy people. Also, the mean intake of diet soda was more than three litres per day in the bulimic patients (Ohrn et al. 1999; Tong and D'Alessio 2011).

Enamel loss by erosion is exacerbated by subsequent abrasion. The amount of softened enamel removed by tooth brushing is a function of the chemical composition of the erosive medium (Hemingway et al. 2006). There is a relationship between erosion and brushing after meals and just before going to bed, type of toothbrush and brushing technique (Hooper et al. 2007).

3.4.2.2.2.2 Extrinsic Sources

Extrinsic sources include environmental factors, medicaments and lifestyle choices including diet.

3.4.2.2.2.2.1 Environmental Factors

People who work in places where there are acid fumes and aerosols, as well as exposure to gases containing hydrochloric or sulphuric acid are at high risk of dental erosion (ten Bruggen Cate 1968). Although recent strict health and safety laws have been implemented in industries, such as battery or munition production, labial surface erosion of upper and lower teeth may still occasionally be seen (Imfeld 1996).

3.4.2.2.2.2.2 Medicaments

Any drug taken orally that has a pH value lower than 5.5 may cause loss to the outer surface of enamel. Giunta (1983) reported the erosive effect of some medications such as chewable vitamin C tablets, aspirin tablets and powders (Sullivan and Kramer 1983) and the amphetamine drug, ecstasy. Ecstasy also causes a profound dry mouth and tooth grinding which further exacerbates TSL (Redfearn et al. 1998).

There are three mechanisms by which medicaments cause erosion. These are direct effects, indirect effect or a combination of both (Meurman and ten Cate 1996; Tredwin et al. 2005). The direct effect occurs by the direct acidity of the drug itself (e.g. Vitamin C). The indirect effect of medication such as that caused by ecstasy, on the other hand, occurs as a result of xerostomia caused by the drug which in turn causes the dental erosion. The third method occurs when the drug is acidic and causes xerostomia as one of its side effects (Tredwin et al. 2005).

Several studies have examined a possible association between erosion and inhaled medication used to treat asthma (Shaw et al. 2000; Hamasha et al. 2014). It has been suggested that such aerosols may have a direct effect on the tooth or may pose an indirect risk due to xerostomia produced by the beta 2 agonist content of drugs such as terbutaline and salbutamol (Shaw et al. 2000; Hamasha et al. 2014). Inhalers which deliver these medicaments may be used up to four times a day over long periods and since 10% (1.1 million) of the UK children in 2014 (Asthma UK 2014) were affected by asthma, erosion produced by associated medication could pose a significant population-wide dental health problem (Mukherjee et al. 2014). However, the precise mechanism between asthma and TSL remains unclear (McDerra et al. 1998; Al-Dlaigan et al. 2002).

3.4.2.2.2.2.3 Lifestyle and diet

A healthy lifestyle and diet means more fruits and vegetables are being consumed, which increases the acidity of the oral cavity. The widespread use of refrigeration making fruit and vegetables available all year round and this may also contribute to higher levels of TSL (Fox 2010). A higher intake of low pH and sugar-containing drinks such as sport drinks, are also associated with an increase in the prevalence of dental erosion (Meurman et al. 1990b; Parry et al. 2001).

An unhealthy lifestyle, on the other hand, may be a combined problem as the effect can be doubled, with direct erosion through alcohol abuse and indirect erosion through gastrointestinal symptoms that include frequent reflux and vomiting (Araujo et al. 2004).

The most important aetiological factor for dental erosion is the consumption of acidic food and drinks, which will damage the teeth with direct contact (Hemingway et al. 2006). Even worse, both intrinsic and extrinsic sources may work together to produce severe dental erosion. One major aetiological factor in erosion is the daily consumption of acidic beverages which increased between 1986-2009 from 44% to 53% of children (4-18 years old) (Wen Ng et al. 2012).

Dietary acids include citric, phosphoric, ascorbic, malic, tartaric, oxalic and carbonic acid (Moynihan 2005). These acids are found in many types of dietary sources such as fruits, fruit juices, soft drinks and sweets. *In vitro* studies have shown that fruit juices caused 3-10 times more erosion than whole fresh fruits (Moynihan 2005). Which may be caused by increasing the wettability and exposure time of enamel by acidic solution more than the solid form of the fresh fruits (Zero 1996; Jager et al. 2012).

There are various types of beverages and foodstuff responsible for extrinsic erosion. The pH of these types of food and drinks such as fruit and orange juices and soft drinks is 2.4-3.2 which is far below the critical pH of the enamel (pH 5.5) and is enough to produce severe erosion (Larsen and Nyvad 1999; Dawes 2003; Shellis and Wilson 2004). Sucking and ingestion of acidic citrus fruit also leads to excessive dental erosion (Asher and Read 1987). In addition, fruit juices with low acidity such as orange juice (pH $\approx$ 3.8) will erode the enamel due to its high citric acid content (Hughes et al. 2000; Rees et al. 2006). A study by Zheng *et al.* (2009) evaluating the effect of citric acid on enamel showed a significant erosion with decreased microhardness. The effects of various types of organic acids depends mainly on their physiochemical properties such as their pH, neutralisable acidity (Zero and Lussi 2005a). These factors are discussed in Sections 3.6.2.3.2.

According the National Diet and Nutrition Survey in 2010 (Department of Health 2010), there is an increased consumption of fruit juice in all age groups with the same high level of consumption in women and girls. Furthermore, a very strong link was found between carbonated drinks and the development of erosion (Johansson et al. 2002). Studies have shown that the acidic drinks affect the enamel microhardness and soften the enamel and dentine (Bodecker 1945; Lussi et al. 2012). The erosive effect of phosphoric acid and citric acid is greater than that of the carbon dioxide they contain (Fox 2010). Moreover, alcopops, cider and wine may be responsible for an increase in the prevalence of dental erosion, especially in younger individuals (Rees 2004).

In vitro studies showed that the erosive effect of tea on the enamel is five times that of traditional black tea (Brunton and Hussain 2001; Phelan and Rees 2003). Ice tea drinks have a strong erosive effect due to their citric acid and Vitamin C content (Rees 2004). In addition, there are some contributing factors with the diet such as the length of contact time with the acidic food (Johansson et al. 2004) and the swallowing habits (e.g. swishing the drink around the teeth) (Shellis et al. 2005).

3.4.2.2.3 Concerns about novelty sweets and dental erosion

It had been suggested that the frequent consumption of novelty sweets might cause dental erosion. Dietary acids included in the formulation of novelty sweets include citric and malic acids (Davies et al. 2008). The *in vitro* study by Beeley (2005) showed that the pH of novelty sweets was 1.7-3.4, which is far below the critical value (pH 5.5) for causing dental erosion. Beeley's pH ranges were comparable to the reported pH of some novelty sweets by Davies *et al.* (2008) and Gambon *et al.* (2009) which was 2.3-3.12 and 1.9- 2.3 respectively. Furthermore, Robyn *et al.* (2008). and Wagoner *et al*. (2009) found that the pH of sour candies was 1.9-4 and 2.47-3.7 respectively.

In addition, studies have shown that the neutralisable acidity of novelty sweets ranged from 9.67-66.9 ml of 0.1M sodium hydroxide. In comparison to orange juice, novelty sweets need a higher amount of sodium hydroxide than orange juice (20-37 ml). This means that the acids found in novelty sweets are stronger and may cause the pH to drop for a longer time before it reaches the 'safe' pH of 7 (Davies et al. 2008). The pH drop below the critical value (5.5) for long periods causes the dissolution of enamel and dentine (Lussi et al. 1993; Larsen and Pearce 1997).

A number of sour sweets were investigated in a laboratory study and found that they all had an erosive potential, sometimes even higher than that of orange juice (Davies et al. 2008; Robyn et al. 2008). Other researchers have reported that frequent chewing of acidic chewing gums and using novelty candy sprays may cause erosion even with high salivary buffering capacity and the absence of immediate tooth brushing (Bolan et al. 2008; Gambon 2009). An *in vitro* study by Wagoner *et al.* (2009) showed that the sour novelty candies had a high erosive potential even in the presence of salivary protective mechanism. A study by Jensdottir *et al.* (2005) reported that sucking an acidic candy resulted in a drop of the pH of the oral cavity to 4.5 and needed five minutes to go back to neutral. It was also found that 70% of the buffering capacity was exerted at the time of sucking the candy. In addition, it was found by Gambon *et al.* (2006) and Gambon *et al.* (2007) that candy sprays and gel caused a drop of the pH of the mouth to reach between 4 and 5 for 2-3 minutes.

3.5 Socio-economic status and oral health

Poverty, deprivation, and low socioeconomic status reflect various attitudes, behaviours and experiences related to oral health. This may be caused mainly by lacking the access to health services and poor diet choices (Hobdell et al. 2003). Food poverty is recognised as "the inability to afford or to have access to food to make up a healthy diet" (Department of Health 2005).

It has been found that there are significant oral health disparities across the EU countries related to socio-economic status (Patel 2012; Schwendicke et al. 2015). Furthermore, the adult dental health survey (2009) and child dental health survey (2013) reported that the experience of oral cancers, dental caries, gum disease and other oral diseases were significantly greater in families with low socio-economic status.

In the UK, the reported figures of children in families with relative and absolute low income After Housing Cost (AHC) in 2013/14 were 2.3 million (21%) and 2.6 million (23%) respectively. Furthermore, 37% of children were reported to be in workless families in the UK (Department for work and pensions 2015).

In conclusion, the data presented above from the literature reflects the well-established link between frequent consumption of acidic and sugary diet and the development of dental erosion, dental caries and obesity in children. It also presented the aetiology and prevalence of obesity, dental caries and dental erosion amongst UK children

With the expansion of novelty sweets in the UK market which potentially target the children as the principal consumers of confectionary, there is concern about the potential public health implications of novelty sweets.

The previous section of the literature review discussed the various sociological factors which may influence both the children's food preference, dietary habits and buying behaviour.

The next section of the literature review will review the oral science part and physicochemical properties of acidic solutions which may influence tooth erosion. Furthermore, the available methods for evaluating the potential erosive potential of foods and drinks will be also discussed.

3.6 Tooth structure

A human tooth is composed of three major structures namely enamel, dentine and pulp. Enamel is the outermost layer in the crown of the tooth (Figure 10).

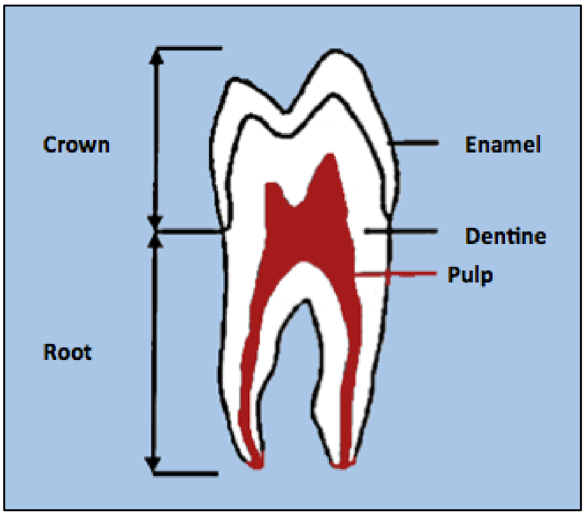


Figure 10. A diagram of a premolar tooth shows the parts of the tooth (Figure Based on Oliveira et al. 2010).

3.6.1 Dentine-pulp complex

The dental pulp is a unique tissue enclosed inside the hard surrounding tissue of dentine (Yu and Abbott 2007). These tissues are structurally and functionally inter-related, and are therefore termed the 'pulp-dentine complex' (Linde and Goldberg 1993). The tough dentine provides protection and mechanical support to the connective tissue of the pulp by formation of tertiary dentine by the odontoblasts (Bergenholtz 1990). On the other hand, the pulp provides sensory innervation to the dentine and is capable of stimulating dentine formation in response to noxious stimuli (Orchardson and Cadden 2001).

3.6.2 Enamel

Enamel is the outermost layer of the anatomical crown. Its thickness varies from 2.3 mm over the cusp's tip to 1-1.3 mm over the lateral surfaces of the permanent teeth (Khera et al. 1990). In primary teeth the thickness of enamel is typically 1 mm or less.

The composition and structure of enamel depends on the type of tooth (permanent or primary, erupted or unerupted) (Nilsson et al. 1998) as well as on the location within the crown of the tooth (surface or subsurface) (Shore et al. 2010).

Accordingly, it is important to consider such factor in selecting enamel samples for erosion tests or in comparing different studies. Difference in enamel properties may lead to difference in the susceptibility of enamel sample to erosive material.

3.6.2.1 Chemical composition of enamel

Enamel is a highly mineralised tissue and consists of 95% (w/w) minerals, 4% (w/w) water and 1% (w/w) organic material. The organic material is composed mainly of amelogenins and enamelin. The mineral part of enamel is mainly nonstoichiometric impure calcium hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$) (Oliveira et al. 2010). Carbonate is one of the major impurities which ranges from 2.7-5% (w/w). In addition, small amounts of sodium (0.6% w/w), magnesium (0.2%), potassium (0.03%) and fluoride are present. These constituents are not distributed in a homogenous manner within enamel (Driessens et al. 1984). As a result, the exact composition of enamel may differ from person to person, from tooth to tooth and from one location to another within the same tooth. These differences are responsible for the biologic difference between enamel samples.

It has been found that the concentration of calcium and phosphate decreases from the surface of enamel towards the interior, while the protein increases (Driessens et al. 1984).

Surface enamel contains a larger amount of fluoride and lesser amounts of carbonate and magnesium than the inner layers. The difference in the distribution of fluoride, carbonate and magnesium is usually associated with the increase in the solubility of enamel (Nilsson et al. 1998).

In comparison to primary teeth (80% of minerals), permanent teeth have a higher degree of mineralisation (95% of minerals), lower carbonate and higher level of phosphorous (Youravong et al. 2008; Oliveira et al. 2010).

3.6.2.1.1.1 Apatite

Some *in vitro* studies have used synthetic apatite instead of human enamel (Baig et al. 1999). The main advantages are the possibility of controlling the conditions of the experiment and testing the effect of each single factor on the erosion process. In addition, the variation between samples is very small thus erosion experiments can be undertaken even with a small sample size. However, there is a great variation between the composition and solubility of synthetic apatite and human enamel making it the least relevant substrate for simulating the clinical condition (Zero 1996).

3.6.2.1.2 Factors relevant in the erosion process

There are many factors that influence the amount of tissue loss when enamel is attacked by an acidic solution. These factors are categorised into three groups, namely factors related to the properties of the enamel, properties of the solution and properties of the interface between the two.

3.6.2.1.2.1 Contact angle (wettability)

There are three major factors that influence the wetting of a solid by a liquid. The first is the relative surface energy of the solid and the surface tension of the liquid. This is a function of the inherent chemical composition and polarity of the surfaces to be bonded. The second factor is the viscosity of the liquid, which is a measure of the resistance to flow. The third is the surface topography of the solid surface. Contact angle is often used to measure the wettability of solid surfaces and the effect of different viscosities of liquids on the wettability of solid surfaces (Eick et al. 1972). An *in vitro* study conducted by Ireland *et al.* (1995) of various acidic solutions found that the contact angle formed between these solutions and the enamel surface affected the adhesiveness and wettability of the enamel surface which in turn affects the amount of enamel loss which caused longer enamel exposure to acidic solution.

The measurement of the contact angle and enamel wettability by solutions is relevant to this study because it is a part of the assessment of the erosive potential of the top ten most commonly available novelty sweets in addition to the assessment of the other physiochemical properties of the novelty sweets.

Contact angle can be defined as the angle formed at the liquid-solid interface in the droplet profile (Kwok and Neumann 1999). When the drop spreads on the solid surface that means that the contact angle is small and the wettability is high because the liquid spreads on a wider surface area. If the drop blobs on to the solid surface, that means that the contact angle is large with low wettability because the liquid spreads on a small surface area (Decker et al. 1999). The surface tension of the liquid is the main determinant of the contact area. In pure liquid, its molecules are equally distributed which give the net force of zero. Surface tension is a result of unbalanced net force of molecules (Decker et al. 1999).

Organic contaminants such as pellicles may prevent or reduce wetting and result in higher contact angles. As a surface is cleaned and treated to remove contaminants the contact angle typically will decrease as wetting improves and surface energy increases (Good 1993; Li and Shan 2012). Any contact angle taken on a drop which is in motion is considered a dynamic contact angle measurement while measurement taken while the drop is static is considered a static contact angle (Lee and Lee 2011). Many studies have reported that the dynamic contact angle is the main determinant of the penetration of the liquid into the solid surface (Hilpert 2009).

3.6.2.1.2.1.1 Methods used to measure the contact angle (wettability) of a solid surface by a liquid

There are four methods to measure the contact angle of liquid on a solid surface. In order to measure the contact angle, the effect of the surface roughness of the solid material should be reduced by making it as smooth as possible. There are many ways of preparing the solid surfaces including solvent coating, heat pressing and surface polishing (Meiron et al. 2004). In the present study, the enamel surfaces were prepared by surface polishing.

3.6.2.1.2.1.1.1 Static drop method

In this technique, the contact angle of a liquid on a polished surface can be measured using a direct measurement. The solid surface can be placed and the liquid drop placed using a micrometre tube (Figure 12). The test samples are illuminated and contact angle is measured by a telescope equipped with an eyepiece. The contact angle can be measured by reading the measurement in the eyepiece (Bachmann et al. 2000; Dupont and Legendre 2010).

Recent developments include the test samples being photographed by a camera for detailed interpretation. In addition, high magnification can be used for accurate measurements. This technique is easy to use with a small amount of liquid (a small drop). However, the main disadvantages of this technique are the interpersonal and intrapersonal variations (Lander et al. 1993; Hilpert 2009).

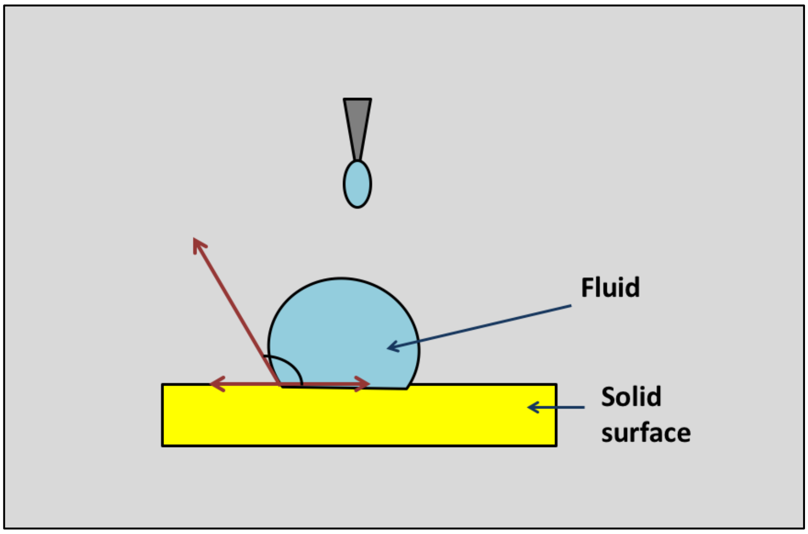


Figure 11. Contact angle measurement using static drop method (Figure based on Meiron et al. 2004).

3.6.2.1.2.1.1.2 Captive bubble method

This technique is based on injecting a small air bubble (0.05 ml) into the test liquid, immersing the solid sample in the liquid above the air bubble and measuring the contact angle between the air bubble and the solid (Marmur 1998) (Figure 13). The main advantages of this technique is that the placement of the air bubble will minimise the contamination of the solid-liquid interface and controlling the temperature of the liquid (Drelich et al. 1996). However, it requires high amount of liquid to use this technique (Lander et al. 1993).

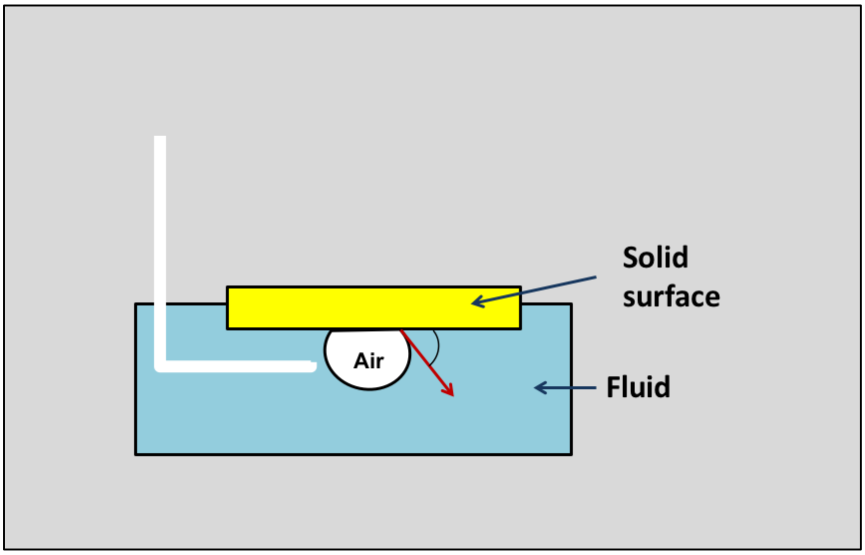


Figure 12. Contact angle measurement using captive bubble method (Figure based on Meiron et al. 2004).

3.6.2.1.2.1.1.3 Tilting plate method

In this technique, after placing a drop of tested liquid, the contact angle is measured after tilting the solid sample towards one side of solid surface. The solid sample gradually tilted until the meniscus of the liquid formed horizontally on the side before the drop moves (Dupont and Legendre 2010) (Figure 14). So unlike the static drop method, the drop is in this technique is a semi-dynamic method (tilted but not moving). This technique is introducing the idea of having the contact angle while the drop in more interactive condition between the liquid and the solid. Recently, a scanning laser beam has been used to measure the contact angle accurately (Lander et al. 1993; Shang et al. 2008).

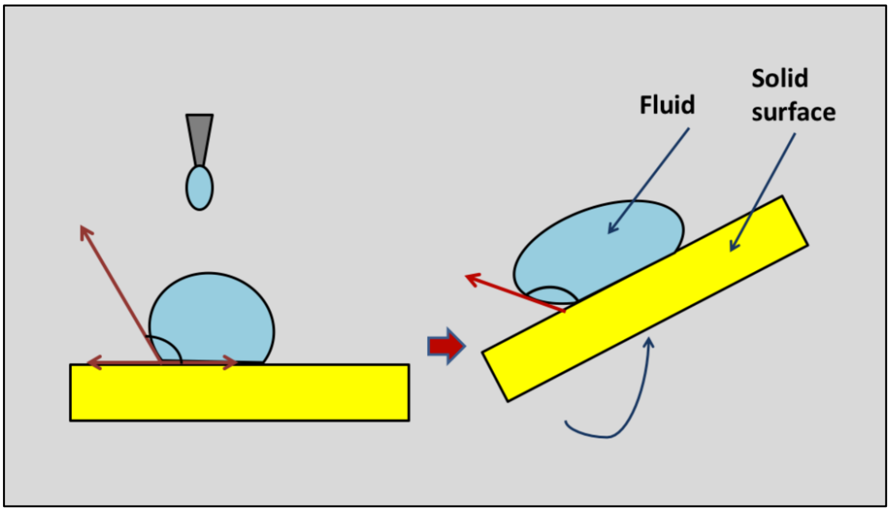


Figure 13. Contact angle measurement using tilting plate method (Figure based on Meiron et al. 2004).

3.6.2.1.2.1.1.4 Wilhelmy balance method

This technique is widely used to measure the contact angle on solid surfaces (Meiron et al. 2004; Lodge and Bhushan 2006). The solid sample brought in contact with the liquid at a mass level not at a drop level which provide better and more realistic assessment of the contact angle (Meiron et al. 2004) (Figure 15). In this technique, the solid sample has to be smooth and prepared to be in a slide shape (Rame 1997). By using this technique, the contact angle can be measured with high accuracy and reproducibility (Lander et al. 1993; Shang et al. 2008). Recently, a computer-assisted measurement of this technique was developed which is called a Dynamic Contact Angle Analyser (Meiron et al. 2004).

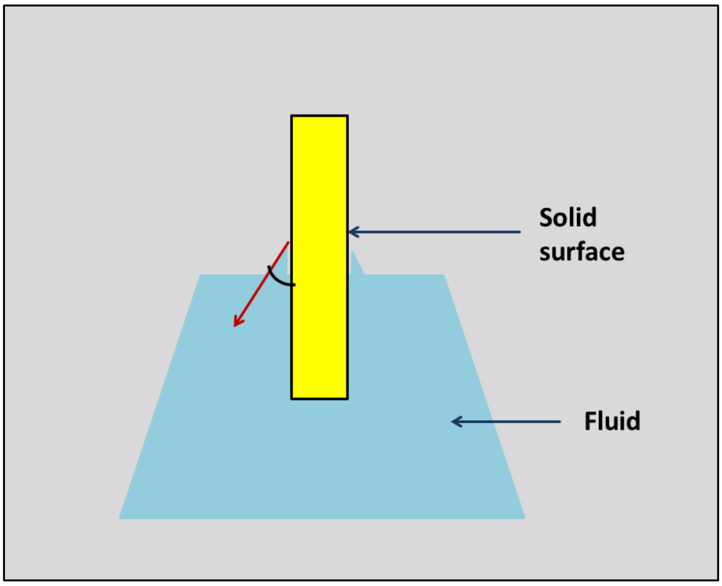


Figure 14. Contact angle measurement using the Wilhelmy balance method (Figure based on Meiron et al. 2004).

In this study, the Wilhelmy balance method was used by using a Dynamic Contact Angle analyser.

3.6.2.1.2.2 Chelation

Besides interacting with the phosphate and hydroxyl ions of the enamel, some components in solution can also interact with calcium ions. A common way is the chelation of calcium ions by the anionic part of certain organic acids, such as citrate and tartrate which one of the properties give them their erosive potential. Chelation is the bonding of metal ions to groups of organic molecules to form a soluble ion pair (Barbour et al. 2008). Chelation promotes the dissolution by reducing the concentration of free calcium ions, according to the law of the equilibrium state, as well as by detaching calcium ions from the crystal surface (Lussi et al. 1993; Larsen and Nyvad 1999).

3.6.2.1.2.3 Degree of saturation

The overall ability of a solution to dissolve a substrate can be determined by the degree of saturation. The degree of saturation is based on the ratio between the ion activity product of the solution before contact with hydroxyapatite and the solubility product at the equilibrium state (Barbour et al. 2005a; Eisenburger 2009).

For example, if the amount of calcium and phosphate in a solution is close to their saturation concentration at the given pH, less dissolution of hydroxyapatite is observed (Barbour et al. 2003). The solution is either saturated, unsaturated or supersaturated with regards to the substance. In a saturated solution, no net material loss or gain can be observed, since the ion activity product is identical to the solubility product. In an unsaturated solution, the material dissolves, while precipitation of the solid can be observed in a supersaturated solution (Shellis 1988; Zero 1996; Barbour et al. 2005a).

3.6.2.1.2.4 Viscosity

Viscosity can be defined as the mechanical friction between molecules in motion and the resistance to deformation as a result of mutual attraction of the molecules. In other words, viscosity is the resistance to flow (Schaefer 2014).

One of the factors which has been suggested to affect the amount of dental erosion is the viscosity of acidic solutions. Higher viscosity causes less amount of enamel loss caused by acidic solutions (Aykut-Yetkiner et al. 2013). It has been found that the addition of polymers in the acidic solution minimise the erosive potential of the acidic solution not only because of the formation of the surface polymer layer, but also because of the modification of the viscosity of the solution (Barbour et al. 2005b; Beyer et al. 2012).

It has also been suggested that the viscosity of acidic solution affects the velocity of its flow which in turn affects the adhesiveness of the solution to the enamel surface, wettability of enamel surface and clearance of the dissolution products, which may affect the erosive potential of the acidic solution (West et al. 2000; Eisenburger and Addy 2003).

Based on viscosity behaviour as a result of shear rate, stress and deformation of the fluid, there are two types of fluids, namely Newtonian and non-Newtonian fluids. The Newtonian fluids are described as fluids which flow with a simple linear relation between shear stress (MPa) and shear rate (1/s). This relationship is known as Newton's Law of Viscosity (Schaefer 2014). Examples of Newtonian fluids include water, honey and organic solvents. The non-Newtonian fluids, on the other hand, are the fluids in which their viscosity is dependent on shear rate or deformation and time. The non-Newtonian fluids possess a non-linear relation between shear stress and shear rate (Munizaga and Barbosa 2005; Yaseen et al. 2005).

There are two types of non-Newtonian fluids. Firstly, the shear-thickening fluid whose viscosity increases with the shear rate such as corn-starch in water which becomes more viscous when mixed or stirred. Secondly, shear-thinning fluids whose viscosity decreases with the shear rate such as paints and ketchup (Munizaga and Barbosa 2005; Qi et al. 2009).

The liquid products of novelty sweets tested in the present study would be Newtonian fluids with viscosity being increased above that of water by dissolution of sugars and any thickening agents.

3.6.2.1.2.4.1 Methods to measure the viscosity

There are six different methods developed to measure viscosity. These methods are the following.

3.6.2.1.2.4.1.1 Capillary viscometer

This method is one of the earliest methods used in measuring viscosity. The technique was based on using a capillary tube to measure the time needed for the fluid to pass the whole length of the tube. It was developed before the 20th century and known as U-tube, Ostwald or Ubbelohde viscometers (Srivastava and Burns 2006; Digilov and Reiner 2007).

During the measurement procedure, the fluid is drawn into the upper bulb by capillary suction then left to flow down to the lower bulb in the other arm. The time needed for the fluid to pass from the upper bulb to the lower bulb is multiplied by the factor of the viscometer and the viscosity is calculated (McKinley and Tripathi 2000; Digilov and Reiner 2007). Some disadvantages related to this type of viscometer include the difficulty in reading the marks if the fluid discolours the glass tube and the effect of varying temperatures of the fluids measured (Digilov and Reiner 2007).

3.6.2.1.2.4.1.2 Falling sphere viscometer

In this type of viscometer, the fluid is placed in a glass tube vertically and a metal sphere is placed in the top of the tube and allowed to move down the tube. The time required for the sphere to pass through the fluid is calculated and multiplied by the viscosity factor to calculate the viscosity. It is based on the frictional force or drag force exerted on the sphere by the fluid (Brizard et al. 2005a). To maximise the accuracy of this technique, different diameter metal balls can be used with the same fluid and compared with other test fluids (Brizard et al. 2005b).

There are some drawbacks of this viscometer which include the uncounted effect of the sphere surface roughness and effect of temperature. However, a water-controlled bath can be used with some new types of this viscometer (Feng et al. 2005).

3.6.2.1.2.4.1.3 Falling piston viscometer

This type of viscometer is composed of a piston and a cylinder with a narrow end. The fluid is placed in the cylinder first then followed by placing the piston allowing the fluid to flow through the narrow tube while the piston is moving down by an air lifting mechanism (Bair 2004). The viscosity measurement is based on the time required for the piston to move to the bottom of the cylinder and the fluid through a narrow tube (Dindar and Kiran 2002). This type of viscometer is simple to use and needs minimal maintenance (Cullen et al. 2000).

3.6.2.1.2.4.1.4 Bubble viscometer

This type of viscometer is based on the time required for an air bubble to pass upward through the test fluid in a glass tube. It is most commonly used for resins and varnishes. The faster the bubble passes through the fluid, the lower the viscosity and vice versa (Park and Jeong 2011). This method is considered an accurate method of measuring the viscosity. However, it might be difficult to control and count the effect of the shape of the bubble in the tube (Cullen et al. 2000).

3.6.2.1.2.4.1.5 Vibrational viscometer

This viscometer is based on measuring the damping of an oscillating electromechanical resonator placed in the middle of the test fluid. This resonator oscillates in different directions (Lee et al. 2012) and the viscosity is measured based on the power needed for the resonator to maintain the vibration, measuring the frequency of the resonator in different directions or the time required for the oscillating to disappear once the machine is switched off (Cullen et al. 2000; Yabuno et al. 2013; Yabuno et al. 2014).

3.6.2.1.2.4.1.6 Rotational viscometer

This type of viscometer is one of most commonly used viscometers in the food and pharmaceutical industries (Larsson et al. 1983; Casaretto et al. 2012). It is based on measuring the resistance of fluid to torque. It measures the torque required to move and rotate a spindle placed in the middle of a fluid at a specific speed (shear rate) (Qi et al. 2009). The rotational viscometer measures the viscosity proportional to the motor torque that is required for turning the spindle against the fluid's viscous forces (Dao et al. 2009). This is called the Searle principle (Giese 1995; Munizaga and Barbosa 2005). The higher the viscosity the more the torque required to rotate the spindle. The flow curve (viscosity) can be simply developed by having the shear stress (torque) against the shear rate (velocity). It is easy to use, accurate and does not require skills and experience (Dao et al. 2009).

In the present study, the viscosity of the tested fluids was tested using a rotational viscometer.

3.6.2.1.2.5 Temperature

The solubility of a solid in a given solution depends also on the temperature of this solution and whether the dissolution process is exothermic (e.g. energy, usually as heat, is released during the solution) or endothermic (e.g. energy is required during the dissolution process). Most solids dissolve in an endothermic reaction, which means that their solubility increases with an increase in the solution temperature (Barbour et al., 2006). This phenomenon has been observed for enamel and it has been found that an increase in the temperature by 10 degrees leads to 20% increase in the enamel solubility (Amaechi et al., 1999b, West et al., 2000). In addition, Eisenburger and Addey (2003) found that erosion depth caused by soft drinks was significantly increased with the increase in temperature from 11 μm at 4° C to 35.8 μm at 50° C. This was also supported by the findings of the study of Amaechi *et al.* (1999a) who found that the dental erosion depth was significantly more pronounced with the increase in the temperature from 4° C to 20° C and from 20° C to 37° C. This follows the Arrhenius equation which is widely applied as a model of the temperature effect on the rate of chemical reaction and biological processes of food (Peleg et al., 2012). The Arrhenius equation shows that for any chemical reaction, the increase in the temperature by 10° C doubles the reaction rate and the decrease in the temperature by 10° C decreases the reaction rate by a factor of 2 (Peleg et al., 2012, Laidler, 1984). This means that the chilled soft drinks, for example, have a lower erosive potential than the same drink at room temperature (Amaechi et al., 1999b, Eisenburger and Addy, 2003).

3.6.2.1.2.6 Diffusion

Besides the composition of the materials used in demineralisation studies and the properties of the applied solutions, the interface between the two (particularly the thickness of the diffusion layer), plays an important role concerning the observed amount of material loss.

Ions dissolved from the outmost surface of a solid can only move away into the solution by diffusion, which is a slow process, based on the microscopic movement of the particles. Diffusion always occurs spontaneously and is due to the free thermal movement of ions. On average, a material transport in the direction of lower concentration is obtained (Larsen, 1990). Since the rate of dissolution is normally greater than the diffusion, ions can accumulate near the crystal surface thus raising the degree of saturation near the surface and therefore slowing down the dissolution process, even if the bulk of the solution is undersaturated. Stirring the solution can minimize the diffusion layer. However, even with strong stirring a thin liquid layer (10-100 μm thick) remains on the surface due to adhesion forces (West et al., 2000). It is therefore of great importance to keep the diffusion layer as thin as possible throughout an experiment carried out *in vitro* by stirring the solution to refresh the hydrogen ions (Barbour et al., 2005a).

3.6.2.1.3 Factors protecting the enamel surface

It has been found that *in vitro* tests demineralisation is accelerated by a factor of 10 to 20 compared to *in situ* studies (Hughes et al. 1999a). It is more likely that specific processes which can reduce the extent of an erosive challenge are present in the oral environment, with saliva and the acquired pellicle layer being the most important factors.

Saliva confers the major protective function against wear and dental caries. Flow of saliva and its buffering capacity also play an important role in the prevention of caries and erosion by acid clearance, reducing demineralisation and enhancing hard tissue remineralisation with its high calcium, phosphate and fluoride content (Llena-Puy 2006).

Reduced salivary flow which might be age related or following surgical excision of one or more major salivary glands, Sjögren's syndrome, use of antidepressants, sedatives, tranquillizers or radiotherapy in the head and neck region predisposes not only to rapid caries development but also to dental erosion (Holmes 1998). In addition to its diluting and flushing effects, changes in the flow rate of saliva may also affect its buffering capacity and concentrations of secreted ions available for remineralisation (Cho et al. 2010). Consumption of carbonated drinks may reduce salivary flow and thereby lessen the protective effects of saliva for the teeth (Cheng et al. 2009).

Another role of saliva is the formation of the acquired pellicle which is formed by the adherence of a protein–based layer to the outer surface of the teeth which seems to protect against erosion by forming a diffusion barrier and preventing direct acid-tooth contact, thus reducing the dissolution rate of hydroxyapatite (Hannig and Balz 2001). This protection depends mainly on the composition, thickness and maturation time of the pellicle. Studies have suggested that there is an inverse relationship between the thickness of the acquired salivary pellicle and erosive effects of acids (Larsen and Pearce 1997; Amaechi et al. 1999c).

3.6.2.1.4 Methods used to investigate tooth surface loss

There are a number of methods that can either detect compositional changes in the demineralising solutions (e.g. chemical analysis of calcium and phosphate concentrations) or capable of measuring change in mineral density (e.g. microradiography) or the loss of surface material (e.g. profilometry) has been applied.

3.6.2.1.4.1 Types of methods

3.6.2.1.4.1.1 *In vivo* studies

As already pointed out, *in vivo* studies are based on the direct examination of the human dentition. Long-term *in vivo* investigations offer the most direct indication of the fact that material loss takes place in the oral environment and that its severity has increased in recent years (Borjian et al. 2010).

Despite their importance for identifying the influence of erosion on the human dentition, these studies have a number of drawbacks. A major problem is that the observed changes are often not specifically due to enamel erosion (Lekkas et al. 1992).

Clinically identified changes of the dentition (tooth wear) are more likely based on a combination of factors, which include erosion as well as attrition (wear of dental hard tissue due to tooth-tooth contact) and abrasion (wear of dental hard tissue due to contact with foreign objects).

Since the severity of the material loss is determined after the structural changes took place, case histories are often the only way to link a specific erosive agent to the observed changes (Grenby 1996). This, in most cases is very challenging (Margaritis and Nunn 2014). Furthermore, it would be unethical to design an experiment in which the natural dentition of the volunteer is damaged (Butterworth 2011; Horner and Minifie 2011). It is therefore impossible to use *in vivo* techniques for systematically testing the erosive effect of acidic food.

3.6.2.1.4.1.2 *In vitro* and *in situ* studies

Compared to the studies conducted *in vivo*, *in vitro* studies allow better control of the experimental conditions. In particular, *in vitro* studies offer the highest amount of control, leading to more reproducible results (Hughes et al. 1999a; Barbour and Rees 2004).

The term *in situ* (also called *in vivo-in vitro or in situ/ex vivo*) is used if an erosive challenge takes place in the oral environment and assessed in the laboratory (Jones et al. 2002; Magalhaes et al. 2007). The *in situ* model of dental erosion was developed by Lekkas *et al.* (1992). The test samples can be either hydroxyapatite discs, or bovine or human enamel samples. They are fixed in the mouth by intra oral appliance for a prolonged amount of time and removed prior to determination of overall material loss at predetermined time points (Creanor et al. 1986; Featherstone and Zero 1992; West et al. 1999). This technique allows one to control the amount and exposure as well as the intervals between erosive challenges. In these studies, differences in the susceptibility of the volunteers to erosion are difficult to account for and lead to an increase in the standard deviations of the final results.

3.6.2.1.4.2 Dissolution of calcium and phosphate

Different methods are used for the determination of Ca and P in solution. The most common technique for measuring the amount of calcium is the atomic absorption spectroscopy (AAS) (Grenby et al. 1990; Meurman et al. 1990a). This method is based on the absorption of light by calcium atoms. It is possible to detect calcium concentration of around 1 μg/l with high reproducibility (standard deviation: 0.5-2%) (Grenby et al. 1990).

A widely used spectrophotometric technique for determining P in solution is based on the intensity of the blue colour of a stable reduced phosphomolybdate complex. This method facilitates the detection of around 10 μg/L phosphate (Grenby and Saldanha 1995). However, a major drawback of this technique is that great care must be taken to eliminate interference from other drink components, such as citrate, that can alter the colorimetric response.

The detection of Ca and/or P combines high sensitivity and reproducibility with a relatively fast and simple operative procedure. Furthermore, the described techniques belong to the few methods which can measure erosion on native (unpolished) enamel surfaces with high precision.

However, a major drawback of the determination of Ca and P in solution is the inability to link the measured amount of dissolved material to specific features on the enamel surface.

3.6.2.1.4.3 Profilometry

Profilometry or surfometery is a well-established technique which is extensively used in the surfaces science and dental research. The profilometer can be used to measure the contour of the surface, the profile and roughness quantitatively (Barbour and Rees 2004).

Profilometry was used first by Ashmore *et al.* (1972) to measure the enamel abrasion caused by toothpastes. The major advantage of this technique was its ability to measure the dissolution rate of enamel *in vitro* as well as *in situ*, due to the fact that consecutive measurements can be obtained on the same enamel surface (Hughes et al. 1999a).

Based on the available types of profilometer, erosion test measurement can be divided into two main techniques. These are contact profilometer and the more recent non-contact profilometer (Elton et al. 2009) (Figure 16).

In contact profilometery, a spherical diamond tip is driven across the specimen surface at a constant force. The analog voltage following the vertical movements of the tip is transformed into the surface profile, which is used for determining the amount of enamel loss due to an erosive challenge (Barbour and Rees 2004; Rodriguez and Bartlett 2010). The resolution depends on the tip radius as well as on the roughness of the surface. In the literature, a number of different tip radii are mentioned. The radius of those tips varying up to a factor of 20 in size (e.g. r=1 μm and r= 20 μm) (West et al. 1998). A general resolution in x can therefore not be given, but as a rule of thumb, it can be said that features smaller than the diameter of used tip cannot be accurately measured. The resolution in depth (z-direction) has been reported to be around 10nm (Barbour and Rees 2004). Measurement can be obtained easily and quickly, making it logistically possible to investigate change in a large number of samples.

In non-contact profilometry, the same idea of measuring the contour as in the contact profilometry, the profile and the roughness of the enamel surface is measured. However, instead of the tip which run across the enamel surface in contact profilometer, a laser beam scans the surface and reproduces a three dimensional figure of the scanned surface with the reading of the surface roughness and profile to be compared with the baseline readings (Whitehead et al. 1995). The main disadvantages of non-contact profilometer are the cost of the machine, complexity of the measurement procedure and the time consuming (20-30 minutes) taken for each reading (Lu et al. 2001).

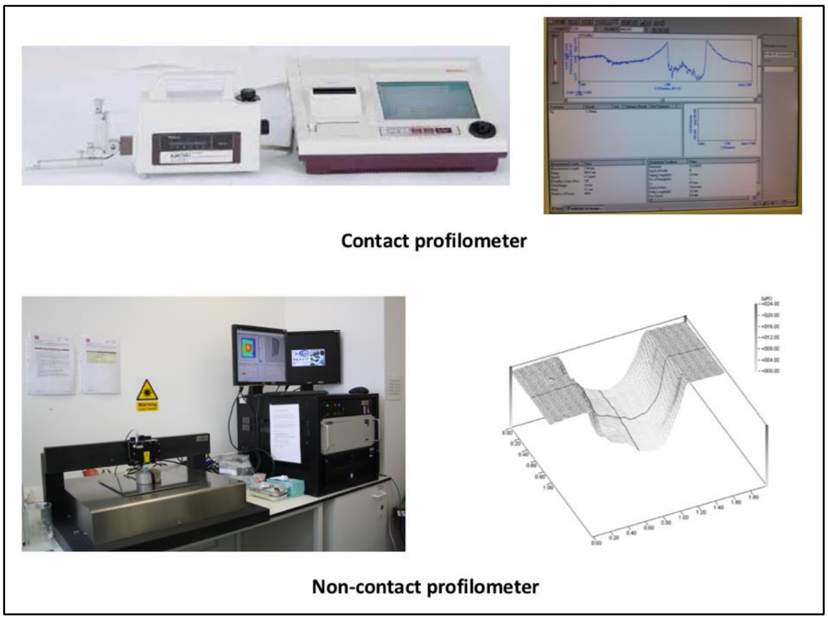


Figure 15. Contact and non-contact profilometers (Figure based on Elton et al. 2009).

In this study, the amount of surface and subsurface enamel loss potentially caused by the novelty sweets will be assessed using a contact profilometry (surfometer).

3.7 Literature review conclusions

The expansion of the novelty sweet market in the UK has significant potential public health implications for children and young adults as they may contribute to dental erosion, dental caries and obesity.

Epidemiological studies have highlighted that frequent consumption of acidic foods and/or drinks can lead to the development of dental erosion. Many of these acidic products also contain high levels of free sugars which may contribute to the development of dental caries. It is therefore possible to see patients who have erosion of enamel who then go on to develop dental caries.

Novelty sweets are of particular concern because they contain both high levels of free sugars and acids. Furthermore, their product design facilitates regular frequency of consumption as many are in re-sealable packages. Consequently, they have the potential to cause dental erosion, dental caries and for children to consume many "empty calories" which could lead to the development of obesity.

To date, studies on the health implications of novelty sweets are limited, addressing only the pH, neutralisable acidity and enamel loss. The objective of this study was to build on existing research by:

- Identifying the most commonly available types of novelty sweets, assessing their price range and where and how they were displayed in shops.

- An *in vitro* assessment of the ability of the top ten most commonly available novelty sweets to cause dental erosion by measuring their pH, neutralisable acidity, viscosity and contact angle with the enamel surface.
- Analysis of the top ten most commonly available novelty sweets' sugar content, allowing an assessment of their ability to cause dental caries and obesity.
- An assessment of schoolchildren's understanding and beliefs about novelty sweets assessed by focus group study. This focus group work informed the design of a questionnaire to assess the children's consumption of novelty sweets.
- An assessment of sensory taste thresholds for sweet and sour in children to analyse any potential link between their taste thresholds and consumption of novelty sweets.

Materials and Methods, Results and Discussion

4 Materials and methods, results and discussion

4.1 Study structure

This study has used an innovative blend of qualitative sociological research methods together with more traditional laboratory based oral science methods to assess the likely impact of novelty sweets on dental health.

The sociological aspects of the study involved using three different but interlinked approaches:

1. An initial scoping study of shops in the Cardiff area was undertaken to establish which were the ten most commonly available novelty sweets, how they were displayed in commercial premises and the unit cost of these popular brands of novelty sweets.
2. A focus group discussion was undertaken with a group of schoolchildren aged 11-16 years to assess their understanding and beliefs about novelty sweets. This was undertaken to help design a questionnaire to assess any link between the sensory sweet and sour thresholds in children and their consumption of novelty sweets. Analysis of any age or gender related variations in sensory sweet and sour taste thresholds were also undertaken.
3. The questionnaire designed in stage 2 above was completed by a second group of schoolchildren aged 11-16 years. This was completed at the same

time as the sensory taste threshold tests for the two selected basic tastes (sweet and sour) commonly found in novelty sweets.

The oral science part of the project in the laboratory tested the 10 most commonly available novelty sweets identified in section 1 above. The assessments undertaken were:

- pH
- Neutralisable acidity
- Surface wettability
- Viscosity
- Sugar content
- Surface and subsurface enamel loss

An outline of the study flow for the sociological aspects and the oral science aspects parts of the study is illustrated in Figure 17.

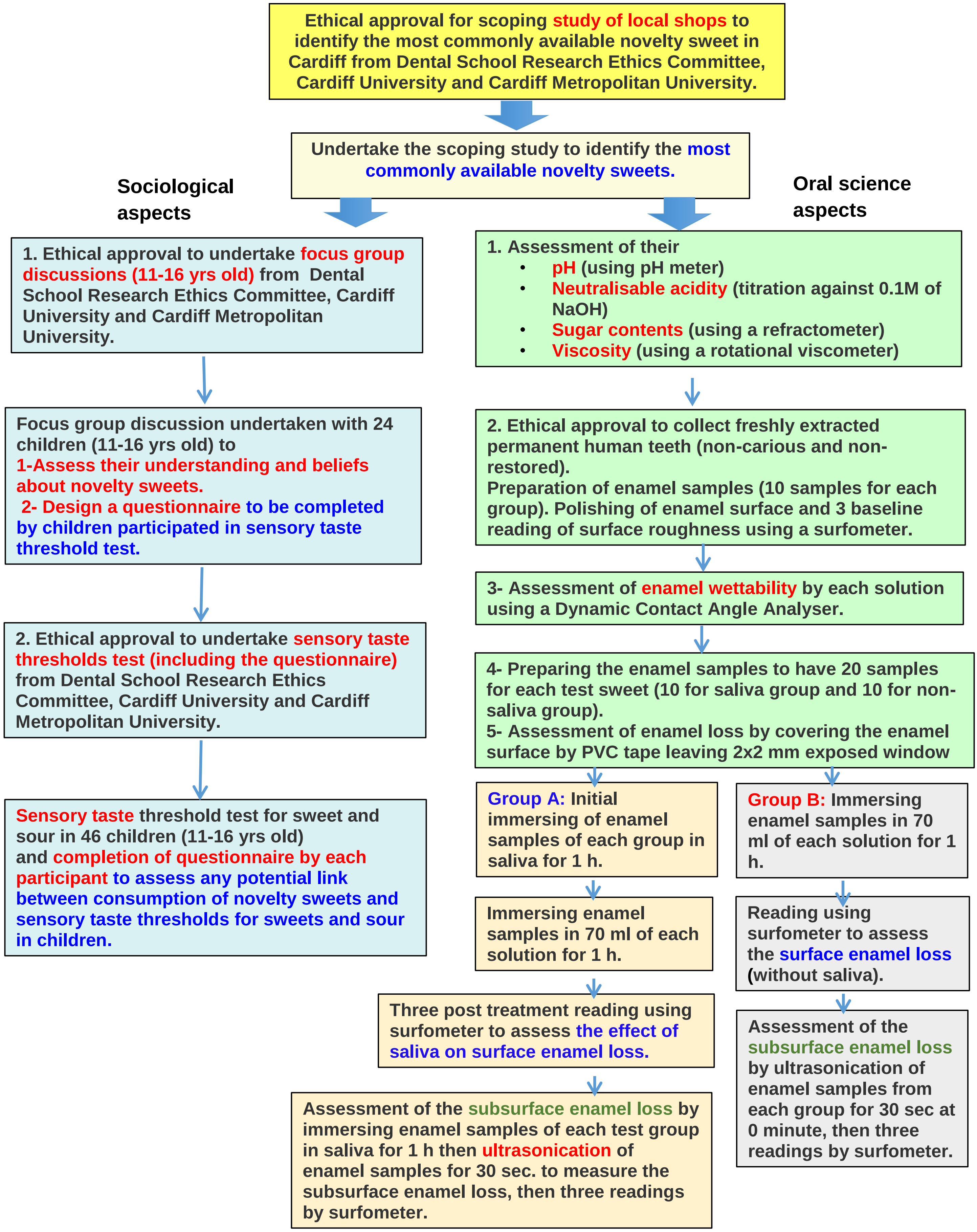


Figure 16. A flow chart illustrating the structure of this study.

4.2 Assessment of the most available novelty sweets

Scoping visits were undertaken to determine the commonly available varieties of novelty sweets available to high school children attending selected schools in Cardiff, UK. A list of the most available novelty sweets was created by visiting selected city centre stores and shops located near five high schools (the "school fringe") (Sinclair and Winkler 2009; Crawford et al. 2012) and three supermarkets from the wider Cardiff conurbation. Visiting shops in the school fringe, city centre and supermarkets were undertaken following the findings of focus group work, concerning children's understanding and use of novelty sweets, amongst 9-10 years old reported by Stewart *et al.* (2013).

High schools (educating children aged 11-16 years) were purposely selected to represent a cross-section of the socio-economic characteristics of the city using the Welsh Index of Multiple Deprivation (WIMD 2011). Five high schools were selected one in each deprivation quintile. Each school represented a level of deprivation within the five deprivation levels outlined by the WIMD.

The WIMD is an official index, which measures the level of deprivation in small areas in Wales. Deprivation is defined as

> ''a lack of opportunities and resources to which we might expect to have access in our society, for example good health and a clean and safe environment'' (WIMD, 2011, p.3).

The overall deprivation level is a weighted sum of deprivation assessed by eight domains, which include, employment (23.5%), income (23.5%), education (14%), health (14%), community safety (5%), geographical access to services (10%), housing and physical environment (5%). The weights reflect the importance of the domain as an aspect of deprivation, and the quality of the indicators available for that domain (WIMD 2011).

The WIMD is assigned to the 1,896 lower super output areas (LSOAs) of small geographical areas derived for census implementation in Wales. Regardless of the geographical size of the areas, the size of the population is intended to be approximately the same in each LSOA. In order to select schools which represented the different levels of deprivation in the Cardiff area, the ranked areas were divided into quintiles i.e. most deprived, second most deprived, middle deprived, second least deprived and least deprived (WIMD 2011).

The schools were purposely selected to represent geography and socio-economic characteristics of the city. Catchment areas for schools demonstrated the wide urban mix of the population (Cardiff Council 2013). The locations of the five schools, city centre stores and supermarkets are shown in Figure 18.

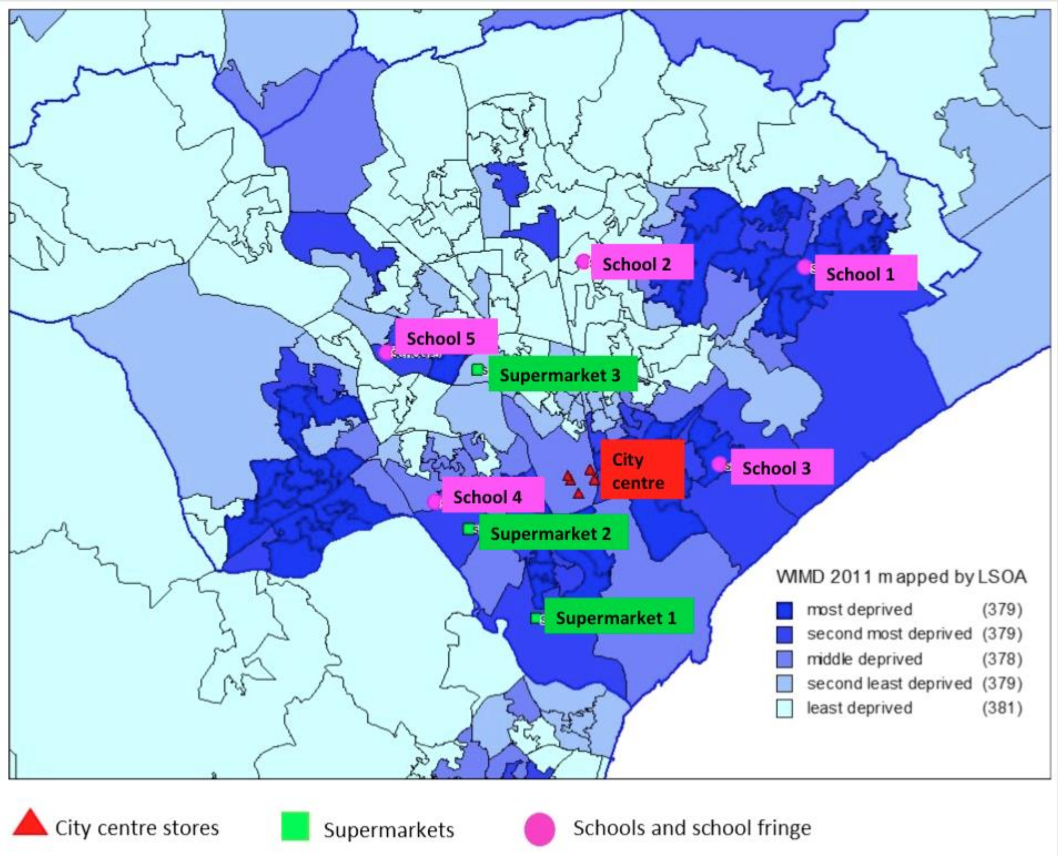


Figure 17. Reference locations (5 schools, city centre stores and 3 supermarkets) Cardiff Unitary Authority, by quintiles of deprivation, (WIMD 2011).

The school fringe was determined following the guidance of Sinclair and Winkler (2009) and Crawford *et al.* (2012) who reported that shops within the school fringe are one of the main sources of food to children when children are walking to and from school. They suggested that students visit shops within the school fringe about six times a week. Suburban use of school fringe shops was about 3.6 times per week while the urban use of school fringe shops was higher at 11 visits per week.

Shops located within the school fringe (within a radius of 10 minutes walking distance) were visited. A stopwatch was used to estimate the walking distance of each shop selling novelty sweets from the chosen schools. Shops around the schools were visited just before children left school at the end of the school day (14:00 hrs – 15:00 hrs).

Purposely selected city centre stores located in the main shopping street in Cardiff city centre and shops within 10 minutes walking distance from this were visited. This was not limited to sweet shops, it is known that some fashion stores stock sweets such as Next, Marks and Spencer and Primark. In addition to this, three supermarkets from the wider Cardiff conurbation were also visited.

For the shops in the city centre and the supermarkets, visits were conducted during weekends. At all visits, novelty sweets available for sale were noted using a data collection table which was developed according to the methodology adopted by Sinclair and Winkler (2009) and Crawford *et al.* (2012) (Appendix 2). In addition, the retail prices and the location of the sweet display were recorded with regard to the height of the shelves and the proximity to the check out as these factors are known to affect children's purchase of confectionary (Birch and Fisher 1998; Mela 1999; Wansink 2004; Andreyeva et al. 2010; Elliott et al. 2013).

Post visit, an assessment was made of the difference in availability of novelty sweets in relation to deprivation.

4.2.1 Participants

To undertake the scoping visit work, ethical approvals were obtained from the Dental School Ethics Committee, Cardiff University (Appendix 3).

The selected stores were contacted on the day of the scoping visits. A form providing general information about the visit together with a participant's information sheet (Appendix 4) and consent form were given to the shop's manager (Appendix 5). The consent form was designed to allow the shop's manager to sign giving their formal consent. Manager verbal assent (agreement to participate) in addition to the written consent was sought on the day of the scoping visit.

A brief outline of what would happen during each visit was also given to the shop managers verbally in addition to the written participant information sheet provided by the researcher (Appendix 5).

4.2.2 Data recording and handling

During each visit, the findings at the various shops were collected using a data collection table (Appendix 2). All data was recorded using unique identifiers designed to maintain anonymity such as "School 1, Shop 1 in the least deprived area".

Each visit lasted for between 10-15 minutes and the data below was collected.

1. The presence or absence of novelty sweets.
2. Types of novelty sweets.
3. Prices, locations and methods of display.

In addition to this, the variations in the availability of novelty sweets in relation to deprivation were subsequently assessed.

Data was analysed using SPSS v20 (IBM Corporation, Chicago, USA). Analysis of data included descriptive statistics, incorporating frequency distributions and cross tabulations. MapInfo v10 (Pitney Bowes, New York, USA) was used to represent the Welsh Index of Multiple Deprivation (WIMD) and store location data.

4.2.3 Debriefing of shop manager

At the end of the visit the shop's manager was given a formal debrief letter to allow receipt of a copy of the summary of findings once prepared (Appendix 6).

4.2.4 Results of assessment of novelty sweets' availability

A total of 68 stores were visited and 19 of these stores sold at least one type of novelty sweet. In total 84 novelty sweets (including repeats of some types) were identified for sale in the 19 stores and a histogram of availability is shown in Figure 19.

A summary of the availability of novelty sweets in relation to the school fringe, city centre stores and 3 supermarkets is given in Table 6. School 3, in the most deprived area, had the largest percentage of shops selling novelty sweets, this was also apparent within the city centre, where at each location 50% (5 out of 10 shops) sold them. In addition, more varieties of novelty sweets were sold around these two locations, 16 varieties in close proximity to school 3 and 17 varieties within the selected city centre shops. Furthermore, School 2 in the least deprived area had no shops around the school fringe selling novelty sweets (out of the 11 visited), as was the case for school 5 which bordered the second least deprived area out of 10 shops visited.

Both Schools 1 and 4 which were in the second most and middle deprived areas of Cardiff respectively had 33% (4/12) of shops selling novelty sweets. The shops surrounding School 1 stocked 15 varieties of different novelty sweet, compared with 11 types in shops close to School 4. Only one of the three supermarkets visited sold novelty sweets; however this was the only supermarket situated within the school fringe of School 4, in the middle deprived area of the city, which stocked 5 types of novelty sweets. In addition, the novelty sweets were displayed on low shelves (< 40 inches) in 74% (14 out of 19) of the shops, which means that they were accessible to all age groups. Furthermore, in 37% (7 of 19) of the shops, novelty sweets were displayed in close proximity to the checkout (The remainder were displayed in dedicated confectionary aisles).

The frequency distribution of the prevalence of the novelty sweets (Figure 19) clearly shows that the most frequently available sweet variety was *Brain Licker*, available in 8 separate shops. At the other end of the distribution there were 18 unique sweet varieties, including *Alien Liquid Candy* (liquid), *Lick the teeth* (Lollipop), *Snot Shots* (solid) and *Sour Shocks Chew* (chewable solid), which were each available in one shop only.

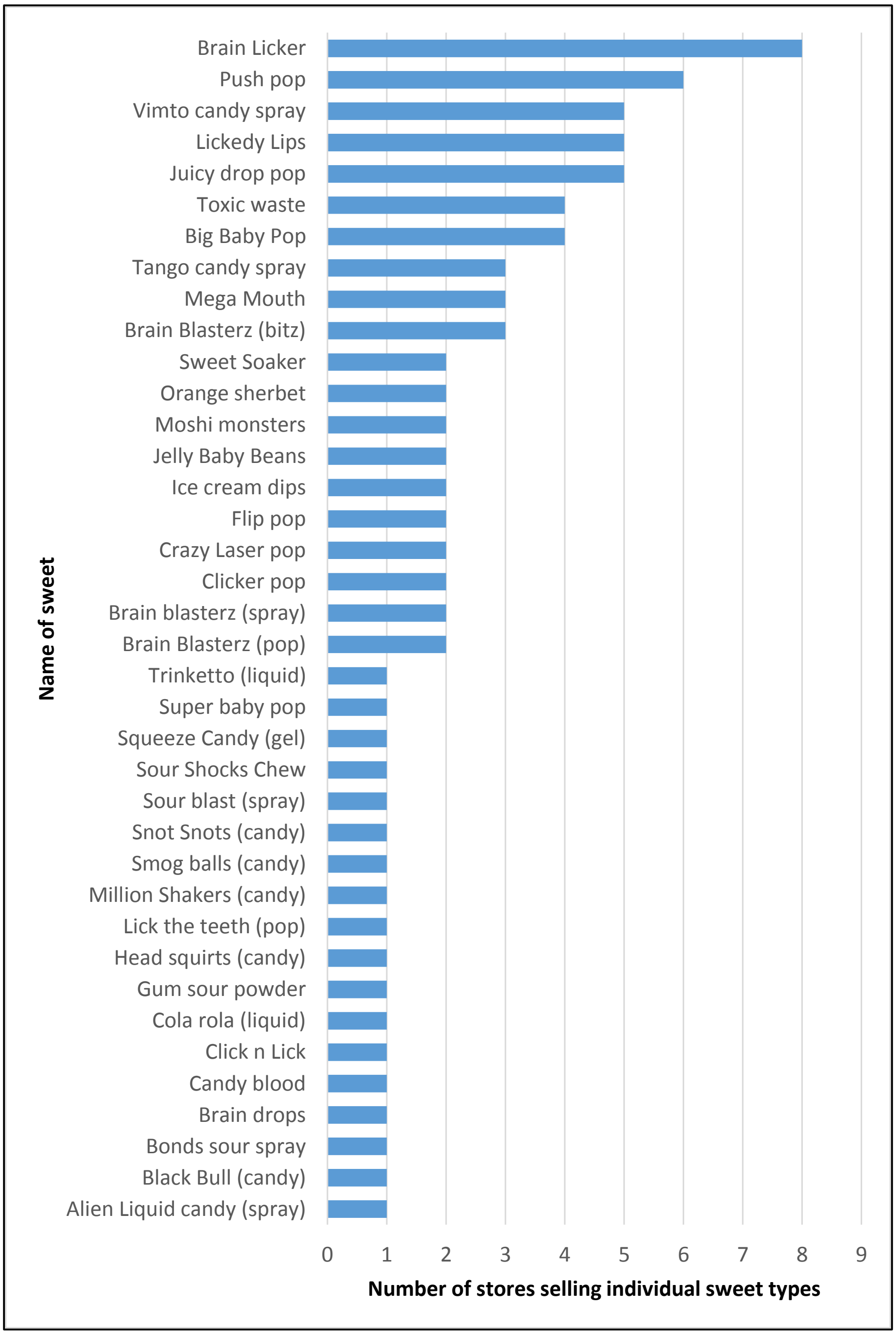


Figure 18. Prevalence in 19 stores, out of the 68 visited, stocking one or more novelty sweets.

Table 5. Summary of types and price range of novelty sweets in shops within school fringes, city centre stores and supermarkets.

	WIMD (2011) 1/5th deprivation of school location	No. of visited shops	No. of shops selling sweets	Types of Novelty sweets	Price range
School 1	Second Most deprived	12	4	15	0.10p-£1.49
School 2	Least deprived	11	0	None	-
School 3	Most deprived	10	5	16	39p-£1
School 4	Middle deprived	12	4	11	39p-99p
School 5	On border with second least deprived	10	0	None	-
City centre	-	10	5	17	39p-99p
3 supermarkets	-	3	1	5	39p-£2.99

4.2.4.1.1 Price of the available novelty sweets in Cardiff

The price distribution of all of the novelty sweets identified is shown in Figure 20.

The average price of the 38 unique novelty sweet varieties was 96p with a range from £0.10 (for *Sour Shocks Chew*) to £2.99 (for *Candy Blood*). Thirty-two of the 84 sweet types (including repeats of some types) were priced at £1.00.

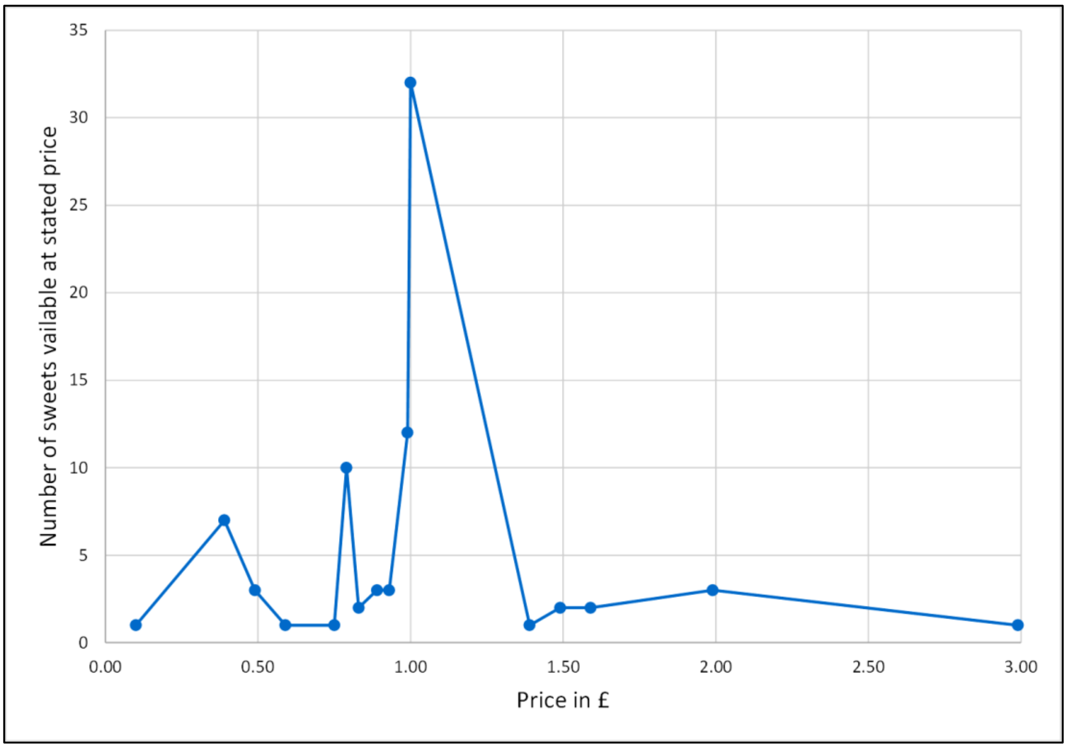


Figure 19. Price distribution of all 84 novelty sweets (including repeats).

4.2.4.1.2 Categories of the available novelty sweets in Cardiff

The novelty sweets were categorised into 7 main types reflecting their textural properties, i.e. gels, sprays, liquids and hard candy. A distribution of the form of the sweets is presented in Table 7. The most available product formulations were solid lollipops (e.g. Baby Pop), liquid spray (e.g. Vimto Candy Spray) liquids (e.g. Brain Licker) and solid candy (e.g. Toxic Waste).

Table 6. Categories of the available novelty sweets.

Consistency	**Form of sweet**	**Number (including repeats)**
liquid	liquid	17
liquid	spray	18
gel	gel	1
liquid + solid	liquid+ lollipop	1
solid	candy	17
solid	lollipop	21
solid	lollipop + powder	6
solid	powder	3
Total	**Total**	**84**

4.2.4.1.3 The ten most available novelty Sweets in Cardiff

The top ten most commonly available novelty sweets to high school children in Cardiff were identified out of the 38 unique types of novelty sweets (Figure 19). The price range of the most commonly available novelty sweets was in the range of 39p-£1 with a mean price of 90p.

A visual representation of the identified ten most available novelty sweets in the Cardiff area, their forms and contents are presented in Figure 21 and Table 8 and these were (in descending order):

- Brain Licker,
- Push Pop,
- Juicy Drop,
- Lickedy Lips,
- Vimto candy spray,
- Big Baby Pop,
- Toxic Waste,
- Tango candy spray,
- Brain Blasterz Bitz, and
- Mega Mouth candy spray.

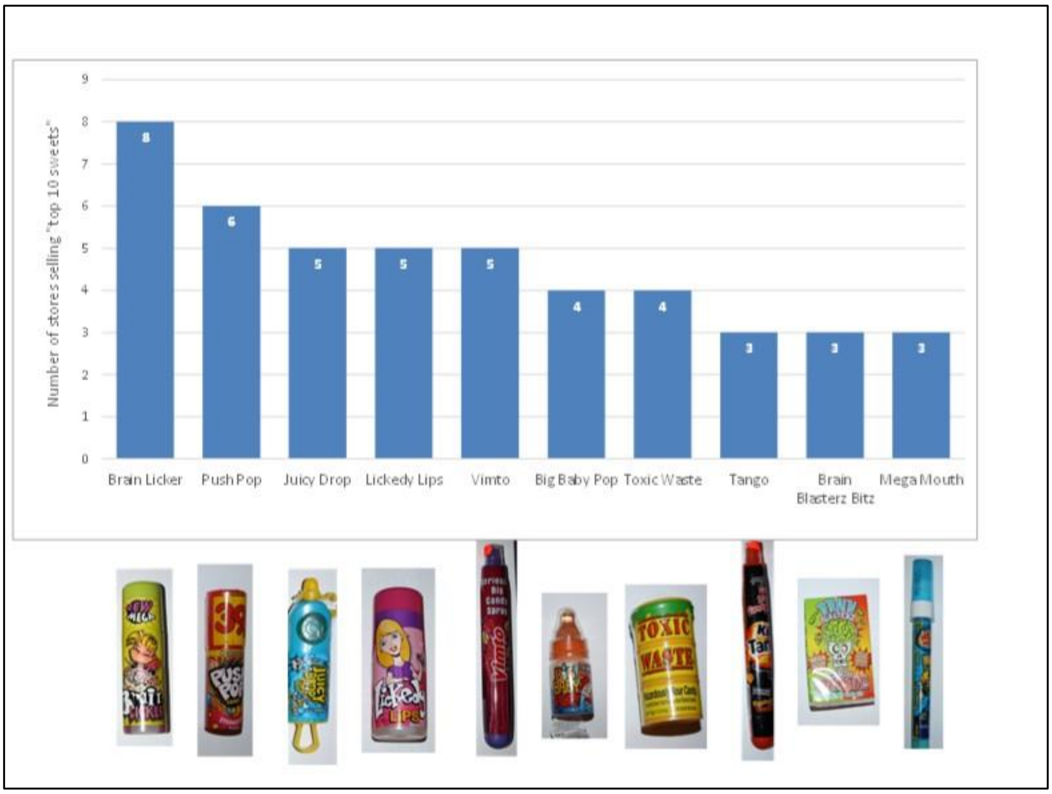


Figure 20. The ten most available novelty sweets in the Cardiff area. Numbers relate to the number of stores (n=19) the sweets were found in.

Table 7. Ingredients listed on the 10 most available novelty sweets in Cardiff area.

Product	Form	Ingredients
Brain Licker	Liquid	Glucose-fructose syrup, acidifiers, citric acid, lactic acid, malic acid
Lickedy Lips	Liquid	Glucose-fructose syrup, acidifiers, citric acid, lactic acid, malic acid
Push Pop	Lollipop	Sugar, glucose syrup, lactic acid
Vimto	Spray	Sugar, malic acid, citric acid, acid regulator (sodium citrate)
Tango	Spray	Sugar, malic acid, citric acid, acid regulator (sodium citrate)
Juicy Drop Pop	Liquid + lollipop	Sugar, glucose syrup, fructose syrup, citric acid, malic acid
Toxic Waste	solid	Sugar, glucose syrup, citric acid, malic acid
Big Baby Pop	Lollipop + powder	Sugar, glucose syrup, citric, lactic acid
Mega Mouth	spray	Sugar, citric acid
Brain Blasterz	Solid	Sugar, acidity regulator

4.2.5 Discussion of novelty sweets' availability

From the results of the initial scoping study, the most available novelty sweets identified in the Cardiff area were (in descending order) Brain Licker, Push Pop, Juicy Drop, Lickedy Lips, Vimto Candy Spray, Big Baby Pop, Toxic Waste, Tango Candy Spray, Brain Blasterz Bitz and Mega Mouth Candy Spray. These results were consistent with the UK studies of Beeley (2005) and Davies *et al.* (2008) and the Dutch study of Gambon *et al.* (2009). Beeley (2005) included Brain Licker, Juicy Drop Pop, Mega mouth and Big Baby Pop as the most commonly available types. Davies *et al.* (2008) also included Brain Licker, Juicy Drop Pop and Mega Mouth as the most common types of novelty sweets that were available in the last decade. The scoping study confirmed that a wide range of novelty sweets with different types of presentation were available, for example spray (e.g. Mega Mouth and Vimto Candy Spray), lollipop with powder (e.g. Big Baby Pop) and liquid (e.g. Brain Licker). Lickedy Lips is a new 'female' version of Brain Licker which was not available when the studies of Beeley (2005), Davies *et al.* (2008) and Gambon *et al.* (2009) were undertaken.

The finding of this study showed that there was a wide expansion in the UK confectionary market. In this study 84 novelty sweets (including repeats) were found and 38 unique types were identified. This finding supports the reported figures showing that the sugar confectionary market is growing (worth £5.41 billion in 2011) (Mintel 2012).

This study also showed that there were no novelty sweets available in two thirds of the large supermarkets visited. However, five types of novelty sweets were available in one supermarket which was located in close proximity to one of the schools visited. This finding showed that children targeted marketing of these sweets is being used as a strategy by this particular supermarket chain. This finding is consistent with the findings of Crawford *et al.* (2012) who found that a number of popular chain and franchised businesses around schools used the targeted marketing to attract children in the UK. This finding also supports the findings of Story and French (2004) and Harris and Graff (2011) who found that children targeted marketing was widely used by popular chains in the USA. The promoted and advertised foods were predominantly foods with high sugar and fat. It was also found by Caraher *et al.* (2014) that there was an average number of 41.8 “junk food” outlets around each school in London.

It was also observed that the availability of novelty sweets was greater in the most deprived areas. This result is consistent with the study by Drewnowski (2012) and Drewnowski and Spector (2004) who also reported that there was an increased availability of sweets in deprived areas probably because they were a low cost energy source in the USA. A study by Reidpath *et al.* (2002) found that children in deprived areas were 2.5 times more exposed to outlets than children within the least deprived areas in Australia. The majority of foods available in these outlets were predominantly high sugar and fat products. Macdonald *et al.* (2007) found that there was a significant relationship between level of deprivation and number of outlets selling high calorific food in Scotland and England.

The price of all the available types of novelty sweets found in shops around the selected schools and in shops in the city centre was in the range of 10p-£2.99. In comparison, the price range of the ten most commonly available novelty sweets was in the range of 39p- £1, with a mean price of 90p. This mean price is well within the average of weekly pocket money available to children in the UK which was found to be £6.20 in 2015 (Lloyds Banking Group-Halifax 2015). Therefore, children could potentially buy multiple units of these most commonly available sweets each week. It is important to highlight that children (7-15 years old) spend their money mainly on confectionary chocolate, crisps, canned drinks and personal goods (Sodexho 2005).

Within the shops and supermarkets visited, novelty sweets were displayed on relatively low shelves (<40 inches) in 74% of shops, and 37% of these sweets were displayed close to checkout or where the people queued for the checkout.

These results also showed that physical engagement was being widely used by retailers in a child-targeted marketing approach designed to trigger the visual interaction and the memory of children. A large number of novelty sweets were therefore accessible to all age groups of children. The majority of the novelty sweets were displayed below the maximum reach (<40 inches) of all age groups reported by Pheasant and Haslegrave (2006) and Smith and Norris (2004). It is also known that the use of physical engagement is a highly successful aspect of marketing (McNeal 2003) and there was ample evidence of this being used by a large number (74%, n=14) of the shops and supermarkets visited in this study.

4.3 Sociological aspects of the study

It has been suggested by many authors that children's food choices are determined by this taste preference (Pangborn and Giovanni 1984; Liem and Mennella 2002, 2003; Perez-Rodrigo et al. 2003). Therefore, the aim of the next part of the present study was to assess the children's understanding and beliefs about novelty sweets and to design a questionnaire using focus group discussions. The questionnaire was completed by the children participating in the subsequent sensory taste thresholds test to identify any potential link between their sensory thresholds for sweet and sour and their consumption of novelty sweets.

4.3.1 Focus groups to inform the assessment of the sweet and sour tastes thresholds

The focus group work was carried out at the Food Industry Centre at Cardiff Metropolitan University (CMU).

Focus groups were used for the generation of information on collective views, and the meanings that lie behind those views. A focus group approach was chosen to explore the topic and collect group language or narratives to be used at the sensory taste thresholds test stage (Bloor et al 2001). Two separate focus group discussions were undertaken, each with 8-12 children until saturation was reached.

It has been suggested that once the findings are repeated, with no new areas raised that means that the saturation level is reached and no further group discussion is needed (McLeod et al. 2000; Burnard et al. 2008).

4.3.1.1 Methodology

4.3.1.1.1 Participants of focus group discussion

To undertake the focus group work in children aged 11-16 years old, ethical approvals were obtained from Dental School Ethics Committee, Cardiff University (Appendix 7) and Cardiff School of Health Science, Cardiff Metropolitan University (Appendix 8).

Cardiff Metropolitan University (CMU) hosts a number of open days for local school children which are funded by Welsh Government (WG) and are aimed at increasing interest in tertiary education at a young age. CMU already had well established links with a number of local schools where the children visit but also take part in various food workshops within the Food Science and Technology Department.

This part of the study was undertaken at two of these open days which allowed access to a total of twenty-four 11-16-year-old schoolchildren.

4.3.1.1.1.1 Consent and participant information arrangements

The nominated School was contacted 4 weeks in advance of the study and a form giving general information about the day for parents (parents letter) (Appendix 9), a participant information sheet (Appendix 10) and parental consent forms (Appendix 11) were distributed via the class teacher for the children to take home. The consent form was designed to allow the parent/guardian to sign giving their formal consent in addition to obtained parental written consent. The child's verbal assent (agreement to participate) was also sought on the day, prior to the focus group session starting.

4.3.1.1.2 Programme for the focus group discussions

Children that attended the day who had consent were included in the study, whilst those who turned up with no consent form were excluded from the study. These children were corralled in a separate area and given a simple dental health talk (Appendix 12). These children also received an age specific dental pack containing a child's toothbrush and age appropriate toothpaste at the end of the talk. Toothbrushes and toothpastes were provided by **G**laxo**S**mith**K**line, UK.

For those children who did take part in the focus groups, the day began with a talk led by Cardiff Metropolitan University that set out the organisation of the day and also explained where the "dental" part of the day fitted into the programme. No mention of the specific aims of the dental project, particularly its focus on novelty sweets, was made at this stage so as not to bias the group in any way.

When the children reached the designated time of their visit for this study, they were corralled in an area manned by at least two adult supervisors at all times to avoid issues of the children (more than 8) being supervised by just one adult (National Society for the Prevention of Cruelty to Children 2013).

A brief outline of what was about to happen during this session was given by the researcher (Ayman Aljawad (AA)). Intended focus group prompts, based on a previous study (Stewart et al, 2013), were set out. Two focus group discussions were undertaken on 2 separate days (12/11/2014 and 07/01/2015) and lasted for about 90 minutes with a break of 10-15 minutes in the middle of each session. The sessions were undertaken by the researcher (AA) and one moderator from Cardiff

Dental School (Maria Morgan (MM)) and another moderator from CMU (Ruth Fairchild (RF)). The questions discussed with the focus groups are listed below.

Start off with a simple game to get the children to list the names of all the sweets they know and like.

1. Do you eat sweets?

2. What type of sweets do you eat? (Probe preference)

3. Then, the 10 types of novelty sweets introduced with actual sweets shown as prompts.

4. Are you familiar with these types of sweets? (Probe knowledge about novelty sweets).

5. Which types of novelty sweets do you know/ like/dislike?

6. Where do you get them from?

7. When would you have them?

8. What do you think parents/other guardians think of these sweets?

9. What do you like/dislike about them?

10. Do you like other sweet and/or sour foods?

11. Where can these sweets be bought? (Probe when they go there, with whom).

12. What would happen if you eat them all at once?

13. Who do you think these products are aimed at?

4.3.1.1.3 Debriefing

Participants were also given a formal debrief letter to allow receipt of a copy of the summary of findings once prepared (Appendix 13).

4.3.1.1.4 Data handling

The focus group responses were digitally recorded using a professional dictation machine (Olympus DS-2500, Essex, UK) and fully transcribed verbatim using a professional transcription kit (Olympus AS-2400, Essex, UK) for manual thematic content analysis (Burnard et al. 2008). The focus group observer (AA) made a note of the proceedings using a diagram of the seating arrangements, initials and gender of the participating children. The observer also made brief notes of the discussions which were cross referenced with the audio recordings so that individual contributions could be followed. However, all contributions were referenced using unique identifiers designed to maintain anonymity such as "Girl 1", where the number refers to the number of the child in the group. One of the moderator was writing notes to help cross referencing each child while transcription the discussion from the voice recorder.

Following familiarisation with the data, thematic frameworks were identified according to the key issues of the research objectives, and the data was indexed according to the framework, with the coding categories refined appropriately in response to the data (Burnard et al. 2008).

Audio files, transcripts and participants were identified only by a unique identifying number to ensure confidentiality. The data was analysed on a Cardiff University computer which was password protected. All audio data was backed up to a password protected hard disk drive which was held in a locked fire proof filing cabinet.

The paper diagrams used to aid cross referencing of the audio recordings mentioned above were destroyed by shredding at the end of the study.

4.3.1.2 Analysis of the focus groups' discussion

The focus groups' discussion was analysed using thematic analysis. Thematic analysis is a process of analysing multiple phases in sequence. These phases include familiarisation with the data, coding (summing up of what was mentioned in the script), generating themes and subthemes (if applicable), researching through the data and production of a report (Burnard et al. 2008). Thematic analysis describes patterns (themes) across the qualitative data. A theme captures important data which represents a level of patterned response to the research question (Braun and Clarke 2006). More detailed analysis can be obtained by generating subthemes from a particular theme within the data (Holloway and Todres 2003; Braun and Clarke 2006).

Twenty-four children participated in this part of the study, 54.2% were males (n=13) and 45.8% were females (n=11). Their ages ranged from 11 -16 years.

Following the process of thematic analysis, the following recurrent themes and subthemes were identified. The compositional structure of themes is presented in Appendix 14.

1. Children's familiarity with sweets

- 1.1. Variety of sweets consumed by children
- 1.2. Familiarity of novelty sweets amongst children

2. Accessibility and availability of novelty sweets to children

2.1. Independency of children's purchasing decision

3. The routine nature of novelty sweets' consumption (when and where eaten)

3.1 Influence of peers and friends on the novelty sweets' consumption

4. Children's belief about for which age/gender these sweets aimed.

5. Reasons of like/dislike of novelty sweets

5.1. Taste and flavour of novelty sweets

5.2. Packaging criteria of novelty sweets (re-sealability, visual attraction and multiple ways of consumption).

5.3. Parents belief and awareness concerning novelty sweets

The detailed analysis of focus group discussions' themes and subthemes is the following:

4.3.1.2.1 Familiarity of sweets amongst children

4.3.1.2.1.1 Variety of sweets consumed by children

The focus group discussion started by a simple game to get the children to list the types of sweets they consume. The children were keen to mention a wide variety of confectionary. These included, chocolate, jelly sweets, chewable sweets, lollipops, sour/sweet confectionary and marshmallows. None of the children in either group mentioned novelty sweets before being prompted to talk about them; although, one child did refer to sour sweets as one type of the sweets they consumed. ‘Tangfastics’ and ‘Skittles’ which are also sweet sour confectionary were also specifically mentioned.

AA: Do you eat sweets? What type of sweets do you eat?

Boy 11 “Jelly Babies”

Boy 9 “Chewits”

Boy 9 “Wine Gums”

Boy 11 “Fruit Pastilles”

Girl 3 “Marshmallows”

Boy 10 “Lindor Balls”

Boy 11 “I like Guylan Shells”

Boy 9 “Aero Bubbles”

Boy 11 “Galaxy Caramel”

Boy 9 “Dairy Milk”

Boy 11 “Tangfastics”

Boy 9 “Mentos”

Boy 8 “Twix”

Boy 10 “Mars bar”

Boy 7 “Skittles”

Boy 24 “Sour sweets”

Girl 18 "Chuppa Chups Lollies"

Girl 19 "I like also M&M's and Skittles"

Boy 12 "I like Mars bar and Tootie Fruity"

4.3.1.2.1.2 Familiarity of novelty sweets amongst children

The ten most commonly available novelty sweets identified in the first stage of this study were introduced with actual sweets used as prompts. Children were familiar with the most common types of novelty sweets, they had tried some of them and they liked them.

AA: Have you seen these sweets before, do you try/ like them?

Children (in group) "Yes"

Boy 23 "I really love them".

Boy 22 "I've seen them all and I eat all of these".

Girl 19 "I've seen the Brain Licker and Lickedy Lips and Toxic Waste and Push Pop".

Children liked different types of the top ten most available sweets identified in this study, although two children specifically mentioned that they did not like Toxic Waste.

AA: Which types of these sweets do you like/dislike?

Boy 11 "Vimto"

Boy 10 "Tango"

Boy 11 " Yes, I like them, but I don't like Toxic Waste".

Girl 19 "I don't like Toxic Waste".

Children were familiar with the ten most commonly available novelty sweets types identified in this study, had tried them, and liked the majority of them.

4.3.1.2.2 The routine nature of novelty sweets consumption (when and where eaten)

Children mentioned purchasing and eating sweets regularly, some every day and others a few times a week. Frequency of purchasing and consumption was associated with availability of money and autonomy of food selection. The questions below were asked by the researcher (AA) to initiate the children's response about the frequency of purchasing and consumption of novelty sweets.

AA: How often do you buy and eat these sweets?

BOY 11 "Everyday"

BOY 10 "It is like every 2 days. I go to the shop, if I have enough money I buy a lot of sweets to eat, if I don't have money, I don't buy any sweets. It depends on the money I got"

BOY 9 "It's like every Friday"

BOY 8 "Every other day"

BOY 7 "Every Friday"

GIRL 5 "Everyday"

GIRL 4 “Everyday”

GIRL 3 “I have it every week”

GIRL 2 “Everyday”

BOY 12 “3-4 times a week”

BOY 13 “3 times a week”

BOY 14 “2 times a week”

BOY 15 “Once a week”

BOY 16 “Everyday”

BOY 7 “Probably about 3-4 times a month”

BOY 18 “Once a week except during our journey to Southampton, I have sweets for the whole weekend”

GIRL 19 “Twice every three weeks”

BOY 21 “About 4-5 times a week”

BOY 22 “4-5 times a day, all in the afternoon. 4-5 different times in the afternoon”

GIRL 23 “Once a week

BOY 24 “Once a week”

AA: When would you buy them?

Boy 9 “Sometimes before school, but mostly after”

Boy 18 “After school around 3:30 on my way home”

Girl 19 “I usually buy them with my parents on the weekend or Fridays if I don’t, after school”

Children mentioned that they eat them whenever possible, during lessons, after tea, when they are tired and their free time.

AA: When do you eat them?

Boy 10 “Whenever”

Boy 16 “I normally have them in my pocket to eat them during lessons”

GIRL 3 “When I feel tired or when I don’t do anything”.

Some children stated that they take the whole sweet at once while other children said that they eat it more frequently by closing it and keep it for later.

AA: Do you keep them and eat them over time or all at once?

Girl 21 “Sometimes I keep them for later sometimes I eat them all at once”.

Boy 15 “All at the same time”

Frequency was also linked to weekend consumption and activities, such as travelling to visit family and friends, when food control by parents was more permissive.

Boy 18 “Once a week except during our journey to Southampton, I have sweets for the whole weekend.”

Additionally, children indicated that they were allowed to eat sweets after meals but only if they were still hungry.

Girl 19 "Twice every three weeks. Sometimes after my dinner, if I'm not full"

Children are eating sweets frequently, some buy their own, others are given them by parents or guardians and frequency is increased at weekends.

4.3.1.2.2.1 Influence of peers and friends on the novelty sweets' consumption

Children mentioned that they share novelty sweets around at school or at home. They also mentioned that they can purchase novelty sweets from friends at school when they did not buy them from shops. Furthermore, children also purchase and share novelty sweets with peers and friends.

GIRL 3 "I usually share them around at school or to give it to my sister if I don't like them".

BOY 11 "If you don't go to the shop you can just buy them from a friend".

Boy 22 "Some friends sell them at school but they cost us more than the shops"

GIRL 4 "I've seen all of them when I go with my sister to buy sweets".

BOY 14 "I buy them with my sister from local shops".

Peers and friends influence the consumption of novelty sweets by sharing and selling novelty sweets at school, as well as being available in local shops and city centre shops. Novelty sweets were involved in the social interaction between children and reflect the great influence of peers and friends on novelty sweet consumption.

4.3.1.2.3 Availability and accessibility of novelty sweets to children

Children provide a lot of information about this aspect. They mentioned that they bought novelty sweets from local shops to school and take them home which gave a great importance to the school fringe as an important source of such types of sweets.

The questions below were asked by the researcher (AA) to initiate the children's response about the availability and accessibility of novelty sweets.

AA: Where do you get these types of sweets from?

Boy 3 "I go to the shop, if I have enough money I buy a lot of sweets to eat"

Children also had sweets bought for them and several mentioned that these were viewed as "treats".

Boy 9 "My mum allows me to buy them only for treat"

Boy 22 "My mum and grandma buy them and give them to my brother as a treat"

Girl 19 "I got most of these from different shops but mainly local shops to school and home"

Boy 11, Boy 10, Boy 9 "Shops near school"

Children also mentioned that they bought these sweets from supermarkets and from shops in the city centre.

Girl 19 “Sometimes with my family from supermarkets and sometimes with the girls from the city centre”.

Children (in group) “From corner shop and supermarkets. Big shops like Tesco and ASDA”

Children mentioned that these sweets are easily accessible in shops.

AA: When you go to the shops to buy them, are these sweets easily accessible for you?

Children (in group) “Yeah”

However, two children mentioned that they were displayed behind the counter and on the top shelf which may reflect the difference in reach of the children.

Girl 19 “I cannot reach the top shelf”

Boy 18 “I usually find them behind the counter”

The accessibility and marketing was also influenced by the shopkeepers' perspective on the effect of consuming these sweets on children.

Boy 18 “I’ve seen them behind the counter and I thought they’re not a normal type of sweet because the guy is hiding them. At that time I was thinking is this guy is crazy but now I know that because there is a lot of sugar in them”.

“One time the guy in the shop who wants to buy them: are you sure you want these? And he gave it to the guy and said take it on your own risk”.

Children mentioned that the novelty sweets were displayed in different locations in shops which included the sweet aisle, around the counter; first when enter the shop, all over the shop.

Girl 21 "I find them as soon as I walk into the shop"

Girl 17 "Sweets are available all over the shop".

Boy 16 "Usually around the counter there are a lot of sweets"

Novelty sweets were widely available, easily accessible and displayed in physical engagement areas within shops. The children maximum reach and shopkeepers' perspective on these sweets may limit the accessibility of these sweets. One of the sources of novelty sweets was from parents and grandparents as a "treat". The concept of "treat" was familiar to the children.

4.3.1.2.3.1 Independency of children's purchasing decision as an influence of the available pocket money

Children had a noticeable knowledge about the price range of the novelty sweets.

AA: How much do these sweets cost?

Boy 11 "These are for a pound Brain Licker and Lickedy Lips".

Girl 5 "This is for 89p" (Big baby Pop).

Children linked the amount of novelty sweets they purchase to the amount of pocket money available to them.

RF: Is that a lot of money?

Children (in group) "No".

Boy 11 "Well. I go to the shop, if I have enough money I buy a lot of sweets".

Children highlighted the packaging/pricing aspect of the novelty sweets.

Boy 12 "When I buy toxic waste for a pound, it's worth it because you will have 10 pieces in it".

Children were familiar with the prices of the novelty sweets and considered their prices to be affordable. Children linked the price with the content of the package which shows the high level of awareness of children about marketing aspects of products. The pocket money available to children was a decisive factor in the amount and frequency of buying the novelty sweets. Furthermore, one of the main determinants of the independency of purchasing novelty sweets is the pocket money available to children.

4.3.1.2.4 Children's belief about which age/gender novelty sweets are aimed at

Children had different opinions regarding the age and gender novelty sweets were intended for. The majority of children mentioned that these sweets were aimed at both boys and girls. The question below were asked by the researcher (AA) to initiate the children's response about their belief about whom novelty sweets were aimed at.

AA: Who do you think these products are aimed at (Boys/girls, Age, Children/parents)?

Boy 23 "Boys and girls",

Boy 24 "Boys and girls"

Girl 20 "I would think that they are mainly aimed at both genders".

Three children said that some types of the novelty sweets are suitable for girls only and other types suitable for boys.

Boy 10 "That's for girls (Lickedy Lips) and the green one (Brain Licker) for boys".

Boy 18 "There are some sweets are mainly for girls like Lickedy Lips"

Boy 15 "I think it is like most of these are for boys but couple of these for example are aimed at girls only like Lickedy Lips and Big Baby Pop".

With regards to age, children mentioned different age groups, which can be applied, to both boys and girls.

Girl 21 "From year 4 to late teens"

Girl 19 "I think it should be like year 9 plus"

Boy 18 "I don't think that you should be eating them before the age of 8 years"

Children mentioned that strong taste was linked to the gender and personality.

Girl 20 "It is too strong for me personally but for Boy 17"

Boy 24 "Depends on personality and characteristics of the person. Because I see some people in year 11 [eating them] and they look too young".

Children also thought that children older than 15 years (year 10) start to eat more other types of sweets (other than novelty sweets).

Girl 20 "When they get older they will eat other sweets like Haribos more than these."

Interestingly, one child (Girl 20) read the label on one of the novelty sweets and found that these sweets contained citric acid and the warning “This sweet is suitable for 3 years and above” which was considered by this child to be too young.

Different ideas were held by children in relation to gender and age of whom these sweets are aimed at. The difference in the age and gender in consumption of novelty sweets were linked to the strength (sourness) of some types the sweets. The children felt that some types were more suitable for male or female, different personalities and ages.

However, all of them agreed that children consume these types of sweets regularly.

4.3.1.2.5 Reasons of like and dislike of novelty sweets

Analysis of the factors which influenced the consumption of novelty sweets by children was undertaken and various factors were identified. The questions below were asked by the researcher (AA) and the moderators (RF and MM) to initiate the children response about reasons behind liking novelty sweets.

4.3.1.2.5.1 Taste and flavour of novelty sweets

Children stated that they liked novelty sweets because their taste.

AA: What do you like/dislike about them?

Boy 10 “They are nice and sweet and tasty”

Girl 2 “They taste nice”

Girl 1 "They are sweet"

Children also mentioned that they liked the sour taste of the novelty sweets and they could manage the strength of the taste. They stated that if they did not like the sweet or sour part of the novelty sweets, they just ignore it and enjoy the taste they liked. This may suggest that some children could unpair the sour/sweet combination of the novelty sweets.

Boy 15 "I like those one cuz I normally I like sour stuff cuz I know I can handle it. But the sweet stuff I've never been a fan of stuff like sweet"

Other children liked the pairing of the sour taste and sweets taste.

Girl 19 "I like when I eat Toxic Waste they're like really sour but then they go sweet"

Boy 10 "when you eat something sweet and then it turns to sour, it tastes really nice"

Girl 21 "I like sour sweet and I seem to like ignore the sour part and just take the sweetness in".

Taste was considered by some children to be a reason for not eating some types of these sweets. Four children mentioned that they do not like the types of sweets or they were hard to eat because they were too sour. They specifically mentioned Toxic Waste as a type of novelty sweet which was too sour for them.

Girl 19 "I don't like Toxic Waste because it is really really sour"

Boy 18 "I hate sour things"

Children mentioned that because of the strong sourness of Toxic Waste, they ate it only for a challenge.

Boy 18 "I hate sour things, but I hate sour things and I remember my friends used to give them to me to see my reaction because when I eat sour things I kinda have like a really spasm".

Boy 11 "I don't like Toxic Waste. Only for a challenge because it is too sour".

The strong sour taste was a reason given not to eat the novelty sweets by some children. For some challenge takers, the strong sour taste was a reason for them to eat them, although they did not like the taste.

Children mentioned various effects when eating these sweets all at once.

AA: What would happen if you eat one whole sweet in one go?

Girl 13 "Feel sick"

Girl 19 "I feel funny feeling in my teeth".

The negative and unpleasant feelings when the children eat the whole package of novelty sweets in one go may drive them to consume the single package more frequently, in small amounts, taking advantage of the re-sealability.

Children stated that they would like to have more flavour of these sweets available in the market. They like to have them in single and mixed flavours.

Children said that the ideas of new flavours they suggested came from the flavours of fruits. Children also expressed their likeness for the sourness of some fruits.

AA: Is there any flavour of these sweets you would like to make?

Children (in group) "Strawberry, raspberry, blackcurrant, cherry, chocolate, bubble gum, tropical, apple, orange and apple"

RF: What are the sour foods/drinks you like?

Boy 16 "I like grapes, apple and melon".

Boy 15 "I really like apples".

Girl 13 "I like grapes, apple and fruits juices from concentrate"

Some children mentioned that they like the sweet and sour taste in different types of food and drinks.

AA: Do you like other sweet and/or sour foods?

Girl 3 "I do the basic cup cake and I add a lemon juice. It is really nice"

Boy 18 "When we talk about sweet and sour, I have to mention sweet and sour chicken".

Children also mentioned that the sport drinks that they drink are sour and sweet and some of them taste like the novelty sweets.

MM: Do sport drinks taste sour like these sweets?

Girl 1 "Some of them yes"

The children's taste preference of fruits and other sweet and sour foods and drinks influenced the taste preference of the novelty sweets. Children were able to enjoy or unpair the combination of the sweet sour combination of the novelty sweets, to lessen the effect of the least liked taste.

4.3.1.2.5.2 Packaging criteria of novelty sweets

4.3.1.2.5.2.1 Way of eating of novelty sweets

Children in the focus group mentioned that they liked the variability of ways of eating. The way of eating these sweets are variable as they come in different shapes and consistency (lollipop, spray, sherbet, etc.).

AA: What do you like about these types of sweet?

Boy 11 "Comes in different shapes. They are different, the one you can lick (Brain Licker), these you can spray (Vimto, Tango and Mega Mouth) and sucking like Toxic Waste"

Children liked the way of eating the novelty sweets and the level of sugar content or the strength of the taste of them.

Boy 22 "I like the spray one better than all of them. I think it doesn't contain a lot of sugar".

Boy 11 "Sucky sweets like Toxic Waste is different because it hurts your tongue"

Children enjoyed the variety of way of eating the novelty sweets and linked the way of eating with the ingredients and taste strength of the novelty sweets.

Some children did not like some types of novelty sweets because of the way of eating such as sucking hard candies and lollipops rather than chewy sweets.

Boy 7 “I’m not so big on sucky sweets as well”

Girl 13 “I don’t like the sucky one or the spray one”

Other children do not like certain ways of eating the novelty sweets.

4.3.1.2.5.2.2 Re-sealability of novelty sweets

Re-sealability of the novelty sweets was found to be advantageous by the children. Re-sealability was clearly related to the frequency of eating the novelty sweets.

Boy 9 “You can save it for later instead of buying another one”.

Girl 2 “They last longer”

Boy 12 “I normally eat a little bit at time like after tea then to keep it for later. Sometimes, I keep eating it for 3-4 days”

4.3.1.2.5.2.3 Visual attraction of novelty sweets’ packages

Children mentioned that they liked the colours of the novelty sweets.

AA: what do you like about these sweets?

Boy 11 “Comes in different shapes and colours”

Girl 13 “I like the colour of this sweet (Toxic Waste)”.

Girl 13 “I like the bright colours”.

Children mentioned that the colour of the package and the sweet inside the package appealed to them visually. They liked the various colours of the novelty sweets.

RF: Is it the colour of the package or the sweets inside?

Girl 13 "Both. I like these bright yellow, pink and green. It appeals to my sight".

RF: Is there any colour of these sweets you like?

Boy 11 "Red"

Boy 10 "Red, Blue"

The colour of the sweets and the package had an effect on children's choice of the novelty sweets. There was more than one colour preferred by children.

4.3.1.2.5.3 Parent's belief and awareness about novelty sweets

Children mentioned that their parents think that these sweets are bad for their health.

AA: What do you think parents/other guardians think of these sweets?

Boy 17 "Parents don't like them very much. Because they these are not good for our health"

Boy 14 "I don't think parents approve of this kind of things at all. They might do everything they can to stop you eating them".

However, apparently children can independently buy and consume these sweets without their parents' knowledge or during the trolley loading in the supermarkets.

Boy 11 "My mum doesn't allow me to buy anything from these sweets".

Boy 10 "I put some of these sweets by trolley loading".

Boy 22 "Parents actually hate them and that's why children take them secretly".

Children mentioned that parents might allow eating these sweets only for small amount.

Boy 15 "I think parent thinks that they are all right in small amounts because it's like everything is quite good in small amounts"

Boy 12 "My mum approves some".

Children believed that parents do not agree to children eating these types of sweets because of the potential effect on their health. There was some parents' permissive agreement of consumption of small amount of sweets. However, the power of parents was limited and children could buy and eat these sweets secretly and independently which again may be related to the available pocket money.

4.3.1.3 Discussion of focus group work

A wide range of sweets were mentioned by children participating in this part of the study. Prior to the novelty sweets being introduced none of them mentioned novelty sweets as defined by Stewart *et al.* (2013) or identified in the studies investigating novelty sweets (Beeley 2005; Davies et al. 2008; Gambon 2009). However, several types of sweet and sour sweets were mentioned as favourites indicating a liking for the combination of sweet and sour in confectionery.

Although the children were not including novelty sweets as a type regularly consumed children were all very familiar with the most commonly available novelty sweets after being presented with them in the focus group discussion.

The focus group discussions highlighted that the children consumed novelty sweets both regularly and frequently. The high frequency of consumption of sugar is one of the most important risk factors in developing dental caries (Burt and Pai 2001; Moynihan and Kelly 2014) and obesity (Malik et al. 2006; Malik and Hu 2012; Te Morenga et al. 2013). The high frequency of consumption and longer exposure of acidic food and drinks is also known to be an important risk factor in developing dental erosion (Al-Majed et al. 2002; Bartlett et al. 2011; Jager et al. 2012; Sovik et al. 2015).

Children mentioned that when they ate the whole package of novelty sweets at once, they reported feeling sick, experiencing a “rush”, “spasm” or toothache. Spasm, for example, may be considered one of the facial expressions reflecting the strength of the taste as reported by Wendin *et al.* (2011) who found that facial reaction towards the basic tastes indicated the high quality and strength of the taste. The lower the strength of the taste made the taste more acceptable. However, in the study of Stewart *et al.* (2013) the knowledge of younger children (9-10 years old) was not as good with regards to health effects of novelty sweets as compared to the older age group participating in this study (11-16 years old).

The results of the focus group work showed that the mixture of sweet and sour tastes found in the novelty sweets was acceptable and enjoyed by the children involved, only two children mentioned that they did not like the sour taste alone. This is similar to the findings of Capaldi and Privitera (2007) who found that one of the child’s taste learning strategies is pairing the least preferred taste with a preferred taste, in this case sour with sweet.

It was also found that children were able to unpair the paired sweet and sour tastes in the novelty sweets and enjoyed only the taste they prefer and ignored the other tastes. This finding suggests that children are able to be selective in appreciating the preferred taste and this is an area for further research (Liem and Mennella 2002; Liem et al. 2004b; Drewnowski et al. 2012).

The focus groups' discussion found that the children preferred the novelty sweets because of the various ways available to consume them (Lollipop, spray, licking etc.). The common feature of all of the varieties of ways of eating the sweets is that they are re-sealable and the children found that re-sealability of novelty sweets was advantageous. This feature of novelty sweets was also reported by Stewart *et al.* (2013).

The re-sealability of the novelty sweets may cause a more frequent and longer duration of exposure of teeth to the acid which is a known a risk factor of enamel dissolution (Zero and Lussi 2005a). It has been also found in *in vitro* studies that the spray type, lollipop and gel forms of novelty sweets have the potential to cause dental erosion (Gambon et al. 2006; Brand et al. 2009; Gambon 2009). Furthermore, it has been found that the frequency of exposure to sugary diet is significantly related to developing dental caries (Anderson et al. 2009).

The results of the focus group work also showed that children believed that novelty sweets sold in spray form were less sweet than the other forms of novelty sweets. This finding is supported by the findings of the sugar content measurements in this study. It was found that novelty sweets which come in spray had the lowest amount of sugar (Tango Candy Spray and Vimto Tango Spray) (Table 19). Although, the sugar content in the novelty sweets sold in spray form was less than the other forms it still contributed around 1/3 of the packet contents (Table 7). The frequent exposure to its sugar and acidic contents in the spry candies still has the potential to cause dental erosion (Davies et al. 2008; Bartlett et al. 2011; Lussi and Carvalho

2015) and dental caries (Burt and Pai 2001; Karjalainen et al. 2001; Anderson et al. 2009; Moynihan and Kelly 2014). It was reported by Gambon *et al*. (2009) and Gambon et al. (2007) that although the sour candies such as Mega Mouth caused increases in the salivary flow, it caused a drop in the oral pH for a considerable time which may cause dental erosion and dental caries. It was found by Spielman (1990) that the increase in salivary flow may cause a high sour taste threshold which in turn may lead to increased consumption of the acidic food.

Children also mentioned in the focus group discussion that the novelty sweets were affordable and the amount of novelty sweets they purchased depends on the pocket money available to them. This finding showed that the major influence of the price and available money in purchasing and consumption of novelty sweets independently. Spending of the pocket money on purchasing novelty sweets is consistent with the finding of Powell and Chaloupka (2009) and Andreyeva *et al.* (2010) who found that price was one of the main factors in selecting healthy or unhealthy foods options such as sweets.

The children also discussed the packaging/pricing aspects of the novelty sweets in terms of how many sherbets in the package or how big the package was in relation to the price. This finding is consistent with findings of John (1999) who found that children's (7 years old and upward) understanding of the market becomes wider and more sophisticated. This finding may be important in relation to the child's purchasing decision which will be in turn be influenced by advertising products to children, particularly television advertising (Marquis et al. 2005; Chamberlain et al. 2006). Furthermore, parent's concept-oriented communication style (discussed in

Section 3.3.2) during shopping plays an important role in making children analytical customers (Caruana 2003).

Children also mentioned in the focus groups that they bought novelty sweets from local shops to school and took them to their homes which indicates the school fringe as a primary source of such types of sweets. They also mentioned that they bought the novelty sweets from city centre shops and supermarkets. This finding strongly supports the methodology used in this study of identifying the most commonly available novelty sweets using scoping visits to stores in the school fringe, city centre and supermarkets. The school fringe as defined by Sinclair and Winkler (2009) as one of the main areas where children can access unhealthy food is also borne out in this study. This finding is supported by the findings of Sinclair and Winkler (2009) and Crawford et al. (2012) who identified high amount of foods with high sugary and caloric contents in the school fringe in London and Scotland respectively.

Children also mentioned in the focus group discussion that they bought novelty sweets from friends at school and share them together. This indicates that consumption of novelty sweets may be considered part of the social interaction between children. This finding is consistent with the findings of other studies which have reported a strong influence of peers and friends on the children's dietary behaviour (Oliver and Thelen 1996; Marshall et al. 2007; Salvy et al. 2012). Furthermore, this finding also showed the use of school as a place of "Black Market" by children. For example, in 2014, it was reported in the UK that one schoolboy had earned more than £14,000 by selling sweets, crisps and fizzy drinks to schoolchildren. He hired two other children in this business and paid them £5.50 each per day (Mirror 2014).

Children also mentioned in the focus groups that parents and grandparents gave them novelty sweets as a “treat”. The exact definition of the treat from the children’s perspective varied but was based on the events and frequency of being given the treats by their parents/grandparents. Novelty sweets being viewed as a “treat” was also identified by Stewart *et al.* (2013) who indicated that although children mentioned that the novelty sweets were consumed as a “treat”, the exact definition of “treat” does not apply to the novelty sweets as they are more readily available to children and regularly consumed. Furthermore, the exact definition of treat seems to be subjective to each child or/and parent perspective which may vary from child or/and parent to another. This may provide an additional source of novelty sweets to the children and may increase their consumption which in turn may put them at a higher risk of experiencing dental erosion (Davies et al. 2008; Bartlett et al. 2011), dental caries (Malik et al. 2006) and obesity (Te Morenga et al. 2013).

Children in the focus groups also confirmed that they had ready access to novelty sweets in local shops, particularly in the sweet aisle and checkout area. This finding nicely mirrors the findings of this study from the scoping study of the shops around school fringe. The wide availability of accessibility of novelty sweets in the shops visited may be linked to the high popularity of these sweets amongst children. It was suggested by Birch *et al.* (2007) that the availability and accessibility of food significantly influences to the children’s food preference.

The ease of availability and accessibility of novelty sweets in shops is likely to result in increased consumption of these sweets (Gambon et al. 2012). They reported that children were extensively exposed to intense marketing of these acidic sweets which were widely available and accessible to children in the market.

Children in this study also mentioned that their parents think that these sweets are bad for their health and tried to limit their consumption. This reflected that parents were aware about the potential effects of novelty sweets on their children's health. However, it was found by Stewart *et al*. (2013) that parents lack the awareness and familiarity with novelty sweets and their potential risk on general and dental health. This may be explained by the difference in the age groups in this study (11-16 years old) and age group in the study of Stewart et al. (2013) (9-10 years old) which may be reflected by the ability of the older age group to discuss these topics.

It was also observed that parents' power was also very limited in restricting children's buying and eating behaviour, children could easily overcome this obstacle of parent's opinions and bought these items secretly and independently. This finding is similar to that reported by Roberts *et al.* (2003) who suggested that the parents' efforts in limiting the child's access to sweets was undermined by the earlier influences in the child's life and pocket money.

This may make parents role in limiting the consumption of these sweets less effective which may result in developing oral diseases and obesity. For example, many authors found there was a direct relationship between parental dietary belief and behaviour, and children experiencing oral diseases (Poutanen et al. 2006; Fisher-Owens et al. 2007; Hooley 2012) and obesity (Bruss et al. 2003; Lindsay et al. 2006).

Responses from the focus groups concerning the target group these sweets were marketed to indicated different opinions regarding age and gender. Some children thought they were aimed at themselves and their peers (11-16 years old), whilst others felt they were aimed at older children. Children also mentioned that both girls and boys could eat novelty sweets, although some types of sweets were thought to be specifically designed for girls or for boys.

Children also thought that novelty sweets were not suitable for children younger than 9 years old because of their strong sour taste. This finding of this study shows the awareness of some children of the possible harm of the novelty sweets. However, the findings of the study of Stewart *et al.* (2013) showed that children lacked the clarity about the possible harm of these sweets on health. Which again may be explained by the children being younger in the study of Stewart *et al.* (2013) (9-10 years old) than the age group included in this study (11-16 years old).

4.3.1.4 Using findings from the focus group discussion to design a questionnaire

Based on the themes identified from the two focus group discussions, a semi-structured questionnaire was designed for the children to complete at the same time as the sweet and sour sensory taste thresholds tests. No further group discussion was required as all themes and subthemes mentioned in the first focus group discussion were repeated in the second focus group discussion, which suggests that the saturation level of data was reached (McLeod et al. 2000; Burnard et al. 2008).

Children participating in the focus groups showed a substantial level of familiarity with novelty sweets, likes, dislikes and various range of frequency of consumption. The children also mentioned the easy accessibility of novelty sweets in local shops near school and home, city centre and supermarkets. Furthermore, children showed a high preference for sweet/sour food and drinks such as sweet and sour chicken, apple and fruit smoothies. Children also mentioned their interest in drinking carbonated and sports drinks.

Children also mentioned their parent’s beliefs about novelty sweets and the parents’ efforts to limit their consumption of novelty sweets. However, the children’s food choices were independent from their parents’ decisions. Furthermore, the children’s available pocket money made the ability to restrict consumption limited.

All the above mentioned elements were included in the questionnaire which was completed by each child participating in the sensory taste thresholds test for sweet and sour to link each element with each child’s consumption behaviour and liking of novelty sweets, gender and age. The questionnaire is presented in Appendix 15.

The following aspects were included in the questionnaire:

- Initials
- Age
- Gender
    - The pictures and the actual packages of the top ten most commonly available novelty sweet to identify If the children bought them or/and somebody else bought them for the child.
    - If the child tried them.
    - If the child Liked/disliked them.
- Frequency of novelty sweet consumption.

- Reasons of like/dislike of novelty sweets which included sweet taste, sour taste, price, way of eating, easy accessibility and toys that came with them.
- If the child liked to eat fresh fruit/juice/smoothies and the child's perception of their taste.
- If the child had tried/liked carbonated drinks/sports drinks and the child's perception of their taste.
- If the child had tried/liked sweet and sour chicken and the child's perception of their taste.

The questionnaire was included in the ethical approval documents submitted to undertake the sensory testing to explore the potential link between the sweet and sour sensory taste thresholds and consumption of the novelty sweets.

4.3.2 Testing sour and sweet absolute and recognition thresholds

Ethical approval was obtained from the Dental School Ethics Committee, Cardiff University (Appendix 16) and Cardiff School of Health Sciences, Cardiff Metropolitan University to undertake the sensory taste threshold testing for sweet and sour in schoolchildren (11-16 years old) (Appendix 17). Two separate sets of different concentrations of sweet and sour solutions as suggested by British Standards (2011) were tasted by children to assess their sensory taste thresholds for sweet and sour and to relate the taste thresholds to their consumption and liking of novelty sweets and to their age and gender.

4.3.2.1 Methodology

Participants were asked to complete a structured questionnaire to determine their liking for, and use of sweet and sour novelty sweets and related food and beverage products. The questionnaire development is outlined above in Section (4.3.1.4). The questionnaire comprised questions to assess sweet and sour food preferences and intakes together with questions specifically related to the sweet and sour sensory testing (Appendix 15).

The sample size for the sensory work was 46 schoolchildren aged 11-16 years old who were recruited from local secondary schools via existing links with the Food Industry Centre, Cardiff Metropolitan University (CMU). Sensory panels were conducted using British Standard approved test rooms at CMU using a well-established basic sensory threshold assessment (British Standards Institute 2011).

4.3.2.1.1 Participants of testing sweet and sour thresholds and questionnaire completion

The study was undertaken at two CMU open days on 02/07/2015 and 13/01/2016. A total of Forty-six children (11-16 years old) participated in this part of the study, 45.7% were males (n=21) and 54.3% were females (n=25). The average age of the participants was 14.14 years.

4.3.2.1.1.1 Inclusion criteria of participants

1- Age: Between 11-16 years old.
2- Gender: Male or Female.
3- Children with no special educational needs (SEN).

4- Children with no allergy or intolerance to any type of food.

5- Non-asthmatic children.

6- Children who can speak and write in English.

7- Child who had an informed consent form signed by parent or guardian.

4.3.2.1.1.2 Exclusion criteria of participants

1- Children with Special Education Needs (SEN); this exclusion criteria was used as there was no trained staff to manage these cases. Children with special educational needs (SEN) are extremely unlikely to attend as Cardiff Metropolitan University uses these open days as a means of recruiting potential future graduates.

2- Children who are younger or older than high schoolchildren; this exclusion criteria was used to link the findings of this part with the consumption of the novelty sweets identified in the school fringe of the selected five high schools in Cardiff (First stage of the present study reported in section (4.2).

3- Non-English speaker; this criteria was used because no Welsh or other language speaker supervisors were available.

8- Children with allergy or intolerance towards any type of food or drinks. Whilst the sweet and sour solutions are known to be safe, a cautious approach by excluding children with food allergies was adopted.

4- Asthmatic children were excluded as inhaler use might affect the taste discrimination ability (Toogood 1990; Dubus et al. 2001; Godara et al. 2011).

5- Children who had no informed consent form signed by parent or guardians were excluded; as obtaining formal consent was required for each participant as a requirement of the ethical approval for this study.

4.3.2.1.1.3 Participant arrangements

4.3.2.1.1.3.1 Obtaining the consent form

The nominated Schools were contacted 4 weeks in advance of the study and a form giving general information about the day for parents (a participant information sheet) (Appendix 18) and parental consent forms (Appendix 19) were distributed via the class teacher for the children to take home. The consent form was designed to allow the parent/guardian to sign giving their formal consent. Children's verbal assent in addition to the obtained parental written consent was also sought on the day, prior to the sensory testing and by their volunteering to complete and return the associated questionnaire.

4.3.2.1.2 Preparation of sweet and sour solutions

Sweet and sour sets of solutions necessary for the taste perception part of the study were set up in conjunction with the CMU technician assigned to the Sensory Analysis Suite.

For each set, one bottle of each concentration stated below was prepared at the Food Industry Centre, CMU the day before the test. Each sample cup was coded for each number from A1 to A13 for the sweet taste and from B1 to B13 for the sour taste (Table 9 and 10). The sweet solution was prepared using granulated sugar (British sugar, UK) while for the sour solution, 100% citric acid (Meridianstar, West Midlands, UK) was used. A two decimal place scale (0.01 mg) was used (DualRange, Mettler-Toledo Ltd, Leicester, UK) (Figure 22). Each concentration of both sweet and sour solutions was dissolved in 1 litre of demineralised water.

Dissolution of the citric acid was enhanced by use of heated water. All these concentrations were maintained at safe levels, so that the sour solutions were no stronger than 0.15% and the sweet solutions were no stronger than 1% (British Standards, 2011). Prior to use all samples were refrigerated. Samples were removed from the refrigerator the morning of the study to allow samples to get to room temperature prior to serving.

Table 8. Concentrations and codes of sweet solutions.

Code	Solution
A1	Water
A2	Water
A3	Water
A4	Water
A5	0.004% (0.04g – 1Ltr)
A6	0.008% (0.08g – 1Ltr)
A7	0.015% (0.15g – 1Ltr)
A8	0.031% (0.31g – 1Ltr)
A9	0.062% (0.62g – 1Ltr)
A10	0.125% (1.25g – 1Ltr)
A11	0.25% (2.5g – 1Ltr)
A12	0.5% (5g – 1Ltr)
A13	1% (10g – 1Ltr)

Table 9. Concentrations and codes of sour solutions.

Code	Solution
B1	Water
B2	0.001% (0.01g – 1Ltr)
B3	0.002% (0.02g – 1Ltr)
B4	0.004% (0.04g – 1Ltr)
B5	0.008% (0.08g – 1Ltr)
B6	0.012% (0.12g – 1Ltr)
B7	0.024% (0.24g – 1Ltr)
B8	0.048% (0.48g – 1Ltr)
B9	0.096% (0.96g – 1Ltr)
B10	0.1% (1g – 1Ltr)
B11	0.11% (1.1g – 1Ltr)
B12	0.12% (1.2g – 1Ltr)
B13	0.15% (1.5g – 1Ltr)

Figure 21. The scale used to prepare the sweet and sour solutions.

4.3.2.1.3 Program of the visit

4.3.2.1.3.1 Introductory session

On the day of the sensory thresholds study, the schoolchildren began with a talk led by CMU staff that set out the organisation of the day and they also explained where the “dental’ part of the day fitted in. No mention of the specific aims of the dental project, particularly its focus on taste thresholds, was made so as not to bias the group in any way. This session was scheduled to be carried out from 9:35-9:50am.

4.3.2.1.3.2 Dental health talk

Following the threshold testing and questionnaire all children were corralled in a separate area and given a simple dental health presentation incorporating fundamental oral hygiene and dietary messages (Appendix 12). The children also received an age specific dental pack contain a child's toothbrush and age appropriate toothpaste at the end of the talk. Whether they had taken part in the sensory testing or not were given a dental pack free of charge provided by GSK (**G**laxo**S**mith**K**line, UK).

This session was scheduled for 10:00-10:15am. Children were supervised by at least two adults at all times.

4.3.2.1.3.3 Data collection session

This part of the day was carried out from 10:20-11:30am.

In the Food Industry Centre, CMU, there were 2 sides to the test room. One side was where the technician provided the previously prepared sets of sweet and sour test solutions while the other side of the room divider was where the children tasted the solutions in BSI standard testing booths (Figure 23-25). Each participant tasted a series of 2x13 solutions each starting with water and becoming sweeter/more acidic up to a known identification threshold (British Standards Institute 2011). Data was captured on the threshold testing capture form (Appendix 20). Then, each participant was asked to complete the semi-structured questionnaire about novelty sweets (Appendix 15).

Figure 22. Preparation side of the sensory testing room.

Figure 23. Presentation format of thirteen coded solutions, water cup, spit cup and tissue provided for each participant.

Figure 24. Testing booths used by participants.

4.3.2.1.3.4 Debriefing

At the end of the day the children were given a formal debrief letter to allow receipt of a copy of the summary of findings once prepared (Appendix 21).

4.3.2.1.4 Data handling

SPSS v20 (IBM Corporation, Chicago, USA) was used to analyse the data generated from the questionnaire element of the study. The analysis was descriptive in nature incorporating frequency distributions and cross tabulations. Chi-square test was also used with statistical significance set at $p<0.05$ (Field 2013). The analysis was conducted to examine differences between gender, age and ability to taste thresholds against frequency of consumption of novelty sweets and sweet and sour tastes preference. A Sign binomial test was used to examine the significance set at $p<0.05$ between children who correctly and incorrectly perceived the sensory taste thresholds (Field 2013).

Data was entered directly to the Cardiff University drive which was password protected. No individual participant was identifiable at the end of the study**.**

Analysis of sensory data focused upon the correlation between sweet and sour threshold and reported sweet and sour food and beverage intake as outlined below.

The average normal level of absolute and recognition thresholds for sweet and sour solutions in children in the UK are shown in below table (Table 11) (British Standards Institute 2011). The absolute threshold is the level at which an individual perceives a difference between the water and the next solution but the taste is not identified. While the recognition threshold is the level at which the individual perceives and recognises the taste of the solutions (Liem and Mennella 2003; Popper and Kroll 2003; Liem et al. 2004a).

Table 10. Average normal absolute and recognition sweet and sour thresholds in children.

Thresholds	Sweet solutions	Sour solutions
Absolute threshold	**A5** (0.004% of sugar)	**B2** (0.001% of citric acid)
Recognition threshold	**A12** (0.5 % of sugar)	**B7** (0.024% of citric acid)

4.3.2.2 Results of sensory testing and questionnaire

The results of the sensory taste threshold testing and questionnaire showed various levels of ability to recognise the absolute and recognition thresholds for both sweet and sour amongst the children. This ability was analysed in relation to the children's age, gender, frequency of novelty sweets consumption and liking of the sweet and sour tastes of novelty sweets.

There were significantly fewer children able to perceive the absolute thresholds of sweet (30%), sour (15%) and both (7%), than those that could not. More children were able to perceive the recognition thresholds of sweet (65%), sour (65%) and both (48%). The older age group of children (14-16) years old were significantly better in perceiving the sweet absolute thresholds (67%) in comparison to the younger age group (11-13 years old) (7%) ($p<0.05$). Furthermore, children were better in perceiving the sour precognition threshold but did not reach the statistically significant level ($p=0.055$). Older children were also better in perceiving the sweet recognition threshold and sour absolute thresholds but was non-statistically significantly better ($p>0.05$). Female children were also better in perceiving the vast majority of the taste thresholds but they were not statistically significantly better ($p>0.05$). There were no significant associations between the perception of the taste thresholds for sweet and sour in children and frequency of novelty sweets consumption ($p>0.05$) except for the perception of sour recognition threshold ($p<0.05$).

Children who liked novelty sweets because of the sweet and sour taste were significantly less able to recognise the sweet absolute threshold (30%) ($p=0.015$), but non-significantly better in perceiving the sweet recognition threshold (63.2%)

(p=0.243). There was only one child (male) who stated that he did not like the novelty sweets because of the sweet and he correctly perceived the sweet sensory thresholds.

Furthermore, Children who liked novelty sweets because of the sour taste were significantly less able to perceive the absolute sour threshold (18.4%) (p=0.009), but better in perceiving the sour recognition threshold (68.4%) (p>0.05), than those who stated they disliked novelty sweets. There were 14 children who stated that they did not like the novelty sweets because of the sour taste (12 (85.7%) of them correctly perceived the sweet absolute threshold and 11 (78.6%) correctly perceived the sour recognition threshold).

4.3.2.2.1 Perception of absolute and recognition thresholds

4.3.2.2.1.1 Perception of absolute thresholds

Fourteen (30%) children correctly perceived the sweet absolute threshold, 7 (15%) correctly perceived the sour absolute threshold, only 3 (7%) children correctly perceived both the sweet and sour absolute thresholds and 28 (60%) did not correctly perceive both the absolute thresholds. There was a statistically significant difference between the number of children who correctly perceived the absolute threshold and those who did not (p<0.05) (Figure 26). There were 15 (33%) children who correctly perceived the absolute threshold of one taste but not the other.

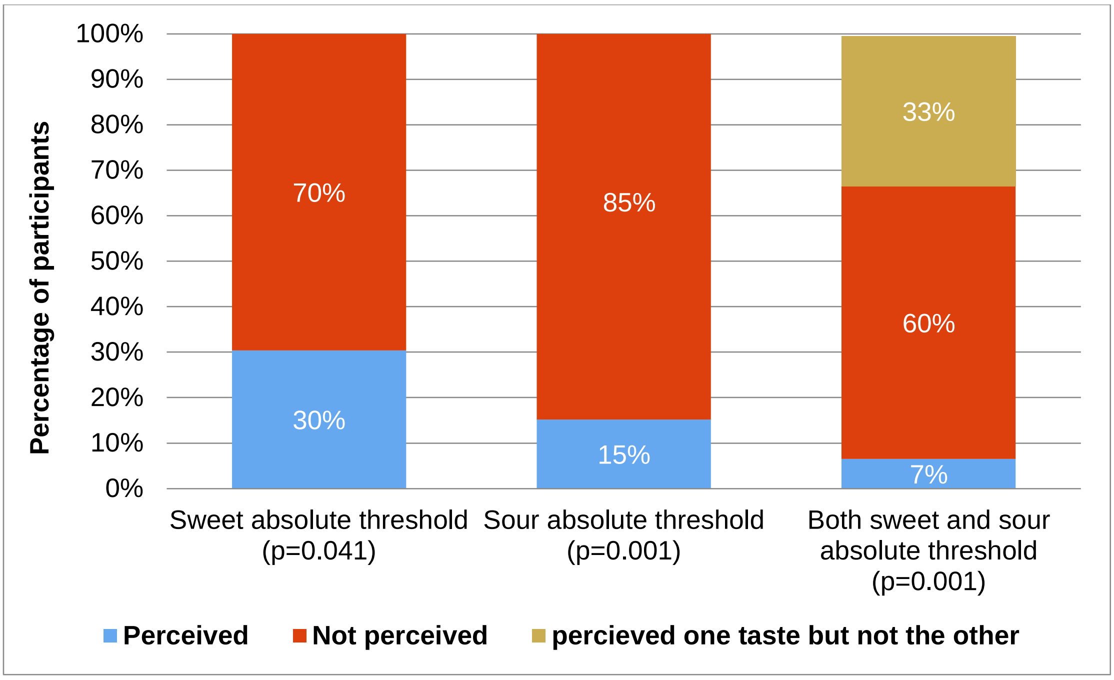


Figure 25. Children who perceived and did not perceive sweet, sour and both sweet and sour absolute thresholds.

4.3.2.2.1.2 Perception of recognition thresholds

Thirty (65%) children correctly perceived the sweet recognition threshold, 30 (65%) perceived the sour recognition threshold, 22 (48%) children correctly perceived both the sweet and sour recognition thresholds and 8 (17%) could not correctly perceive both recognition thresholds. There was no statistically significant difference between the number of children who correctly perceived the sweet or sour thresholds and those who did not ($p>0.05$) However, there was statistically significant difference between the number of children who perceived both recognition thresholds and those children who did not ($p<0.05$) (Figure 27). There were 16 (35%) children who correctly perceived the recognition threshold of one taste but not the other.

There was a statistically significant difference between children who correctly perceived the sweet absolute threshold (30.4%) and who correctly perceived the sweet recognition threshold (65%) (p=0.024). Furthermore, there was a statistically significant difference between children who correctly perceived the sour absolute threshold (15.2%) and who correctly perceived the sour recognition threshold (65%) (p=0.001).

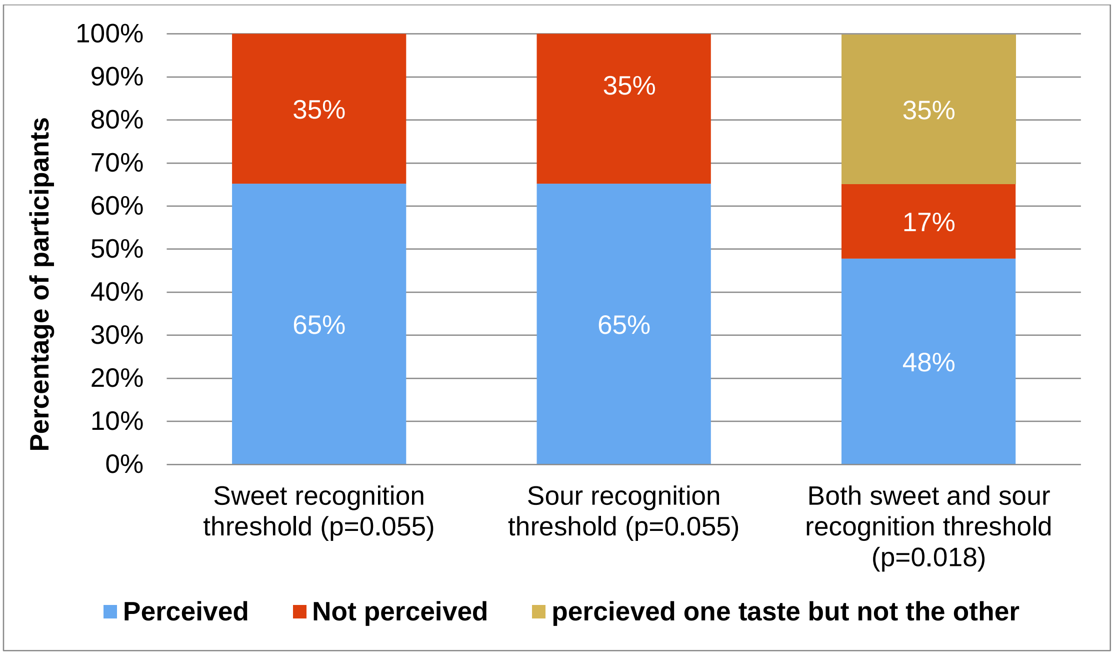


Figure 26. Children who perceived and did not perceive sweet, sour and both sweet and sour recognition thresholds.

4.3.2.2.2 Comparison of taste thresholds' perception and age

4.3.2.2.2.1 Comparison of sweet absolute threshold's perception and age

Twenty-six (60%) children were 11-13 years old and 18 (40%) were 14-16 years old participated in this part of the study. Older children were significantly more able to identify sweet tastes at the absolute threshold than younger children. Only 2 (7%) of the 11-13 years old children correctly perceived the absolute sweet threshold, whilst 24 (93%) did not. Twelve (67%) of the 14-16 year olds correctly perceived the sweet absolute threshold, whilst 6 (33%) did not (Figure 28). The results showed a statistical significant association between the age and perception of the sweet absolute threshold (χ^2 18.33, df=1, p=0.001).

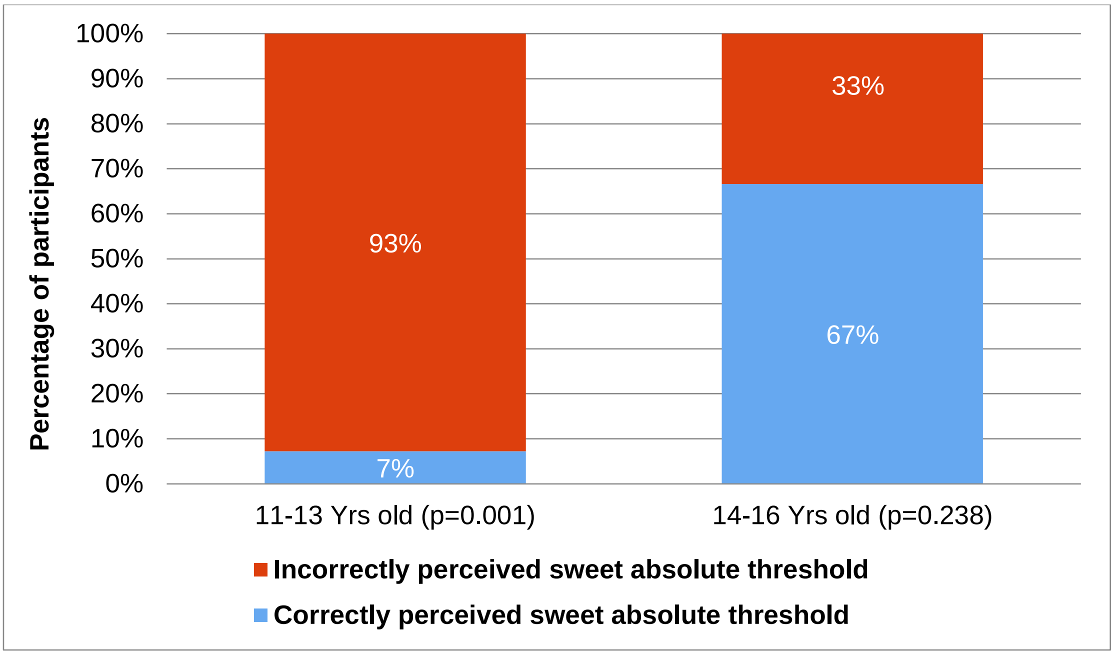


Figure 27. Comparison of sweet absolute threshold's perception by age.

4.3.2.2.2.2 Comparison of sweet recognition threshold's perception and age

Seventeen (60%) of the 11-13 years old children correctly perceived the sweet recognition threshold, whilst 11 (40%) did not. Thirteen (72%) of the 14-16 years old children correctly perceived the sweet recognition threshold, whilst only 5 (28%) did not. The results showed no statistical significant association between the age perception of the sweet recognition threshold (χ^2 0.64, df=1, p=0.424) (Figure 29).

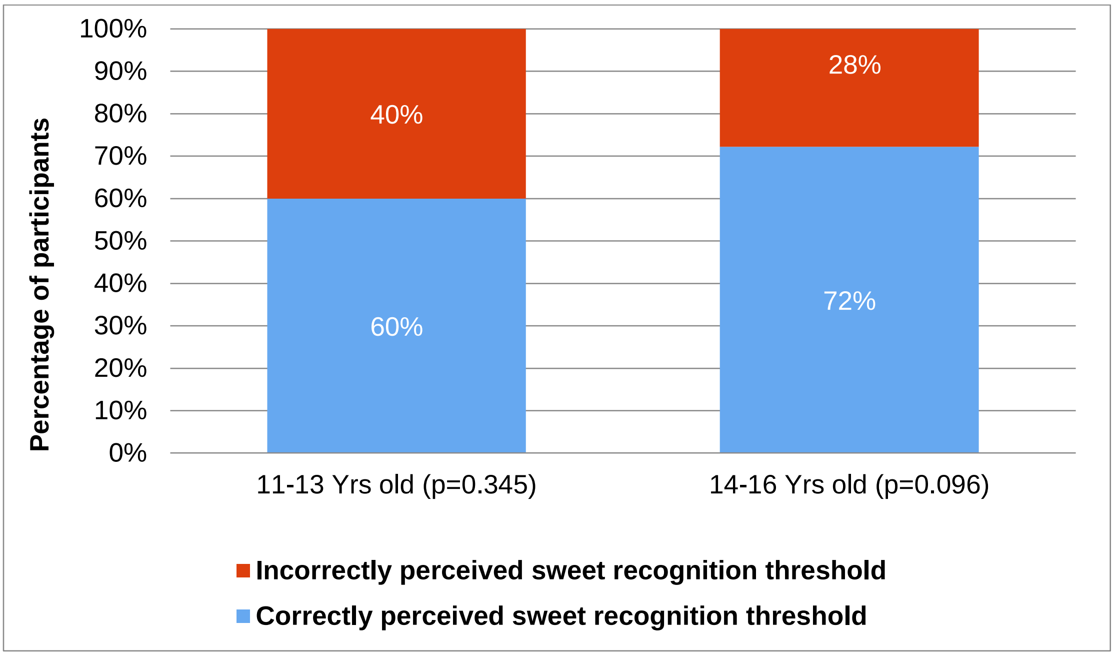


Figure 28. Comparison of sweet recognition threshold's perception and age.

4.3.2.2.2.3 Comparison of sour absolute threshold's perception and age

Only 4 (14%) of the 11-13 years old children correctly perceived the sour absolute threshold, whilst 24 (86%) did not. Only 3 (17%) of the 14-16 years old children correctly perceived the sour absolute threshold, whilst 15 (83%) did not. The results showed no statistically significant association between the age and perception of the sour absolute threshold (χ^2 0.048, df=1, p=0.826) (Figure 30).

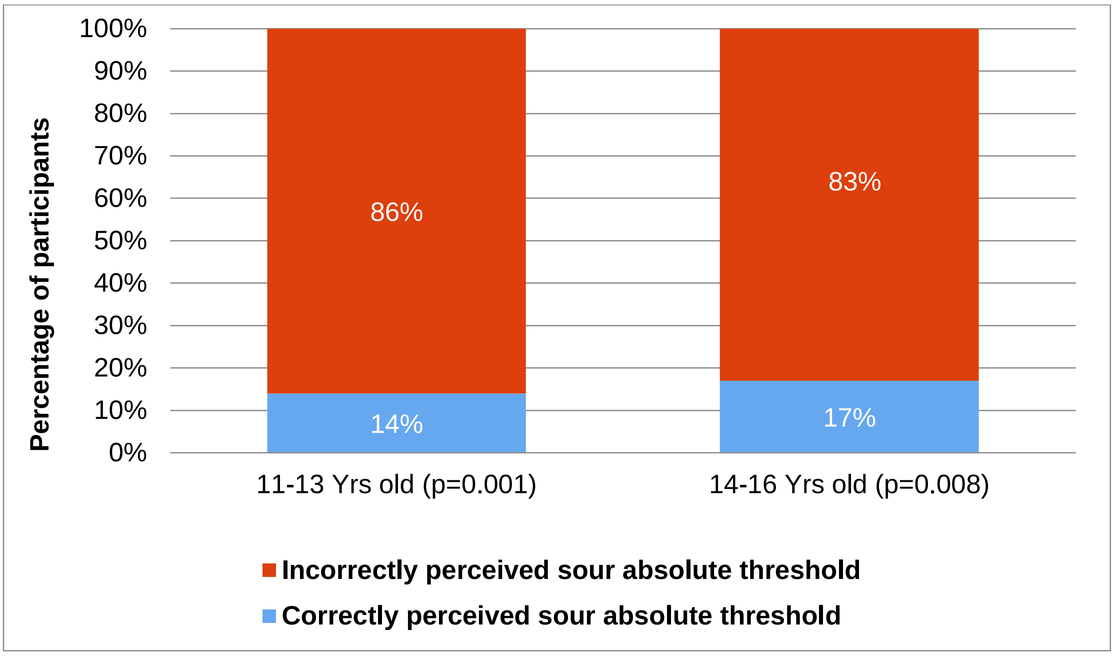


Figure 29. Comparison of sour absolute threshold's perception and age.

4.3.2.2.2.4 Comparison of sour recognition threshold's perception and age

Seventeen (60%) of the 11-13 years old children correctly perceived the sour recognition threshold, whilst 11 (40%) did not. Thirteen (72%) of the 14-16 years old children correctly perceived the sour recognition threshold, whilst only 5 (27%) did not. There was no statistically significant association between the age and perception of sour recognition threshold (χ^2 0.64, df=1, p=0.424) (Figure 31).

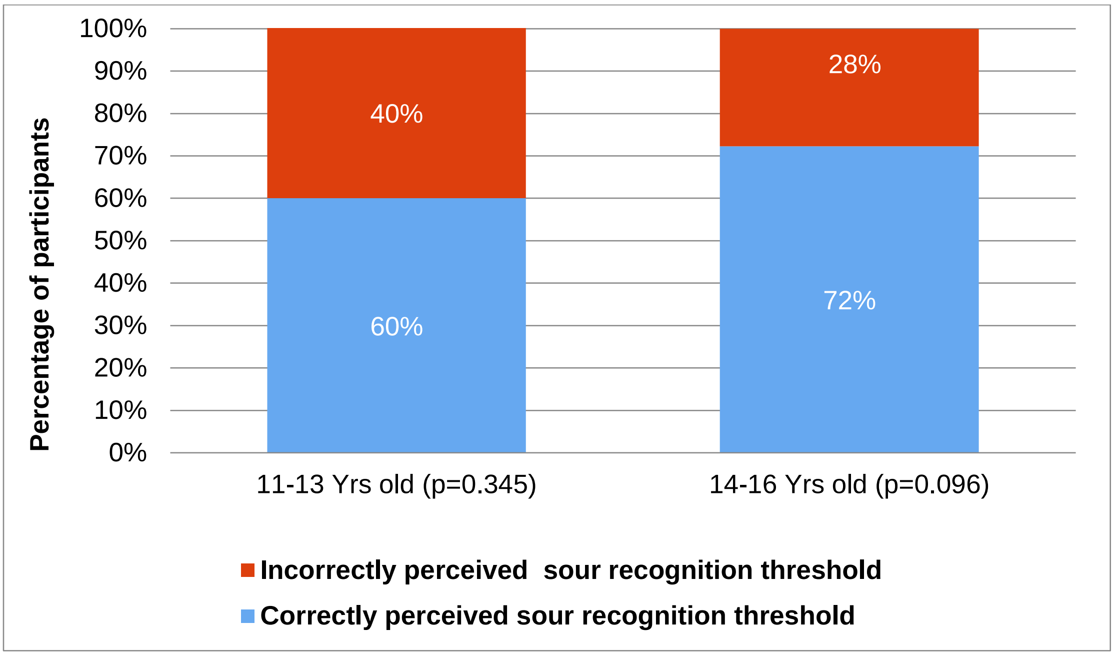


Figure 30. Comparison of sour recognition threshold's perception and age.

4.3.2.2.3 Comparison of taste thresholds' perception and gender

4.3.2.2.3.1 Comparison of sweet absolute threshold's perception and gender

Only 9 (36%) of the females correctly perceived the sweet absolute threshold, compared with 5 (24%) of the males. Sixteen (64%) of the female and sixteen (76%) of the male children incorrectly perceived the sweet absolute threshold. The results showed no statistically significant association between gender and perception of the sweet absolute threshold (χ^2 0.801, df=1, p=0.371). The percentages of male and female children within the children who correctly and incorrectly perceived the sweet absolute threshold are presented below in Figure 32.

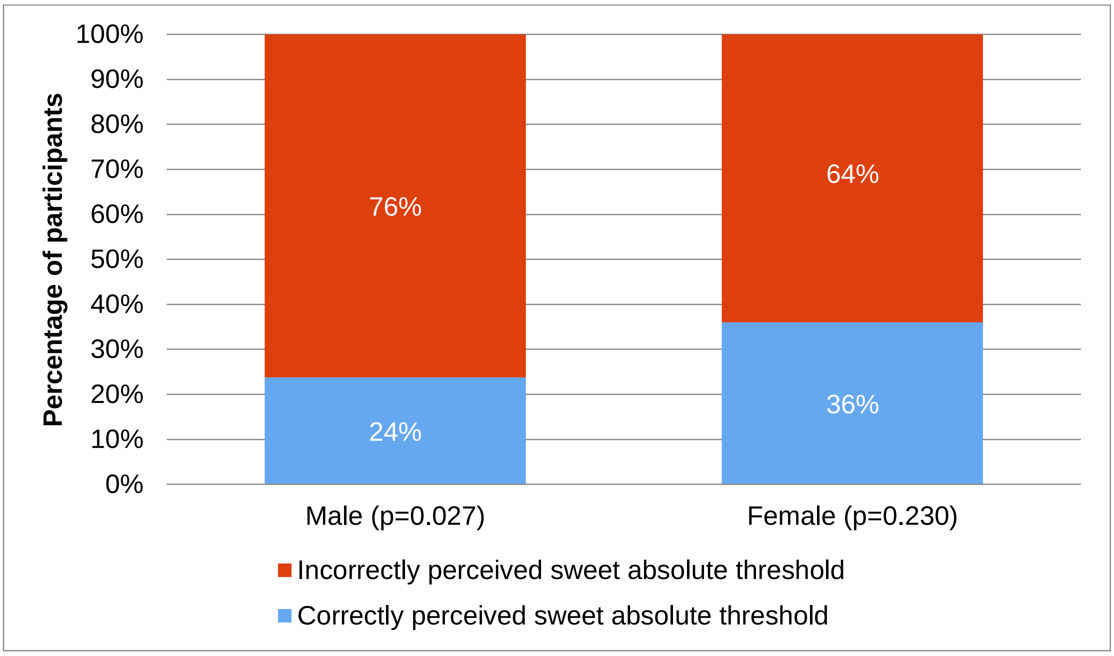


Figure 31. Comparison of sweet absolute threshold's perception and gender.

4.3.2.2.3.2 Comparison of sweet recognition threshold's perception and gender

Nineteen (76%) of the females correctly perceived the sweet recognition threshold, whilst only 11 (52%) of the males did. Six (24%) females and 10 (48%) males incorrectly perceived the sweet recognition threshold. The results showed no statistically significant association between gender and the perception of sweet recognition threshold (χ^2 2.8, df=1, p=0.094). The percentages of male and female children amongst the children who correctly and incorrectly perceived the sweet recognition threshold are presented below in Figure 33.

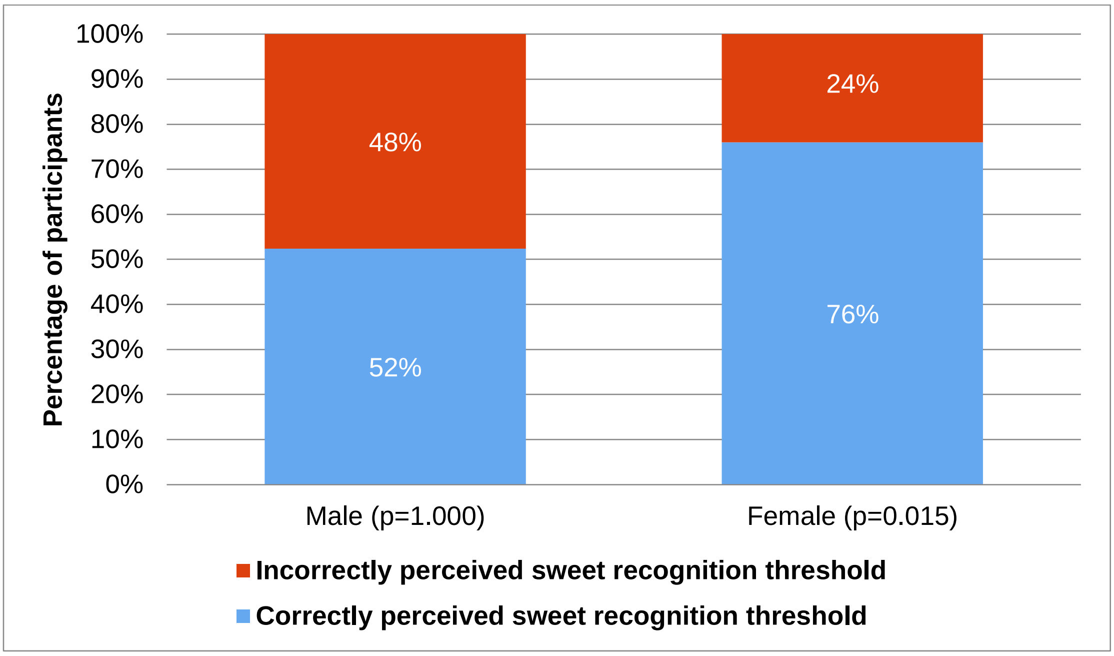


Figure 32. Comparison of sweet recognition threshold's perception and gender.

4.3.2.2.3.3 Comparison of sour absolute threshold's perception and gender

Only 4 (16%) of the female children correctly perceived the sour absolute threshold, whilst only 3 (14%) of the male children did. Twenty-one (84%) female children incorrectly perceived the sour absolute threshold, whilst 18 (86%) of the male children did. The results showed no statistically significant association between the gender and perception of the sour absolute threshold (χ^2 0.026, df=1, p=0.872). The percentages of male and female children within the children who correctly and incorrectly perceived the sour absolute threshold are presented below in Figure 34.

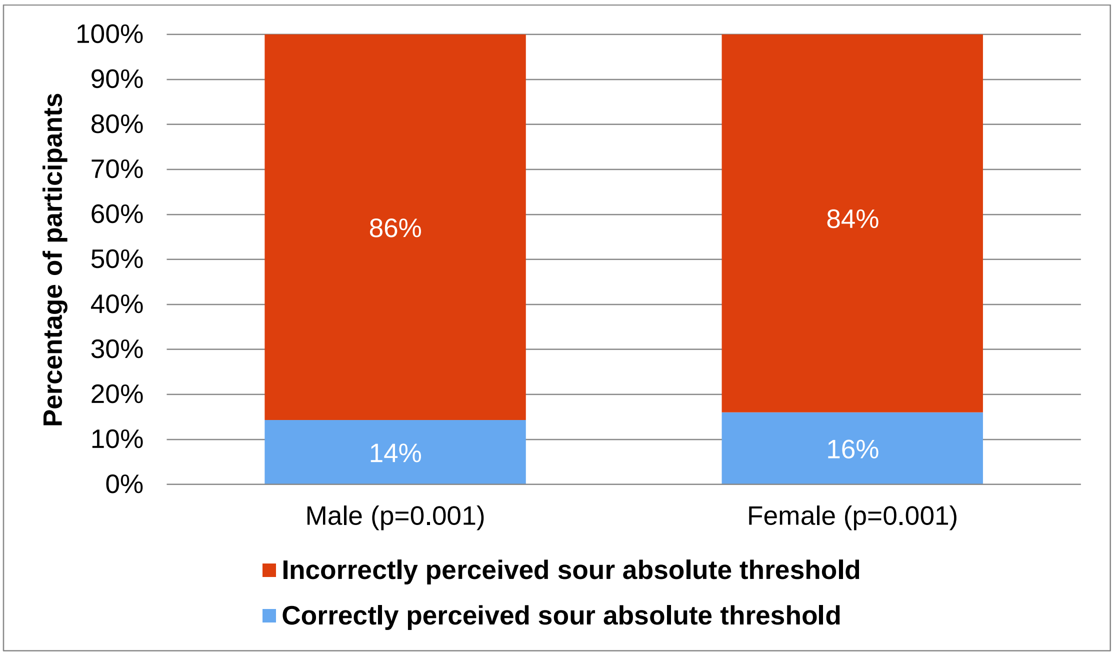


Figure 33. Comparison of sour absolute threshold's perception and gender.

4.3.2.2.3.4 Comparison of sour recognition threshold's perception and gender

Fourteen (67%) of the male children correctly perceived the sour recognition threshold, whilst only 7 (33%) of the male children did not. Sixteen (64%) female children correctly perceived the sour recognition threshold, whilst 9 (36%) of the female children did not. The results showed no statistical significant association between the gender and perception of the sour recognition threshold (χ^2 0.036, df=1, p=0.850) (Figure 35).

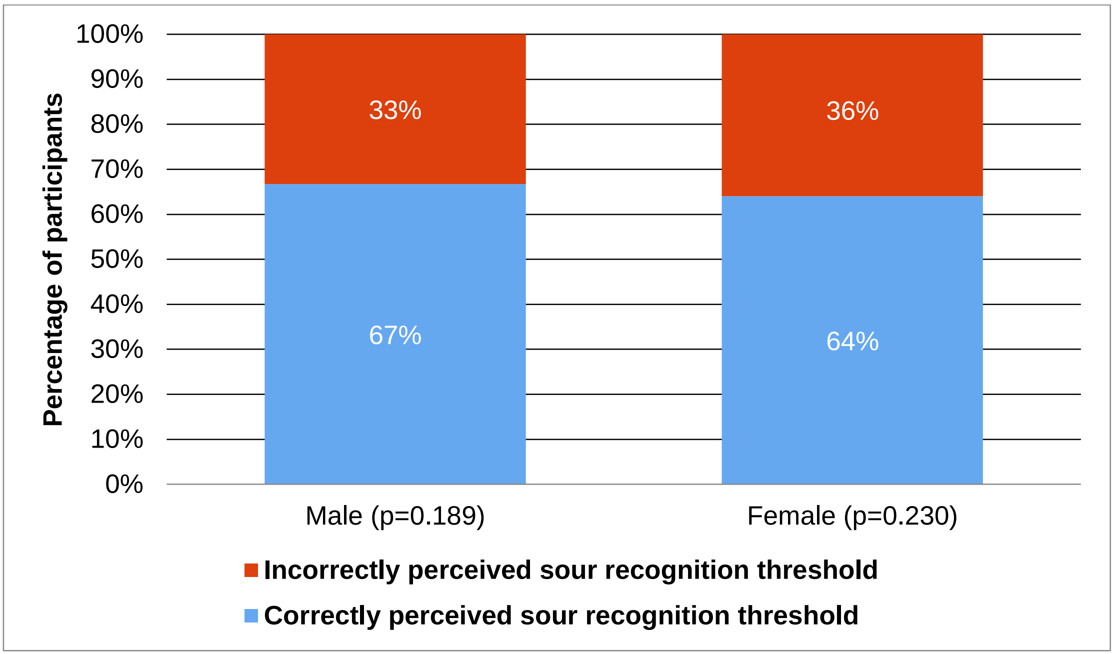


Figure 34. Comparison of sour recognition threshold and gender.

4.3.2.2.4 Comparison of liking of novelty sweets and gender

Thirty-eight (82.6%) children stated that they liked novelty sweets because of the sweet taste. Whilst 29 (63%) children stated that they liked the novelty sweets because of the sour taste. Twenty-five (54.3%) children stated that they liked novelty sweets because of both the sweet and sour tastes. Whilst only one (2.2%) child stated that they did not like novelty sweets because of both the sweet and sour tastes. Seven children (15.2%) did not answer the question on whether they liked novelty sweets due to sweet or sour.

4.3.2.2.4.1 Comparison of liking of novelty sweets due to the sweet taste and gender

Twenty-one (84%) female children stated that they liked novelty sweets because of the sweet taste while 17 (81%) male children did. It is important to note that seven children did not answer the question on liking of novelty sweets because of the sweet taste in the questionnaire. The results showed no statistical significant association between gender and liking of novelty sweets because of the sweet taste (χ^2 1.225, df=2, p=0.542) (Figure 36).

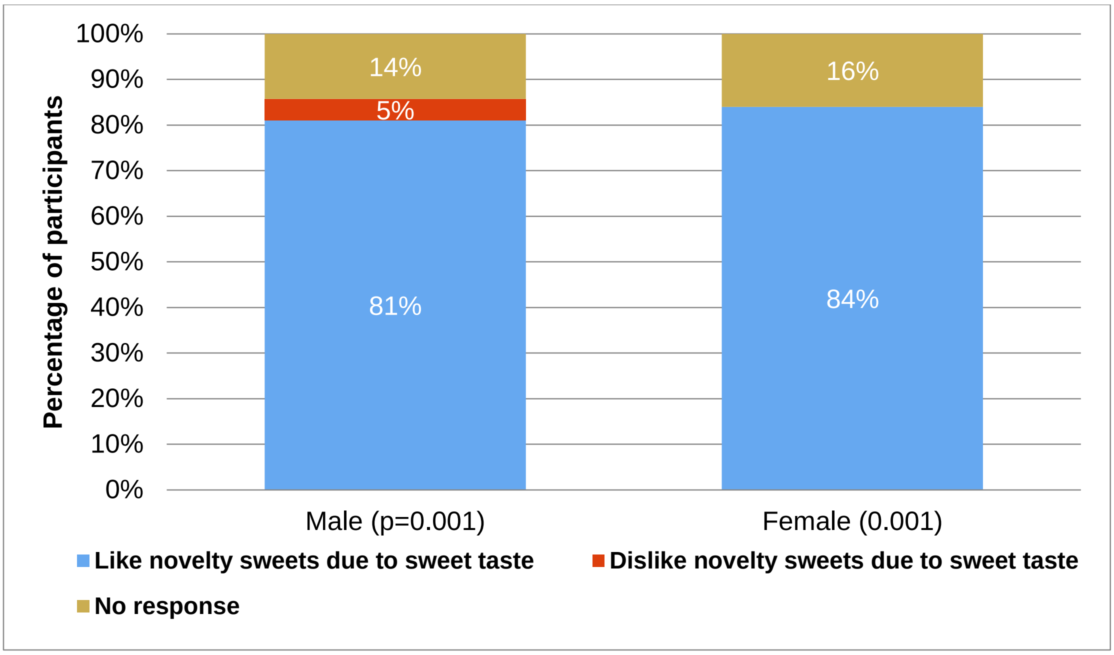


Figure 35. Comparison of liking novelty sweets due to the sweet taste and gender. *7 children did not respond to the question on liking novelty sweets due to sweet taste in the questionnaire.*

4.3.2.2.4.2 Comparison of liking of novelty sweets due to the sour taste and gender

Sixteen (56%) females stated that they liked novelty sweets because of the sour taste compared with 15 (71%) males. It is important to note that three children did not answer the question on liking of novelty sweets because of the sour taste in the questionnaire. The results showed no statistically significant difference between gender and liking the novelty sweets because of the sour taste (χ^2 1.172, df=2, p=0.557) (Figure 37).

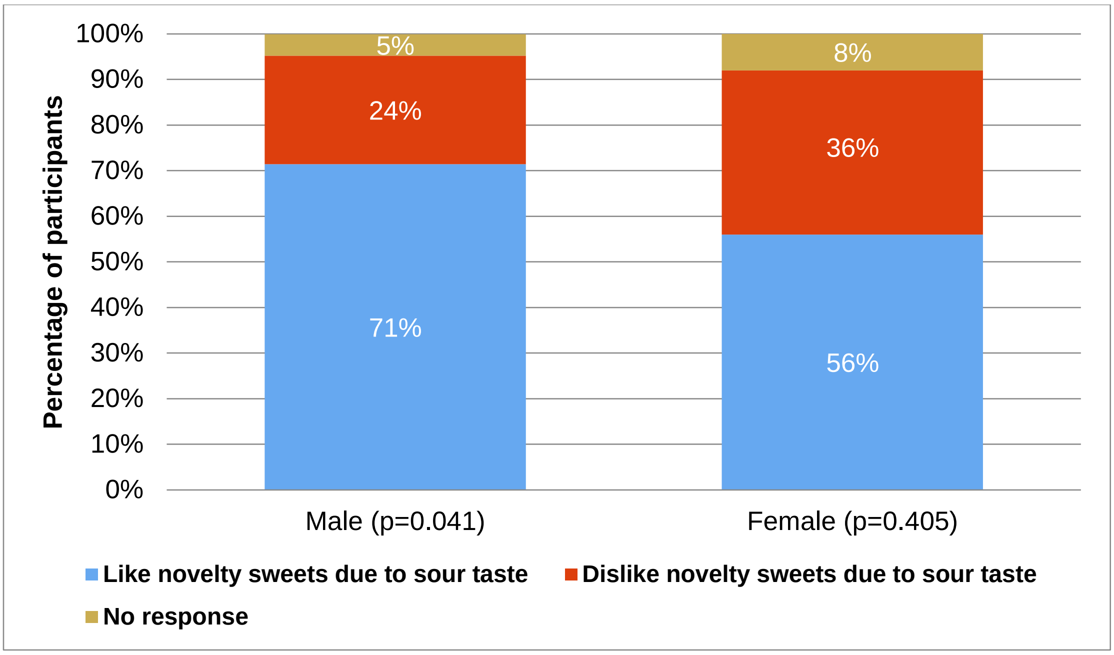


Figure 36. Comparison of liking novelty sweets due to the sour taste and gender. *3 children did not respond to the question on liking novelty sweets due to sour taste in the questionnaire.*

4.3.2.2.5 Comparison of taste thresholds' perception and frequency of novelty sweets' consumption

4.3.2.2.5.1 Comparison of sweet absolute threshold's perception and frequency of consumption

Twenty (43.5%) children stated that they consume the novelty sweets less than once per month; 4 (20%) of these correctly perceived the sweet absolute threshold, the remaining 16 (80%) did not (statistically significantly different, p=0.012). Twenty-one (45.5%) children stated that they consume the novelty sweets on a weekly and daily basis; 9 (43%) of these correctly perceived the sweet absolute threshold, the remaining 12 (57%) did not (no statistically significant association, p=0.664). Five (11%) children stated that they had never eaten novelty sweets. Only one (20%) of these children correctly perceived the sweet absolute threshold and 4 (80%) did not. The results showed no statistically significant association between the frequency of novelty sweets' consumption and perception of the sweet absolute threshold (χ^2 2.8, df=1, p=0.245). The percentages of children who consumed novelty sweets "less than once per month", "weekly or daily" or "never" within the children who correctly and incorrectly perceived the sweet absolute threshold are presented below in Figure 38.

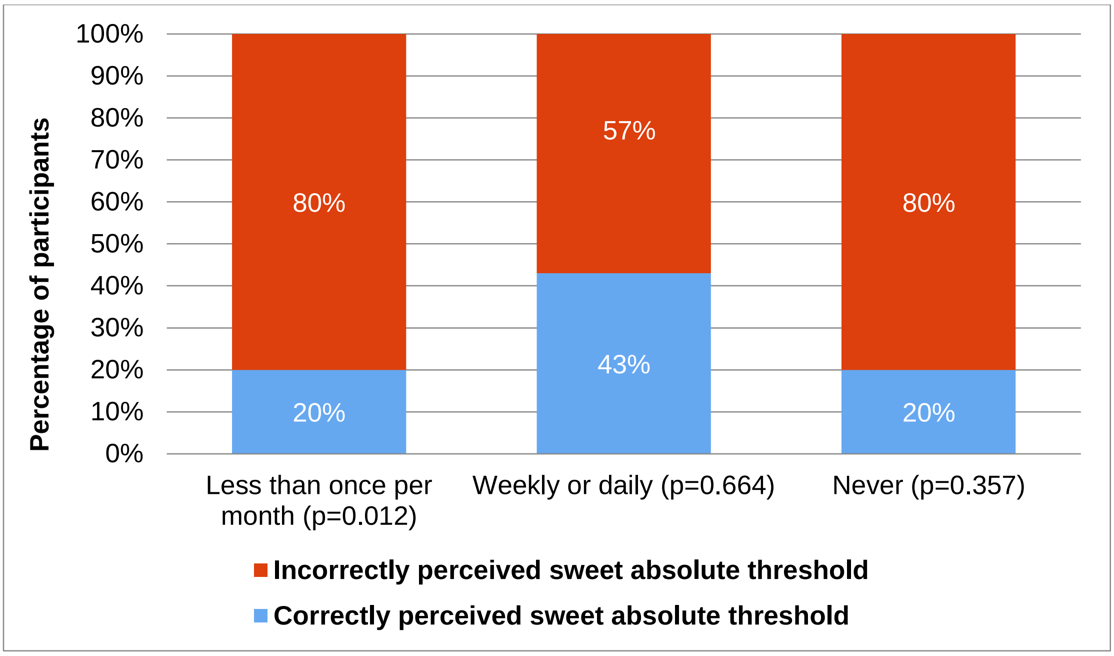


Figure 37. Comparison of sweet absolute threshold's perception and frequency of consumption.

4.3.2.2.5.2 Comparison of sweet recognition threshold's perception and frequency of consumption

Of the 20 (43.5%) children who reported consuming novelty sweets less than once per month, 15 (75%) correctly perceived the sweet recognition threshold, whilst 5 (25%) did not (statistically significantly different, p=0.041). Of the 21 (45.5%) children who reported consuming novelty sweets weekly or daily, 12 (57%) correctly perceived the sweet recognition threshold, whilst 9 (43%) did not (was not statistically significantly different, p=0.664). Of the 5 (11%) children who stated that they have never eaten novelty sweets, 3 (60%) correctly perceived the sweet recognition threshold and 2 (40%) did not. The results showed no statistically significant association between the different frequency groups of novelty sweets' consumption and perception of the sweet recognition threshold (χ^2 1.5, df=2, p=0.471). The percentages of children who consumed novelty sweets "less than once per month", "weekly or daily" or "never" within the children who correctly and incorrectly perceived the sweet recognition threshold are presented below in Figure 39.

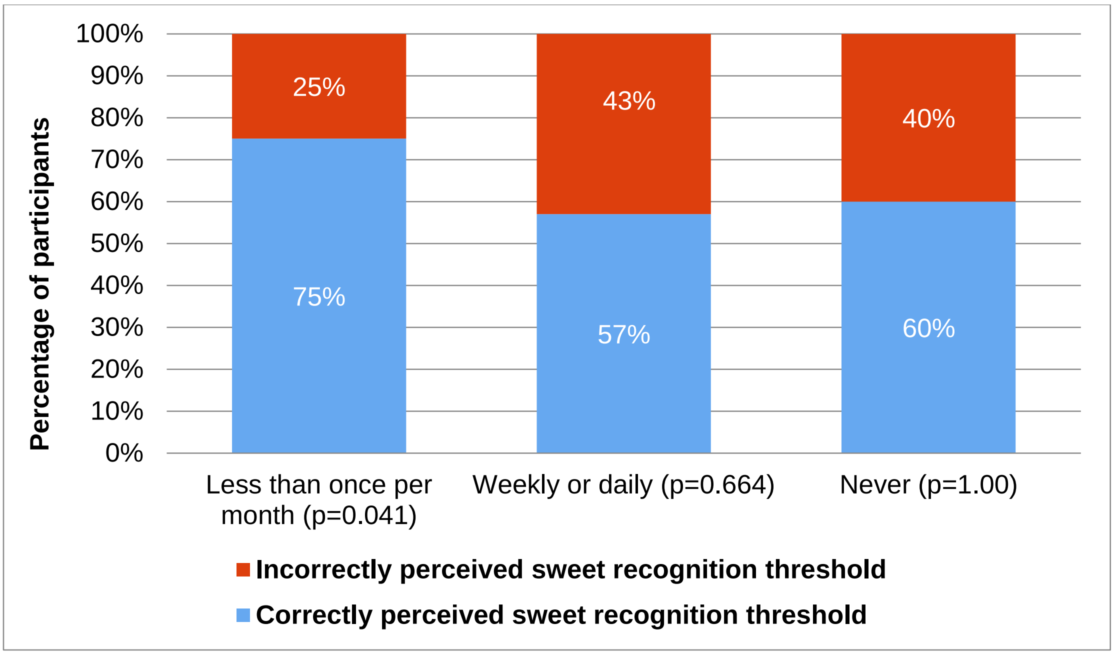


Figure 38. Comparison of sweet recognition threshold's perception and frequency of consumption.

4.3.2.2.5.3 Comparison of sour absolute threshold's perception and frequency of consumption

Of the 20 (43.5%) children who reported consuming novelty sweets less than once per month, only 4 (20%) correctly perceived the sour absolute threshold, whilst 16 (80%) did not (statistically significant association, p=0.012). Of the 21 (45.5%) children who reported consuming novelty sweets weekly or daily, 2 (10%) correctly perceived the sour absolute threshold, whilst 19 (90%) did not (statistically significant association, p=0.001). Of the 5 (11%) children who stated that they have never eaten novelty sweets, only one (20%) correctly perceived the sour absolute threshold and 4 (80%) did not. The results of perception of sour absolute threshold between groups, showed no statistically significant association between the frequency of novelty sweets' consumption and perception of the sour absolute threshold (χ^2 0.971, df=2, p=0.615). The percentages of children who consumed novelty sweets "less than once per month", "weekly or daily" or "never" within the children who correctly and incorrectly perceived the sour absolute threshold are presented below in Figure 40.

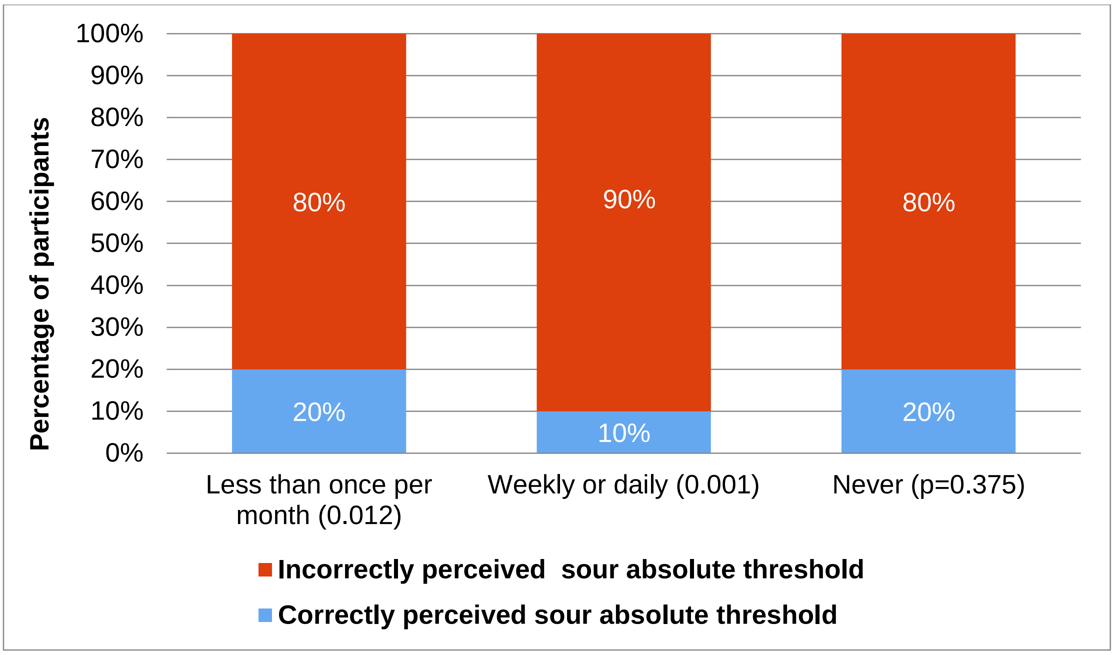


Figure 39. Comparison of sour absolute threshold's perception and frequency of consumption.

4.3.2.2.5.4 Sour recognition threshold's perception and frequency of consumption

Of the 20 (43.5%) children who reported consuming novelty sweets less than once per month, 9 (45%) correctly perceived the sour recognition threshold, and 11 (55%) did not (was not statistically significantly different, p=0.201). Of the 21

(45.5%) children who reported consuming novelty sweets weekly or daily, 17 (80%) correctly perceived the sour absolute threshold, whilst only 4 (20%) did not (statistically significantly different, p=0.007). Of the 5 (11%) children who stated that they have never eaten novelty sweets, 1 (20%) correctly perceived the sour recognition threshold and 4 (80%) did not. The results showed a statistically significant association between the frequency groups of novelty sweets' consumption and perception of the sour recognition threshold (χ^2 6.3, df=2, p=0.041). The percentages of children who consumed novelty sweets "less than once per month", "weekly or daily" or "never" within the children who correctly and incorrectly perceived the sour recognition threshold are presented below in Figure 41.

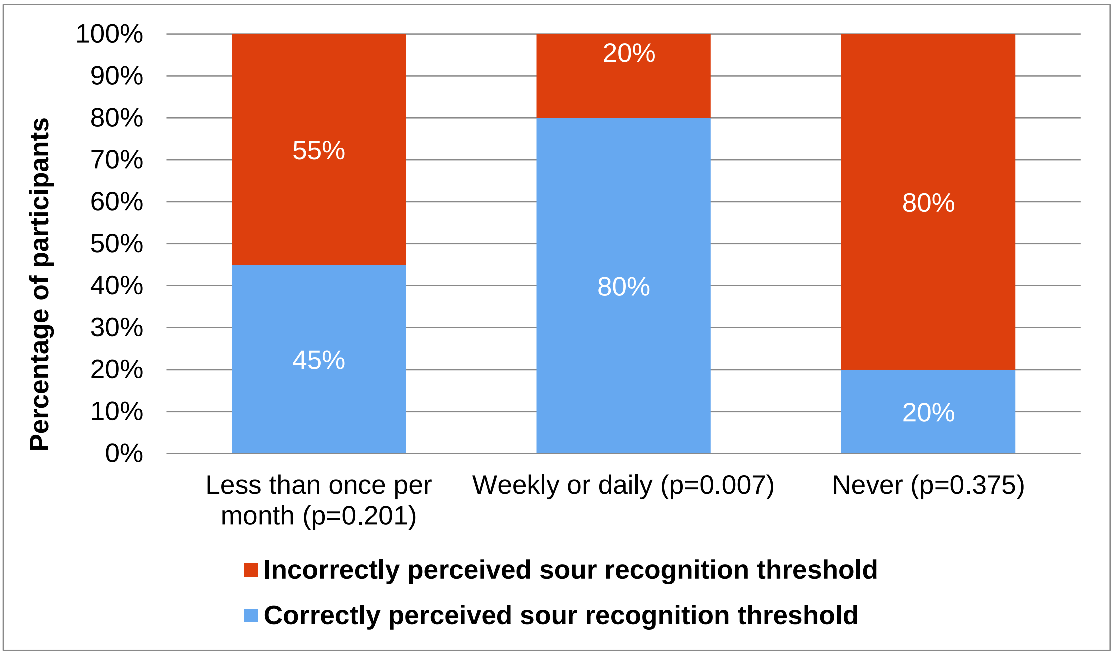


Figure 40. Comparison of sour recognition threshold's perception and frequency of consumption of novelty sweets.

4.3.2.2.6 Comparison of taste thresholds' perception and liking novelty sweets

Thirty-eight (82.6%) children stated that they liked novelty sweets for at least one of the reasons provided (Figure 66). One female child mentioned in the "other reasons for like or dislike" section that she disliked novelty sweets because of the strong taste. The percentages of children who liked or disliked novelty sweets and did not respond to this question are presented in Figure 42.

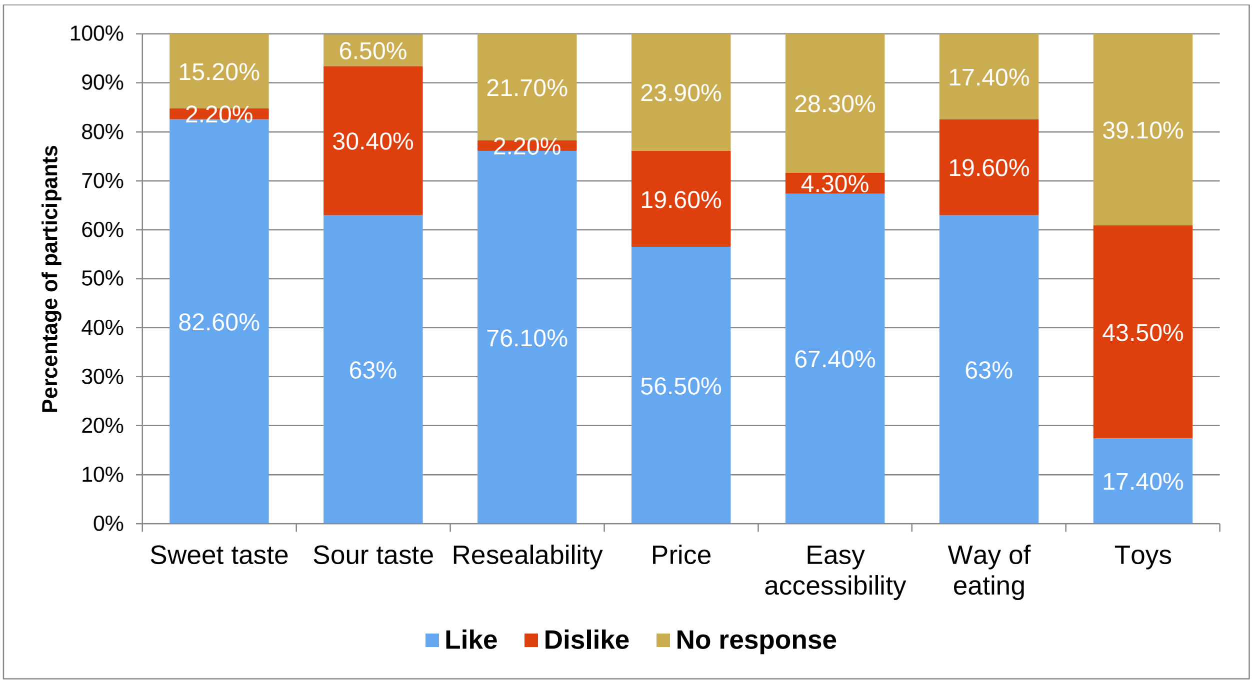


Figure 41. Reasons given for liking/disliking novelty sweets by participating children n= 46.

The results showed that the vast majority of children liked novelty sweets because of the sweet taste (82.6%), re-sealability (76%), accessibility (67.4%), sour taste (63%) and way of eating (63%). More than half of the children (56.5%) liked novelty sweets because of their prices and only 19.6% did not like the novelty sweets because of their price. Toys incorporated into the sweets are clearly not important in this age group with only 17.4% of them liking novelty sweets because of the toys.

4.3.2.2.6.1 Comparison of sweet absolute threshold's perception and liking novelty sweets due to sweet taste

Thirty-eight (82.6%) children stated that they liked novelty sweets because of the sweet taste. Out of the 38 who reported liking the sweet because of the sweet taste, there were statistically significantly less children who correctly perceived the absolute sweet threshold (n=11 (30%)) than who did not (n=27 (70%)) ($p<0.015$). Only one (3%) child indicated that they did not like novelty sweets because of the sweet taste, they also correctly perceived the sweet absolute threshold. It is important to note that 7 (15%) children did not answer the question on whether they liked novelty sweets in the questionnaire. The percentages of children who liked and disliked novelty sweets due to their sweet taste against the children who correctly (30%) and incorrectly (70%) perceived the sweet absolute threshold are presented below in Figure 43.

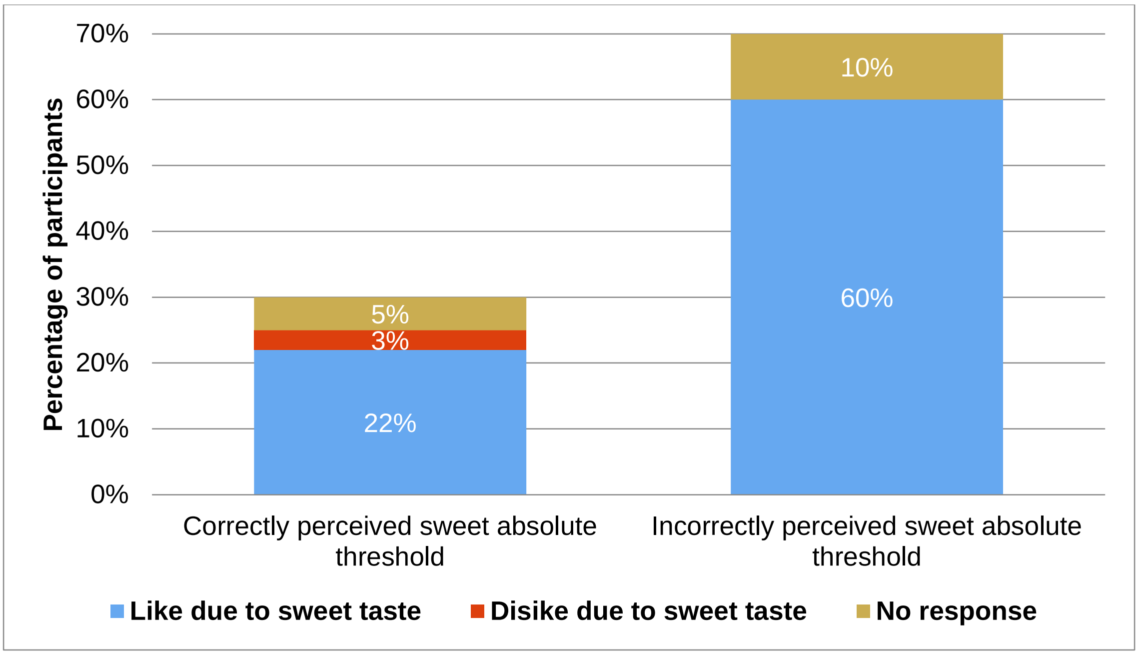


Figure 42. Comparison of sweet absolute threshold's perception and liking novelty sweets due to the sweet taste. *Seven children did not respond to the question on liking novelty sweets in the questionnaire*.

4.3.2.2.6.2 Comparison of sweet recognition threshold's perception and liking of novelty sweets due to the sweet taste

Of the 38 (82.6%) children who reported liking novelty sweets because of their sweet taste, 24 (63.2%) correctly perceived the sweet recognition threshold, whilst 14 (36.8%) did not (no significant difference (p=0.243)). The percentages of children who liked and disliked novelty sweets due to sweet taste against the children who correctly (65%) and incorrectly (35%) perceived the sweet recognition threshold are presented below in Figure 44.

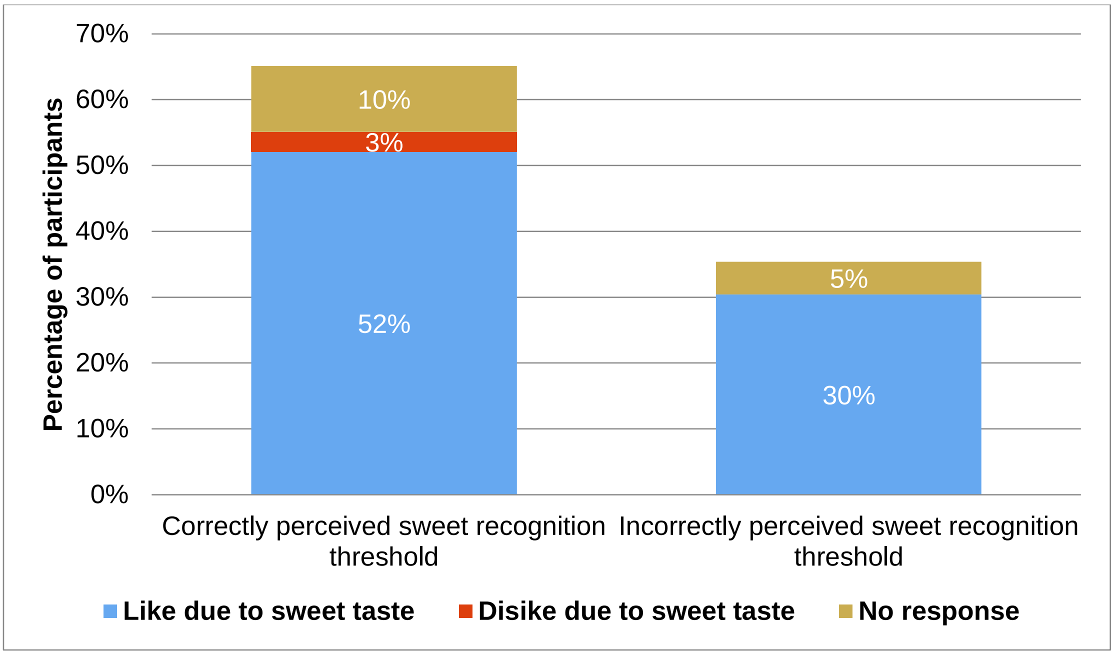


Figure 43. Comparison of sweet recognition threshold and liking novelty sweets due to the sweet taste. *Seven children did not respond to the question on liking novelty sweets in the questionnaire.*

4.3.2.2.6.3 Comparison of sour absolute threshold's perception and liking novelty sweets due to sour taste

Twenty-nine (63%) children stated that they liked novelty sweets because of the sour taste. 5 (17.2%) of these correctly perceived the absolute sour threshold, the remaining 24 (82.8%) did not. Out of the 29 who reported liking the novelty sweets because of the sour taste, there were statistically significantly less children who correctly perceived the absolute sour threshold (n=5 (17.2%)) than who did not (n=24 (82.8%)) ($p<0.001$). Only 14 (30%) children indicated that they did not like novelty sweets because of the sour taste (2 of these children perceived the sour absolute threshold correctly). It is important to note that 3 (7%) children did not answer the question on whether they liked novelty sweets. The percentages of children who liked and disliked novelty sweets due to sour taste against the children who correctly (15%) and incorrectly (85%) perceived the sour absolute threshold are presented below in Figure 45.

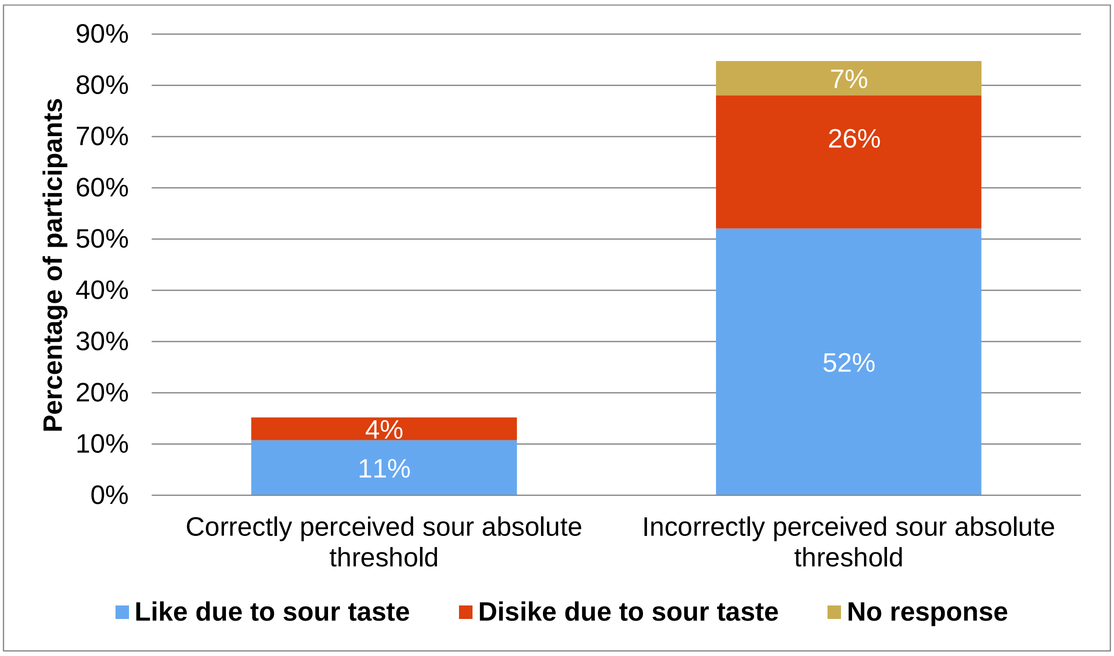


Figure 44. Comparison of sour absolute threshold's perception and liking novelty sweets due to the sour taste. *Three children did not respond to the question on liking novelty sweets in the questionnaire.*

4.3.2.2.6.4 Comparison of sour recognition threshold's perception and liking novelty sweets due to sour taste

Thirty (65%) of the children correctly perceived the sour recognition threshold, whilst 16 (35%) did not. Of the 29 (63%) children who reported liking novelty sweets because of the sour taste 17 (58.6%) correctly perceived the sour recognition threshold, whilst 12 (41.4%) did not (no significant difference (p=0.458)). The percentages of children who liked and disliked novelty sweets due to sour taste amongst the children who correctly (65%) and incorrectly (35%) perceived the sour recognition threshold are presented below in Figure 46.

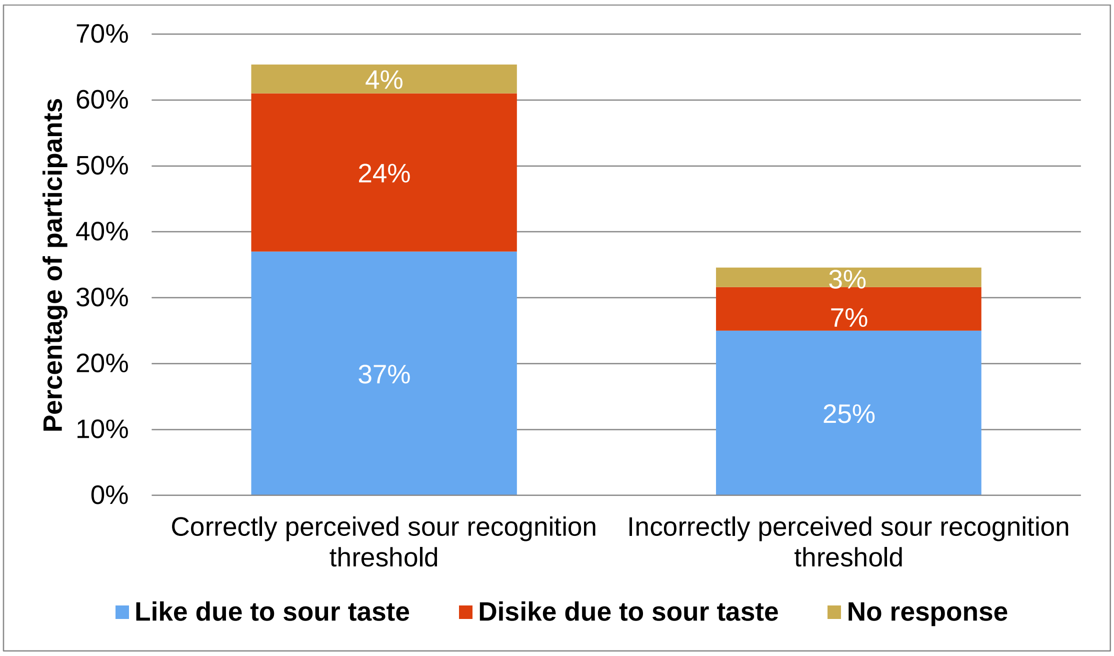


Figure 45. Comparison of sour recognition threshold's perception and liking novelty sweets due to the sour taste. *Three children did not respond to the question on liking novelty sweets in the questionnaire.*

4.3.2.2.7 Comparison of novelty sweets and liking of other food types

Forty-five (98%) children stated that they liked to eat/drink single fresh fruit/juice/smoothie, 26 (56%) liked to eat fresh mixed fruits/juice/smoothie, 43 (93%) liked and consumed carbonated and sport drinks and 29 (63%) liked and ate sweet/sour chicken (Figure 47).

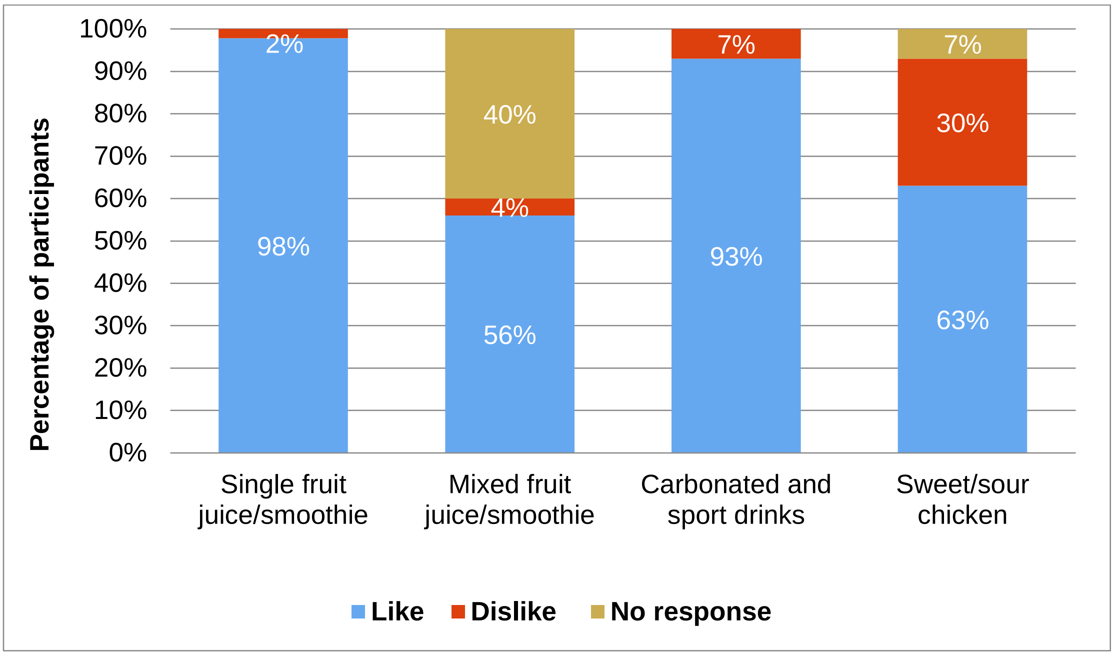


Figure 46. Children's liking of other sweet/sour food types.

With regards to the liking of novelty sweet in relation to the preferred other types of sweet and sour foods and drinks, the results showed the following (Figure 48)

- Out of the 98% (n=45) children who liked and ate single fruit types or fruit juice, 82% liked novelty sweets (n=37) (there was a significant difference, p=0.001).

- Out of the 56% (n=26) children who liked and ate mixed fruit types or mixed juices, 80% (n=21) liked novelty sweets (there was a significant difference, p=0.001).
- Out of the 98% (n=43) children who liked and consumed carbonated and sports drinks, 84% (n=36) liked novelty sweets (there was a significant difference, p=0.001).
- Out of the 63% (n=29) children who liked and ate sweet/sour chicken, 86% (n=25) liked novelty sweets (there was a significant difference, p=0.001).

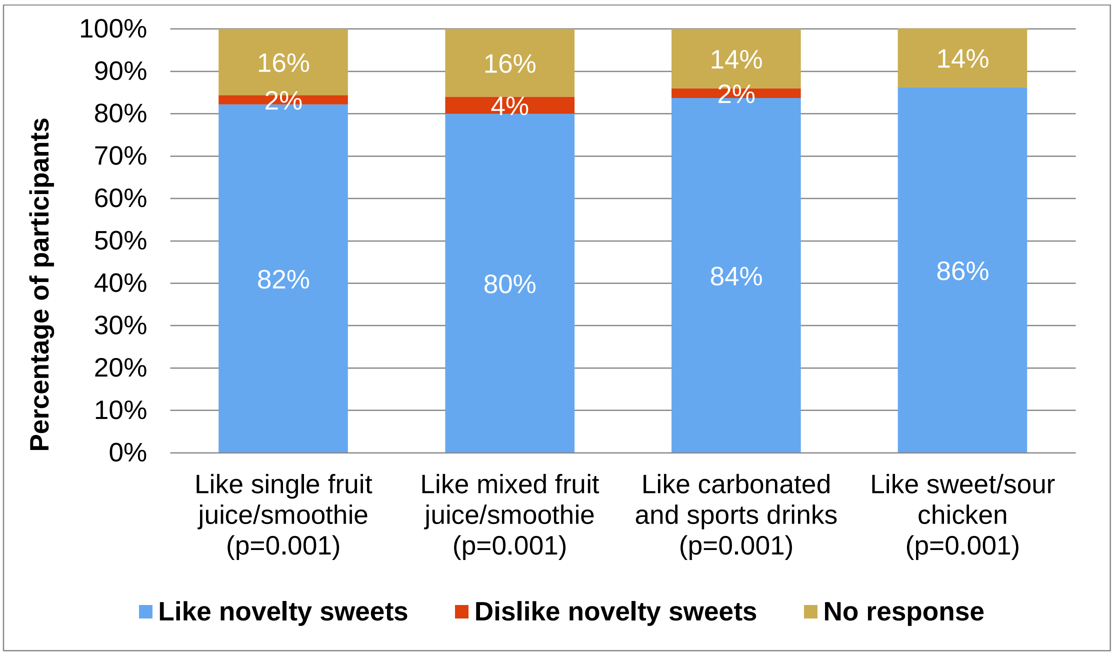


Figure 47. Comparison of liking of novelty sweets and other types of food.

The summary of findings is presented in Table 12 and the raw data of the sensory testing and questionnaire is presented in Appendix 22. Results with statistical significant difference are highlighted in red colour ($p<0.05$) in Table 12.

Table 11. Summary of main findings of sensory testing and questionnaire. P values <0.05 are highlighted in red colour.

	Children (n=46)	Age		Gender		Frequency		Liked sweet and sour tastes of novelty sweets	
		11-13y (n=28)	14-16 y (n=18)	M (n=21)	F (n=35)	Weekly/daily (n=21)	Less than once monthly (n=20)	Liked sweet taste (n=38)	Liked sour taste (n=29)
Correctly perceived sweet absolute thresholds	30% (n=14)	7% (n=2)	67% (n=12)	34% (n=5)	36% (n=9)	43% (n=9)	20% (n=4)	30% (n=11)	24% (n=7)
(p value)	p=0.041	p=0.001		p=0.371		p=0.245		p=0.015	p=0.009
Correctly perceived sweet recognition thresholds	65% (n=30)	60% (n=17)	72% (n=13)	52% (n=11)	76% (n=19)	57% (n=12)	75% (n=15)	63.2% (n=24)	62% (n=18)
(p value)	p=0.055	p=0.424		p=0.94		p=0.471		p=0.243	p=0.265
Correctly perceived sour absolute thresholds	15% (n=7)	14% (n=4)	17% (n=3)	14% (n=3)	16% (n=4)	10% (n=2)	20% (n=4)	18.4% (n=7)	17.2% (n=5)
(p value)	p=0.001	p=0.826		p=0.872		p=0.651		p=0.001	p=0.001
Correctly perceived sour recognition thresholds	65% (n=30)	60% (n=17)	72% (n=13)	66.7% (n=14)	64% (n=16)	80% (n=17)	45% (n=9)	68.4% (n=26)	58.6% (n=17)
(p value)	p=0.055	p=0.424		p=0.850		p=0.041		p=0.035	0.458
Correctly perceived both sweet and sour absolute thresholds	7% (n=3)	0%	16.6% (n=3)	5.5% (n=1)	8% (n=2)	10% (n=2)	5% (n=1)	23.6% (n=9)	17.2% (n=5)
(p value)	p=0.001	p=0.008		p=0.659		p=0.140		p=0.419	p=0.455
Correctly perceived both sweet and sour recognition thresholds	48% (n=22)	42.8% (n=12)	55.5% (n=10)	42% (n=9)	52% (n=13)	47% (n=10)	45% (n=9)	50% (n=19)	41.3% (n=12)
(p value)	p=0.018	p=0.697		p=0.295		p=0.580		p=0.031	p=0.238

4.3.2.3 Discussion of sensory work and questionnaire

The results of the sensory taste thresholds testing part of this study showed that statistically significantly fewer children were able to correctly perceive the sweet absolute threshold (30.4%) than children who perceived the sweet recognition threshold (65.2%) (p=0.024). This meant that 2/3 of the sample needed higher sugar concentrations to recognise the sweet taste at low concentration. This data was comparable to previous studies which have suggested that children are not sensitive enough to a sweet taste and that they therefore prefer a high concentration of sugar in food (Desor and Beauchamp 1987; Zandstra and de Graaf 1998; De Graaf and Zandstra 1999; James et al. 1999).

This finding is supported by the results of this study which showed that there was no significant association between children with high sweet and sour sensory thresholds consuming novelty sweets more frequently.

The findings of this study also showed that significantly fewer children were able to correctly perceive the sour absolute threshold (15%) than the sour recognition threshold (65%) (p=0.001). This means that the majority (2/3) of children needed higher amounts of citric acid concentrations to recognise the sour taste.

Significantly fewer (p=0.001) children (21.4% n=3) were able to correctly perceive both the sweet and sour absolute thresholds compared with the majority of children (70% n=24) who correctly perceived only either the sweet or sour absolute thresholds.

This finding is consistent with the finding of Liem *et al.* (2004b) who found that there was an inverse relationship between the sour taste preference and sensitivity to sour stimuli.

The low sensitivity to sweet and sour may be an influence in the high level of consumption of confectionery including novelty sweets. It may also drive the children to choose confectionery with higher amounts of sugar and acid to enable them to perceive the sweet and sour tastes. This may be reflected in a high consumption rate of acidic foods and drinks by children (45.5% consumed novelty sweets daily or weekly).

The findings of this section showed that there was an inverse relationship between the liking of novelty sweets due to their sweet taste and the perception of the sweet absolute thresholds. Furthermore, children who liked novelty sweets because of the sweet taste were significantly less sensitive to the sweet absolute threshold (30% only can correctly perceived the absolute threshold) than the sweet recognition threshold (63.2%) (p=0.043). Furthermore, children who liked novelty sweets because of the sour taste were significantly less sensitive in perceiving the sour absolute threshold (17.2%) than the sour recognition threshold (58.6%) (p=0.02) compared with children who did not like novelty sweets due to their sour taste. There were 14 children who stated that they did not like the novelty sweets because of the sour taste. Only two (14.3%) of the 14 children who disliked the novelty sweets because of the sour taste correctly perceived the sour absolute threshold and the remaining 12 (85.7%) did not. Only 3 (21.4%) of the children who stated that they did not liked the novelty sweets because of the sour taste correctly perceived the sour recognition threshold and the remaining 11 (78.6%) did not.

This means that children who liked novelty sweets due to the sweet and sour tastes had low sensitivity to the sweet and sour tastes. These findings showed that the preference for sweet and sour taste seems to decrease the sensitivity of children to sweet and sour tastes and may play a role in increasing the consumption of novelty sweets.

The result of the present study showed that 58.6% of the children (11-16 years old) who correctly perceived the sour recognition taste liked novelty sweets due to their sour taste. This is consistent to the findings of Liem *et al.* (2004b) who also found that 58% of children (7-12 years old) who correctly ranked the sour taste liked sour gelatine sweets.

This indicates that regular users of novelty sweets are more likely to recognise the threshold, indicating that those that do not eat them are unable to identify the taste. That means that the children that recognise the taste are more likely to like and eat more sweet/sour foods.

The data of the present study showed that female children were better at perceiving the sweet sensory thresholds than male. The female and male participants who correctly perceived the sweet absolute threshold were 36% (n=9) and 33.8% (n=5) respectively. Whilst the female and male who correctly perceived sweet recognition were 76% (n=19) and 52.4% (n=11) respectively. Female children were slightly better in perceiving the sour absolute threshold and male children were slightly better in perceiving the sour recognition threshold. The female and male participants who correctly perceived the sour absolute threshold were 16% (n=4) and 14% (n=3) respectively. Whilst the female and male participants who correctly perceived the sour recognition were 64% (n=16) and 66.7% (n=14) respectively.

This data was comparable with the findings of the study by Allesen *et al.* (2009) which reported that female children were more sensitive to sweet and sour tastes than male children. However, in the present study the male and female children showed more similar thresholds. This may be explained by the higher sample size included in the study of Allesen *et al.* (2009) which was 8,900 children.

The results of the present study showed that slightly more females (84%) liked the novelty sweets due to the sweet taste than male (81%). Furthermore, more male children (71%) liked the novelty sweets because of the sour taste than females (56%). This is also supported by the finding of the focus group work of this study, which showed a higher popularity rating of novelty sweets with a strong sour taste such as Toxic Waste amongst boys, compared to girls. The findings of the present study are also consistent with the findings of Allesen *et al.* (2009) who found that male children prefer food with a stronger sour taste in comparison to girls (although results were not significantly different). The findings of this study and the study of Allesen et al. (2009) suggest that there is no significant association between gender and preference of sweet and sour tastes.

It was also reported by Liem and Mennella (2003) that more than half of the children participating in their study liked the sour taste and they were significantly less food neophobic (willing to try new foods) and able to try any type of food. .

The findings of this study also showed that 82.6% (n=38) of participants liked novelty sweets due to the sweet taste and 63% (n=29) liked novelty sweets due to the sour taste. This was also reflected in the high number (n=21, 45.7%) of children who consumed novelty sweets daily or weekly. This finding is consistent with what has been suggested by many authors that children's food choices are for the most part determined by their taste preferences (Pangborn and Giovanni 1984; Liem and Mennella 2002, 2003b; Perez-Rodrigo et al. 2003). This finding was also supported by the reported findings by Privitera and Wallace (2011) and Sijtsema *et al.* (2012) who found that there was a positive relationship between frequent exposure of sweet tasting foods in the diet and the liking of sour and sweet tastes, which were significantly associated with high consumption of sugary foods such as chocolate and sour foods such as fruits.

Worryingly, this high frequency of consumption of novelty sweets puts children at high risk of experiencing dental erosion, dental caries and obesity (Burt and Pai 2001; Gambon et al. 2012; Te Morenga et al. 2013; Sovik et al. 2015).

The present study also showed no significant association between perception of the sweet and sour sensory thresholds and frequency of consumption of novelty sweets ($p>0.05$). Children who consumed novelty sweets on a daily, weekly or less than once per month had low sensitivity to sweet and sour thresholds. This might show that the low sensitivity to sour and sweet tastes may be influenced by the preference of novelty sweets but not the frequency. Frequency being more associated with price and availability of the sweets.

The findings of this present study showed that children liked novelty sweets due to various criteria including their sweet taste (82.6%), sour taste (63%), re-sealability (76%), affordability (56.5%), accessibility (67.4%), ways of eating (63%) and toys that came with them (17.4%). These elements are the main features of the novelty sweets which may be related to their popularity in children. The qualitative study of Stewart *et al.* (2013) also found that these criteria of novelty sweets were also preferred by children. Children, aged 11-16 years old in the sensory work of this study reported that toys were not an important element attracting them to the novelty sweets. This finding was also similar to the finding of Stewart et al (2013) who also found that the toy element of the novelty sweets was not highly regarded by children aged 9-10 years old.

The findings of this study showed that there were a significant association between age of children and perception of sweet sensory taste (p=0.001). The results showed that children in the older group (14-16 years old) of children were more sensitive to sweet and sour tastes than younger age group (11-13 years old) to sweet in low concentrations (7% of 11-13 years old correctly perceived the sweet absolute threshold in comparison to 67% 14-16 years old). Older age group children were slightly more sensitive to sour concentrations than younger group. There were 16% of 14-16 year olds who correctly perceived the sour absolute threshold, 72% correctly perceived the sour recognition threshold in comparison to 14% and 60% of 11-13 year olds respectively.

This data was consistent with the results of studies conducted by De Graaf and Zandstra (1999), James *et al.* (1999) and Liem and Mennella (2003) who suggested that older children or adolescents were more sensitive to sensory taste for sweet and sour than younger children.

The difference in sweet and sour perception between younger and older age groups may be related to the higher salivary flow in younger children which is about 1.75 ml/min and gradually reach 1 ml/min (stimulated saliva) by the age of adolesence (Dawes 1987; Leonor et al. 2009) which has been found to potentially increase taste thresholds (Dawes 1987; Spielman 1990). For example, it was found by Liem *et al.* (2004b) that children who liked sour tastes had high saivary flow and they were more willing to try a new types of novel candies which may be related to their lower sensory thresholds to sour.

Furthermore, this finding may also mean that the younger children were not as able as older children to understand the test which was also suggested by Guinard (2000) who found that young children had less experience to scale the sensory taste solutions. Furthermore, it was found that the ability of children to categorise and analyse information become strong and more efficient with age (Carey et al. 2009).

The findings of this present study also showed that there was a significant association between liking and consumption of sweet and sour drinks and foods such as carbonated drinks, fruits and sweet and sour chicken and liking of novelty sweets. This finding is confirming that the taste preference is one of the main determinants of food preference in children and the actual consumption of the foods (Liem and Mennella 2003; Grimm et al. 2004; Privitera and Wallace 2011).

4.4 Oral science aspects of the study

The final part of this study was an assessment of the ability of the ten most commonly available novelty sweets to cause enamel erosion. This included an assessment of their pH, neutralisable acidity, and surface and subsurface enamel loss. In addition to this, the contact angle with enamel, their viscosity and sugar content was also assessed. The results showed that the pH of nine types of novelty sweets tested was statistically significantly lower than the critical pH value of enamel dissolution (5.5) and eight of them were statistically significantly lower than the orange juice (3.7) ($p<0.05$). Furthermore, the neutralisable acidity of seven sweets was statistically significantly higher than the orange juice (28.3 ml NaOH) ($p<0.05$). The erosive potential of six novelty sweets was statistically significantly higher than the erosive potential of the orange juice ($p<0.05$). Delayed ultrasonication by 1 h, reduced the amount of subsurface enamel loss by 0.52-1.45μm in presence of saliva. Some acidic solutions had low contact angles, low viscosity and higher sugar content than orange juice.

4.4.1 Preparation of the ten most available sweets

The ten most commonly available novelty sweets identified in part 1 of this study and their contents are presented in the table below (Table 14).

Table 12. The top ten most commonly available novelty sweets and their contents.

Novelty sweet	Name	Labelled contents by the manufacturers
	Brain Licker	glucose-fructose syrup, acidifiers, citric acid, lactic acid, malic acid
	Lickedy Lips	glucose-fructose syrup, acidifiers, citric acid, lactic acid, malic acid
	Push Pop	Sugar, glucose syrup, lactic acid
	Vimto	Sugar, malic acid, citric acid, acid regulator (sodium citrate)
	Tango	Sugar, malic acid, citric acid, acid regulator (sodium citrate)

	Juicy Drop Pop	Sugar, glucose syrup, fructose syrup, citric acid, malic acid
	Toxic Waste	Sugar, glucose syrup, citric acid, malic acid
	Big Baby Pop	Sugar, glucose syrup, citric, lactic acid
	Mega Mouth	Sugar, citric acid
	Brain Blasterz	Sugar, acidity regulator

Before measuring the pH, neutralisable acidity, contact angles, sugar content and undertaking the erosion test, sweets which were in solid form were powdered using a pestle and mortar (Figure 49). Then, 10g of powder was dissolved in 20ml of distilled water according to the method described by Davies *et al.* (2008) (Figure 50). This applied to five products; Push Pop, Brain Blasterz, Toxic Waste, Juicy Drop Pop and Big Baby Pop.

For any novelty sweet which came in two parts such as liquid or powder and solid parts, each part was tested separately. This approach applied to two products, Juicy Drop Pop and Big Baby Pop.

Figure 48. Using pestle and mortar to powder the solid sweets.

Figure 49. Preparation of sweet solution.

4.4.2 Preparation of enamel samples

Enamel specimens were prepared from human teeth provided by the tooth bank, Cardiff University following obtaining an ethical approval from South East Research Ethics Committee, Cardiff, UK (Ref. 12/WA/0289) (Appendix 23).

Measurement of the contact angle required the preparation of crowns with a flat enamel surface for each side (buccal, lingual, mesial and distal). Sectioning of teeth was undertaken using a low speed machinery saw with a water soluble coolant (Model 650 low speed diamond wheel saw, South Bay Technology, US). Samples were surface polished using 600 grit then 1200 grit abrasive discs on an automatic polishing machine (Kemet International Limited, Maidstone, UK) under water cooling to give a flat surface to allow the contact angle analyser to measure the contact angle between each novelty sweet solution and enamel surface and to allow surfometry to measure the surface roughness (Figure 51). Three baseline readings were taken using a contact profilometer (Mitutoyo, surftest-SV2000, Mitutoyo America, USA) for each sample. Samples with a stylus deflection to baseline of less than 0.30 μm were used in the study (Figure 52). To undertake the contact angle measurements, enamel crowns were randomly allocated to each test groups (10 sample for each group) using a random allocation software v 2.0 (RAS, v 2.0) (Saghaei, Asfahan, Iran) (Schulz and Grimes 2002; Dettori 2010). Enamel samples were labelled by permanent marker from 1 to 140 to allow the software to randomly allocate 10 samples for 14 groups.

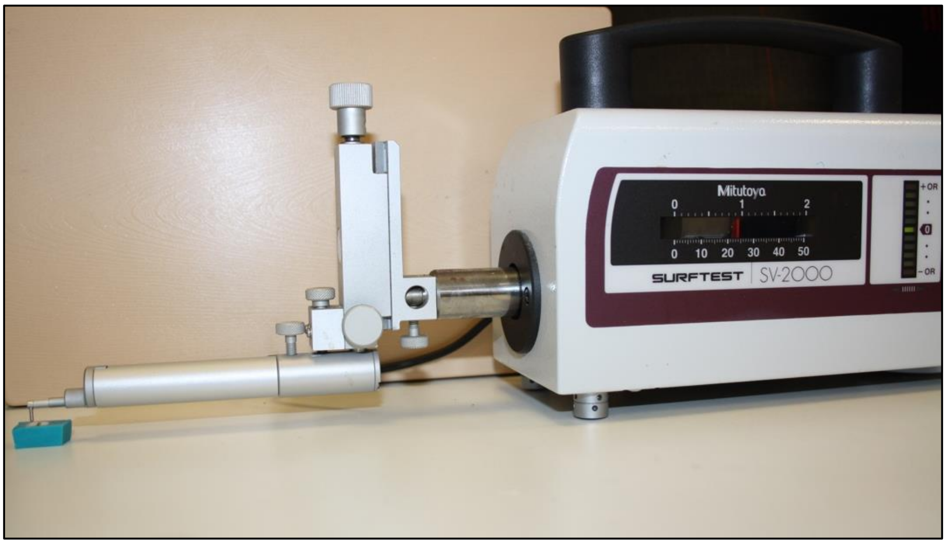


Figure 50. Three baseline readings using a contact surfometer were undertaken.

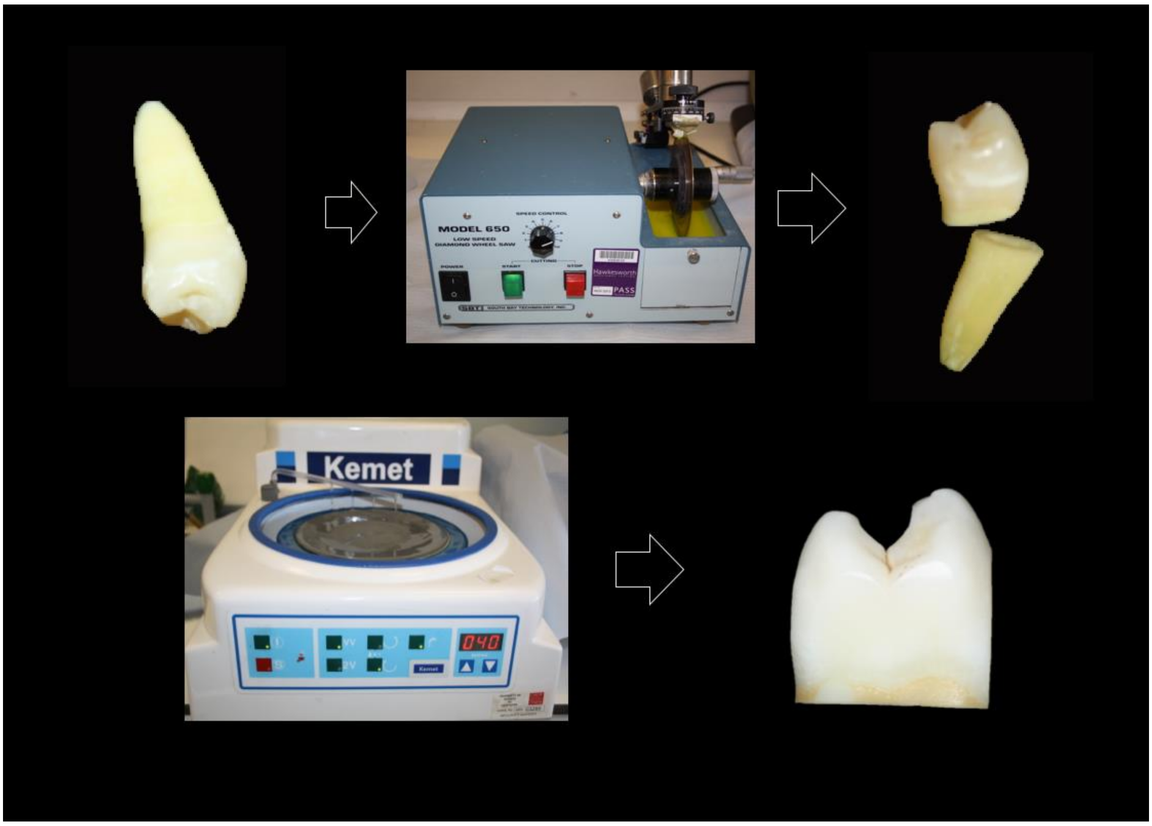


Figure 51. Teeth sectioning and polishing using machinery saw and polishing machine.

For the measurement of enamel erosion (surface and subsurface erosion), teeth (crowns) with flattened enamel surfaces were sectioned (Figure 53). Each enamel sample was embedded in low exothermic epoxy resin (Stycast 1266, Emerson & Cuming, Nijverheidsstraat, 2431 Westerlo, Belgium) (Figure 54). To undertake the enamel erosion test, specimens were also randomly allocated to one of 14 treatment groups (n=10 for each group) for groups initially treated by saliva for 1 h and another 14 treatment groups (n=10 for each group) without initial treatment in saliva using the random allocation software v 2.0 (RAS, v 2.0). Enamel samples were labelled from 1 to 280 by permanent marker to allow the random allocation software to allocate 10 samples for each group randomly. These groups were 12 sweets, water and Tropicana orange juice.

Figure 52. Crown sectioning to obtain enamel specimens for erosion tests.

Figure 53. Placement of enamel specimens in epoxy resin.

4.4.3 pH

4.4.3.1 Methodology

The pH of each novelty sweet was assessed using an electronic pH meter (HANNA pH meter HI 2210, HANNA instrument, Michigan, USA) and a magnetic stirrer (Figure 55). The pH meter was calibrated before each use using pH 7 and 4.01 buffering solutions and the probe was washed using distilled water between each use to remove any remaining sweet residue. The pH of each sweet was measured using ten samples and mean and standard deviations were calculated. The pH was measured at both room temperature (n=10) and body temperature (n=10) (37°C) within a temperature controlled room (Figures 56 and 57).

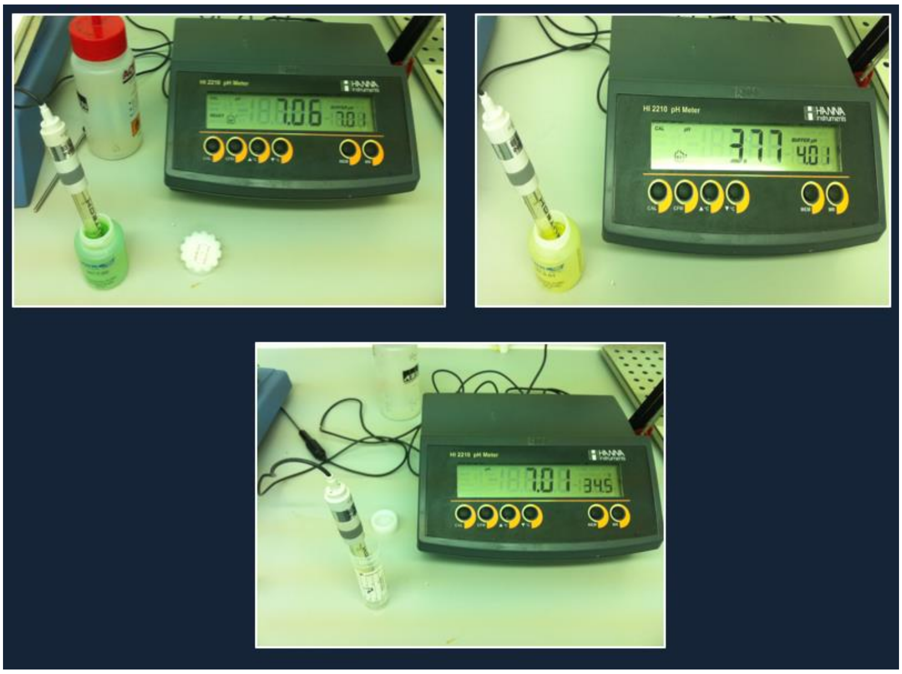


Figure 54. Calibrating the pH meter using known pH 7 and 4.

Figure 55. Measuring pH at room and body temperatures.

Figure 56. Temperature controlled room.

4.4.3.2 pH results

The pH of the tested novelty sweets ranged from 1.83-3.20 at room temperature and from 1.95-3.20 at body temperature. Toxic Waste had the lowest pH value at both room and body temperatures 1.84 and 1.95 while the lollipop of Big Baby Pop had the highest pH value of 3.21 at room and 3.18 at body temperatures. Statistical analysis was undertaken using Analysis of Variance (ANOVA) followed by Tukey's Multiple Comparison Test with statistical significance set at $p<0.05$ (Field 2013), there was no statistical significant difference in pH of all tested novelty sweets at room and body temperature ($p>0.05$).

The pH of nine (highlighted in red colour in Table 14) out of the ten of novelty sweets (at both room temperature and boy temperature) was statistically significantly lower than the critical pH value of enamel dissolution of 5.5 (Lussi 1993; Larsen and Pearce 1997; Larsen and Nyvad 1999; Dawes 2003) ($p<0.05$). These sweets were Brian Licker (1.92), Toxic Waste (1.83), Lickedy Lips (1.9), Vimto Candy Spray (2.43), Brain Blasterz (2.3), Big Baby Powder (2.3), Tango (3.18), Mega Mouth (1.83) and Juicy Drop Syrup (2.24).

The pH of eight sweets (at both room temperature and boy temperature) was also statistically significantly lower than the pH of the orange juice (3.7) used as a control ($p<0.05$). It was found that the pH of Brian Licker (1.92), Toxic Waste (1.83), Lickedy Lips (1.9), Vimto Candy Spray (2.43), Brain Blasterz (2.3), Big Baby Powder (2.3), Mega Mouth (1.83) and Juicy Drop Syrup (2.24) were all statistically significantly lower than the pH of the orange juice when tested at room temperature and body temperature. The pH of the orange juice was 3.75 at room temperature and 3.81 at body temperature.

The pH of the top ten most commonly available novelty sweets tested at room temperature and at body temperature are summarised in Table 14 and the raw data is presented in Appendix 24 and Appendix 25.

Table 13. pH of tested novelty sweets at room and body temperature. Values in red are statistically significantly lower than the pH of 5.5 ($p<0.05$).

Material	Mean pH at room temperature	SD	Mean pH at body temperature	SD
Big Baby Pop (pop)	3.22	0.043	3.18	0.033
Big Baby Pop (powder)	2.3	0.011	2.37	0.02
Brain Blasterz	2.3	0.01	2.3	0.008
Brain Licker	1.92	0.02	2.05	0.033
Juicy Drop (pop)	3.12	0.018	3.16	0.021
Juicy Drop (Syrup)	2.24	0.007	2.33	0.02
Lickedy Lips	1.9	0.017	2	0.041
Mega Mouth	1.83	0.043	1.93	0.033
Push Pop	3.11	0.023	3.15	0.011
Tango	3.18	0.022	3.21	0.021
Toxic Waste	1.83	0.026	1.93	0.035
Vimto	2.43	0.016	2.46	0.015
Orange Juice (Tropicana smooth)	3.7	0.02	3.81	0.01

4.4.4 Neutralisable acidity

The destructive potential of the novelty sweets are not only determined by their pH. The neutralisable acidity will also influence the erosive potential and the greater the amount of NaOH needed to raise the pH to 7, the longer the time needed for the saliva to neutralise it (Larsen 1990; Lussi et al. 2004).

4.4.4.1 Methodology

The neutralisable acidity was tested by placing 20ml of each prepared sweet in a separate glass beaker on a magnetic stirrer, 0.1M sodium hydroxide (NaOH) was gradually added until neutrality was reached. The pH meter was used to assess the change in the pH of the solution throughout the titration process. The NaOH solution was prepared by adding 10g of solid NaOH in 240ml of distilled water to provide a 1M NaOH solution. The liquid was then diluted further to get a molarity of 0.1M NaOH. The amount of sodium hydroxide needed to increase the pH to 7 was noted.

The neutralisable acidity of each sweet was tested using ten samples and the mean and standard deviations were calculated (Figure 58). Neutralisable acidity was measured at both room temperature (n=10) and body temperature (n=10) within a temperature controlled room. Three readings were taken for each sample.

Figure 57. Measuring neutralisable acidity at room and body temperatures.

4.4.4.2 Neutralisable acidity results

The values of neutralisable acidity of the most commonly available novelty sweets ranged from 201.3 and 202 ml of 0.1M NaOH for the syrup of the Juicy Drop to 9 and 9.2 ml for Push Pop at room and body temperature respectively. Statistical analysis was undertaken using ANOVA followed by Tukey's Multiple Comparison Test with statistical significance set at $p<0.05$, there was no significant difference in neutralisable acidity of all tested novelty sweets at room and body temperatures ($p>0.05$).

The means neutralisable acidity of seven sweets (highlighted in red colour in Table 15) was statistically significantly higher than the neutralisable acidity of the orange juice (28.4 ml NaOH) ($p<0.05$). It was found that the neutralisable acidity of Toxic Waste (93.6 ml), Lickedy Lips (40.2 ml), Vimto Candy Spray (70 ml), Tango Candy Spray (41.6 ml), Brain Licker (49 ml), Juicy Drop Syrup (201 ml) and Mega Mouth (95 ml) was statistically significantly higher than the neutralisable acidity of the orange juice when tested at room temperature and body temperature which was 28.3 ml and 28.4 ml respectively.

The neutralisable acidity values for the tested novelty sweets at room temperature and body temperature are given in Table 15 and the raw data is provided in Appendix 26 and Appendix 27. The titration curves of the tested novelty sweets are shown in Figure 59.

Table 14. Neutralisable acidity of tested novelty sweets at room temperature and body temperature. Values in red are statistically significantly higher than the orange juice (p<0.05).

Subject	Mean Titratable Acidity at room temperature in ml	SD	Mean Titratable Acidity at body temperature in ml	SD
Big Baby Pop (pop)	10.1	0.16	10.4	0.14
Big Baby Pop (powder)	10.4	0.11	10.6	0.2
Brain Blasterz	29	0.15	29.5	0.34
Brain Licker	49	0.43	48.5	0.13
Juicy Drop (pop)	9.9	0.17	10.2	0.24
Juicy Drop (Syrup)	201.3	0.87	202	0.43
Lickedy Lips	40.2	0.23	40.7	0.42
Mega Mouth	95	0.16	95.3	0.14
Push Pop	9	0.083	9.2	0.11
Tango	41.65	0.45	41.6	0.42
Toxic Waste	93.6	0.71	94.1	0.43
Vimto	69.7	0.36	70.7	0.42
Orange Juice (Tropicana smooth)	28.3	0.46	28.4	0.55

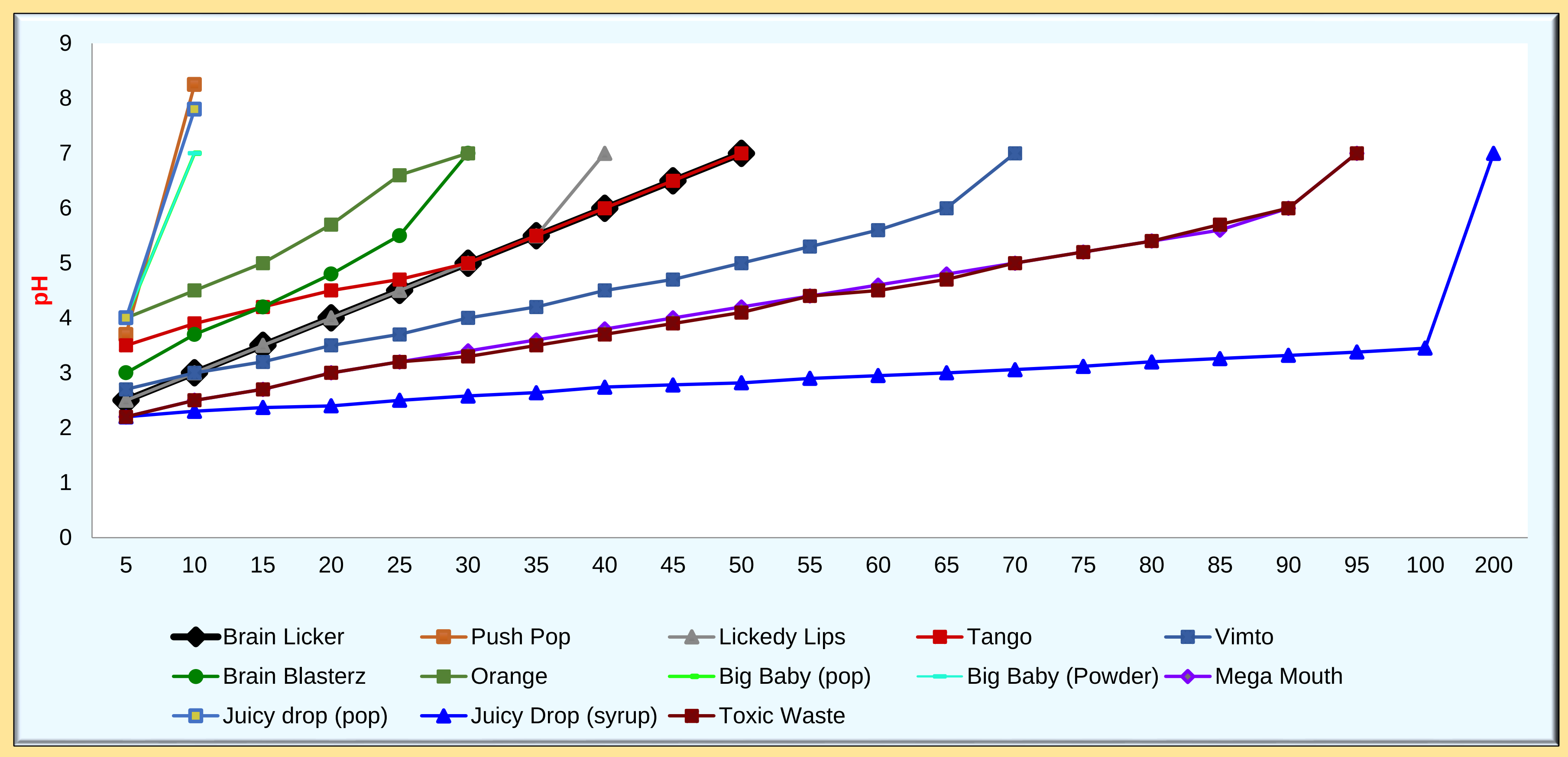


Figure 58. Titration curve of tested novelty sweets using 0.1M NaOH.

The titration curves above show that there was a wide variation between the neutralisable acidity of the tested novelty sweets based on the amount of sodium hydroxide needed to reach to pH of 7. For example, the titration curve of Juicy drop syrup, Mega Mouth and Vimto show a sustained plateau curve or a slow gradual increase for a long period of time with the addition of the sodium hydroxide to the solutions. The titration curves of other types of novelty sweets such as Push pop and Big Baby (Pop and powder) show a faster and sharper increase in the pH with the addition of sodium hydroxide.

4.4.5 Contact angle measurement (wettability)

The contact angle formed between each sweet solution and the enamel surface was measured to assess the degree of enamel wettability. This is important because the angle between these solutions and the enamel surface affect the adhesiveness and wettability which in turn would influence the contact time between the sweet and the tooth intra-orally (Ireland et al. 1995).

4.4.5.1 Methodology

The contact angels between each solution and the prepared flat enamel surfaces were measured using a Dynamic Contact Angle Analyser (Figures 60, 61 and 62).

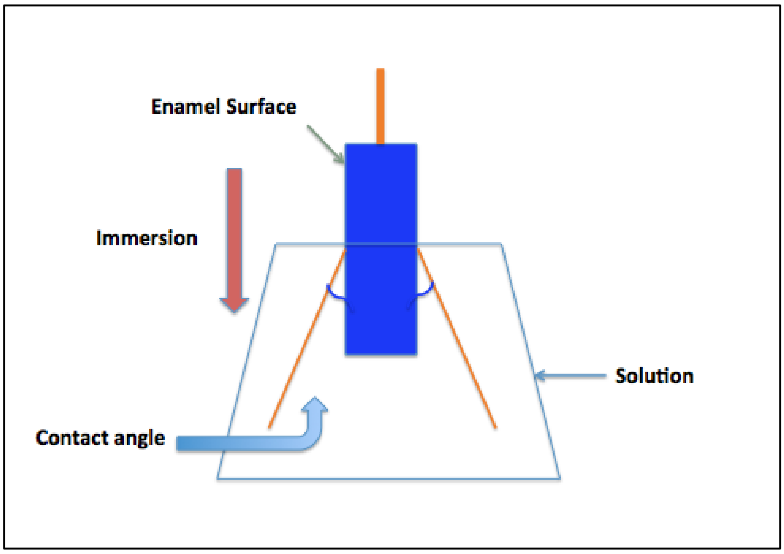


Figure 59. A figure shows the contact angle between a sweet solution and enamel surface.

A dynamic contact angle analyser (model 312; Thermo Cahn, Madison, Wisconsin, USA) linked to a RM compatible computer was used to measure the contact angles. The methodology used to measure the contact angle included the following.

1- The enamel specimens and the sweet solutions were prepared as described in section 4.3.2. 40 ml of sweet solution was placed in a glass beaker and placed on a movable table of the contact angle analyser.

2- Each enamel specimen was attached to an electrobalance holder above the glass beaker which was placed on the movable table. The table gradually moved with the glass beaker upward towards the enamel sample once activated by the computer while the wetting medium scanned along at a constant speed via a computer-controlled stage.

Figure 60. Enamel sample attached to the electrobalance holder.

3- The enamel sample was then pulled up by the downward movement of the table once the appropriate depth in the solution was reached.

4- For each test group, 10 enamel specimens were used at room temperature.

5- The enamel specimen was immersed and emersed. This allowed for measurement of wetting tensions which was subsequently used to calculate the contact angles by the software in the computer linked to the contact angle analyser.

6- The mean contact angle and standard deviation of the ten measurements of each sweet were calculated.

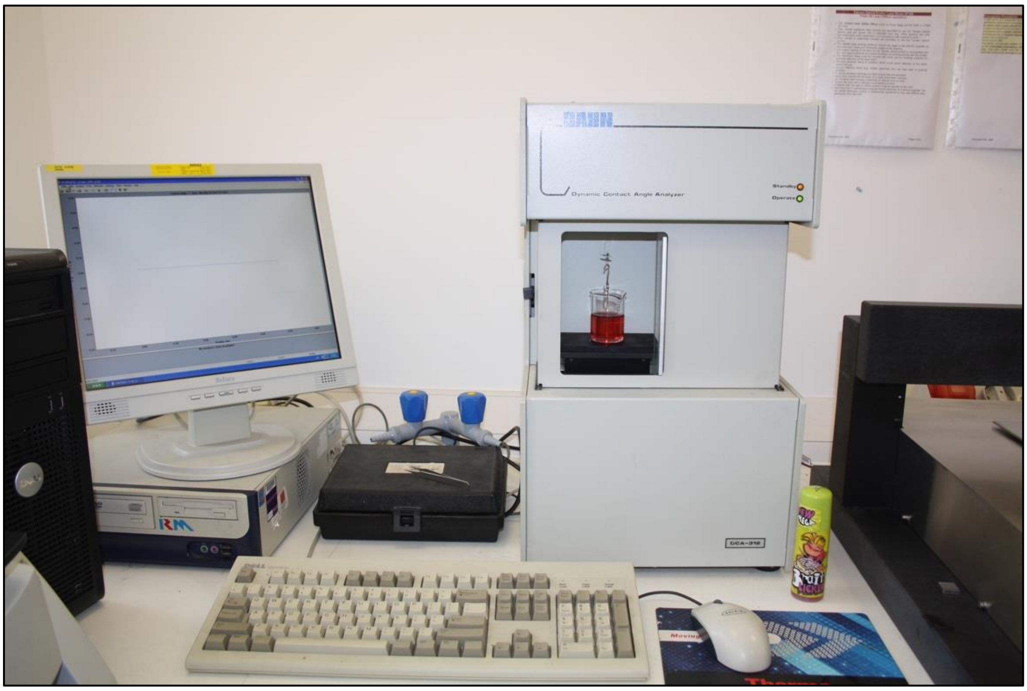


Figure 61. The dynamic contact angle analyser.

4.4.5.2 Contact angle (wettability) results

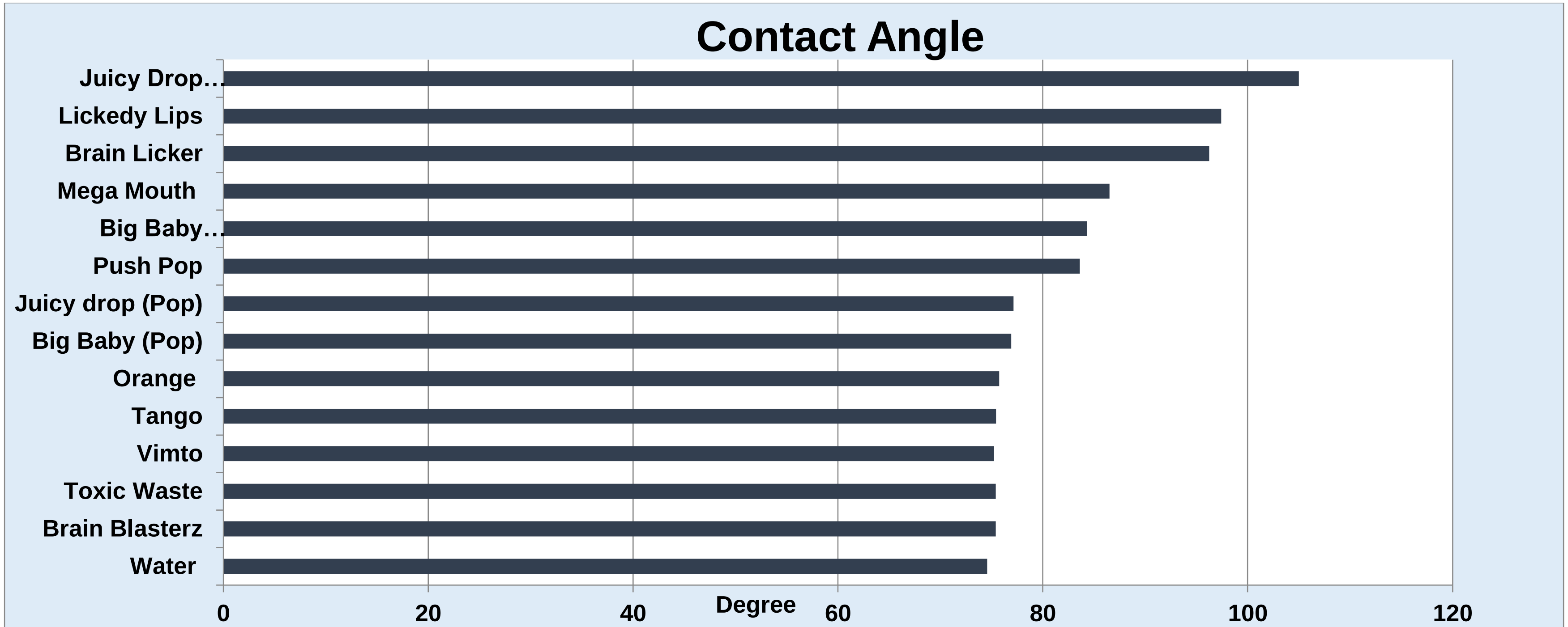
The results show that the highest contact angle was formed between enamel surface and Juicy drop syrup with 105° which causes less wettability of enamel surface while the smallest contact was between the enamel surface and the Vimto solution with 75.22° which causes high wettability of the enamel surface. The contact angle between enamel surface and orange juice (Tropicana smooth) and between enamel surface and water were 75.745° and 74.55° respectively.

The contact angle between four types of the most commonly available novelty sweets tested and enamel surface were smaller than the contact angle between the orange juice and enamel surface. These sweets were Brain Blasterz (75.4°), Tango Candy Spray (75.43°), Toxic Waste (75.4°) and Vimto Candy Spray (75.22°). Statistical analysis was undertaken using ANOVA followed by Tukey's Multiple Comparison Test with statistical significance set at $p<0.05$, there was no significant difference in contact angle measurments of all tested novelty sweets and orange juice ($p>0.05$).

The lower contact angle between these sweets and enamel surface reflected the higher enamel wettability and diffusion caused by these sweets and potentially higher amount of enamel loss. The contact angles of the tested novelty sweets are presented in Table 16 and the raw data of the contact angle measurements is presented in Appendix 28. Figure 63 shows the contact angle formed between the enamel surface and all the tested solutions in graphical format (in descending order).

Table 15. Contact angles measured between the tested novelty sweets and enamel surface.

Material	Average contact Angle	SD
Big Baby (Pop)	76.9°	2.93
Big Baby (Powder)	84.3°	3.14
Brain Blasterz	75.4°	2.9
Brain Licker	96.25°	2.06
Juicy Drop (Pop)	77.14°	2.42
Juicy Drop (Syrup)	105°	3.04
Lickedy Lips	97.4°	2.58
Mega Mouth	86.5°	1.8
Push Pop	83.6°	2.81
Tango	75.43°	0.7
Toxic Waste	75.4°	2.34
Vimto	75.22°	2.15
Water	74.55°	2.6
Orange Juice	75.745°	2.9



	Water	Brain Blasterz	Toxic Waste	Vimto	Tango	Orange	Big Baby (Pop)	Juicy drop (Pop)	Push Pop	Big Baby (Powder)	Mega Mouth	Brain Licker	Lickedy Lips	Juicy Drop (Syrup)
Contact Angle	74.55	75.4	75.4	75.22	75.43	75.745	76.9	77.14	83.6	84.3	86.5	96.25	97.4	105

Figure 62. Contact angles measured between the tested novelty sweets and enamel surface.

4.4.6 Novelty sweet viscosity

4.4.6.1 Methodology

One of the factors which may affect the amount of dental erosion is the viscosity of the acidic solution (Aykut-Yetkiner et al. 2013). Higher viscosity solutions cause lower amounts of enamel loss (Eisenburger et al. 2003; Barbour et al. 2006; Beyer et al. 2012; Aykut-Yetkiner et al. 2013).

The viscosity of the novelty sweets which came in liquid forms, in addition to orange juice (Tropicana smooth) and water was measured using a rotational viscometer (Cole-Parmer, London, UK) (Figure 64). This was applied to Vimto Candy Spray, Tango Candy Spray, Mega Mouth, Juicy Drop Pop, Brain Licker and Lickedy Lips.

Figure 63. The basic rotational voscometer used in this part of study.

Laboratory steps of viscosity measurement were as the following:

1. The test material was placed in a beaker with an amount sufficient to immerse the spindle and reach to the level of groove cut in the spindle shaft (Figure 65).

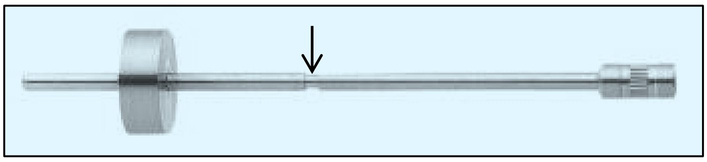


Figure 64. A spindle with a groove in the middle of the shaft.

2. The spindle was attached to the lower shaft of the viscometer. The lower shaft was held in one hand and the spindle screwed clockwise.
3. The spindle size was chosen according to the thickness of the material. The thicker the material, the smaller the spindle and vice versa (Figure 66).

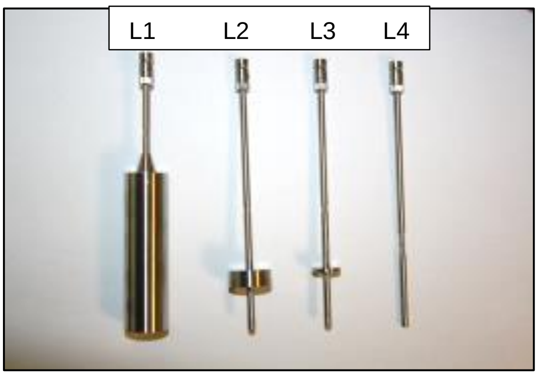


Figure 65. Different sizes of spindles used.

4. The speed (shear rate) was selected to be 100 RPM based on the “try and error” method of choosing the ideal speed for liquids. This technique is based on selecting a speed (e.g. 100 RPM) with the biggest spindle (L1) and start measuring the viscosity of water. If the viscosity of water was correct (around 1mPa-s), the selected speed should be followed to compare the viscosity of other materials, although the spindle could be changed if an error appeared (a smaller spindle required for more viscous material) (Barnesa and Nguyenb, 2001, Cullen et al., 2000, Munizagaa and Cánovas, 2005). In this study, a speed of 100 RPM was used and followed for all tested materials.
5. The viscosity measurement was taken by depressing the clutch and turn the viscometers motor “on”.
6. Then the viscosity was measured by pressing the enter button and the spindle started to rotate until the readings stabilised in the screen at a fixed reading (Figure 67). It typically took 30 seconds for the reading to stabilise.

Figure 66. The rotational viscometer with a sample to test.

7. Ten enamel samples were used for each material and a mean and SD calculated.
8. Between each measurement, the spindle was removed and washed out by water to remove the test material and dried.
9. All the measurements were taken at room temperature and all measurement were made on the same day.

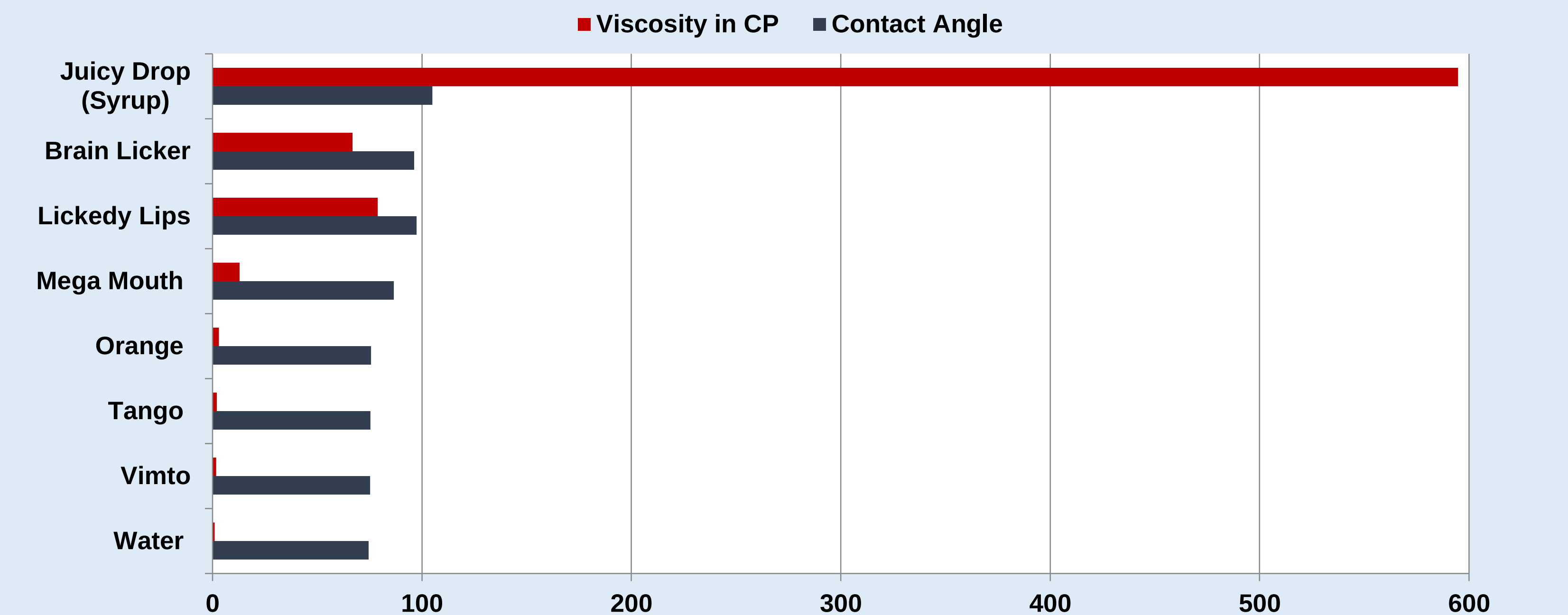
4.4.6.2 Viscosity results

The results show that the sweet with the highest viscosity is the Juicy Drop Syrup at 594.81 mPa-s and the lowest was the Vimto spray at 1.78 mPa-s, in comparison to the orange juice (Tropicana smooth) at 3 mPa-s and water at 1 mPa-s. Statistical analysis was undertaken using ANOVA followed by Tukey's Multiple Comparison Test with statistical significance set at $p<0.05$, there was a statistical significant difference in viscosity between four types (highlighted in red colour in Table 17) of the most commonly available novelty sweets and orange juice ($p<0.05$). These novelty sweets were Mega Mouth (12.85 mPa-s), Lickedy Lips (78.82 mPa-s), Brain Licker (66.90 mPa-s) and Juicy Drop Syrup (594.81 mPa-s). Figure 68 presents the viscosity of the novelty sweets tested in addition to the contact angle measurements. These two measurements are strongly linked to the diffusion of acidic solution into the enamel surface and subsequent enamel loss (Ireland et al. 1995; Aykut-Yetkiner et al. 2013).

The viscosity of the novelty sweets which came in liquid form, water and orange juice are presented in Table 17. The raw data for the viscosity measurements is presented in Appendix 29.

Table 16. The viscosity of the novelty sweets, orange juice and water. Values in red are statistically significantly higher than the viscosity of orange juice.

Material	Spindle size	Viscosity (mPa-s) (n=10)	SD
Brain Licker	L2	66.90	0.13
Juicy Drop Syrup	L3	594.81	0.10
Lickedy Lips	L2	78.82	0.13
Mega Mouth	L1	12.85	0.13
Tango	L1	2.00	0.03
Vimto	L1	1.78	0.04
Water	L1	1.00	0.02
Orange Juice (Tropicana smooth)	L1	3.00	0.54



	Water	Vimto	Tango	Orange	Mega Mouth	Lickedy Lips	Brain Licker	Juicy Drop (Syrup)
Viscosity in CP	1	1.78	2	3	12.85	78.82	66.9	594.81
Contact Angle	74.55	75.22	75.43	75.745	86.5	97.4	96.25	105

Figure 67. A histogram showing both the viscosity and contact angle of each tested novelty sweets.

4.4.7 Sugar content measurement using a refractometer

4.4.7.1 Methodology

The sugar content of the novelty sweets was measured to assess the potential risk of dental caries and obesity development in children who frequently consume these sweets.

The sugar content of the ten most commonly available novelty sweets, orange juice and water were measured using a refractometer (PCE-032, PCE instruments UK Lid., Southampton, UK). The refractometer is a device which measures the sugar content of a liquid depending on its refractive index (discussed in section 3.4.2.1.4.1.2). The refractometer and its components are shown in Figures 69 and 70.

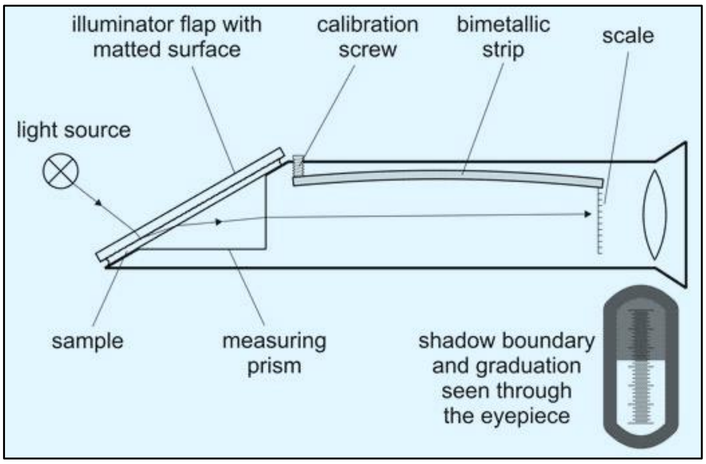


Figure 68. Components of the refractometer.

Figure 69. The refractometer used in this part of study.

The sugar content of novelty sweets was measured using the refractive index method following the method of Agbazue *et al.* (2014). The laboratory steps of sugar content measurement were as the following:

1- Before the measurement was taken, the refractometer was calibrated using water which gave a reading of 0%.

2- Approximately $1cm^3$ of sample was placed on the top of the prism until the entire surface of the prim was covered without any air bubbles.

3- The illuminator flap cover was placed over the sample.

4- The refractometer was held toward a natural light source (window) horizontally.

5- Through the eyepiece, the amount of sugar content was read from the graduated scale.

6- Between each measurement, the surface of the prism was washed with tap water and dried using a clean napkin.

7- 10 sweets samples were used in this test and all the measurements were taken at room temperature.

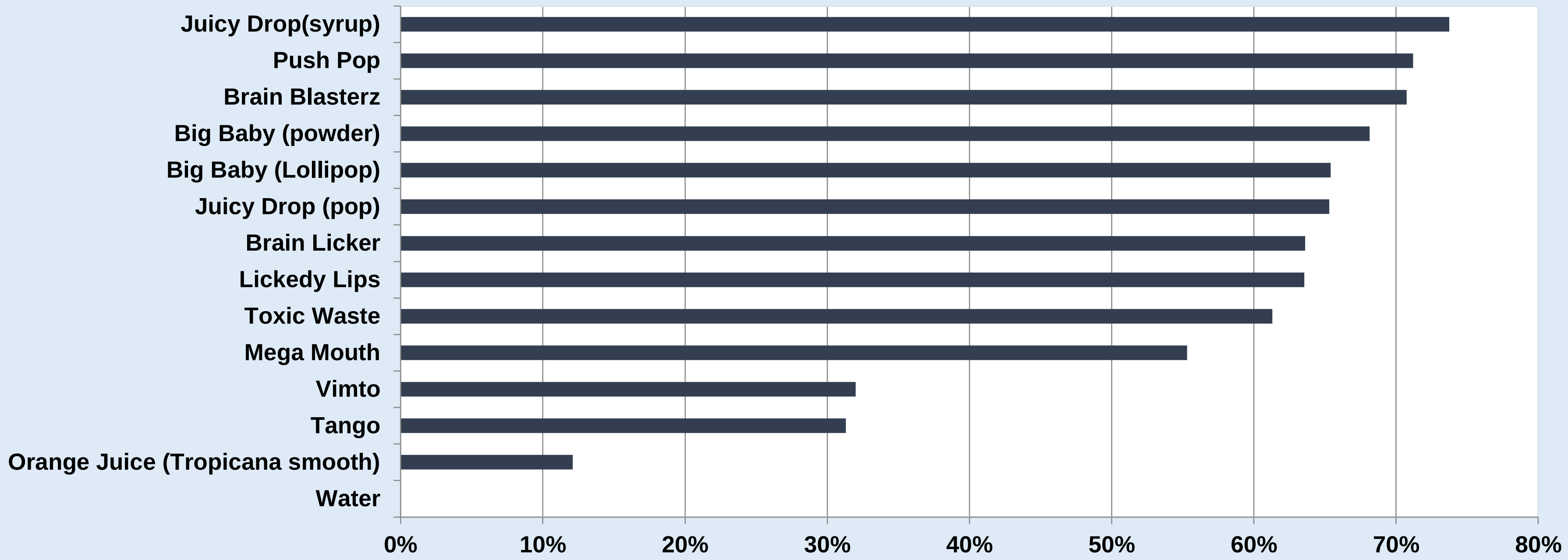
4.4.7.2 Sugar content results

The results showed that the highest amount of sugar in the tested novelty sweets was present in Juicy Drop Syrup at 73.75%, while the least amount of sugar was present in Tango Candy Spray at 31.30%. The average amount of sugar in the top ten novelty sweets was 56.8%. The amount of sugar content present in orange juice and water were at 12.1% and 0% respectively. Furthermore, five types of the most commonly available novelty sweets did not provide any details about the amount of the sugar content on the labels. These were Push Pop, Mega Mouth, Juicy Drop (Pop and Syrup), Big Baby (Pop and Powder) and Toxic Waste. The results showed the measured sugar content was 0.75% (Brain Blasterz) to 30.2% (Vimto Candy Spray) higher than the labelled sugar content by the manufacturers.

The results of the sugar contents measurements with labelled amount of sugar content by the manufacturers are presented in Table 18 and Figure 71. The raw data is presented in Appendix 30.

Table 17. Sugar content of the tested novelty sweets.

Material	Labelled amount of sugar	Measured Sugar Content (N=10)	SD
Big Baby (Pop)	-	65.40%	0.43
Big Baby (Powder)	-	68.15%	0.22
Brain Blasterz	70%	70.75%	0.33
Brain Licker	50%	63.60%	0.37
Juicy Drop (Pop)	-	65.30%	0.60
Juicy Drop (Syrup)	-	73.75%	0.33
Lickedy Lips	50%	63.55%	0.47
Mega Mouth	-	55.30%	0.40
Push Pop	-	71.20%	0.84
Tango	1.80%	31.30%	0.45
Toxic Waste	-	61.30%	0.78
Vimto	1.80%	32.00%	0.53
Water	-	0%	0
Orange Juice (Tropicana smooth)	10%	12.10%	0.22



	Water	Orange Juice (Tropicana smooth)	Tango	Vimto	Mega Mouth	Toxic Waste	Lickedy Lips	Brain Licker	Juicy Drop (pop)	Big Baby (Lollipop)	Big Baby (powder)	Brain Blasterz	Push Pop	Juicy Drop(syrup)
% of Sugar Content	0%	12.10%	31.30%	32%	55.30%	61.30%	63.55%	63.60%	65.30%	65.40%	68.15%	70.75%	71.20%	73.75%

Figure 70. Sugar content of the tested novelty sweets.

4.4.8 Enamel erosion tests

In this part of the study, the erosive potential of the most commonly available novelty sweets was assessed by measuring the surface and subsurface enamel loss using a surfometer.

When enamel is exposed to dietary acid this causes an almost immediate loss of surface enamel, while the softened enamel below may remineralises over 1-2 hours (Jaeggi and Lussi 1999). The extent of the subsurface enamel softening can be assessed by ultrasonicating the enamel specimens following the surface enamel loss using method of Esinberger *et al.* (2000).

The potential protective effect of the saliva was also assessed by having an additional group of enamel specimens. These specimens were initially treated by saliva before the surface and subsurface enamel erosion testing was undertaken.

4.4.8.1 Saliva collection

Stimulated neutral saliva was collected from the researcher (AA) using paraffin wax provided in the saliva-check kit (GC Europe N.V., Leuven, Belgium). The age of the researcher (subject) at the time of saliva collection was 34 years. The saliva sample was collected in the morning between 10:00am and 12:00pm.

4.4.8.1.1.1 Subject's criteria

1- Clear from systemic diseases or any drugs to manage systematic disease.

2- Non- smoker.

3- No acute or chronic diseases involving the salivary glands.

4- No signs or symptoms of “oral dryness” or “oral burning”.

5- Age range of 20 to 40 years.

6- Does not consume alcohol.

7- No previous exposure to radiation therapy to the head or neck region.

Prior to saliva collection, the subject had refrained from eating or drinking for at least 1 hour.

Saliva was collected in the late morning (between 10:00am-12:00pm) and collected saliva samples were stored in a water bath at body temperature.

The salivary pH and buffer capacity of the collected saliva was checked using the saliva-check kit (GC Europe N.V., Leuven, Belgium). The pH of the saliva used was 7.6 while the buffer capacity was normal/high (Figures 72-74).

Figure 71. Saliva-check kit.

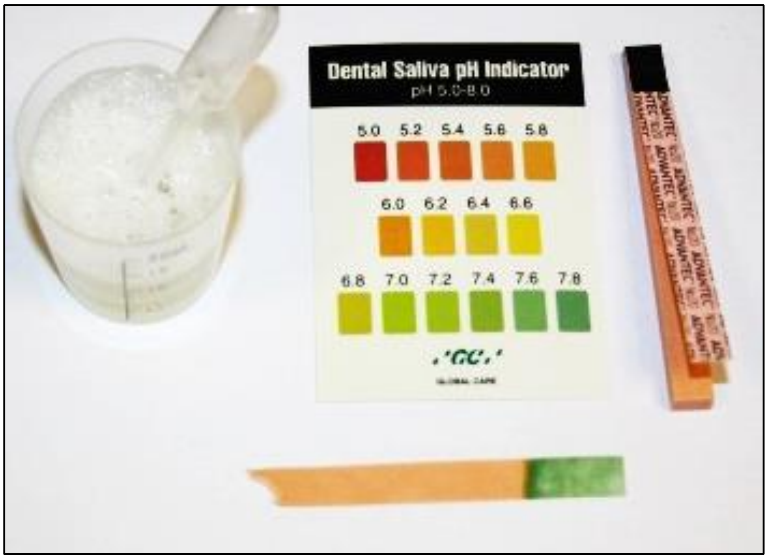


Figure 72. The pH of the used neutral saliva.

Figure 73. The buffer capacity of the used neutral saliva.

4.4.8.2 Preparation of enamel specimens

Enamel specimens were prepared from human teeth provided by the tooth bank, Cardiff University as previously described in Section (4.2.2).

The test groups included the 10 test sweets but two sweets had both solid and syrup components which were tested separately thus giving a total sweets' sample size of 12.

The surfometer (Mitutoyo, surftest-SV2000, Mitutoyo America, USA) was calibrated using a known metal surface reading which was supplied by the manufacturer with the surfometer.

Following initial light polishing to create a flat surface and three baseline readings were taken (Reading 1) for each enamel sample using a contact surfometer (Figure 75 and Figure 76). The average baseline measurement was calculated. Enamel surface were allocated to each test group as previously mentioned in section (4.2.2).

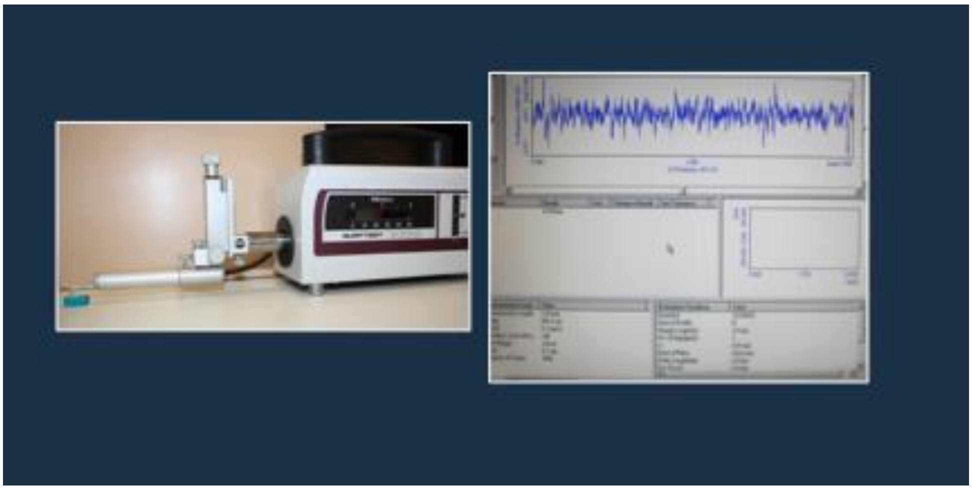


Figure 74. Taking baseline readings using the surfometer.

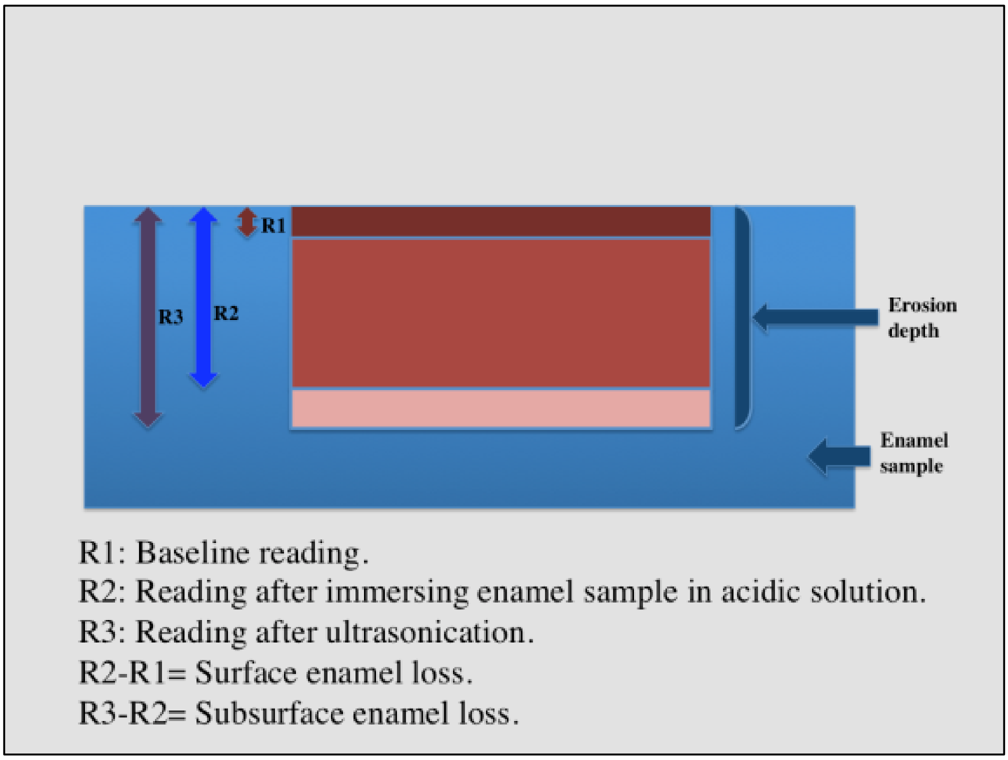


Figure 75. Different readings of the erosion test taken by the surfometer.

4.4.8.3 Surface enamel loss

4.4.8.3.1 Methodology

The enamel specimens were taped using PVC (Polyvinyl Chloride) tape (Henleys Medical supplies, Hertfordshire, UK) to expose a central window so that 2mm window of enamel sample was exposed as shown in Figure 77 below.

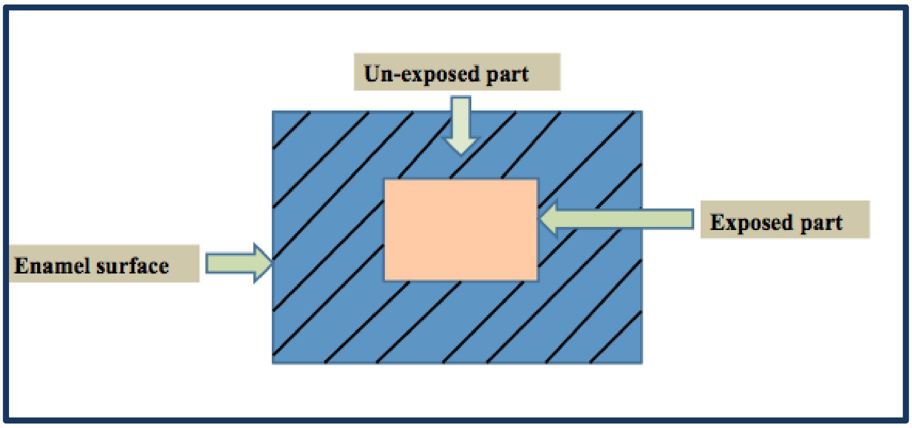


Figure 76. The figure shows the exposed and unexposed parts of the enamel surface.

For each tested sweet and control groups, enamel samples were divided into two groups with ten enamel samples in each group. One group of ten enamel specimens (Group A) were immersed in natural saliva (collected from the researcher) for 1 hour in a water bath set at 37^{o}C, before immersing them in each sweet solution for 1 hour to assess the effect of saliva pre-treatment on the amount of enamel loss.

A second (Group B) was exposed to 70 ml of a sweet solution for 1 hour without immersing in saliva. For both groups, the glass beaker placed in a thermostatically controlled water bath at 37 degrees C with a magnetic stirrer (Figure 78).

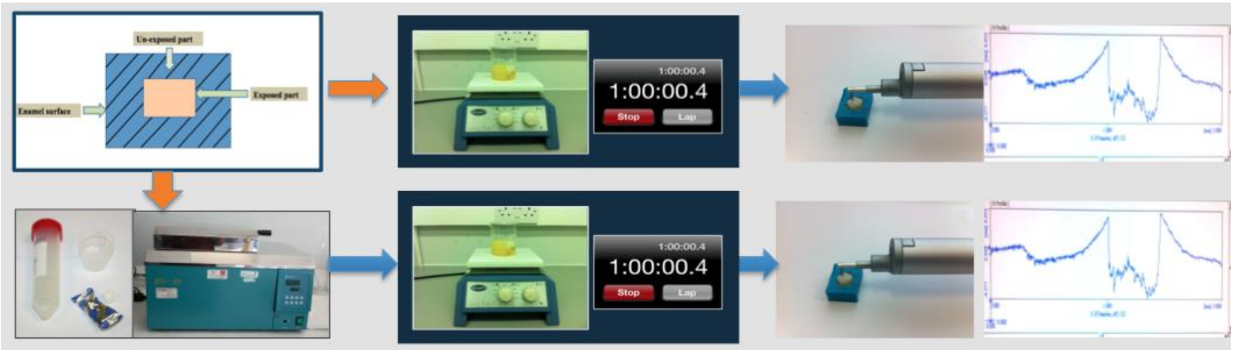


Figure 77. Surface erosion test. Group A: immersing enamel samples in saliva for 1 hour then acidic solution for another 1 hour then measured by surfometer, Group B: Immersing enamel samples in solution for 1 hour then measured by surfometer.

Following exposure, samples were washed with distilled water, dried and the surface profiles of the exposed surface measured using surface profilometery and compared to pre-exposure baseline measurements. The value measured by the surfometer is the average of both erosion depth and roughness of the exposed surface (Figure 79).

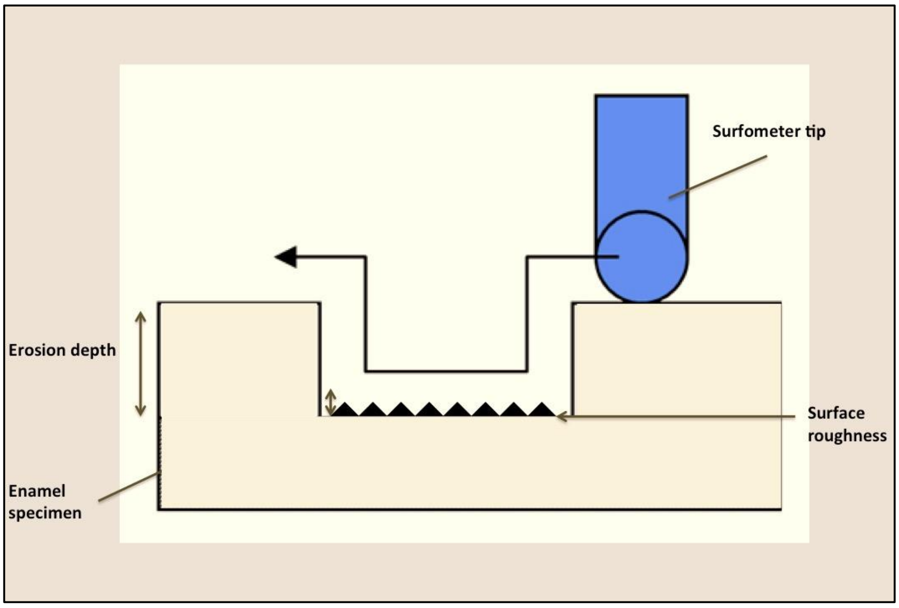


Figure 78. The measured values by surfometer.

Surface enamel loss (Reading 2) (Figure 76) in both groups (A and B) was assessed using the contact surfometer using the method of West *et al.* (1998). The total surface enamel loss was calculated by deducting the baseline reading (R1) from the post-exposure reading (R2).

4.4.8.3.2 Results of surface erosion test

Surface enamel loss caused by novelty sweets ranged from 2.5 – 17.64 μm. Using Analysis of Variance followed by Tukey's test with statistical significance set at $p<0.05$, the erosion caused by six novelty sweets (in both Group A and Group B) was statistically significantly higher than the erosion caused by orange juice (positive control) ($P<0.05$). These novelty sweets were Toxic Waste, Vimto Candy Spray, Tango Candy Spray, Brain Blasterz, Big Baby Pop, Juicy Drop Pop (highlighted in red colour in Table 20). Surface enamel loss caused by novelty sweets after initial placement of enamel specimens in saliva in saliva (1h) then in the sweet solution (1h) were slightly lower and ranged from 1.95-15.77 μm. A pre-treatment cycle using saliva reduced surface enamel loss by 0.34-1.87 μm.

Furthermore, there was no statistical significant difference between amount of surface enamel loss with enamel samples initially placed in saliva for one hour and amount of surface enamel loss without immersing the samples in the saliva of all groups ($p>0.05$).

The amount of enamel surface loss in μm of the both groups, group A when initially placed in saliva for one hour prior to immersing them for another hour in acidic solution and group B with immediate immersing of enamel samples in acidic solutions for 1h are presented in Table 19 and Figures 80 -82. The raw data of surface erosion is presented in Appendix 31 and Appendix 32.

Table 18. Total surface enamel loss with initial placement in saliva (Group A) and without initial placement in saliva (Group B) in µm. Values in red are enamel loss statistically significantly more than the amount removed by orange juice ($p<0.05$).

Material	Surface E loss with initial placement in saliva for 1 hour (in µm)	Surface E loss without Initial placement in Saliva for 1 hour (in µm)
Big Baby (Pop)	7.85	8.78
Big Baby (powder)	4.30	4.92
Brain Blasterz	12.56	13.75
Brain Licker	2.71	3.06
Juicy drop (Pop)	7.12	7.84
Juicy drop (Syrup)	2.68	3.30
Lickedy Lips	1.95	2.50
Mega Mouth	4.84	5.90
Push Pop	2.80	3.65
Tango	7.63	8.96
Toxic Waste	15.77	17.64
Vimto	9.30	10.46
Water	0.017	0.03
Orange Juice	3.62	4.75

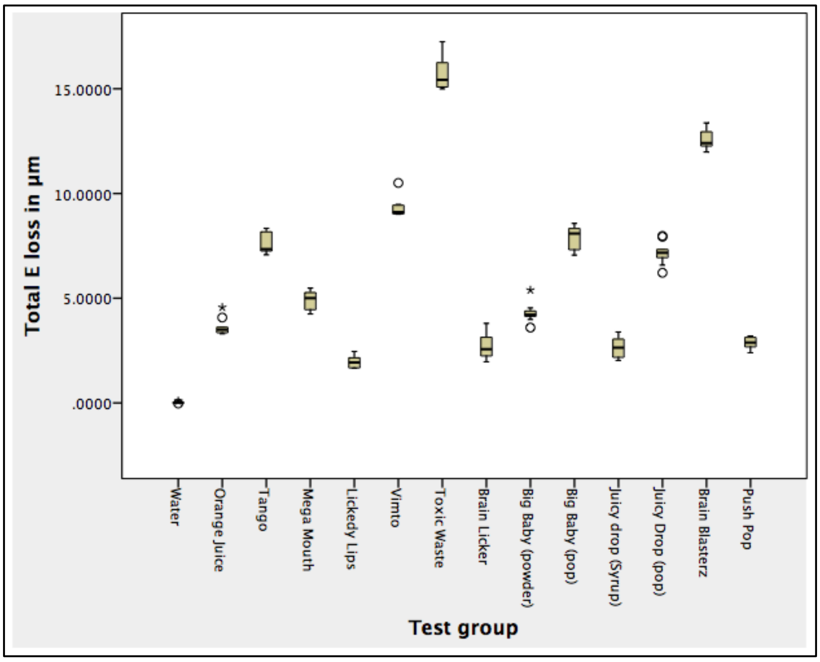


Figure 79. Total surface enamel loss in test groups with initial placement in saliva (Group A).

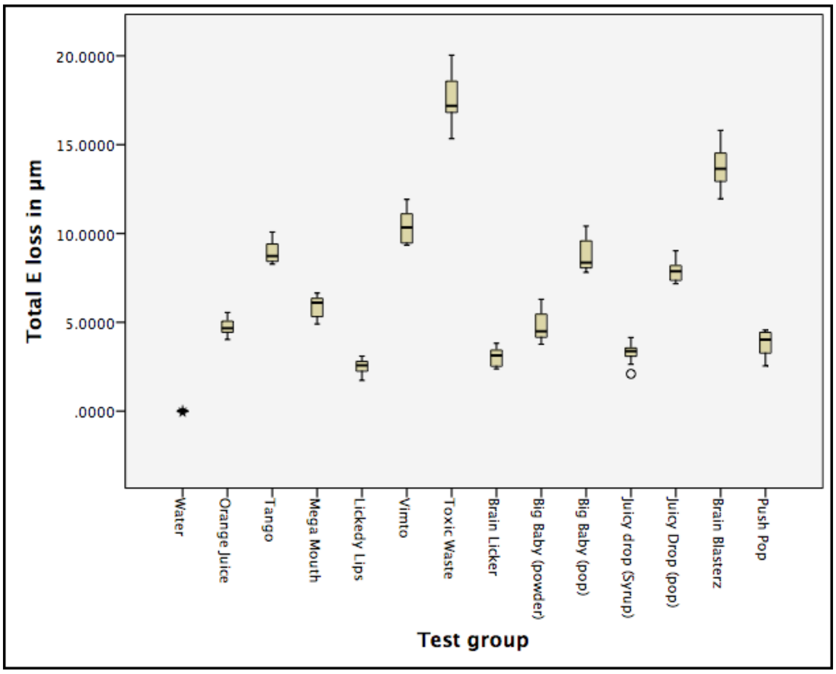
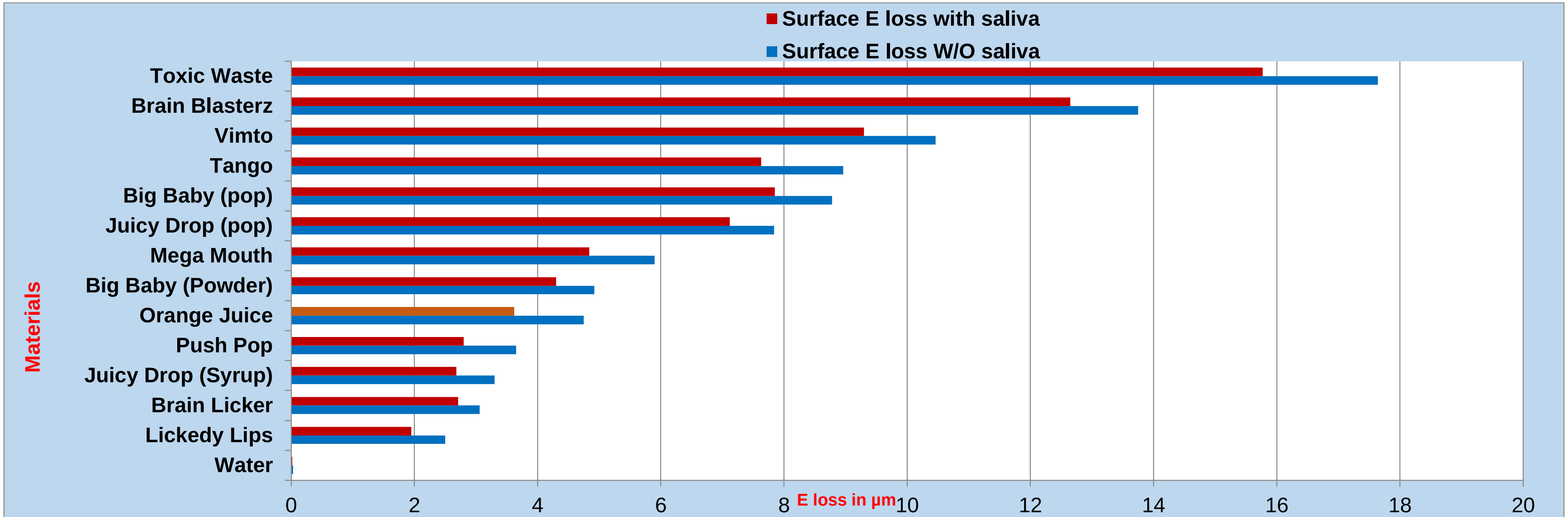


Figure 80. Total surface enamel loss in test groups without initial placement in saliva (Group B).

These boxplot figures above show the differences between pre-treatment and post-treatment surface enamel loss value by acidic solutions of the ten samples in Group A (with initial placement in saliva) in Figure 80 and group B (without initial in placement in saliva) in Figure 81. A box encloses the middle 50 percent, where the median drawn as a horizontal line inside the box. The vertical lines (also known as whiskers, extend from each end of the box. The lower whisker is drawn from the lower quartile to the smallest point within 1.5 inter-quartile ranges. The other whisker is drawn from the upper quartile to the largest point within 1.5 interquartile ranges from the upper quartile. The outliers are presented by stars (*) and circles (o). Since the data is not normally distributed, the results are shown using a boxplot.

- The figures above (Group A and Group B) show that the differences in average pre-immersing to post-immersing surface enamel loss value for six sweet types were statistically significantly higher than that of the control (i.e., orange juice) ($p<0.05$).
- The average amount of total surface enamel loss value for each sweet in group A (with initial placement in saliva) were slightly lower than the average amount of total enamel loss in group B (without initial placement in saliva) but not statistically significantly lower ($p>0.05$).



	Water	Lickedy Lips	Brain Licker	Juicy Drop (Syrup)	Push Pop	Orange Juice	Big Baby (Powder)	Mega Mouth	Juicy Drop (pop)	Big Baby (pop)	Tango	Vimto	Brain Blasterz	Toxic Waste
Surface E loss with saliva	0.017	1.95	2.71	2.68	2.8	3.62	4.3	4.84	7.12	7.85	7.63	9.3	12.65	15.77
Surface E loss W/O saliva	0.03	2.5	3.06	3.3	3.65	4.75	4.92	5.9	7.84	8.78	8.96	10.46	13.75	17.64

Figure 81. Total surface enamel loss with initial placement in saliva (Group A) and without initial placement in saliva (Group B).

4.4.8.4 Subsurface enamel loss

As previously mentioned, when enamel is exposed to dietary acid this causes an almost immediate loss of surface enamel, while the enamel below this is softened and remineralises slowly. Furthermore, this subsurface softened layer can be easily removed by toothbrushing (Jaeggi and Lussi 1999).

The extent of subsurface softening was assessed by ultrasonicating the enamel specimens after exposure to the test sweets following the method of Eisenburger *et al.* (2000).

4.4.8.4.1 Methodology

The enamel samples were placed in saliva in 37°C water bath for one hour immediately after having the amount of surface enamel loss using surfometer and before ultrasonication for 30 seconds using 100W power at 38 kHz. Group B, on the other hand, was placed immediately in an ultrasonic bath for 30 seconds using 100W at 38 kHz at 0 minute after immersing in acidic solutions and having the amount of surface enamel loss using the surfometer.

After measuring the amount of enamel loss (Reading 2), the ten enamel specimens in group A were placed in natural saliva for 1 hour to assess the effect of saliva on the sub-surface enamel loss. Then, they were placed in the ultrasonic bath at 37ºC for 30 seconds. Then, the amount of subsurface loss was measured using the contact surfometer (Reading 3).

The ten enamel specimens in group B were placed in the ultrasonic bath at 37ºC for 30 seconds immediately after immersing them in the sweet solution and measuring the amount of enamel loss using the contact surfometer (Reading 2). Then, the amount of subsurface loss was measured using the contact surfometer (Reading 3) (Figure 83).

The total amount of subsurface enamel loss was calculated by deducting reading 2 (R2) from reading 3 (R3) (Figure 84).

Figure 82. Subsuraface erosion test. Group A: immersing enamel samples in saliva for 1 hour then ultrasonication for 30 seconds then measured by surfometer, Group B: Immediate ultrasonication for 30 seconds then measured by surfometer.

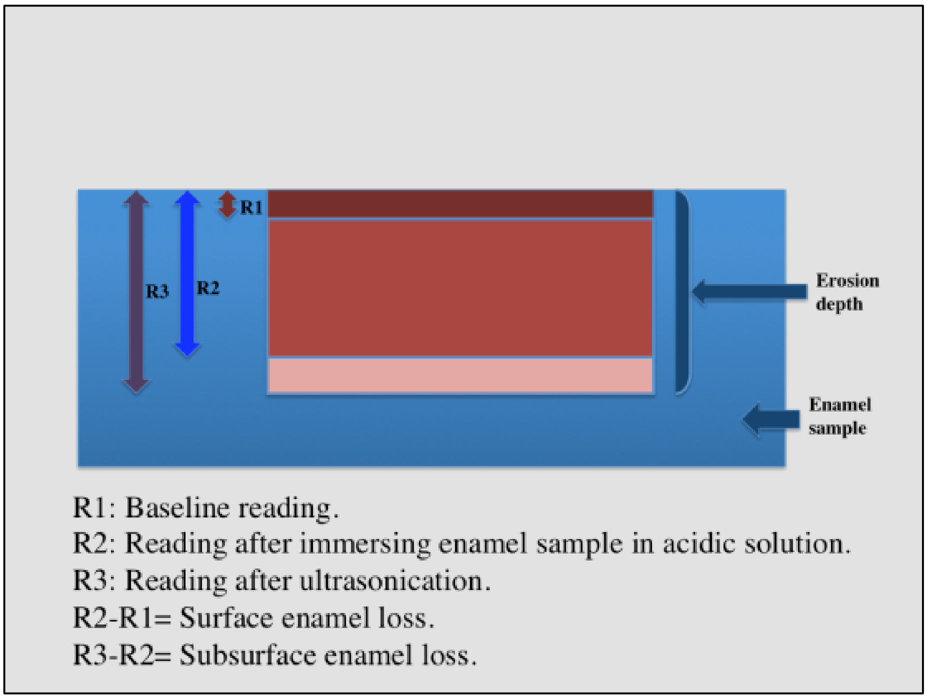


Figure 83. Different readings of the erosion test taken by the surfometer.

4.4.8.4.2 Results of subsurface erosion test

The amount of subsurface enamel loss caused by the tested novelty sweets after 1 hour together with immersing in saliva prior to ultrasonication for 30 seconds ranged from 0.23-0.85 μm (Group A). The amount of subsurface enamel loss caused by the novelty sweets with immediate ultrasonication (without immersing in saliva) ranged from 0.75-2.3 μm.

The means subsurface enamel loss in Group A with initial placement of enamel samples in saliva after the immersing of samples in sweet solutions and prior to the ultrasonication and Group B with immediate ultrasonication caused by six test sweet (highlighted in red colour in Table 21) were statistically significantly higher than the mean subsurface enamel loss caused by the orange juice ($p<0.05$). These novelty sweets were Brain Blasterz, Juicy Drop Pop, Toxic Waste, Mega Mouth, Tango Candy Spray and Vimto Candy Spray.

Furthermore, the amount of subsurface enamel loss caused by the tested novelty sweets in group A (with initial placement in saliva for 1 hour prior to ultrasonication) was a statistically significantly lower than the amount of subsurface enamel loss in Group B (with immediate ultrasonication without immersing the samples in the saliva ($p< 0.05$).

The results of the two groups of sub-surface softening part of this project are presented in Table 20 and Figure 85-87 and the raw data of subsurface enamel loss is presented in Appendix 33.

Table 19. Total subsurface enamel loss with saliva (Group A) and without saliva (group B). Values in red are enamel loss statistically significantly more than the amount removed by orange juice ($p<0.05$).

Material	Subsurface E loss with saliva	Subsurface E loss w/o saliva
Big Baby (Pop)	0.34	1.21
Big Baby (Powder)	0.34	1.14
Brain Blasterz	0.81	2.15
Brain Licker	0.43	1.157
Juicy drop (Pop)	0.48	1.96
Juicy Drop (Syrup)	0.28	0.91
Lickedy Lips	0.3	0.94
Mega Mouth	0.4	1.6
Push Pop	0.23	0.75
Tango	0.39	1.72
Toxic Waste	0.85	2.3
Vimto	0.55	1.84
Water	0.027	0.028
Orange Juice	0.35	1.29

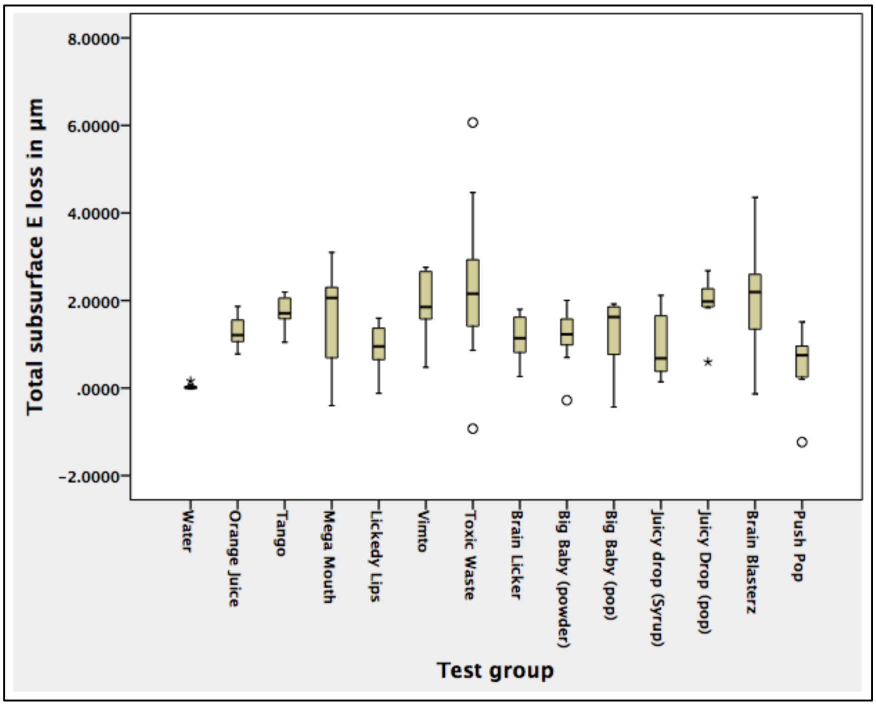


Figure 84. Total subsurface enamel loss in test groups with initial placement in saliva prior to ultrasonication (Group A).

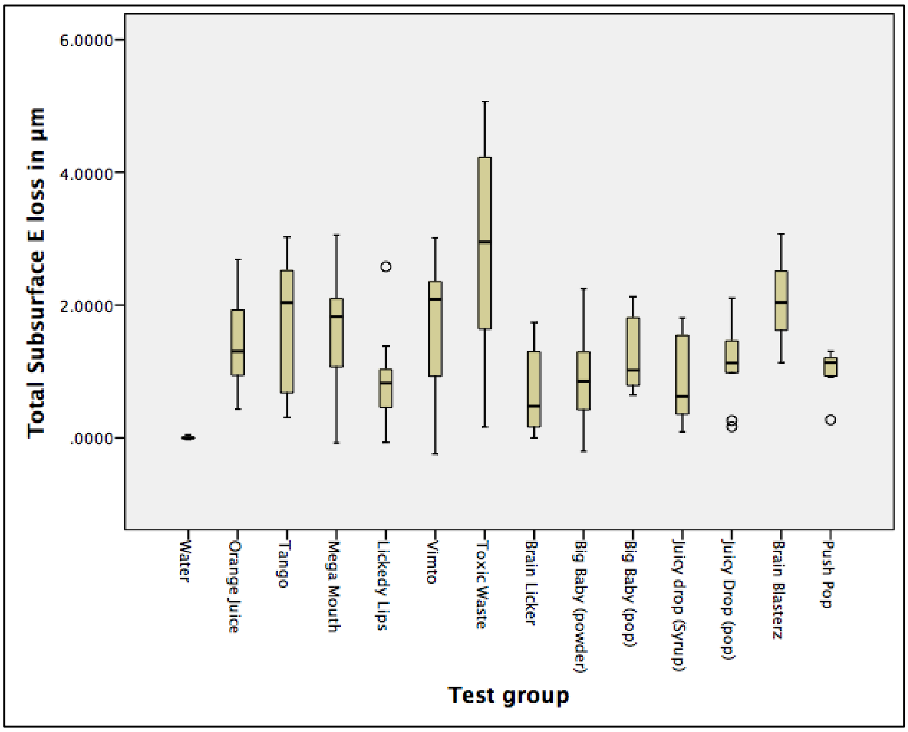


Figure 85. Total subsurface enamel loss in test groups without initial placement in saliva prior to ultrasonication (Group B).

These boxplot figures above show the differences pre-ultrasonication to post-ultrasonication subsurface enamel loss value of the ten samples in Group A (with initial placement in saliva) in Figure 85 and group B (without initial in placement in saliva) in Figure 86. A box encloses the middle 50 percent, where the median drawn as a horizontal line inside the box. The vertical lines (known also as whiskers), extend from each end of the box. The lower whisker is drawn from the lower quartile to the smallest point within 1.5 inter-quartile ranges. The other whisker is drawn from the upper quartile to the largest point within 1.5 interquartile ranges from the upper quartile. The outliers are presented by stars (*) and circles (o). Since the data is not normally distributed, the results are shown using a boxplot

- The figures above (Group A and Group B) show that the differences in average pre-ultrasonication to post-ultrasonication subsurface enamel loss value for six sweet types were statistically significantly higher than that of the control (i.e., orange juice) ($p<0.05$).

The average amount of total enamel loss value for each sweet in group A (with initial placement in saliva) were lower than the average amount of total enamel loss in group B (without initial placement in saliva) and was statistically significantly lower ($p<0.05$).

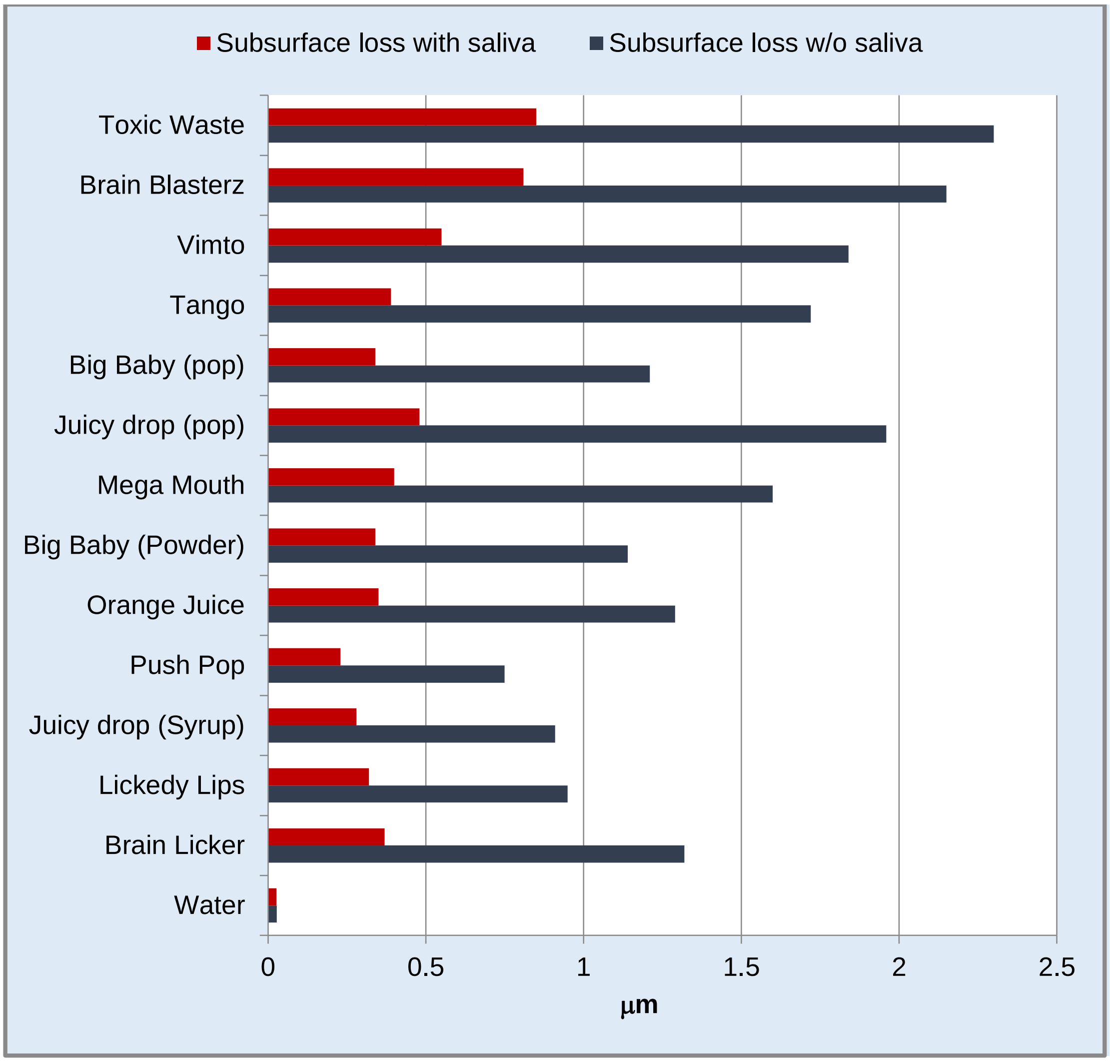


Figure 86. Total subsurface enamel loss with initial placement in saliva prior to the ultrasonication (Group A) and immediate ultrasonication without placement saliva (Group B).

A summary of the physiochemical properties and erosion test results of this study are presented in Table 21.

Table 20. The physiochemical properties and the erosive potential of the tested top ten mostly available novelty sweets.

Material	pH	Neutralisable acidity (ml NaOH)	Contact angle	Viscosity (mPa-s)	Sugar content (%)	Surface E loss with saliva (μm)	Surface E loss w/o saliva (μm)	Subsurface E loss with saliva (μm)	Subsurface E loss w/o saliva(μm)
Big Baby (pop)	3.22	10.1	76.9	-	65.4	7.85	8.78	0.34	1.21
Big Baby (powder)	2.3	10.4	84.3	-	68.15	4.3	4.92	0.34	1.14
Brain Blasterz	2.3	28.9	75.46	-	30.75	12.65	13.75	0.81	2.15
Brain Licker	1.9	48.5	96.25	66.9	63.6	2.71	3.06	0.43	1.157
Juicy drop (pop)	3.12	9.9	77.14	-	65.3	7.12	7.84	0.48	1.96
Juicy drop (Syrup)	2.24	201.3	105	594.81	73.75	2.68	3.3	0.28	0.91
Lickedy Lips	1.92	40.7	97.4	78.82	63.55	1.95	2.5	0.3	0.94
Mega Mouth	1.83	95	86.5	12.85	55.3	4.84	5.9	0.4	1.6
Push Pop	3.11	9	83.6	-	71.2	2.8	3.65	0.23	0.75
Tango	3.18	40.65	75.43	2	31.3	7.63	8.96	0.39	1.72
Toxic Waste	1.83	93.3	75.4	-	61.3	15.77	17.64	0.85	2.3
Vimto	2.43	69.7	75.22	1.78	32	9.3	10.46	0.55	1.84
Water	7	-	74.55	1	0	0.017	0.03	0.027	0.028
Orange Juice	3.7	28.3	75.745	3	12.1	3.62	4.75	0.35	1.29

4.4.9 Discussion of oral science aspects

4.4.9.1 pH values

The pH of the novelty sweets was measured to assess the erosive potential on dental enamel. The hydroxyapatite starts to dissolve if the pH on the enamel surface drops below the pH critical value of enamel dissolution (5.5) (Dawes 2003). This study found that the pH of the most common novelty sweets ranged from 1.83-3.20. It was found that the pH of Brian Licker (1.92), Toxic Waste (1.83), Lickedy Lips (1.9), Vimto Candy Spray (2.43), Brain Blasterz (2.3), Big Baby Powder (2.3), Mega Mouth (1.83) and Juicy Drop Syrup (2.24) were significantly lower than the pH of the orange juice when tested at room temperature and body temperature. The pH of the orange juice was 3.77 at room temperature and 3.81 at body temperature.

The findings of this study showed that there were no statistical significant differences in pH between all the tested novelty sweets at room and body temperature ($p>0.05$) which is consistent with the findings of Amaechi *et al.* (1999b) who found that a difference in temperature did not affect the pH of the measured acidic solutions.

These findings were comparable to the result of the study by Beeley (2005) who found that the pH of the novelty sweet she tested (Brain Licker, Juicy Drop Pop, Mega mouth and Big Baby Pop) ranged from 1.7-3.4. The results were also similar to the findings of Davies *et al.* (2008) who found that the pH of the novelty sweets ranged from 2.3-3.14 (Brain Licker, Juicy Drop Pop and Mega Mouth were common with this study). The result of this study is comparable to the findings of Robyn *et al.* (2008) who found the pH of the sour candies including some novelty sweets was ranged from 1.8 to 4 (Big Baby Pop was common with this study). The pH of Big Baby Pop was 3.22 (for the Pop) and 2.3 (for the Powder) in this study compared to 2.5 in the findings of Robyn *et al.* (2008).

The results are similar to the study of Gambon *et al.* (2009) that found that the pH of different flavours of Mega mouth candy spray ranged from 1.9-2.3. This is almost identical to the finding of this study (1.83-1.95 of the pH for Mega Mouth Spray). The findings of this study are also comparable to the findings of Wagoner *et al*. (2009) who found that the pH of the sour candies ranged from 2.47 to 3.7.

The pH of nine of the tested sweets out of the ten were also below the critical pH value (5.5) for enamel erosion below which hydroxyapatite may dissolve (Larsen and Nyvad 1999; Dawes 2003; Shellis and Wilson 2004). This means that the repeated consumption of such types of sweets may initiate erosive tooth surface loss.

4.4.9.2 Neutralisable acidity

The erosive potential does not exclusively depend on the pH of the novelty sweets, but it also depends on their neutralisable acidity. The greater the neutralisable acidity, the longer it takes for the saliva to neutralise it (Zero and Lussi 2005b). The data from the present study shows that the neutralisable acidity of 20 ml of the most common novelty sweets was from 9.1-201ml of 0.1M NaOH was needed to reach a pH of 7 at room temperature and from 9.23-202.3 ml NaOH at body temperature. It was also found that the neutralisable acidity of Toxic Waste, Lickedy lips, Vimto candy spray, Tango candy spray, Brain Licker, Juicy drop (Syrup) and Mega Mouth was significantly higher than the neutralisable acidity of the orange juice when tested at room temperature and body temperature. The neutralisable acidity of the orange juice was 28.3 ml and 28.4 of 0.1M NaOH at room temperature and body temperature respectively.

These findings are comparable to the result of the study of Davies *et al.* (2008) which found that the neutralisable acidity of the tested novelty sweets range from 9.78 – 77ml of 0.1 NaOH and the neutralisable acidity of orange juice was 37.1 ml of 0.1 NaOH. The neutralisable acidity of Juicy Drop Pop was 10 ml for the pop and 201 for the syrup NaOH (this study) and 66 ml NaOH (Davies et al. 2008), Mega Mouth was 95 ml NAOH (this study) and 45.3 ml NaOH (Davies et al. 2008) and Brain Licker was 48.5 ml NAOH (this study) and 49 ml NaOH (Davies et al. 2008). The difference in the neutralisable acidity of Juicy Drop Pop may be explained by testing the pop and syrup of Juicy Drop Pop separately in this study, while in the study of Davies *et al.* (2008) both together. The difference in the neutralisable acidity of Mega Mouth between this study and the study of Davies *et al.* (2008) may be explained by possible a change in the formula of these sweets between 2008 and the time of assessment of these sweets. In this study, no change seems to be done in the formula of Brain Licker, as the neutralisable acidity in both studies was the same.

The resulting range of neutralisable acidity values suggests strongly that most of novelty sweet tested can potentially cause a drop in intra-oral pH considerably which could cause clinically significant erosion (Lussi and Jaeggi 2008).

4.4.9.3 Viscosity and contact angle

The viscosity and contact angle between of the top ten novelty sweets and enamel surface were measured to assess the wettability of enamel and subsequent diffusion into the enamel surface and cause enamel dissolution (Ireland et al. 1995; Aykut-Yetkiner et al. 2013). The findings of this study showed that the higher the contact angle values were of novelty sweets, the lower the wettability of enamel surface and therefore potentially less amount of enamel loss even. For example, the contact angle between the Juicy Drop Syrup and enamel surface was 105 degrees (higher than orange juice at 75.7 degrees) and the viscosity was 594 mPa-s (higher than orange juice which was 3 mPa-s), but caused significantly less amount of surface enamel loss 3.3 μm (less than orange juice 4.75 μm). The pH of the Juice Drop Syrup was 2.24 (lower than the orange juice 3.7) and the neutralisable acidity was 201 ml NaOH (higher than orange juice 28.3 ml NaOH).

These findings showed that the viscosity of novelty sweets' solutions and the contact angle with enamel surface by these sweets were potentially important determinants of the amount of enamel loss. This finding is consistent with the finding of Aykut-Yetkiner (2013) who found that the amount of enamel loss was dependent on the viscosity of the acidic solutions not only its chemical properties. This finding is also consistent with the finding of Ireland *et al.* (1995) who found that the wettability of the enamel surface affected the amount of enamel loss which resulted in longer enamel exposure to acidic solution.

4.4.9.4 Sugar content

The sugar content of novelty sweets was measured to assess the potential of these sweets in developing dental caries and obesity in children as they may contain high level of free sugars. The actual amount of sugar in the labels does not always reflects the exact amount of sugar (Walker et al. 2014). The results of this study showed that all the novelty sweets had high percentages of sugar content (30-73%) (Average at 56.8%). The finding of this study is comparable to the findings of Walker and Goran (2015) who found that the average amount of the sugar contents of 100 of the analysed common food items marketed to children was 74%. They also found that the majority of analysed products had sugar contents either more or less than the labelled amount. Furthermore, the finding of this study is also comparable with the finding of Ventura *et al.* (2011) who found that the sugar contents of the acid beverages ranged from 47-65%. Worryingly, the findings of this study showed that 50% of the most commonly available novelty sweets were without labelled amount of sugar; making the control of free sugars consumption within the recommended amount for children (5%) (Scientific Advisory Committee on Nutrition, 2015) particularly children at risk of obesity and dental caries challenging.

The findings of this study showed that children consuming novelty sweets are exposed to very high amount of free sugars which puts children who consume them at high risk of dental caries (Burt and Pai 2001; Moynihan and Kelly 2014) and obesity (Te Morenga et al. 2013). Furthermore, it showed that it is very challenging to maintain the recommended amount of consumed free sugar within the dietary energy recommendation (5%) for children (Scientific Advisory Committee on Nutrition 2015) if these products are consumed regularly.

Although the measurement of the sugar content in this study did not provide the exact types of sugar in the novelty sweets, it provided new information about the sugar content of the most commonly available novelty sweets to children. Furthermore, the sugar measured in the novelty sweets is categorised as a free sugars, which is vital to know their content in food consumed by children.

4.4.9.5 Enamel erosion tests

The erosion tests were undertaken *in vitro* in terms of surface and subsurface enamel loss to assess the ability of the novelty sweets in causing dental erosion clinically. The findings of the present study show that the surface enamel loss caused by six of the novelty sweets tested was statistically significantly more than the enamel loss caused by the orange juice ($p<0.05$). The amount of enamel loss caused by Toxic Waste, Vimto Candy Spray, Tango Candy Spray, Brain Blasterz, Big Baby Pop, and Juicy Drop Pop was significantly different than the enamel loss caused by orange juice.

These findings were consistent with the findings of a previous study which included one or more types of the tested novelty sweets in this study (Davies et al. 2008). There were three common novelty sweets between this study and the study of Davies *et al.* (2008). The amount of surface enamel loss caused by Juicy Drop Pop, Mega Mouth and Brain Licker in this study is comparable to the amount of enamel loss caused by the same sweet in the study of Davies *et al.* (2008). The amount of surface enamel loss caused by Juicy Drop Pop was 3.3 μm (this study) and 2.16 μm (Davies et al 2008), Mega Mouth was 5.9 μm (this study) and 5.71 μm (Davies et al 2008) and Brain Licker was 3.06 μm (this study and 2.85 μm (Davies et al 2008).

The results of the surface erosion tests showed that the mean amount of surface enamel removed by orange juice was 4.75 μm. The greatest amount of enamel removed was by Toxic Waste at 17.64 μm, while the least amount of surface enamel removed was by Brain Licker at 2.5 μm.

The results of this study showed that the amount of enamel loss caused by the orange juice was 4.75 μm. This was close to the findings of Davies *et al.* (2008) [5.27 μm], Rees *et al.* (2007) [3.24 μm], Phelan and Rees (2003) [5.2 μm], Hunter *et al.* (2009) [5.3 μm] and Rees *et al.* (2007) [3.2 μm].

It was found in this study that amount of enamel loss was not directly correlated with the pH and neutralisable acidity values. This is a common finding reported by previous workers such as Davies *et al.* (2008) and Ehlen *et al.* (2008).

The results of this study also showed that there was no significant effect of saliva on the amount of surface enamel loss ($p>0.05$), but it did significantly reduce the subsurface enamel loss ($p<0.05$). Thus, the findings of this study also showed that the saliva confers a protective function against the subsurface dental erosion. The result found that the saliva significantly reduced the amount of subsurface enamel loss if enamel specimens were placed in saliva for 1 hour prior to erosion testing. The placement of enamel sample in saliva reduced the subsurface amount of enamel loss from 0.75-2.3 μm (without placement in saliva) to 0.23-0.82 μm (with placement in saliva). This finding suggests that delayed tooth brushing for 1 hour may allow the softened subsurface enamel to remineralise.

This is consistent with a study of Jaeggi and Lussi (1999) and Hemingway *et al.* (2006) who found that the subsurface enamel loss caused by tooth brushing depended on the duration of time between enamel erosion and tooth brushing with an estimated time for enamel remineralisation ranged from 30-60 minutes.

The result of this study also showed that there was not significant difference between the amount of surface enamel loss caused by novelty sweets with initial placement of enamel samples in saliva for one hour and without placement ($p>0.05$). This finding may be explained by the possibility that there was no enough time for saliva to form an acquired pellicle or the formed pellicle was thin and did not make a significant protection from surface enamel loss. This finding is consistent with a study of Nekrashevych *et al.* (2004) who found that dental pellicle formed by placing enamel samples in saliva reduced the surface enamel loss by organic acids but it was not significantly reduced. Furthermore, at low pH, the inorganic acids such as citric acid are complex acids which provide protons which directly attack the mineral surface. This means that dissolution effects of inorganic acid is very destructive and may progress even after the pH at the tooth surface has recovered (Jarvinen et al. 1991; Hunter et al. 2008).

For example, citric acid is clinically used for root conditioning in surgical periodontal therapy for demineralisation debris resulted from mechanical root surface debridement (Soares et al. 2010; Cavassim et al. 2012; Prasad et al. 2012). Furthermore, citric acid and malic acid are also used to remove the smear layer during the root canal treatment (Sousa and Silva 2005; Bonsor et al. 2006; Arslan et al. 2014; Kandil et al. 2014).

The acquired pellicle formed by the adherence of a protein–based layer to the outer surface of the teeth seems to protect against erosion by forming a diffusion barrier and preventing direct acid-tooth contact, thus reducing the dissolution rate of hydroxyapatite (Hannig and Balz 2001). This protection depends mainly on the composition, thickness and maturation time of the pellicle. The studies have shown that there is an inverse relation between the thickness of the acquired salivary pellicle and the effect of erosive ability of the acids (Amaechi et al. 1999c).

Discussion

5 Overall discussion of this study

This study was conducted to obtain qualitative and quantitative data about the public health implications of novelty sweets in children.

The data obtained in the first stage of this study provided better understanding and filled the gap in knowledge about the availability and marketing criteria of novelty sweets. Factors that may affect the children's purchasing decisions were also assessed in this part. Furthermore, qualitative data obtained by conducting this study assessed children's understanding and beliefs about novelty sweets, which reflected the familiarity of these sweets amongst children.

The sociological part of this study provided qualitative data to explore any potential link between the children's sensory taste thresholds and consumption of novelty sweets. Data provided in this part can be used to understand the sensory taste element behind the consumption of novelty sweets and can be used as a basis for further research.

The oral science part of the study was carried out to obtain quantitative data concerning the physiochemical properties of the novelty sweets in relation to their erosive potential, ability to cause dental caries and development of obesity. Furthermore, qualitative data about the early stage of *in vitro* surface enamel loss and later stage of subsurface enamel softening was also obtained in this part of this study. This data could be used not only to determine the destructive effects of the novelty sweets on enamel, but also to provide better understanding of the diffusion and demineralisation processes of dental enamel and the influence of saliva on these processes.

It was found in results of this study that the novelty sweets were widely available and accessible to children in local shops close to schools, shops in the city centre and supermarkets. The availability of products with high sugar content in the school fringe readily available to children was also observed by other workers such as Sinclair and Winkler (2009) and Crawford *et al.* (2012). The findings of this study showed that there was a wide range of various unique types (n=38) of novelty sweets available in the market with affordable prices for children (10p-£2.99). Worryingly, this finding showed that children can access a wide range of products with "free" sugars as a dietary source of energy. The wide availability, accessibility and affordability of these sweets makes the dietary recommendation of limiting the children's consumption of food with "free" sugars to less than 5% extremely challenging (Scientific Advisory Committee on Nutrition 2015).

It was also reported in this study that there was a direct relationship between availability of novelty sweets and deprivation level. This finding confirmed the findings of previous studies which showed that sugar is available as a low cost energy source (Drewnowski 2012). It also showed that the availability of such types of sweets could act as a factor within the strongly documented relationship between socio-economic level, oral health and obesity (Drewnowski and Darmon 2005; Law et al. 2007).

Worryingly, in the UK, the reported figures of children in families with relative and absolute low income After Housing Cost (AHC) in 2013/14 were 2.3 million (21%) and 2.6 million (23%) respectively. Furthermore, 37% of children were reported to be in workless families in the UK (National statistics 2014). These children from a low socio-economic status household are at a high risk of experiencing non-communicable diseases including dental erosion, dental caries and obesity.

It is important to mention that at the time of undertaking the scoping study to identify the most commonly available novelty sweets in relation to different levels of deprivation in Cardiff, the most recent WIMD was WIMD 2011. However, WIMD 2014 was released in December 2015 (after undertaking the scoping study). It was reported that a very minimal changes identified between WIMD 2011 and WIMD 2014. It was reported that relatively few of the LSOAs move between WIMD deciles (less than 5%) with no LSOAs moved by more than one decile. This change is suggested to be very minimal and does not affect distribution of the deprivation areas in Cardiff (WIMD 2014).

This study also provided qualitative data addressing the familiarity of novelty sweets amongst children. The finding showed that children like them, purchase and consume them regularly. This finding is consistent with the finding of Stewart *et al.* (2013) who also found that children were familiar and regularly consumed novelty sweets.

The findings of this study also found that children were attracted to the novelty sweets for various reasons. These reasons included the sweet and sour taste, affordability, accessibility and way of eating them (e.g. lollipop, spray, etc.). Furthermore, children were also attracted by the visual presentation of these sweets in terms of colour and packaging.

This data about children's familiarity of novelty sweets, factors attracting children to buy and consume them is vital to assess the sophisticated marketing of products to children particularly these types of sweet. The understanding of the marketing aspects of these sweets would help in initiating an action plan in limiting the availability and accessibility of these sweets to children.

The results of this study also showed that there was a high influence of peers and friends on purchasing and consumption of novelty sweets. Furthermore, it was found that some children sold novelty sweets at school which showed that schools were used as a “black market” to sell unhealthy food with high free sugars content.

In this study, the sensory taste thresholds for sweet and sour in children was assessed to explore any link between the sensory taste threshold and consumption of novelty sweets. The finding of this study showed that the vast majority of children had low sensitivity to sweet and sour tastes and needed high amounts of sugar and citric acid to recognise the tastes. This showed that the majority of children had high sensory thresholds for sweet and sour. Furthermore, the finding of this study also showed that there was a significant association between the liking of sweet and sour tastes and high sensory taste thresholds for sweet and sour taste. This may show that children who like the novelty sweets need to consume high amount of novelty sweet to sense and enjoy the novelty sweet. A study by Wendell *et al.* (2010) suggested that there is an influence of genetic variations on taste preference and dietary habit which is significantly associated with high caries susceptibility or resistance.

The assessment of sensory testing in this study was undertaken in subjects without assessment of their general and oral health conditions. This made linking the sensory taste thresholds to the general oral health impossible. However, the main aim of this work was to assess the link between the sensory taste thresholds and novelty sweet consumption in children. Furthermore, linking the sensory taste thresholds and consumption of subjects participating in the sensory work to the deprivation level was not undertaken. As the participating subjects were recruited by the Cardiff Metropolitan University as a part of a previously established open day programme hosted by the Cardiff Metropolitan University (CMU), it was difficult to track from which WIMD area each subject came from.

The data of this part of the study may provide better understanding to initiate a public health plan to assess the taste threshold in children experiencing dental erosion, dental caries and obesity. Therefore, a big public health programme needs to be initiated to elevate adults' awareness especially those working in prevention of oral and public health problems.

The assessment of the physiochemical properties of the top ten most commonly available novelty sweets identified in the first stage of this study was carried out *in vitro*. The findings of this study showed that the tested novelty sweets had pH lower than the critical pH value of enamel dissolution (5.5) with nine sweets statistically significantly lower ($p<0.05$). Furthermore, the pH of eight of them was statistically significantly lower than the pH of orange juice (3.7) ($p<0.05$). The neutralisable acidity of seven tested novelty sweets was statistically significantly higher than the orange juice. These finding were comparable to the findings of previous authors who tested the pH and neutralisable acidity of common types of novelty sweets, some of which were also tested in this study (Beeley 2005; Davies et al. 2008; Gambon 2009). These findings confirming the high ability of the novelty sweets in causing enamel dissolution.

Additionally, the erosive potential of the top ten most commonly available novelty sweets was also assessed by measuring the contact angle between the acidic solution of novelty sweet and the enamel surface. Furthermore, the viscosity of the novelty sweets was also measured. The contact angle and viscosity reflects the level of wettability of enamel surface and subsequent diffusion and dissolution. The data showed that the viscosity and contact angle between enamel surface and sweet solution were indirectly related to the amount of enamel loss. It was found that four of the novelty sweets had a contact angle smaller than orange juice (but not statistically smaller, $p<0.05$). These findings showed that the ten most commonly available novelty sweets had a high potential to cause wettability of enamel surface and enamel loss. Ireland *et al.* (1995) found that the wettability of the enamel was indirectly related to the contact angle.

Four types of the novelty sweets tested were statistically significantly more viscous than the orange juice ($p<0.05$). This finding reflected the lower ability of some types (the high viscous types) of novelty sweets in causing high wettability of enamel surface and enamel loss. It was found by Aykut-Yetkiner (2013) that viscosity of acidic solutions was one of the determinants of the enamel loss (indirect relationship). However, the novelty sweets with high viscosity measured *in vitro* might not have the same low erosive effect clinically as the other factors need to be considered particularly saliva. Saliva may reduce the viscosity causing high diffusion before it neutralises the pH. Novelty sweets with high viscosity had high neutralisable acidity which required longer time for the saliva to neutralise the pH (Zero and Lussi 2005b).

This is the first study to assess the wettability of enamel surface by measuring the contact angle and viscosity of novelty sweets which provides additional knowledge and better understanding of the factors influencing the erosive potential of novelty sweets.

These findings showed that the ten most commonly available novelty sweets had a high erosive potential in causing dental erosion. It showed that the amount of enamel loss caused by six types of novelty sweets caused significantly more enamel loss than orange juice. The results also showed that saliva reminerlised the softened subsurface enamel and significantly reduced the subsurface enamel loss caused by all tested novelty sweets ($p<0.05$). This finding supports the recommendation of delaying the brushing after consumption of acidic foods and drinks by 30-60 minutes (Jaeggi and Lussi 1999; Hemingway et al. 2008).

The placement of enamel sample in saliva (for 1 h) did not significantly reduced the surface enamel loss. Which was similar to the finding of Nekrashevych *et al.* (2004) who found the saliva reduced the surface enamel but not significantly reduced.

In this study, the assessment of erosive potential of the novelty sweets was undertaken *in vitro* which has limitations in reproducing all the variables in the clinical situation such as the salivary flow and buffering capacity. However, it is impossible to assess the erosive potential of acidic solutions in presence of the other variables in causing the enamel in the *in vivo* studies. Clinically, it is very challenging to exclude other etiological factors of tooth surface loss (Lekkas et al. 1992), while the *in vitro* studies offer the highest amount of control, leading to more reproducible and comparable results (West et al. 1998).

To assess the potential impact of novelty sweet consumption on dental caries and obesity, the sugar content of the top ten most commonly available novelty sweets was measured in this study. The findings of this study showed that these sweets had a high level of sugar (31-73%) which means they could be considered a high calorie foodstuff. The children’s consumption of these sweets may put them at a high risk of developing dental caries and obesity. This study again was the first study measuring the sugar content of novelty sweets.

Conclusions and Recommendations

6 Conclusions and recommendations

6.1 Conclusions

A wide range of novelty sweets were readily available to purchase by high school children in the Cardiff area, particularly in areas of high deprivation. Furthermore, the prices of this type of confectionary were well within the reported pocket money range available to UK children which was £6.20 in 2015 (Lloyds Banking Group-Halifax 2015).

This study also confirmed that there appears to be an expanding market in terms of product diversification. As a result, children like, regularly buy and consume novelty sweets from local shops on their way to school, within city centre stores and supermarkets. Novelty sweets are mainly displayed in easily accessible areas. Children reported liking novelty sweets because they are sweet and sour, re-sealable, accessible, affordable and consumed in different ways. Owners of shops in the school fringe need to be aware of the potential effects of the novelty sweets and actions are potentially required to limit the accessibility of these sweets to children. Some shopkeepers were reported as acting as gatekeepers with regards to these novelty sweets.

There was a negative relationship between the liking of the novelty sweets and the correct perception of sweet and sour sensory thresholds. Children reported consuming novelty sweets regularly and frequently, which may put children at high risk of developing dental erosion, dental caries and obesity. Female children also appeared to be more sensitive to sweet and sour sensory thresholds than boys.

More female children preferred novelty sweets because of their sweet taste, while more boys liked novelty sweets because of the sour taste.

The potential link between sensory sweet and sour thresholds and liking and frequency of consumption is a very important area for future research for dental and general health prevention programmes.

The top ten most commonly available novelty sweets were demonstrated to cause a considerable amount of surface and subsurface enamel loss in the laboratory. Saliva seems to have a protective effect on the subsurface enamel loss if the physical damage such as tooth brushing is delayed for about 60 minutes to allow the softened enamel to remineralise. The pH of the top ten most commonly available novelty sweets was lower than the critical pH value of enamel dissolution and eight of the them below the pH of orange juice, which is known to cause clinical dental erosion. The neutralisable acidity of seven of the top ten most commonly available sweets was higher than the neutralisable acidity of orange juice. The wettability of enamel by novelty sweets seems to be positively related to the amount of surface and subsurface enamel loss, whilst viscosity of novelty sweets seems to be negatively related to the amount of surface and subsurface enamel loss.

The results of the sociological aspects of this study provide further understanding of the children's understanding, beliefs, and their buying and eating behaviours. Furthermore, the results of the oral science aspects provide deeper understanding of the potential effects of these sweets on dental tissues. Those personnel involved in delivering dental and wider health education or health promotion need to be aware of the marketing and potential effect of consumption of novelty sweets on dental and general health.

Parents and children also need to be informed about the possible implications of frequent use of such types of sweets on children's dental and general health. Manufacturers in sweet confectionary sectors require being aware about the potential effect of the novelty sweets on dental and general health of children and reformulation of the novelty sweets might be proposed. If the proposed sugar tax recommended by Public Health England (2015) was applied, it may limit the accessibility of novelty sweets to children to control obesity and diet-related diseases (Sinclair and Winkler 2009).

6.2 Recommendations

6.2.1 Clinical recommendations

The clinical implications of this study include the following.

- Clinicians need to council young patients about the potential development of dental erosion to avoid the frequent consumption of acidic food including novelty sweets.
- Additionally, it is important to inform patients who consume these sweets to avoid any physical challenge such as tooth brushing after the acidic challenge and delayed this by about an hour.
- Establishing an assessment of sensory taste thresholds in young patients with dental erosion as a possible diagnostic tool used in the management and prevention of dental erosion may be possible but the financial implications of this need to be explored further.

6.2.2 Public health recommendations

The public health recommendations of this study include the following.

- Application of mandatory healthy food standards applied to all schools and social settings.
- Application of taxation measures not only to limit the availability of food with high sugar and acid content, but also to encourage a healthy diet. A sugar tax has recently been levied on sugar containing beverages (Public Health England 2015).
- To continuously evaluate the impact of advertising and promotion of unhealthy food to children to limit any potential negative impacts.
- It is important to monitor peers at school to tackle the problem of using schools as a black market for selling unhealthy food.
- Counselling programmes may be also initiated to educate and elevate the parent's awareness about the potential oral and general effects of unhealthy food on their children.
- To encourage shop owners to limit the availability and accessibility of unhealthy food in their shops (mainly in the school fringe), an incentive schemes may be applied and awarded according to the standard of limiting of unhealthy food and promoting the healthy food to children (e.g. bronze, silver and gold). Initiating a training programme for school teachers to be more aware about the healthy eating and to be included in the children's academic curriculum.

- Improving nutrition and limiting unhealthy food availability to children by developing or establishing a local public organisation to work with other local public sector organisations such as schools and hospitals for this purpose.
- Another role of this organisation is to be in contact with the local community including parents and shopkeepers to share ideas about how to tackle any barriers in providing healthy eating to children.
- Additionally, food mapping survey of local shops to identify those shops where unhealthy foods is accessible and affordable to children would be helpful as starting point.
- To work with other general health and dental health promoting programs such as “Designed to Smile” to explain the importance of the health diet and the potential complications of unhealthy food including novelty sweets.
- Another role would be to have direct contact with manufacturers in confectionary sector to address the possibility of modifying the formula and packaging features (e.g. re-sealabilty) of acidic sweets to reduce their potential negative effects on health.

Based on the findings of this study and other previous studies, modification could be applied on novelty sweets criteria to minimise the potential public health implications of novelty sweets. These modifications include the following.

- Increasing the pH and lowering the titratable acidity.
- *Addition of calcium and/or phosphate.*
- *Addition of fluoride.*
- *Addition of organic components.*
- *Lowering the sugar content.*

One of the potential modifications that may be applied to the novelty sweets is to minimise the sugar content. The reduction in the sugar content may have an important result in reducing the risk of developing obesity in children as it relies on the portion size of sugary food (Mattes 2014). However, little help would be gained in reducing the risk of developing dental caries as it relies mainly on the frequency of exposure to sugar more than the amount of sugar (Anderson et al. 2009). However, it has been found that restricting the free sugars intake to less than 10% of total energy significantly reduces dental caries in children (Moynihan and Kelly 2014). Furthermore, a link has been suggested between dental caries and obesity as they have common potential aetiology including a high sugar diet (Silva et al. 2013; Munoz et al. 2013).

However, minimising the sugar content in novelty sweets may result in unfavourable flavour of the novelty sweets to children.

Another possible modification is to replace the sugar by other sweeteners such as xylitol (Milgrom et al. 2009). Xylitol can be extracted from trees, fruits and vegetables. Xylitol is 300-400 times sweeter than sucrose and has 2.4 calories per gram (40% fewer than table sugar) (Honkala et al. 2006). A small amount of xylitol would be enough to provide the required sweetening in food.

It has been reported by the European Food Safety Authority (EFSA) (2011) that xylitol is safe to use in the sweetening of foods and beverages and foods containing this sweetener can make the health claim of ‘regulating body weight, and improving blood glucose and dental health’.

In order to consider replacing the free sugar in novelty sweets, further research needs to be conducted to assess the feasibility of replacing sugar in novelty sweets by other non-cariogenic sweeteners.

6.2.3 Recommendations for future work

- Having more frequent assessment times of the erosive potential of the test groups by surfometer to link the amount of enamel loss with the time of acidic exposure.
- In the assessment of effect of saliva on surface and subsurface enamel loss, more groups with a larger sample size with different salivary buffering levels and salivary flows may be included.
- To assess sensory taste thresholds with comparison with adults and older age groups and also undertake an assessment of smoking and alcohol consumption on sensory taste thresholds.
- Assessment of sensory taste thresholds in groups of subjects with dental erosion, dental caries and obesity and groups with no experience of dental erosion, dental caries and obesity and at different age groups.

References

7 References

Addy, M. & Shellis, R. P. 2006. Interaction between attrition,abrasion and erosion in tooth wear. *Monographs in Oral Science* 20, pp. 17-31.

Agbazue, V. , Ibezim, A. & Ekere, N. 2014. Assessment of Sugar levels in Different Soft Drinks. *Journal of Chemical Science* 12(2), pp. 327 – 334.

Al-Dlaigan, Y. H., Shaw, L. and Smith, A. J. 2001. Dental erosion in a group of British 14-year-old, school children. Part I: Prevalence and influence of differing socioeconomic backgrounds. *British Dental Journal* 190(3), pp. 145-149.

Al-Majed, I., Maguire, A. & Murray, J. 2002. Risk factors for dental erosion in 5-6 year old and 12-14 year old boys in Saudi Arabia. *Community Dent Oral Epidemiol* 30(1), pp. 38-46.

Al-Zahrani, M. S., Bissada, N. F. & Borawskit, E. A. 2003. Obesity and periodontal disease in young, middle-aged, and older adults. *Journal of Periodontology* 74(5), pp. 610-615.

Ali, R. A. R. & Egan, L. J. 2007. Gastroesophageal reflux disease in pregnancy. *Best Practice and Research Clinical Gastroenterology* 21(5), pp. 793-806.

Allesen, B. H., Frost, M. B. & Bredie, W. L. P. 2009. Taste sensitivity and preferences in Danish school children. *In Sensory Science Group Department of Food Science Delegate manual: 8th Pangborn sensory science symposium. 2009. Denmark: University of Copenhagen (KU)*.

Amaechi, B. T., Higham, S. M. & Edgar, W. M. 1998a. The influence of xylitol and fluoride on dental erosion in vitro. *Archives of Oral Biology* 43(2), pp. 157-161.

Amaechi, B. T., Higham, S. M. & Edgar, W. M.1998b. Use of transverse microradiography to quantify mineral loss by erosion in bovine enamel. *Caries Research* 32(5), pp. 351-356.

Amaechi, B. T., Higham, S. M. & Edgar, W. M.1999a. Factors influencing the development of dental erosion in vitro: enamel type, temperature and exposure time. *Journal of Oral Rehabilitation* 26(8), pp. 624-630.

Amaechi, B. T., Higham, S. M. & Edgar, W. M. 1999b. Thickness of acquired salivary pellicle as a determinant of the sites of dental erosion. *Journal of Dental Research* 78(12), pp. 1821-1828.

Anderson, C. A., Curzon, M. E., Van Loveren, C., Tatsi, C. & Duggal, M. S. 2009. Sucrose and dental caries: a review of the evidence. *Obesity Reviews* 10 Suppl 1, pp. 41-54.

Andon, M. B., Kanerva, R. L., Rotruck, J. T. & Smith, K. T.1992. Method of preventing tooth enamel erosion utilizing an acidic beverage containing calcium. *European Journal of Oral Sciences* 28(4), pp. 131-138.

Andrews, F. F. 1982. Dental erosion due to anorexia nervosa with bulimia. *British Dental Journal* 152(3), pp. 89-90.

Andreyeva, T., Long, M. W. & Brownell, K. D. 2010. The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food. *American Journal of Public Health* 100(2), pp. 216-222.

Araujo, M. W., Dermen, K., Connors, G. & Ciancio, S. 2004. Oral and dental health among inpatients in treatment for alcohol use disorders: a pilot study. *Journal of the International Academy of Periodontology* 6(4), pp. 125-130.

Arends, J. & Ten Bosch, J. J. 1992. Demineralization and remineralization evaluation techniques. *Journal of Dental Research* 71 Spec No, pp. 924-928.

Arnadottir, I. B., Holbrook, W. P., Eggertsson, H., Gudmundsdottir, H., Jonsson, S. H., Gudlaugsson, J. O., Saemundsson, S. R., Eliasson, S. T. & Agustsdottir, H. 2010. Prevalence of dental erosion in children: a national survey. *Community Dental Oral Epidemiology* 38(6), pp. 521-526.

Arslan, H., Barutcigil, C., Karatas, E., Topcuoglu, H. S., Yeter, K. Y., Ersoy, I. & Ayranci, L. B. 2014. Effect of citric acid irrigation on the fracture resistance of endodontically treated roots. *European Journal of Dentistry* 8(1), pp. 74-78.

Asahina, K. & Benton, R. 2007. Smell and taste on a high: symposium on chemical senses: from genes to perception. *EMBO Reports* 8(7), pp. 634-638.

Ashcroft, A. & Milosevic, A. 2007a. The eating disorders: 1. Current scientific understanding and dental implications. *Dental Update* 34(9), pp. 544-546, 549-550, 553-544.

Ashcroft, A. & Milosevic, A. 2007b. The eating disorders: 2. Behavioural and dental management. *Dental Update* 34(10), pp. 612-616, 619-620.

Asher, C. & Read, M. J. 1987. Early enamel erosion in children associated with the excessive consumption of citric acid. *British Dental Journal* 162(10), pp. 384-387.

Ashmore, H., Wilson, S. J. & Vanabbe, N. J. 1972. Measurement in vitro of dentin abrasion by toothpaste. *British Dental Journal* 133(2), pp. 60-&.

Asthma UK. 2014. *Asthma facts and statistics, 2014* [Online]. Available at: https://www.asthma.org.uk/about/media/facts-and-statistics/ [Accessed: 22 March 2016].

Attin, T., Koidl, U., Buchalla, W., Schaller, H. G., Kielbassa, A. M. & Hellwig, E. 1997. Correlation of microhardness and wear in differently eroded bovine dental enamel. *Archives of Oral Biology* 42(3), pp. 243-250.

Aykut-Yetkiner, A., Wiegand, A., Bollhalder, A., Becker, K. & Attin, T. 2013. Effect of acidic solution viscosity on enamel erosion. *Journal of Dental Research* 92(3), pp. 289-294.

Azarpazhooh, A. & Main, P. A. 2009. Fluoride varnish in the prevention of dental caries in children and adolescents: a systematic review. *Hawaii Dental Journal* 40(1), pp. 6-7, 10-13; quiz 17.

Azzopardi, A., Bartlett, D. W., Watson, T. F. & Sherriff, M. 2004. The surface effects of erosion and abrasion on dentine with and without a protective layer. *British Dental Journal* 196(6), pp. 351-354; discussion 339.

Bachmann, J., Ellies, A. & Hartge, K. H. 2000. Development and application of a new sessile drop contact angle method to assess soil water repellency. *Journal of Hydrology* 231, pp. 66-75.

Baig, A. A., Fox, J. L., Young, R. A., Wang, Z., Hsu, J., Higuchi, W. I., Chhettry, A., Zhuang, H. & Otsuka, M. 1999. Relationships among carbonated apatite solubility, crystallite size, and microstrain parameters. *Calcified Tissue International* 64(5), pp. 437-449.

Bair, S. 2004. A routine high-pressure viscometer for accurate measurements to 1 GPa. *Tribology Transactions* 47(3), pp. 356-360.

Balakrishnan, M., Simmonds, R. S. & Tagg, J. R. 2000. Dental caries is a preventable infectious disease. *Australian Dental Journal* 45(4), pp. 235-245.

Balooch, M., Wu-Magidi, I. C., Balazs, A., Lundkvist, A. S., Marshall, S. J., Marshall, G. W., Siekhaus, W. J. & Kinney, J. H. 1998. Viscoelastic properties of demineralized human dentin measured in water with atomic force microscope (AFM)-based indentation. *Journal of Biomedical Materials Research* 40(4), pp. 539-544.

Banegas, J. R., Lopez-garcia, E., Gutierrez-Fisac, J. L., Guallar-Castillon, P. & Rodriguez-Artalejo, F. 2003. A simple estimate of mortality attributable to excess weight in the European Union. *European Journal of Clinical Nutrition* 57(2), pp. 201-208.

Baranowski, T., Cullen, K. W. & Baranowski, J. 1999. Psychosocial correlates of dietary intake: advancing dietary intervention. *Annual Review of Nutrition* 19, pp. 17-40.

Barbour, M. E., Finke, M., Parker, D. M., Hughes, J. A., Allen, G. C. & Addy, M. 2006. The relationship between enamel softening and erosion caused by soft drinks at a range of temperatures. *Journal of Dentistry* 34(3), pp. 207-213.

Barbour, M. E., Parker, D. M., Allen, G. C. & Jandt, K. D. 2003. Enamel dissolution in citric acid as a function of calcium and phosphate concentrations and degree of saturation with respect to hydroxyapatite. *European Journal of Oral Science* 111(5), pp. 428-433.

Barbour, M. E., Parker, D. M., Allen, G. C. & Jandt, K. D. 2005a. Human enamel erosion in constant composition citric acid solutions as a function of degree of saturation with respect to hydroxyapatite. *Journal of Oral Rehabilitation* 32(1), pp. 16-21.

Barbour, M. E. & Rees, J. S. 2004. The laboratory assessment of enamel erosion: a review. *Journal of Dentistry* 32(8), pp. 591-602.

Barbour, M. E., Finke, M., Parker, D. M., Hughes, J. A., Allen, G. C. & Addy, M. 2005b. An investigation of some food-approved polymers as agents to inhibit hydroxyapatite dissolution. *European Journal of Oral Sciences* 113(6), pp. 457-461.

Barbour, M. E., Finke, M., Parker, D. M., Hughes, J. A., Allen, G. C. & Addy, M. 2008. Inhibition of hydroxyapatite dissolution by whole casein: the effects of pH, protein concentration, calcium, and ionic strength. *European Journal of Oral Science* 116(5), pp. 473-478.

Bardolia, P., Burnside, G., Ashcroft, A., MIlosevic, A., Goodfellow, S. A., ROLFE, E. A. & Pine, C. M. 2010. Prevalence and risk indicators of erosion in thirteen- to fourteen-year-olds on the Isle of Man. *Caries Research* 44(2), pp. 165-168.

Barnesa, H. A. & Nguyenb, Q. D. 2001. Rotating vane rheometry -a review. *Journal of Non-Newtonian Fluid Mechanics* 98(1), pp. 1-14.

Barness, L. A., Opitz, J. M. & Gilbert-Barness, E. 2007. Obesity: genetic, molecular, and environmental aspects. *American Journal of Medical Genetics* 143A(24), pp. 3016-3034.

Bartlett, D. & Dugmore, C. 2008. Pathological or physiological erosion--is there a relationship to age? *Clinical Oral Investigations* 12 Suppl 1, pp. S27-31.

Bartlett, D. W. & Coward, P. Y. 2001. Comparison of the erosive potential of gastric juice and a carbonated drink in vitro. *Journal of Oral Rehabilitation* 28(11), pp. 1045-1047.

Bartlett, D. W., Coward, P. Y., Goodsman, D. & Darby, J. 1997. Experience of undergraduates from three London dental schools and trainers from the south east of England on interviews for vocational training in 1996. *British Dental Journal* 183(8), pp. 284-288.

Bartlett, D. W., Coward, P. Y., Nikkah, C. & Wilson, R. F. 1998. The prevalence of tooth wear in a cluster sample of adolescent schoolchildren and its relationship with potential explanatory factors. *British Dental Journal* 184(3), pp. 125-129.

Bartlett, D. W., Evans, D. F., Anggiansah, A. & Smith, B. G. 2000. The role of the esophagus in dental erosion. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology* 89(3), pp. 312-315.

Bartlett, D. W., Fares, J., Shirodaria, S., Chiu, K., Ahmad, N. & Sherriff, M. 2011. The association of tooth wear, diet and dietary habits in adults aged 18-30 years old. *Journal of Dentistry* 39(12), pp. 811-816.

Baumrind, D. 1973. *The Development of Instrumental Competence through Socialization*. Canada: Minneapolis: University of Minnesota Press.

Bawa, S. 2005. The role of the consumption of beverages in the obesity epidemic. *Journal of the Royal Society for the Promotion of Health* 125(3), pp. 124-128.

Beebe, D. W. 1994. Bulimia nervosa and depression: A theoretical and clinical appraisal in light of the binge—purge cycle. *British Journal of Clinical Psychology* 33(3), pp. 259-276.

Beeley, J. A. 2005. Novelty Sweets: A New Cause of Erosion? *British Society for Dental Research Annual Sceintific Meeting.*

Bell, E. J., Kaidonis, J. & Townsend, G. C. 2002. Tooth wear in children with Down syndrome. *Australian Dental Journal* 47(1), pp. 30-35.

Bellisle, F. 1999. Glutamate and the umami taste: sensory, metabolic, nutritional and behavioural considerations. A review of the literature published in the last 10 years. *Neuroscience and Biobehavioral Reviews* 23(3), pp. 423-438.

Bellisle, F. & Rolland-Cachera, M. F. 2001. How sugar-containing drinks might increase adiposity in children. *The Lancet* 357(9255), pp. 490-491.

Berg, C. & Forslund, H. B. 2015. The influence of portion size and timing of meals on weight balance and obesity. *Current Obesity Reports* 4(1), pp. 11-18.

Bergenholtz, G. 1990. Pathogenic mechanisms in pulpal disease. *Journal of Endodontics* 16(2), pp. 98-101.

Berry, B. & McMullen, T. 2008. Visual communication to children in the supermarket context: Health protective or exploitive? *Agriculture and Human Values* 25(3), pp. 333-348.

Berry, D. C. & Poole, D. F. 1976. Attrition: possible mechanisms of compensation. *Journal of Oral Rehabilitation* 3(3), pp. 201-206.

Beyer, M., Reichert, J., Sigusch, B. W., Watts, D. C. & Jandt, K. D. 2012. Morphology and structure of polymer layers protecting dental enamel against erosion. *Dental Materials* 28(10), pp. 1089-1097.

Birch, L. L. 1980. Effects of peer models' food choices and eating behaviors on preschoolers' food preferences. *Child Development* 51, pp. 489-496.

Birch, L. L. 1992. Children's preference for high-fat foods. *Nutrition Reviews* 50, pp. 249– 255.

Birch, L. L., Savage, J. S. & Ventura, A. 2007. Influences on the Development of Children's Eating Behaviours: From Infancy to Adolescence. *Canadian Journal of Dietetic Practice and Research* 68(1), pp. s1-s56.

Birch, L. L. 1999. Development of food preferences. *Annual Review of Nutrition* 19, pp. 41-62.

Birch, L. L., Birch, D., Marlin, D. W. & Kramer, L. 1982. Effects of instrumental consumption on children's food preference. *Appetite* 3(2), pp. 125-134.

Birch, L. L. & Fisher, J. O. 1998. Development of eating behaviors among children and adolescents. *Pediatrics* 101(3), pp. 539-549.

Birch, L. L. & Marlin, D. W. 1982. I don't like it; I never tried it: effects of exposure on two-year-old children's food preferences. *Appetite* 3(4), pp. 353-360.

Birch, L. L., Zimmerman, S., & Hind, H. 1980. The influence of social-affective context on the development of children's food preferences. *Child Development* (52), pp. 856-861.

Birch, L. L. 2001. Family environmental factors influencing the developing behavioral controls of food intake and childhood overweight. *Pediatric Clinics of North America* 48(4), pp. 893-902.

Bodecker, C. F. 1945. Local acidity; a cause of dental erosion-abrasion; progress report of the Erosion-Abrasion Committee of the New York Academy of Dentistry. *Annals of Dentistry* 4, pp. 50-55.

Bolan, M., Ferreira, M. C. & Vieira, R. S. 2008. Erosive effects of acidic center-filled chewing gum on primary and permanent enamel. *Journal of Indian Society of Pedodontics and Preventive Dentistry* 26(4), pp. 149-152.

Boles, R. G., Powers, A. L. & Adams, K.. 2006. Cyclic vomiting syndrome plus. *Journal of Child Neurology* 21(3), pp. 182-188.

Bonsor, S. J., Nichol, R., Reid, T. M. S. & Pearson, G. J. 2006. An alternative regimen for root canal disinfection. *British Dental Journal* 201(2), pp. 101-105.

Borjian, A., Ferrari, C. C., Anouf, A. & Touyz, L. Z. 2010. Pop-cola acids and tooth erosion: an in vitro, in vivo, electron-microscopic, and clinical report. *International Journal of Dentistry* 2010, p. 957842.

Boyde, A. & Wood, C. 1969. Preparation of animal tissues for surface-scanning electron microscopy. *Journal of Microscopy* 90(3), pp. 221-249.

Boyland, E. J., Harrold, J. A., Kirkham, T. C. & Halford, J. C. 2011. The extent of food advertising to children on UK television in 2008. *International Journal of Pediatric Obesity* 6(5-6), pp. 455-461.

Brand, H. S., Gambon, D. L., Paap, A., Bulthuis, M. S., Veerman, E. C. & Amerongen, A. V. 2009. The erosive potential of lollipops. *International Dental Journal* 59(6), pp. 358-362.

Braun, V. & Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3(2), pp. 77-101.

British Nutrition Foundation. 2013. *Healthy eating* [Online]. Available at: http://www.nutrition.org.uk/healthyliving/healthyeating [Accessed: 22 March 2016].

British Standards Institute. 2011. *Sensory Analysis Methodology – Method of Investigating Sensitivity of Taste. ISO/DIS3972* [Online]. Available at: https://standardsdevelopment.bsigroup.com/Home/Category/cat_67.240 [Accessed: 22 March 2016].

Brizard, M., Megharfi, M., Mahe, E. & Verdier, C. 2005a. Design of a high precision falling-ball viscometer. *Review of Scientific Instruments* 76(2), pp. 1-16.

Brizard, M., Megharfi, M. & Verdier, C. 2005b. Absolute falling-ball viscometer: evaluation of measurement uncertainty. *Metrologia* 42(4), pp. 298-303.

Brown, A., Mulligan, D. A., Altmann, T. R., Christakis, D. A., Clarke-pearson, K., Falik, H. L., Hill, D. L., Hogan, M. J., Levine, A. E., Nelson, K. G., O'Keeffe, G. S., Dreyer, B. P., Fuld, G. L., MilTeer, R. M., Shifrin, D. L., Strasburger, V. C., Brody, M., Wilcox, B., Steiner, G. L., Noland, V. L. & Media, C. C. 2011. Media Use by Children Younger Than 2 Years. *Pediatrics* 128(5), pp. 1040-1045.

Brunton, P. A. & Hussain, A. 2001. The erosive effect of herbal tea on dental enamel. *Journal of Dentistry* 29(8), pp. 517-520.

Bruss, M. B., Morris, J. & Dannison, L. 2003. Prevention of childhood obesity: sociocultural and familial factors. *Journal of the American Dietetic Association* 103(8), pp. 1042-1045.

Burnard, P., Gill, P., Stewart, K., Treasure, E. & Chadwick, B. 2008. Analysing and presenting qualitative data. *British Dental Journal* 204(8), pp. 429-432.

Burt, B. A. & Pai, S. 2001. Sugar consumption and caries risk: a systematic review. *Journal of Dental Education* 65(10), pp. 1017-1023.

Butler, M. G., Wang, K., Marshall, J. D., Naggert, J. K., Rethmeyer, J. A., Gunewardena, S. S. & Manzardo, A. M. 2015. Coding and noncoding expression patterns associated with rare obesity-related disorders: Prader-Willi and Alstrom syndromes. *Advances in Genomics and Genetics* 2015(5), pp. 53-75.

Butterworth, J. F. 2011. Ethics and human experimentation. *Anesthesiology* 114(4), pp. 1001-1002; author reply 1002-1003.

Caicedo, A., Pereira, E., Margolskee, R. F. & Roper, S. D. 2003. Role of the G-protein subunit alpha-gustducin in taste cell responses to bitter stimuli. *Journal of Neuroscience* 23(30), pp. 9947-9952.

Cairns, G., Angus, K. & Hastings, G. 2009. The extent, nature and effect of food promotion to vhildren: A review of the evidence. Prepared for the World Health Orgnization. *Institute for Social Marketing, University of Stirling and The Open University, United Kingdom*.

Cali, A. M. & Caprio, S. 2008. Obesity in children and adolescents. *Journal of Clinical Endocrinology and Metabolism* 93(11 Suppl 1), pp. S31-36.

Capaldi, E. D. & Privitera, G. J. 2007. Flavor-nutrient learning independent of flavor-taste learning with college students. *Appetite* 49(3), pp. 712-715.

Caraher, M., Lloyd, S. & Madelin, T. 2014. The "School Foodshed": schools and fast-food outlets in a London borough. *British Food Journal* 116(3), pp. 472-493.

Cardiff Council. 2013. *School catchment areas* [Online]. Available at: http://www.cardiff.gov.uk/content.asp?nav=2869,3047,3062,3905&parent_directory_id=2865 [Accessed: 22 March 2016].

Carey, W. B., Crocker, A. C., Elias, E. R., Feldman, H. M. & Coleman, W. L. 2009. *Developmental Behavioral Pediatrics: Expert Consult* Philadelphia USA: Elsevier Inc.

Carlson, L., Grossbart, S. & Tripp, C. 1990. An investigation of mothers communication orientations and patterns. *Advances in Consumer Research* 17, pp. 804-812.

Carlsson, J., Grahnen, H. & Jonsson, G. 1975. Lactobacilli and streptococci in the mouth of children. *Caries Research* 9, pp. 333-339.

Carruth, B. R., Skinner, J. D., Moran, J. D. & Coletta, F. 2000. Preschoolers' food product choices at a simulated point of purchase and mothers' consumer practices. *Journal of Nutrition Education* 32(3), pp. 146-151.

Caruana, A. R. 2003. Children's perception of their influence over purchases: the role of parental communication patterns. *Journal of Consumer Marketing* 20, pp. 55-66.

Carvalho, F. G., Oliveira, B. F., Carlo, H. L., Santos, R. L., Guenes, G. M. & Castro, R. D. 2014. Effect of Remineralizing Agents on the Prevention of Enamel Erosion: A Systematic Review. *Brazilian Research in Pediatric Dentistry and Integrated Clinic* 14(4), pp. 55-64.

Casaretto, C. et al. 2012. Evaluation of Lama glama semen viscosity with a cone-plate rotational viscometer. *Andrologia* 44, pp. 335-341.

Casey, R. & Rozin, P. 1989. Changing children's food preferences: parent opinions. *Appetite* 12(3), pp. 171-182.

Cashdan, E. 1998. Adaptiveness of food learning and food aversions in children. *Social Science Information Sur Les Sciences Sociales* 37(4), pp. 613-632.

Cassinelli, C. & Morra, M. 1994. Atomic force microscopy studies of the interaction of a dentin adhesive with tooth hard tissue. *Journal of Biomedical Materials Research* 28(12), pp. 1427-1431.

Castell, D. O., Murray, J. A., Tutuian, R., Orlando, R. C. & Arnold, R. 2004. Review article: the pathophysiology of gastro-oesophageal reflux disease-oesophageal manifestations. *Alimentary Pharmacology and Therapeutics* 20(suppl 9), pp. 14-25.

Cavassim, R., Leite, F. R. M., Zandim, D. L., Dantas, A. A. R., Rached, R. S. G. A. & Sampaio, J. E. C. 2012. Influence of concentration, time and method of application of citric acid and sodium citrate in root conditioning. *Journal of Applied Oral Science* 20(3), pp. 376-383.

Cen, H., Lu, R., Mendoza, F. A. & Ariana, D. P. 2012. Assessing Multiple Quality Attributes of Peaches Using Optical Absorption and Scattering Properties. *Transactions of the Asabe* 55(2), pp. 647-657.

Chaffee, B. W. & Weston, S. J. 2010. Association between chronic periodontal disease and obesity: a systematic review and meta-analysis. *Journal of Periodontology* 81(12), pp. 1708-1724.

Chamberlain, L. J., Wang, Y. & Robinson, T. N. 2006. Does children's screen time predict requests for advertised products? Cross-sectional and prospective analyses. *Archives of Pediatrics and Adolescent Medicine* 160(4), pp. 363-368.

Chambers, E. 2005. Commentary: Conducting sensory research with children. *Journal of Sensory Studies* 20(1), pp. 90-92.

Chen, S. H., Wang, J.W. & Li, Y.M. 2010. Is alcohol consumption associated with gastroesophageal reflux disease? *Journal of Zhejiang University. Science.* 11(6), pp. 423-428.

Cheng, R., Yang, H., Shao, M. Y., HU, T. & Zhou, X. D. 2009. Dental erosion and severe tooth decay related to soft drinks: a case report and literature review. *Journal of Zhejiang University Science* 10(5), pp. 395-399.

Cho, M. A., Ko, J. Y., Kim, Y. K. & Kho, H. S. 2010. Salivary flow rate and clinical characteristics of patients with xerostomia according to its aetiology. *Journal of Oral Rehabilitation* 37(3), pp. 185-193.

Christensen, C. M., Brand, J. G. & Malamud, D. 1987. Salivary changes in solution pH: a source of individual differences in sour taste perception. *Physiology and Behaviour* 40(2), pp. 221-227.

Chu, F. C., Yip, H. K., Newsome, P. R., Chow, T. W. & Smales, R. J. 2002. Restorative management of the worn dentition: I. Aetiology and diagnosis. *Dental Update* 29(4), pp. 162-168.

Church, S. 2008. Trends in portion sizes in the UK - A preliminary review of published information *Food Standards Agency* [Online]. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.397.8604&rep=rep1&type=pdf [Accessed: 22 March 2016].

Clarke, J. K. 1924. On the bacterial factor in the aetiology of dental caries. *British Journal of Experimental Pathology* 5, pp. 141-147.

Cole, T. J., Freeman, J. V. & Preece, M. A. 1995. Body mass index reference curves for the UK, 1990. *Archives of Disease in Childhood* 73(1), pp. 25-29.

Collys, K., Slop, D., Cleymaet, R., Coomans, D. & Michotte, Y. 1992. Load dependency and reliability of microhardness measurements on acid-etched enamel surfaces. *Dental Materials* 8(5), pp. 332-335.

Cooke, L., Wardle, J. & Gibson, E. L. 2003. Relationship between parental report of food neophobia and everyday food consumption in 2-6-year-old children. *Appetite* 41(2), pp. 205-206.

Cooke, L., Wardle, J., Gibson, E. L., Sapochnik, M., Sheiham, A. & Lawson, M. 2004. Demographic, familial and trait predictors of fruit and vegetable consumption by pre-school children. *Public Health Nutrition* 7(2), pp. 295-302.

Coon, K. A., Goldberg, J., Rogers, B. L. & Tucker, K. L. 2001. Relationships between use of television during meals and children's food consumption patterns. *Pediatrics* 107(1), p. E7.

Crawford, F., Ellaway, A., Mackison, D. & Mooney, J. 2012. '*Is Eating out of School a Healthy Option for Secondary Pupils?', A Feasibility Study to Explore the Nutritional Quality of 'Out of School' Foods Popular with School Pupils Galsgow Centre of Papulation Health* [Online]. Available at: http://www.gcph.co.uk/assets/0000/3539/Out_of_school_foods_report_-_final.pdf [Accessed 22 March 2016].

Creanor, S. L., Strang, R., Telfer, S., Macdonald, I., Smith, M. J. & Stephen, K. W. 1986. In situ appliance for the investigation of enamel de- and remineralization. A pilot study. *Caries Research* 20(5), pp. 385-391.

Cullen, P. J., Duffy, A. P., O'Donnell, C. P. & O'Callaghan, D. J. 2000. Process viscometry for the food industry. *Trends in Food Science and Technology* 11(12), pp. 451–457.

D'Incau, E., Couture, C. & Maureille, B. 2012. Human tooth wear in the past and the present: tribological mechanisms, scoring systems, dental and skeletal compensations. *Archives of Oral Biology* 57(3), pp. 214-229.

Daculsi, G. & Legeros, J. P. 1996. Three-dimensional defects in hydroxyapatite of biological interest. *Journal of Biomedical Materials Research* 31(4), pp. 495-501.

Dahl, B. L., Carlsson, G. E. & Ekfeldt, A.. 1993. Occlusal wear of teeth and restorative materials. A review of classification, etiology, mechanisms of wear, and some aspects of restorative procedures. *Acta Odontologica Scandinavica* 51(5), pp. 299-311.

Damen, J. J., Exterkate, R. A. & Ten Cate, J. M. 1997. Reproducibility of TMR for the determination of longitudinal mineral changes in dental hard tissues. *Advances in Dental Research* 11(4), pp. 415-419.

Dao, T. T., Ye, A. X., Hutchison, G. & Hedman, K. 2009. A High-Performance, fully self-contained rotational viscometer. *American Laboratory* 41(9), pp. 21-32.

Darwin, D. 2009. Advertising obesity: can the U.S. follow the lead of the UK in limiting television marketing of unhealthy foods to children. *Journal of Transnational Law* 42(1), p. 317.

Davies, R., Hunter, L., Loyn, T. & Rees, J. 2008. Sour sweets: a new type of erosive challenge? *British Dental Journal* 204(2), pp. E3; discussion 84-85.

Davies, S. J., Gray, R. J. & Qualtrough, A. J. 2002. Management of tooth surface loss. *British Dental Journal* 192(1), pp. 11-16, 19-23.

Davis, E. P., Donzella, B., Krueger, W. K. & Gunnar, M. R. 1999. The start of a new school year: individual differences in salivary cortisol response in relation to child temperament. *Developmental Psychobiology* 35(3), pp. 188-196.

Dawes, C. 1987. Physiological factors affecting salivary flow rate, oral sugar clearance, and the sensation of dry mouth in man. *Journal of Dental Reearch* 66 Spec No, pp. 648-653.

Dawes, C. 2003. What is the critical pH and why does a tooth dissolve in acid? *Journal of the Canadian Dental Association* 69(11), pp. 722-724.

De Bourdeaudhuij, I. & Van Oost, P. 2000. Personal and family determinants of dietary behaviour in adolescents and their parents. *Psychology and Health* 15(6), pp. 751-770.

De Droog, S. M., Valkenburg, P. M. & Buijzen, M. 2010. Using Brand Characters to Promote Young Children's Liking of and Purchase Requests for Fruit. *Journal of Health Communication* 16(1), pp. 79-89.

De Graaf, C. & Zandstra, E. H. 1999. Sweetness intensity and pleasantness in children, adolescents, and adults. *Physiology and Behaviour* 67(4), pp. 513-520.

De Groot, J. M., Rodin, G. & Olmsted, M. P. 1995. Alexithymia, depression, and treatment outcome in bulimia nervosa. *Comprehensive Psychiatry* 36(1), pp. 53-60.

De Soet, J. J. & De Graaff, J. 1998. Microbiology of Carious Lesions. *Dental Update* 25, pp. 319-324.

Decker, E. L., Frank, B., Suo, Y. & Garoff, S. 1999. Physics of contact angle measurement. *Colloids and Surfaces Physicochemical and Engineering Aspects* 156(1-3), pp. 177-189.

Demeester, T. R., Johnson, L. F., Joseph, G. J., Toscano, M. S., Hall, A. W. & Skinner, D. B. 1976. Patterns of gastroesophageal reflux in health and disease. *Annals of surgery* 184(4), pp. 459-470.

Den Besten, P. K. 1999. Biological mechanisms of dental fluorosis relevant to the use of fluoride supplements. *Community Dental and Oral Epidemiology* 27(1), pp. 41-47.

Department for Work and Pensions. 2015. *Households Below Average Income. An analysis of the income distribution 1994/95 – 2013/14 June 2015 (United Kingdom)* [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437246/households-below-average-income-1994-95-to-2013-14.pdf [Accessed: 24 March 2016].

Department of Health. 1994. *An Oral Health Strategy for England*. London: Department of Health.

Department of Health. 2005. *Choosing a Better Diet: a food and health action plan* [Online]. Available at: http://webarchive.nationalarchives.gov.uk/20130107105354/http:/www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4105709.pdf [Accessed: 22 March 2016].

Department of Health. 2013. *National children's dental health survey in the UK, 2013* [Online]. Available at: http://www.hscic.gov.uk/catalogue/PUB17137 [Accessed: 22 March 2016].

Departement of Health. 2010. *National Diet and Nutrition Survey 2008/2010* [Online]. Available at: http://www.food.gov.uk/multimedia/pdfs/publication/ndnsreport0809.pdf [Accessed: 15 March 2016].

Deshpande, S. D. a& Hugar, S. M. 2004. Dental erosion in children : an increasing clinical problem. *Journal of the Indian Society of Pedodontics and Preventive Dentistry* 22(3), pp. 118-127.

Desor, J. A. & Beauchamp, G. K. 1987. Longitudinal changes in sweet preferences in humans. *Physiology and Behaviour* 39(5), pp. 639-641.

Dettori, J. 2010. The random allocation process: two things you need to know. *Evidence Based Spine Care Journal* 1(3), pp. 7-9.

Dibb S & Gordon S. 2001. *The alliance for better food and farming. TV Dinners: What's Being Served Up by Advertisers?* London: Sustain.

Digilov, R. M. & Reiner, M. 2007. Mass-controlled capillary viscometer for a Newtonian liquid: Viscosity of water at different temperatures. *Review of Scientific Instruments* 78(3), pp. 1136-1143

Dindar, C. & Kiran, E. 2002. Reliable method for determination of the velocity of a sinker in a high-pressure falling body type viscometer. *Review of Scientific Instruments* 73(10), pp. 3664-3670.

Donkin, A. J., Neale, R. J. & Tilston, C. 1993. Children's food purchase requests. *Appetite* 21(3), pp. 291-294.

Dorozhkin, S. V. 1997. Surface Reactions of Apatite Dissolution. *Journal of Colloid and Interface Science* 191(2), pp. 489-497.

Dougherty, M., Story, M. & Stang, J. 2006. Observations of parent-child co-shoppers in supermarkets: children's involvement in food selections, parental yielding, and refusal strategies. *Journal of Nutrition and Education Behavior* 38(3), pp. 183-188.

Drelich, J., Miller, J. D. & Good, R. J. 1996. The effect of drop (bubble) size on advancing and receding contact angles for heterogeneous and rough solid surfaces as observed with sessile-drop and captive-bubble techniques. *Journal of Colloid and Interface Science* 179(1), pp. 37-50.

Drewnowski, A. 1997. Taste preferences and food intake. *Annual Review of Nutrition* 17, pp. 237-253.

Drewnowski, A. 2012. The economics of food choice behavior: Why poverty and obesity are linked. *Obesity Treatment and Prevention: New Directions* 73, pp. 95-112.

Drewnowski, A. & Darmon, N. 2005. The economics of obesity: dietary energy density and energy cost. *American Journal of Clinical Nutrition* 82(1), pp. 265S-273S.

Drewnowski, A., Krahn, D. D., Demitrack, M. A., Nairn, K. & Gosnell, B. A. 1995. Naloxone, an opiate blocker, reduces the consumption of sweet high-fat foods in obese and lean female binge eaters. *American Journal of Clinical Nutrition* 61(6), pp. 1206-1212.

Drewnowski, A., Mennella, J. A., Johnson, S. L. & Bellisle, F. 2012. Sweetness and Food Preference. *Journal of Nutrition* 142(6), pp. 1142S-1148S.

Drewnowski, A. & Specter, S. E. 2004. Poverty and obesity: the role of energy density and energy costs. *American Journal of Clinical Nutrition* 79(1), pp. 6-16.

Driessens, F. C., Heijligers, H. J., Borggreven, J. M. & Woltgens, J. H. 1984. Variations in the mineral composition of human enamel on the level of cross-striations and striae of Retzius. *Caries Research* 18(3), pp. 237-241.

Dubern, B. & Clement, K. 2007. Genetic aspects of obesity. *Presse Med* 36(11 Pt 2), pp. 1598-1605.

Dubus, J. C., Marguet, C., Deschildre, A., Mely, L., Le Roux, P., Brouard, J., Huiart, L. & Reseau, P. 2001. Local side-effects of inhaled corticosteroids in asthmatic children: influence of drug, dose, age, and device. *Allergy* 56(10), pp. 944-948.

Dugmore, C. R. & Rock, W. P. 2004a. A multifactorial analysis of factors associated with dental erosion. *British Dental Journal* 196(5), pp. 283-286; discussion 273.

Dugmore, C. R. & Rock, W. P. 2004b. The prevalence of tooth erosion in 12-year-old children. *British Dental Journal* 196(5), pp. 279-282; discussion 273.

Dupont, J. B. & Legendre, D. 2010. Numerical simulation of static and sliding drop with contact angle hysteresis. *Journal of Computational Physics* 229(7), pp. 2453-2478.

Duschner, H. & Uchtmann, H. 1988. Etching behaviour of bovine enamel after the formation of precipitates adhering to the surface. *Caries Research* 22(2), pp. 72-75.

EFSA. 2011. Scientific Opinion on the substantiation of health claims related to intense sweeteners and contribution to the maintenance or achievement of a normal body weight (ID 1136, 1444, 4299), reduction of post-prandial glycaemic responses (ID 4298), maintenance of normal blood glucose concentrations (ID 1221, 4298), and maintenance of tooth mineralisation by decreasing tooth demineralisation (ID 1134, 1167, 1283). *EFSA Journal* 9(6), pp. 135-148.

Ehlen, L. A., Marshall, T. A., Qian, F., Wefel, J. S. & Warren, J. J. 2008. Acidic beverages increase the risk of in vitro tooth erosion. *Nutrition Research* 28(5), pp. 299-303.

Eick, J. D., Johnson, L. N., Fromer, J. R., Good, R. J. & Neumann, A. W. 1972. Surface topography: its influence on wetting and adhesion in a dental adhesive system. *Journal of Dental Research* 51(3), pp. 780-788.

Eisenburger, M. 2009. Degree of mineral loss in softened human enamel after acid erosion measured by chemical analysis. *Journal of Dentistry* 37(6), pp. 491-494.

Eisenburger, M. & Addy, M. 2003. Influence of liquid temperature and flow rate on enamel erosion and surface softening. *Journal of Oral Rehabilitation* 30(11), pp. 1076-1080.

Eisenburger, M., Hughes, J., West, N. X., Jandt, K. D. & Addy, M. 2000. Ultrasonication as a method to study enamel demineralisation during acid erosion. *Caries Research* 34(4), pp. 289-294.

Eisenburger, M., Shellis, R. P. & Addy, M. 2003. Comparative study of wear of enamel induced by alternating and simultaneous combinations of abrasion and erosion in vitro. *Caries Research* 37(6), pp. 450-455.

Elliott, C. D., Carruthers, R. & Conlon, M. J. 2013. Food branding and young children's taste preferences: a reassessment. *Canadian Journal of Public Health* 104(5), pp. e364-368.

Elton, V., Cooper, L., Higham, S. M. & Pender, N. 2009. Validation of enamel erosion in vitro. *Journal of Dentistry* 37(5), pp. 336-341.

Erickson, S. J., Robinson, T. N., Haydel, K. F. & Killen, J. D. 2000. Are overweight children unhappy?: Body mass index, depressive symptoms, and overweight concerns in elementary school children. *Archives of Pediatrics and Adolescent Medicine* 154(9), pp. 931-935.

Farooqi, I. S. 2006. Genetic aspects of severe childhood obesity. *Pediatric Endocrinology Reviews* 3 Suppl 4, pp. 528-536.

Featherstone, J. D. & Mellberg, J. R. 1981. Relative rates of progress of artificial carious lesions in bovine, ovine and human enamel. *Caries Research* 15(1), pp. 109-114.

Featherstone, J. D., Ten Cate, J. M., Shariati, M. & Arends, J. 1983. Comparison of artificial caries-like lesions by quantitative microradiography and microhardness profiles. *Caries Research* 17(5), pp. 385-391.

Featherstone, J. D. & Zero, D. T. 1992. An in situ model for simultaneous assessment of inhibition of demineralization and enhancement of remineralization. *Journal of Dental Research* 71 Spec No, pp. 804-810.

Fejerskov, O. E. 2003. *Dental Caries, The Disease and its Clinical Management*. Australia: Blackwell publishing limited.

Feng, S., Reardon, P. T., Abbott, J. & Mondy, L. 2005. Improving falling ball test for viscosity determination. *Journal of Fluids Engineering* 128, pp. 157-163.

Ferrero, F. 2003. Wettability measurements on plasma treated synthetic fabrics by capillary rise method. *Polymer Testing* 22(5), pp. 571-578.

Fiates, G. M. R., Amboni, R. D. M. C. & Teixeira, E. 2008. Television use and food choices of children: Qualitative approach. *Appetite* 50(1), pp. 12-18.

Fisher-Owens, S. A., Gansky, S. A., Platt, L. J., Weintraub, J. A., Soobader, M. J., Bramlett, M. D. & Newacheck, P. W. 2007. Influences on children's oral health: a conceptual model. *Pediatrics* 120(3), pp. e510-520.

Fisher, J. O. & Birch, L. L. 1995. Fat Preferences and Fat Consumption of 3-Year-Old to 5-Year-Old Children Are Related to Parental Adiposity. *Journal of the American Dietetic Association* 95(7), pp. 759-764.

Fisher, J. O. & Birch, L. L. 2000. Parents' restrictive feeding practices are associated with young girls' negative self-evaluation of eating. *Journal of the American Dietetic Association* 100(11), pp. 1341-1346.

Food Standards Agency. 2003. *Brain Licker brand of novelty liquid sweets* [Online]. *Available at:* http://tna.europarchive.org/20110116113217/http://www.food.gov.uk/enforcement/alerts/2003/sep/brain_licker [Accessed: 22 March 2016].

Forshee, R. A., Storey, M. L. & Ginevan, M. E. 2005. A risk analysis model of the relationship between beverage consumption from school vending machines and risk of adolescent overweight. *Risk Analysis* 25(5), pp. 1121-1135.

Fox, C. 2010. Evidence summary: how can dietary advice to prevent dental erosion be effectively delivered in UK general dental practice? *British Dental Journal* 208(5), pp. 217-218.

Francis, L. A. & Birch, L. L. 2006. Does Eating during Television Viewing Affect Preschool Children’s Intake? *Journal of the American Dietetic Association* 106(4), pp. 598-600.

Frank, R. A. & Vanderklaauw, N. J. 1994. The Contribution of Chemosensory Factors to Individual-Differences in Reported Food Preferences. *Appetite* 22(2), pp. 101-123.

Freeman, J. V., Cole, T. J., Chinn, S., Jones, P. R., White, E. M. & Preece, M. A. 1995. Cross sectional stature and weight reference curves for the UK, 1990. *Archives of Disease in Childhood* 73(1), pp. 17-24.

French, S. A., Story, M., Neumark, D., Fulkerson, J. A. & Hannan, P. 2001. Fast food restaurant use among adolescents: associations with nutrient intake, food choices and behavioral and psychosocial variables. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity* 25(12), pp. 1823-1833.

Fung, A. & Brearley Messer, L. 2013. Tooth wear and associated risk factors in a sample of Australian primary school children. *Australian Dental Journal* 58(2), pp. 235-245.

Gambon, D. L., Brand, H. S. & Amerongen, A. 2007. Acidic candies affect saliva secretion rates and oral fluid acidity. *Ned Tijdschr Tandheelkd* 114(8), pp. 330-334.

Gambon, D. L., Brand, H. S. & Veerman, E. C. 2012. Dental erosion in the 21st century: what is happening to nutritional habits and lifestyle in our society? *British Dental Journal* 213(2), pp. 55-57.

Gambon, D. L., Van Den Keijbus, P. A. & Van Amerongen, A. N. 2006. Candy sprays and -gels: effect on salivary flow and pH. *Ned Tijdschr Tandheelkd* 113, pp. 27-32.

Gambon, D. L., Nieuw, H. S. & Amerongen, A. V. 2009. The erosive potential of candy sprays. *British Dental Journal* 206(10), pp. E20; discussion 530-531.

Ganss, C., Klimek, J. & Schwarz, N. 2000. A comparative profilometric in vitro study of the susceptibility of polished and natural human enamel and dentine surfaces to erosive demineralization. *Archives of Oral Biology* 45(10), pp. 897-902.

Gaspersic, D. 1985. The prevalence, location and composition of enamel pearls in permanent molars. *Zobozdrav Vestn* 40(1-5), pp. 33-38.

Gelperowic, R. B. 1994. Healthy Food Products for Children: Packaging and Mothers' Purchase Decisions. *British Food Journal* 96(11), pp. pp. 4-8.

Giannini, M., Soares, C. J. & De Carvalho, R. M. 2004. Ultimate tensile strength of tooth structures. *Dental Materials* 20(4), pp. 322-329.

Gibson, E. L., Wardle, J. & Watts, C. J. 1998. Fruit and vegetable consumption, nutritional knowledge and beliefs in mothers and children. *Appetite* 31(2), pp. 205-228.

Gibson, S. & Williams, S. 1999. Dental caries in pre-school children: Associations with social class, toothbrushing habit and consumption of sugars and sugar-containing foods - Further analysis of data from the National Diet and Nutrition Survey of children aged 1.5-4.5 years. *Caries Research* 33(2), pp. 101-113.

Giese, J. 1995. Measuring Physical-Properties of Foods. *Food Technology* 49(2), pp. 54-67.

Giunta, J. L. 1983. Dental erosion resulting from chewable vitamin C tablets. *Journal of American Dental Association* 107(2), pp. 253-256.

Godara, N., Godara, R. & Khullar, M. 2011. Impact of inhalation therapy on oral health. *Lung India* 28(4), pp. 272-275.

Good, R. J. 1993. Contact-Angle, Wetting, and Adhesion - a Critical-Review. *Journal of Adhesion Science and Technology* 7(9), pp. 1015-1015.

Gorman, A., Kaye, E. K., Apovian, C., Fung, T. T., Nunn, M. & Garcia, R. I. 2012. Overweight and obesity predict time to periodontal disease progression in men. *Journal of Clinical Periodontology* 39(2), pp. 107-114.

Grando, L. J., Tames, D. R., Cardoso, A. C. & Gabilan, N. H. 1996. In vitro study of enamel erosion caused by soft drinks and lemon juice in deciduous teeth analysed by stereomicroscopy and scanning electron microscopy. *Caries Research* 30(5), pp. 373-378.

Green, T. B. 2009. Cyclic vomiting syndrome: what does it mean? *Nasnewsletter* 24(2), pp. 52-54.

Grenby, T. H. 1996a. Lessening dental erosive potential by product modification. *European Journal of Oral Science* 104(2 (Pt 2)), pp. 221-228.

Grenby, T. H. 1996b. Methods of assessing erosion and erosive potential. *European Journal of Oral Science* 104(2 (Pt 2)), pp. 207-214.

Grenby, T. H. & Mistry, M. 1998. Suppression of enamel demineralisation by supplementing soft drinks with phosphates. *Journal of Dental Research* 77, pp. 1344-1344.

Grenby, T. H., Mistry, M. & Desai, T. 1990. Potential dental effects of infants' fruit drinks studied in vitro. *British Journal of Nutrition* 64(1), pp. 273-283.

Grenby, T. H. & Saldanha, M. G. 1995. The use of high-phosphorus supplements to inhibit dental enamel demineralisation by ice lollies. *International Journal of Food Science and Nutrition* 46(3), pp. 275-279.

Grimm, G. C., Harnack, L. & Story, M. 2004. Factors associated with soft drink consumption in school-aged children. *Journal of the American Dietetic Association* 104(8), pp. 1244-1249.

Grippo, J. O. 1991. Abfractions: a new classification of hard tissue lesions of teeth. *Journal of Esthetic Dentistry* 3(1), pp. 14-19.

Grippo, J. O., Simring, M. & Schreiner, S. 2004. Attrition, abrasion, corrosion and abfraction revisited: A new perspective on tooth surface lesions. *The Journal of the American Dental Association* 135(8), pp. 1109-1118.

Guinard, J. X. 2000. Sensory and consumer testing with children. *Trends in Food Science and Technology* 11(8), pp. 273-283.

Gunnar, M. R., Tout, K., De Haan, M., Pierce, S. & Stansbury, K. 1997. Temperament, social competence, and adrenocortical activity in preschoolers. *Developmental Psychobiology* 31(1), pp. 65-85.

Gutiérrez, M. D. & Gasga, J. 2003. Microhardness and chemical composition of human tooth. *Journal of Materials Research* 6(3), pp. 367-373.

Habelitz, S., Marshall, S. J., Marshall, G. W. & Balooch, M. 2001. Mechanical properties of human dental enamel on the nanometre scale. *Archives of Oral Biology* 46(2), pp. 173-183.

Hadley, K., Orlandi, R. R. & Fong, K. J. 2004. Basic anatomy and physiology of olfaction and taste. *Otolaryngologic Clinics of North America* 37(6), pp. 1115-1126.

Halford, J. C., Boyland, E. J., Hughes, G., Oliveira, L. P. & Dovey, T. M. 2007. Beyond-brand effect of television (TV) food advertisements/commercials on caloric intake and food choice of 5-7-year-old children. *Appetite* 49(1), pp. 263-267.

Hall, A. F., Sadler, J. P., Strang, R., De Josselin, E., Foye, R. H. & Creanor, S. L. 1997. Application of transverse microradiography for measurement of mineral loss by acid erosion. *Advances in Dental Research* 11(4), pp. 420-425.

Hamasha, A. A., Zawaideh, F. I. & AL-Hadithy, R. T. 2014. Risk indicators associated with dental erosion among Jordanian school children aged 12-14 years of age. *International Journal of Paediatric Dentistry* 24(1), pp. 56-68.

Hannig, M. and Balz, M. 2001. Protective properties of salivary pellicles from two different intraoral sites on enamel erosion. *Caries Research* 35(2), pp. 142-148.

Happer, L. K. 1975. The effect of adults' eating on young children's acceptance of unfamiliar food. *Journal of Experimental Child Psychology* 20, pp. 206-2014.

Harris, G. 2008. Development of taste and food preferences in children. *Current Opinion in Clinical Nutrition and Metabolic Care* 11(3), pp. 315-319.

Harris, J. L., Bargh, J. A. & Brownell, K. D. 2009. Priming effects of television food advertising on eating behavior. *Health Psychology* 28(4), pp. 404-413.

Harris, J. L. and Graff, S. K. 2011. Protecting children from harmful food marketing: Options for local government to make a difference. *Preventing Chronic Disease* 8(5), pp. A92-102.

Harris, R., Nicoll, A. D., Adair, P. M. & Pine, C. M. 2004. Risk factors for dental caries in young children: a systematic review of the literature. *Community Dental Health* 21(1 Suppl), pp. 71-85.

Haugen, L. K. 1992. Biological and physiological changes in the ageing individual. *International Dental Journal* 42(5), pp. 339-348; discussion 349-352.

Health and Social Care Information Centre. 2009. *Adult Dental Health Survey* [Online]. Available at: http://www.hscic.gov.uk/pubs/dentalsurveyfullreport09 [Accessed: 22 March 2016].

Health and Social Care Information Centre. 2014a. *Children's body mass index, overweight and obesity* [Online]. Available at: http://www.hscic.gov.uk/catalogue/PUB19295/HSE2014-ch10-child-obe.pdf [Accessed: 22 March 2016].

Health and Social Care Information Centre. 2014b. *Health Survey for England - 2013, Trend tables* [Online]. Available at: http://www.hscic.gov.uk/catalogue/PUB16077 [Accessed: 22 March 2016].

Hemingway, C. A., Parker, D. M., Addy, M. & Barbour, M. E. 2006. Erosion of enamel by non-carbonated soft drinks with and without toothbrushing abrasion. *British Dental Journal* 201(7), pp. 447-450; discussion 439; quiz 466.

Hemingway, C. A., Shellis, R. P., Parker, D. M., Addy, M. & Barbour, M. E. 2008. Inhibition of hydroxyapatite dissolution by ovalbumin as a function of pH, calcium concentration, protein concentration and acid type. *Caries Research* 42(5), pp. 348-353.

Hilgers, K. K., Kinane, D. E. & Scheetz, J. P. 2006. Association between childhood obesity and smooth-surface caries in posterior teeth: a preliminary study. *Pediatric Dentistry* 28(1), pp. 23-28.

Hill, D. L. and Mistretta, C. M. 1990. Developmental neurobiology of salt taste sensation. *Trends in Neuroscience* 13(5), pp. 188-195.

Hilpert, M. 2009. Effects of dynamic contact angle on liquid infiltration into inclined capillary tubes: (Semi)-analytical solutions. *Journal of Colloid and Interface Science* 337(1), pp. 138-144.

Hobdell, M. H., Oliveira, E. R., Bautista, R., Myburgh, N. G., Lalloo, R., Narendran, S. & Johnson, N. W. 2003. 2003. Oral diseases and socio-economic status (SES). *British Dental Journal* 194(2), pp. 91-96; discussion 88.

Holloway, I. and Todres, L. 2003. The status of method: flexibility, consistency and coherence. *Journal of Qualitative Research* 3(3), pp. 345-357.

Holmes, S. 1998. Xerostomia: aetiology and management in cancer patients. *Support Care Cancer* 6(4), pp. 348-355.

Holsten, J. E. 2010. Exploring the Relationship between Middle School Children's Body Mass Index and the Home Food Environment within the Contextual Process of Food Choice. *Publicly accessible Penn Dissertations* 130, pp. 233-242.

Holt, R. 2003. The food and agriculture organization/World Health Organization expert report on diet, nutrition and prevention of chronic diseases. *Diabetes, Obesity and Metabolism* 5(5), p. 354-367.

Hong, L., Ahmed, A., Mccunniff, M., Overman, P. & Mathew, M. 2008. Obesity and dental caries in children aged 2-6 years in the United States: National Health and Nutrition Examination Survey 1999-2002. *Journal of Public Health Dentistry* 68(4), pp. 227-233.

Hooley, M. S., and H. Millar, L. 2012. The relationship between childhood weight, dental caries and eating practices in children aged 4-8 years in Australia, 2004-2008. *Pediatric Obesity* 7(6), pp. 461-470.

Hooper, S. M., Newcombe, R. G., Faller, R., Eversole, S., Addy, M. & West, N. X. 2007. The protective effects of toothpaste against erosion by orange juice: studies in situ and in vitro. *Journal of Dentistry* 35(6), pp. 476-481.

Horner, J. and Minifie, F. D. 2011. Research ethics I: Responsible conduct of research (RCR)--historical and contemporary issues pertaining to human and animal experimentation. *Journal of Speech Language and Hearing Research* 54(1), pp. S303-329.

HSCIC. 2009. *Health and Social Care Information Centre (HSCIC) Adult Dental Health Survey* [Online]. Available at: http://www.hscic.gov.uk/pubs/dentalsurveyfullreport09 [Accessed:22 March 2016].

HSCIC. 2014a. *Health and Social Care Information Centre, Children's body mass index, overweight and obesity* [Online]. Available at: http://www.hscic.gov.uk/catalogue/PUB19295/HSE2014-ch10-child-obe.pdf [Accessed: 22 March 2016].

Health and Social Care Information Centre. 2014b. *Health Survey for England - 2013, Trend tables* [Online]. Available at: http://www.hscic.gov.uk/catalogue/PUB16077 [Accessed: 22 March 2016].

Hu, F. B. and Malik, V. S. 2010. Sugar-sweetened beverages and risk of obesity and type 2 diabetes: Epidemiologic evidence. *Physiology and Behavior* 100(1), pp. 47-54.

Hughes, J. A., West, N. X., Parker, D. M., Newcombe, R. G. & Addy, M. 1999a. Development and evaluation of a low erosive blackcurrant juice drink in vitro and in situ. 1. Comparison with orange juice. *Journal of Dentistry* 27(4), pp. 285-289.

Hughes, J. A., West, N. X., Parker, D. M., Newcombe, R. G. & Addy, M. 1999b. Development and evaluation of a low erosive blackcurrant juice drink. 3. Final drink and concentrate, formulae comparisons in situ and overview of the concept. *Journal of Dentistry* 27(5), pp. 345-350.

Hughes, J. A., West, N. X., Parker, D. M., Van Den Braak, M. H. & Addy, M. 2000. Effects of pH and concentration of citric, malic and lactic acids on enamel, in vitro. *Journal of Dentistry* 28(2), pp. 147-152.

Hunter, M. L., Patel, R., Loyn, T., Morgan, M. Z., Fairchild, R. & Rees, J. S. 2008. The effect of dilution on the in vitro erosive potential of a range of dilutable fruit drinks. *International Journal of Paediatric Dentistry* 18(4), pp. 251-255.

Hunter, M., West, N. X., Hughes, J. A., Newcombe, R. G. & Addy, M. 2000. Relative susceptibility of deciduous and permanent dental hard tissues to erosion by a low pH fruit drink in vitro. *Journal of Dentistry* 28(4), pp. 265-270.

Hutchings, J. 2003. *Expectations and the Food Industry: The Impact of Color and Appearance*. New York: Kluwer Academic/Plenum Publisher.

Ibbetson, R. 1999. Tooth surface loss: Treatment planning. *British Dental Journal* 186(11), pp. 552-558.

Imfeld, T. 1996. Dental erosion. Definition, classification and links. *European Journal of Oral Science* 104(2 (Pt 2)), pp. 151-155.

Ireland, A. J., Mcguinness, N. & Sherriff, M. 1995. An Investigation into the Ability of Soft Drinks to Adhere to Enamel. *Caries Research* 29(6), pp. 470-476.

Ismail, A. I. and Hasson, H. 2008. Fluoride supplements, dental caries and fluorosis: a systematic review. *Journal of the American Dental Association* 139(11), pp. 1457-1468.

Jaarsveld, C. H. M. and Gulliford, M. C. 2015. Childhood obesity trends from primary care electronic health records in England between 1994 and 2013: population-based cohort study. *Archives of Disease in Childhood* 100(3), pp. 214-219.

Jaeggi, T. and Lussi, A. 1999. Toothbrush abrasion of erosively altered enamel after intraoral exposure to saliva: an in situ study. *Caries Research* 33(6), pp. 455-461.

Jager, D. H., Vieira, A. M., Ruben, J. L. & Huysmans, M. C. 2012. Estimated erosive potential depends on exposure time. *Journal of Dentistry* 40(12), pp. 1103-1108.

James, C. E., Laing, D. G. & Hutchinson, I. 1999. Perception of sweetness in simple and complex taste stimuli by adults and children. *Chemical Senses* 24(3), pp. 281-287.

James, W. P., Nelson, M., Ralph, A. & Leather, S. 1997. Socioeconomic determinants of health. The contribution of nutrition to inequalities in health. *British Medical Journal* 314(7093), pp. 1545-1549.

Jarvinen, V. K., Meurman, J. H., Hyvarinen, H., Rytomaa, I. & Murtomaa, H. 1988. Dental erosion and upper gastrointestinal disorders. *Oral Surgery Oral Medicine Oral Pathology* 65(3), pp. 298-303.

Jarvinen, V. K., Rytomaa, II & Heinonen, O. P. 1991. Risk factors in dental erosion. *Journal of Dental Research* 70(6), pp. 942-947.

Jensdottir, T., Nauntofte, B., Buchwald, C. & Bardow, A. 2005a. Properties and modification of soft drinks in relation to their erosive potential in vitro. *Journal of Dentistry* 33(7), pp. 569-575.

Jensdottir, T., Nauntofte, B., Buchwald, C. & Bardow, A. 2005b. Effects of sucking acidic candy on whole-mouth saliva composition. *Caries Research* 39(6), pp. 468-474.

Johansson, A. K., Lingstrom, P. & Birkhed, D. 2002. Comparison of factors potentially related to the occurrence of dental erosion in high- and low-erosion groups. *European Journal of Oral Science* 110(3), pp. 204-211.

Johansson, A. K., Lingstrom, P., Imfeld, T. & Birkhed, D. 2004. Influence of drinking method on tooth-surface pH in relation to dental erosion. *European Journal of Oral Science* 112(6), pp. 484-489.

Johansson, A. K., Sorvari, R., Birkhed, D. & Meurman, J. H. 2001. Dental erosion in deciduous teeth-an in vivo and in vitro study. *Journal of Dentistry* 29(5), pp. 333-340.

John, D. R. 1999. Consumer socialization of children: A retrospective look at twenty-five years of research. *Journal of Consumer Research* 26(3), pp. 183-213.

Johnson, N. W., Poole, D. F. & Tyler, J. E. 1971. Factors affecting the differential dissolution of human enamel in acid and EDTA. A scanning electron microscope study. *Archives of Oral Biology* 16(4), pp. 385-396.

Johnston, P. A. and Brown, R. C. 2014. Quantitation of Sugar Content in Pyrolysis Liquids after Acid Hydrolysis Using High-Performance Liquid Chromatography without Neutralization. *Journal of Agricultural and Food Chemistry* 62(32), pp. 8129-8133.

Jones, L., Lekkas, D., Hunt, D., Mcintyre, J. & Rafir, W. 2002. Studies on dental erosion: An in vivo-in vitro model of endogenous dental erosion - its application to testing protection by fluoride gel application. *Australian Dental Journal* 47(4), pp. 304-308.

Kandil, H. E., Labib, A. H. & Alhadainy, H. A. 2014. Effect of different irrigant solutions on microhardness and smear layer removal of root canal dentin. *Tanta Dental Journal* 11(1), pp. 1-11.

Kantovitz, K. R., Pascon, F. M., Rontani, R. M. & Gaviao, M. B. 2006. Obesity and dental caries-A systematic review. *Oral Health and Preventive Dentistry* 4(2), pp. 137-144.

Karjalainen, S., Soderling, E., Sewon, L., Lapinleimu, H. & Simell, O. 2001. A prospective study on sucrose consumption, visible plaque and caries in children from 3 to 6 years of age. *Community Dentistry and Oral Epidemiology* 29(2), pp. 136-142.

Kashket, S. and Yaskell, T. 1992. Limitations in the intraoral demineralization of bovine enamel. *Caries Research* 26(2), pp. 98-103.

Kazoullis, S., Seow, W. K., Holcombe, T., Newman, B. & Ford, D. 2007. Common dental conditions associated with dental erosion in schoolchildren in Australia. *Pediatric Dentistry* 29(1), pp. 33-39.

Kelleher, M. G., Bomfim, D. I. & Austin, R. S. 2012. Biologically based restorative management of tooth wear. *International Journal of Dentistry* 2012, p. 742509.

Kelly, B., Halford, J. C., Boyland, E. J., Chapman, K., Bautista-Castano, I., Berg, C., Caroli, M., Cook, B., Coutinho, J. G., Effertz, T., Grammatikaki, E., Keller, K., Leung, R., Manios, Y., Monteiro, R., Pedley, C., Prell, H., Raine, K., Recine, E., Serra-Majem, L., Singh, S. & Summerbell, C. 2010. Television food advertising to children: a global perspective. *American Journal of Public Health* 100(9), pp. 1730-1736.

Kelly, B., Smith, B., King, L., Flood, V. & Bauman, A. 2007. Television food advertising to children: the extent and nature of exposure. *Public Health and Nutrition* 10(11), pp. 1234-1240.

Kelly, J., Turner, J. J. & Mckenna, K.. 2006. What parents think: children and healthy eating. *British Food Journal* 108(5), pp. 413-423.

Keskitalo, K., Knaapila, A., Kallela, M., Palotie, A., Wessman, M., Sammalisto, S., Peltonen, L., Tuorila, H. & Perola, M. 2007. Sweet taste preferences are partly genetically determined: identification of a trait locus on chromosome 16. *American Journal of Clinical Nutrition* 86(1), pp. 55-63.

Market Intelligence. 2012. *Confectionery Market Report 2012* [Online]. Available at: https://www.keynote.co.uk/market-intelligence/view/product/10557/confectionery [Accessed: 22 March 2016]..

Khera, S. C., Turner, J. J. & Mckenna, K. 1990. Anatomy of Cusps of Posterior Teeth and Their Fracture Potential. *Journal of Prosthetic Dentistry* 64(2), pp. 139-147.

Kidd, E. A. and Fejerskov, O. 2004. What constitutes dental caries? Histopathology of carious enamel and dentin related to the action of cariogenic biofilms. *Journal of Dental Research* 83 Spec No C, pp. C35-38.

Kidd, E. A. M. and Joyston-Bechal, S. 1998. *Essentials of Dental Caries*. New York: Oxford University Press.

Kim, S. O., Kwak, J. Y., Choi, B. J. & Lee, J. H. 2005. Oral manifestations of a child with chronic vomiting. *Journal of Dentistry for Children* 72(2), pp. 49-51.

Kinney, J. H. et al. 1993. Atomic-force microscopic study of dimensional changes in human dentine during drying. *Archives of Oral Biology* 38(11), pp. 1003-1007.

Kinney, J. H., Balooch, M., Marshall, G. W. & Marshall, S. J. 1996a. Atomic force microscope measurements of the hardness and elasticity of peritubular and intertubular human dentin. *Journal of Biomechanical Engineering* 118(1), pp. 133-135.

Kinney, J. H., Balooch, M., Marshall, G. W. & Marshall, S. J. 1996b. Hardness and Young's modulus of human peritubular and intertubular dentine. *Archives of Oral Biology* 41(1), pp. 9-13.

Kraus, B. B., Sinclair, J. W. & Castell, D. O. 1990. Gastroesophageal reflux in runners. Characteristics and treatment. *Annals of Internal Medicine* 112(6), pp. 429-433.

Kurihara, K. 2009. Glutamate: from discovery as a food flavor to role as a basic taste (umami). *American Journal of Clinical Nutrition* 90(3), pp. 719S-722S.

Kurihara, K. 2015. Umami the Fifth Basic Taste: History of Studies on Receptor Mechanisms and Role as a Food Flavor. *Biomedical Research International* 2015, p. 189402.

Kwok, D. Y. and Neumann, A. W. 1999. Contact angle measurement and contact angle interpretation. *Advances in Colloid and Interface Science* 81(3), pp. 167-249.

Laidler, K. J. 1984. The development of the Arrhenius equation. *Journal of Chemical Education* 61(6), p. 494.

Lander, L. M., Siewierski, L. M., Brittain, W. J. & Vogler, E. A. 1993. A Systematic Comparison of Contact-Angle Methods. *Langmuir* 9(8), pp. 2237-2239.

Larsen, M. J. 1990. Chemical events during tooth dissolution. *Journal of Dental Research* 69 Spec No, pp. 575-580; discussion 634-576.

Larsen, M. J. and Nyvad, B. 1999. Enamel erosion by some soft drinks and orange juices relative to their pH, buffering effect and contents of calcium phosphate. *Caries Research* 33(1), pp. 81-87.

Larsen, M. J. and Pearce, E. I. 1997. A computer program for correlating dental plaque pH values, cH+, plaque titration, critical pH, resting pH and the solubility of enamel apatite. *Archives of Oral Biology* 42(7), pp. 475-480.

Larsson, H., Odeberg, H. & Bohlin, L. 1983. Studies of Blood-Viscosity with a Newly Constructed Rotational Viscometer Which Operates Via a Desk Top Computer. *Scandinavian Journal of Clinical and Laboratory Investigation* 43(6), pp. 493-502.

Laurance-Young, P., Bozec, L., Gracia, L., Rees, G., Lippert, F., Lynch, R. J. M. & Knowles, J. C. 2011. A review of the structure of human and bovine dental hard tissues and their physicochemical behaviour in relation to erosive challenge and remineralisation. *Journal of Dentistry* 39(4), pp. 266-272.

Law, C., Power, C., Graham, H. & Merrick, D. 2007. Obesity and health inequalities. *Obesity Reviews* 8 Suppl 1, pp. 19-22.

Lee, I., Park, K. & Lee, J. 2012. Note: Precision viscosity measurement using suspended microchannel resonators. *Review of Scientific Instruments* 83(11), pp. 1123-1130.

Lee, J. B. and Lee, S. H. 2011. Dynamic wetting and spreading characteristics of a liquid droplet impinging on hydrophobic textured surfaces. *Langmuir* 27(11), pp. 6565-6573.

Lekkas, D., Hunt, D. & Mcintyre, J. 1992. Development of an in vivo-in vitro model of dental erosion. *Journal of Dental Research* 71, pp. 982-986.

Lemos, D. M. 2004. Saturday morning children television food advertising,The nightmare of nutrition educators. *Journal of Pediatric Gastroenterology and Nutrition* (39(Suppl 1)), pp. S471–S472.

Lendenmann, U., Grogan, J. & Oppenheim, F. G. 2000. Saliva and dental pellicle--a review. *Advances in Dental Research* 14, pp. 22-28.

Leon, F., Couronne, T., Marcuz, M. C. & Koster, E. P. 1999. Measuring food liking in children: a comparison of non verbal methods. *Food Quality and Preference* 10(2), pp. 93-100.

Leonor, S. P., Laura, S. M., Esther, I. C., Marco, Z. Z., Enrique, A. G. & Ignacio, M. R. 2009. Stimulated saliva flow rate patterns in children: A six-year longitudinal study. *Archives of Oral Biology* 54(10), pp. 970-975.

Li, R. and Shan, Y. 2012. Contact angle and local wetting at contact line. *Langmuir* 28(44), pp. 15624-15628.

Liem, D. G., Mars, M. & De Graaf, C. 2004a. Consistency of sensory testing with 4- and 5-year-old children. *Food Quality and Preference* 15(6), pp. 541-548.

Liem, D. G. and Mennella, J. A. 2002. Sweet and sour preferences during childhood: role of early experiences. *Developmental Psychobiology* 41(4), pp. 388-395.

Liem, D. G. and Mennella, J. A. 2003. Heightened sour preferences during childhood. *Chemical Senses* 28(2), pp. 173-180.

Liem, D. G., Mars, M. & De Graaf, C. 2004b. Sour taste preferences of children relate to preference for novel and intense stimuli. *Chemical Senses* 29(8), pp. 713-720.

Liem, D. G. and Zandstra, L. H. 2009. Children's liking and wanting of snack products: Influence of shape and flavour. *International Journal of Behavioral Nutrition and Physical Activity* 6, pp. 255-263.

Liljemark, W. F. and Bloomquist, C. 1996. Human oral microbial ecology and dental caries and periodontal diseases. *Critical Reviews in Oral Biology and Microbiology* 7(2), pp. 180-198.

Linde, A. and Goldberg, M. 1993. Dentinogenesis. *Critical Review of Oral Biology and Medicine* 4, pp. 679-728.

Lindsay, A. C., Sussner, K. M., Kim, J. & Gortmaker, S. 2006. The role of parents in preventing childhood obesity. *Future Child* 16(1), pp. 169-186.

Livingstone, M. B. and Pourshahidi, L. K. 2014. Portion size and obesity. *Advances in Nutrition* 5(6), pp. 829-834.

Llena-Puy, C. 2006. The role of saliva in maintaining oral health and as an aid to diagnosis. *Med Oral Patol Oral Cir Bucal* 11(5), pp. E449-455.

Lloyds Banking Group-Halifax. 2015. *Parents loosen purse strings as Pocket Money increases* [Online]. Available at: http://www.lloydsbankinggroup.com/Media/Press-Releases/2015/halifax/childrens-pocket-money-falls-for-the-second-year-in-a-row/ [Accessed: 22 March 2016].

Lobstein, T. 2014. Reducing consumption of sugar-sweetened beverages to reduce the risk of childhood overweight and obesity. *World Health Orgnization*.

Lodge, R. A. and Bhushan, B. 2006. Wetting properties of human hair by means of dynamic contact angle measurement. *Journal of Applied Polymer Science* 102(6), pp. 5255-5265.

Loesche, W. J. 1986. Role of Streptococcus mutans in human dental decay. *Microbiological Reviews* 50(4), pp. 353-380.

Loesche, W. J. 1992. The specific plaque hypothesis and the antimicrobial treatment of periodontal disease. *Dental Update* 19, pp. 68-74.

Lou, L., Heo, G., Nelson, A. E., Alsagheer, A., Carey, J. P. & Major, P. W. 2009. Chemical composition of enamel surface as a predictor of in-vitro shear bond strength. *American Journal of Orthodontics and Dentofacial Orthopedics* 136(5), pp. 683-688.

Love, R. M. and Jenkinson, H. F. 2002. Invasion of dentinal tubules by oral bacteria. *Critical Reviews in Oral Biology and Medicine* 13(2), pp. 171-183.

Lu, S. F., Gao, Y. S., Xie, T. B., Xie, F., Jiang, X. Q., LI, Z. & Wang, F. M. 2001. A novel contact/non-contact hybrid measurement system for surface topography characterization. *International Journal of Machine Tools and Manufacture* 41(13-14), pp. 2001-2009.

Ludwig, D. S., Peterson, K. E. & Gortmaker, S. L. 2001. Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *Lancet* 357(9255), pp. 505-508.

Ludwig, D. S. and Gortmaker, S. L. 2001. Relation between consumption of sugar-sweetened drinks and childhood obesity: a prospective, observational analysis. *Lancet* 357(9255), pp. 505-508.

Lussi, A. and Carvalho, T. S. 2015. Analyses of the Erosive Effect of Dietary Substances and Medications on Deciduous Teeth. *PLoS One* 10(12), p. e0143957.

Lussi, A. and Jaeggi, T. 2008. Erosion - diagnosis and risk factors. *Clinical Oral Investigations* 12, pp. S5-S13.

Lussi, A., Jaeggi, T. & Zero, D. 2004. The role of diet in the aetiology of dental erosion. *Caries Research* 38 Suppl 1, pp. 34-44.

Lussi, A., Jaggi, T. & Scharer, S. 1993. The influence of different factors on in vitro enamel erosion. *Caries Research* 27(5), pp. 387-393.

Lussi, A., Megert, B., Shellis, R. P. & Wang, X. 2012. Analysis of the erosive effect of different dietary substances and medications. *British Journal of Nutrtion* 107(2), pp. 252-262.

Lussi, A. J., T. and Scharer, S. 1993. The Influence of Different Factors on in-Vitro Enamel Erosion. *Caries Research* 27(5), pp. 387-393.

Macdonald, L., Cummins, S. & Macintyre, S. 2007. Neighbourhood fast food environment and area deprivation-substitution or concentration? *Appetite* 49(1), pp. 251-254.

Magalhaes, A. C., Rios, D., Delbem, A. C., Buzalaf, M. A. & Machado, M. A.. 2007. Influence of fluoride dentifrice on brushing abrasion of eroded human enamel: an in situ/ex vivo study. *Caries Research* 41(1), pp. 77-79.

Mair, L. H., Stolarski, T. A., Vowles, R. W. & Lloyd, C. H. 1996. Wear: mechanisms, manifestations and measurement. Report of a workshop. *Journal of Dentistry* 24(1-2), pp. 141-148.

Maimaran, M. and A. Fishback. 2014. If It’s Useful and You Know It, Do You Eat? Preschoolers Refrain from Instrumental Food. *Journal of Consumer Research* 41(3), pp. 642-655.

Maliderou, M., Reeves, S. & Noble, C. 2006. The effect of social demographic factors, snack consumption and vending machine use on oral health of children living in London. *British Dental Journal* 201(7), pp. 441-444.

Malik, V. S. and Hu, F. B. 2012. Sweeteners and Risk of Obesity and Type 2 Diabetes: The Role of Sugar-Sweetened Beverages. *Current Diabetes Reports* 12(2), pp. 195-203.

Malik, V. S., Popkin, B. M., Bray, G. A., Despres, J. P. & Hu, F. B. 2010. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. *Circulation* 121(11), pp. 1356-1364.

Malik, V. S., Schulze, M. B. & Hu, F. B. 2006. Intake of sugar-sweetened beverages and weight gain: a systematic review. *American Journal of Clinical Nutrition* 84(2), pp. 274-288.

Margaritis, V. and Nunn, J. 2014. Challenges in assessing erosive tooth wear. *Monographs in Oral Science* 25, pp. 46-54.

Malinowska, E., Inkielewicz, I., Czarnowski, W. & Szefer, P. 2008. Assessment of fluoride concentration and daily intake by human from tea and herbal infusions. *Food and Chemical Toxicology* 46(3), pp. 1055-1061.

Marinho, V. C., Higgins, J. P., Logan, S. & Sheiham, A. 2003. Systematic review of controlled trials on the effectiveness of fluoride gels for the prevention of dental caries in children. *Journal of Dental Education* 67(4), pp. 448-458.

Marmur, A. 1998. Contact-angle hysteresis on heterogeneous smooth surfaces: theoretical comparison of the captive bubble and drop methods. *Colloids and Surfaces Physicochemical and Engineering Aspects* 136(1-2), pp. 209-215.

Marquis, M. 2004. Strategies for influencing parental decisions on food purchasing. *Journal of Consumer Marketing* 21(2), pp. 134-143.

Marquis, M., Filion, Y. P. & Dagenais, F. 2005. Does eating while watching television influence children's food-related behaviours? *Canadian Journal of Dietetic Practice and Research* 66(1), pp. 12-18.

Marshall, D., O'Donohoe, S. & Kline, S. 2007. Families, Food and Pester Power: beyond the blame game? *Journal of Consumer Behaviour* 6, pp. 164–181.

Marshall, D., Stuart, M. & Bell, R. 2006. Examining the relationship between product package colour and product selection in preschoolers. *Food Quality and Preference* 17(7-8), pp. 615-621.

Marshall, G. W., Balooch, M., Kinney, J. H. & Marshall, S. J. 1995. Atomic force microscopy of conditioning agents on dentine. *Journal of Biomedical Materials Research* 29(11), pp. 1381-1387.

Marshall, G. W., Balooch, M., Tench, R. J., Kinney, J. H. & Marshall, S. J. 1993. Atomic force microscopy of acid effects on dentin. *Dental Materials* 9(4), pp. 265-268.

Marshall, G. W., Chang, Y. J., Saeki, K., Gansky, S. A. & Marshall, S. J. 2000. Citric acid etching of cervical sclerotic dentin lesions: an AFM study. *Journal of Biomedical Materials Research* 49(3), pp. 338-344.

Mattes, R. 2014. Energy intake and obesity: ingestive frequency outweighs portion size. *Physiology Behaviour* 134, pp. 110-118.

McDerra, E. J., Pollard, M. A. & Curzon, M.. 1998. The dental status of asthmatic British school children. *Pediatric Dentistry* 20(4), pp. 281-287.

McElroy, S. L., Guerdjikova, A. I., Mori, N. & O'Melia, A. M. 2012. Pharmacological management of binge eating disorder: current and emerging treatment options. *Therapeutics and clinical risk management* 8, pp. 219-241.

McKinley, G. H. and Tripathi, A. 2000. How to extract the Newtonian viscosity from capillary breakup measurements in a filament rheometer. *Journal of Rheology* 44(3), pp. 653-670.

McLeod, P. J., Meager, T. W., Steinert, Y. & Boudreau, D. 2000. Using focus groups to design a valid questionnaire. *Academic Medicine* 75(6), pp. 671-671.

McNeal, J. U., and Mindy, F. J. 2003. Children’s visual memory of packaging. *The Journal of Consumer Research* 20(4), pp. 400-428.

Mehta, S. B., Banerji, S., Millar, B. J. & Suarez-Feito, J. M. 2012. Current concepts on the management of tooth wear: part 1. Assessment, treatment planning and strategies for the prevention and the passive management of tooth wear. *British Dental Journal* 212(1), pp. 17-27.

Meiron, T. S., Marmur, A. & Saguy, I. S. 2004. Contact angle measurement on rough surfaces. *Journal of Colloid and Interface Science* 274(2), pp. 637-644.

Mela, D. J. 1999. Food choice and intake: the human factor. *Proceedings of the Nutrition Society* 58(3), pp. 513-521.

Mellberg, J. R. 1992. Hard-tissue substrates for evaluation of cariogenic and anti-cariogenic activity in situ. *Journal of Dental Research* 71 Spec No, pp. 913-919.

Mennella, J. A. and Bobowski, N. K. 2015. The sweetness and bitterness of childhood: Insights from basic research on taste preferences. *Physiology Behaviour* 152(Pt B), pp. 502-507.

Meurman, J. H., Harkonen, M., Naveri, H., Koskinen, J., Torkko, H., Rytomaa, I., Jarvinen, V. & Turunen, R. 1990. Experimental sports drinks with minimal dental erosion effect. *Scandinavian Journal of Dental Research* 98(2), pp. 120-128.

Meurman, J. H. and ten Cate, J. M. 1996. Pathogenesis and modifying factors of dental erosion. *European Journal of Oral Science*104(2 (Pt 2)), pp. 199-206.

Meurman, J. H., Harkonen, M., Naveri, H., Koskinen, J., Torkko, H., Rytomaa, I., Jarvinen, V. & Turunen, R. 1990b. Application of a new mechanical properties microprobe to study hardness of eroded bovine enamel in vitro. *Scandinavian Journal of Dental Research* 98(6), pp. 568-570.

Milan, R. 2008. Editors summary: Sour sweets: a new type of erosive challenge? *British Dental Journal* 204(2), p. 84.

Milgrom, P., Ly, K. A. & Rothen, M. 2009. Xylitol and its vehicles for public health needs. *Advances of Dental Research* 21(1), pp. 44-47.

Milosevic, A., Brodie, D. A. & Slade, P. D. 1997. Dental erosion, oral hygiene, and nutrition in eating disorders. *International Journal of Eating Disorders* 21(2), pp. 195-199.

Mintel. 2012. *Sugar Confectionery UK.* [online] Available at: http://www.sweetretailing.co.uk/index.php/confectionery_advice/view/uk_confectionery_market_update_mintel_2012 [Accessed: 18 March 2016].

Mirror. 2014. *Schoolboy, 15, threatened with suspension for raking in £14,000 selling 'black market' chocolate and crisps* [Online]. Available at:

http://www.mirror.co.uk/news/uk-news/schoolboy-15-threatened-suspension-raking-4665390 [Accessed: 15 March 2016].

Misra, D. N. 1996. Adsorption of Polyacrylic Acids and Their Sodium Salts on Hydroxyapatite: Effect of Relative Molar Mass. *Journal of Colloid and Interface Science* 181(1), pp. 289-296.

Morgan, M., Fairchild, R., Phillips, A., Stewart, K. & Hunter, L. 2009. A content analysis of children's television advertising: focus on food and oral health. *Public Health Nutrition* 12(6), pp. 748-755.

Moynihan, P. J. 2005. The role of diet and nutrition in the etiology and prevention of oral diseases. *Bulletin of World Health Organization* 83(9), pp. 694-699.

Moynihan, P. J. 2014. Response to Letter to the Editor, "Effect on Caries of Restricting Sugars Intake: Systematic Review to Inform WHO Guidelines". *Journal of Dental Research* 93(5), pp. 531-531.

Moynihan, P. J. and Kelly, S. A. 2014. Effect on caries of restricting sugars intake: systematic review to inform WHO guidelines. *Journal of Dental Research* 93(1), pp. 8-18.

Mukherjee, M., Gupta, R., Farr, A., Heaven, M., Stoddart, A., Nwaru, B. I., Fitzsimmons, D., Chamberlain, G., Bandyopadhyay, A., Fischbacher, C., Dibben, C., Shields, M., Phillips, C., Strachan, D., Davies, G., Mckinstry, B., Sheikh, A., Burden & True, R. T. 2014. Estimating the incidence, prevalence and true cost of asthma in the UK: secondary analysis of national stand-alone and linked databases in England, Northern Ireland, Scotland and Wales-a study protocol. *British Medical Journal* 4(11), p. e006647.

Munizaga, G. and Barbosa, G. V. 2005. Rheology for the food industry. *Journal of Food Engineering* 67(1-2), pp. 147-156.

Munoz, M., Adobes, M. M. & Gonzalez De Dios, J.. 2013. Systematic review about dental caries in children and adolescents with obesity and/or overweight. *Nutrition in Hospitals* 28(5), pp. 1372-1383.

Munizagaa, G. T. and Cánovas, V. B. 2005. Rheology for the food industry. *Journal of Food Engineering* 67(1-2), pp. 147–156.

Munson, M. A., Banerjee, A., Watson, T. F. & Wade, W. G. 2004. Molecular analysis of the microflora associated with dental caries. *Journal of Clinical Microbiology* 42(7), pp. 3023-3029.

Murray, J. M., Delahunty, C. M. & Baxter, I. A. 2001. Descriptive sensory analysis: past, present and future. *Food Research International* 34(6), pp. 461-471.

Nakamura, T., Tanigake, A., Miyanaga, Y., Ogawa, T., Akiyoshi, T., Matsuyama, K. & Uchida, T. 2002. The effect of various substances on the suppression of the bitterness of quinine-human gustatory sensation, binding, and taste sensor studies. *Chemical Pharmacology Bulletin* 50(12), pp. 1589-1593.

Nakata, T., Takahashi, M., Nakatani, M., Kuramitsu, R., Tamura, M. & Okai, H. 1995. Role of basic and acidic fragments in delicious peptides (Lys-Gly-Asp-Glu-Glu-Ser-Leu-Ala) and the taste behavior of sodium and potassium salts in acidic oligopeptides. *Bioscience Biotechnology and Biochemistry* 59(4), pp. 689-693.

National Statistics. 2013*. Statistics on Obesity, Physical Activity and Diet: England, 2013* [Online]. Available at: http://www.bhfactive.org.uk/userfiles/Documents/obes-phys-acti-diet-eng-2013-rep.pd [Accessed: 10 March 2016] .

National statistics. 2014. *Households Below Average Income 2013/14* [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/437246/households-below-average-income-1994-95-to-2013-14.pdf [Accessed 15 March 2016].

Neeley, S. M. and Schumann, D. W. 2004. Using animated spokes-characters in advertising to young children - Does increasing attention to advertising necessarily lead to product preference? *Journal of Advertising* 33(3), pp. 7-23.

Nekrashevych, Y., Hannig, M. & Stosser, L. 2004. Assessment of enamel erosion and protective effect of salivary pellicle by surface roughness analysis and scanning electron microscopy. *Oral Health and Preventive Dentistry* 2(1), pp. 5-11.

Nelson, D. G., Featherstone, J. D., Duncan, J. F. & Cutress, T. W. 1983. Effect of carbonate and fluoride on the dissolution behaviour of synthetic apatites. *Caries Research* 17(3), pp. 200-211.

Nestle, M., Wing, R., Birch, L., Disogra, L., Drewnowski, A., Middleton, S., SIGMAN-Grant, M., Sobal, J., Winston, M. & Economos, C. 1998. Behavioral and social influences on food choice. *Nutrition Reviews* 56(5 Pt 2), pp. S50-64; discussion S64-74.

Neumark-Sztainer, D., Story, M., Ackard, D., Moe, J. & Perry, C. . 2000. `The family meals': views of adolescents''. *Journal of Nutrition Education* 32, pp. 329-334.

Neville, L., Thomas, M. & Bauman, A. 2005. Food advertising on Australian television: the extent of children's exposure. *Health Promotion International* 20(2), pp. 105-112.

Ng, M. et al. 2014. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 384(9945), pp. 766-781.

Nielsen, S. J., Siega-riz, A. M. & Popkin, B. M. 2002. Trends in food locations and sources among adolescents and young adults. *Preventive Medicine* 35(2), pp. 107-113.

Nilsson, T., Lundgren, T., Odelius, H., Jonsson, U., Sillen, R. & Noren, J. G. 1998. Differences in co-variation of inorganic elements in the bulk and surface of human deciduous enamel: an induction analysis study. *Connective Tissue Research* 38(1-4), pp. 81-89; discussion 139-145.

Norris, M. B., Noble, A. C. & Pangborn, R. M. 1984. Human saliva and taste responses to acids varying in anions, titratable acidity, and pH. *Physiology Behaviour* 32(2), pp. 237-244.

National Society for the Prevention of Cruelty to Children. 2013. *Recommended adult to child ratios when supervising children, (NSPCC)* [Online]. Available at: https://www.nspcc.org.uk/globalassets/documents/information-service/factsheet-recommended-adult-child-ratios-supervising-children.pdf [Accessed: 15 March 2016].

Nunn, J. 2001. Tooth surface loss: Dental erosion in schoolchildren and socioeconomics. *British Dental Journal* 190, pp. 137-145.

Nunn, J. H. Morris, A. J. Pine, C. M. & Walker, A. 2003. Dental erosion -- changing prevalence? A review of British National childrens' surveys. *International Journal of Paediatric Dentistry* 13(2), pp. 98-105.

Nystrom, M.,Kononen, M., Alaluusua, S., Evalahti, M., Vartiovaara, J. 1990. Development of horizontal tooth wear in maxillary anterior teeth from five to 18 years of age. *Journal of Dental Research* 69(11), pp. 1765-1770.

Organisation for Economic Co-operation and Development. 2014. *OECD Obesity Update 2014* [Online]. Available at: http://www.oecd.org/health/obesity-update.htm [Accessed 15 March 2016].

Ohrn, R. et al. 1999. Oral status of 81 subjects with eating disorders. *European Journal of Oral Science* 107(3), pp. 157-163.

Okazaki, M., Tohda, H., Yanagisawa, T., Taira, M. & Takahashi, J. 1998. Differences in solubility of two types of heterogeneous fluoridated hydroxyapatites. *Biomaterials* 19(7-9), pp. 611-616.

Oliveira, M. A., Torres, C. P., Gomes-silva, J. M., Chinelatti, M. A., De Menezes, F. C., Palma-Dibb, R. G. & Borsatto, M. C. 2010. Microstructure and mineral composition of dental enamel of permanent and deciduous teeth. *Microscopy Research and Technique* 73(5), pp. 572-577.

Oliver, K. and Thelen, M. 1996. Children's perceptions of peer influence on eating concerns. *Journal of Behavior Therapy* 27(1), pp. 25–39.

Orchardson, R. and S. W. Cadden. 2001. An update on the physiology of the dentine-pulp complex. *Dental Update* 28(4), pp. 200-209.

Owens, B. M. 2007. The potential effects of pH and buffering capacity on dental erosion. *General Dentistry* 55(6), pp. 527-531.

Paediatric Dentistry UK. 1999. *National clinical guildlines and policy documents* [Online]. Available at: http://www.nhsbsa.nhs.uk/Documents/ArchivePDF/paediatric_dentistry_uk1999.pdf [Accessed: 10 March 2016].

Pagsberg, A. K. and Wang, A. R. 1994. Epidemiology of anorexia nervosa and bulimia nervosa in Bornholm County, Denmark, 1970-1989. *Acta Psychiatrica Scandinavica* 90(4), pp. 259-265.

Palmer, C. A. 2005. Dental caries and obesity in children: Different problems, related causes. *Quintessence International* 36(6), pp. 457-461.

Palmer, L., Newcomb, C. J., Kaltz, S. R., Spoerke, E. D. & Stupp, S. I. 2008. Biomimetic systems for hydroxyapatite mineralization inspired by bone and enamel. *Chemical Reviews* 108(11), pp. 4754-4783.

Pan, L. Q., Lu, R. F., Zhu, Q. B., Mcgrath, J. M. & Tu, K. 2015a. Measurement of moisture, soluble solids, sucrose content and mechanical properties in sugar beet using portable visible and near-infrared spectroscopy. *Postharvest Biology and Technology* 102, pp. 42-50.

Pan, L. Q., Lu, R. F., Zhu, Q. B., Mcgrath, J. M. & Tu, K. 2015b. Determination of sucrose content in sugar beet by portable visible and near-infrared spectroscopy. *Food Chemistry* 167, pp. 264-271.

Pangborn, R. M. and Giovanni, M. E. 1984. Dietary intake of sweet foods and of dairy fats and resultant gustatory responses to sugar in lemonade and to fat in milk. *Appetite* 5(4), pp. 317-327.

Park, B. D. and Jeong, H. W. 2011. Hydrolytic stability and crystallinity of cured urea-formaldehyde resin adhesives with different formaldehyde/urea mole ratios. *International Journal of Adhesion and Adhesives* 31(6), pp. 524-529.

Parliament UK. 2016. *Obesity Statistics, House of Common Library, Parliament UK* [Online]. Available at: file:///C:/Users/Dental/Downloads/SN03336%20(1).pdf [Accessed: 22 March 2016].

Parry, J., Shaw, L., Arnaud, M. J. & Smith, A. J. 2001. Investigation of mineral waters and soft drinks in relation to dental erosion. *Journal of Oral Rehabilitation* 28(8), pp. 766-772.

Patel, R. 2012. *The State of Oral Health in Europe* [Online]. Available at: http://www.oralhealthplatform.eu/wp-content/uploads/2015/09/Report-the-State-of-Oral-Health-in-Europe.pd [Accessed: 15 March 2016].

Patrick, H. and Nicklas, T. A. 2005. A review of family and social determinants of children's eating patterns and diet quality. *Journal of the American College of Nutrition* 24(2), pp. 83-92.

Peleg, M., Normand, M. D. & Corradini, M. G. 2012. The Arrhenius equation revisited. *Critical Reviews in Food Science and Nutrition* 52(9), pp. 830-851.

Penel, G., Leroy, G., Rey, C. & Bres, E. 1998. MicroRaman spectral study of the PO4 and CO3 vibrational modes in synthetic and biological apatites. *Calcified Tissue International* 63(6), pp. 475-481.

Perez-Rodrigo, C., Ribas, L., Serra-Majem, L. & Aranceta, J. 2003. Food preferences of Spanish children and young people: the enKid study. *European Journal of Clinical Nutrition* 57 Suppl 1, pp. S45-48.

Pergamalian, A. 2003. The association between wear facets, bruxism, and severity of facial pain in patients with temporomandibular disorders *The Journal of Prosthethetic Dentistry* 90(2), pp. 194-200.

Petersen, P. E. 2003. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century--the approach of the WHO Global Oral Health Programme. *Community Dental Oral Epidemiology* 31 Suppl 1, pp. 3-23.

Petersen, P. E., Bourgeois, D., Ogawa, H., Estupinan-Day, S. & Ndiaye, C. 2005. The global burden of oral diseases and risks to oral health. *Bulletin of the World Health Organization* 83(9), pp. 661-669.

Petersen, P. E. and Lennon, M. A. 2004. Effective use of fluorides for the prevention of dental caries in the 21st century: the WHO approach. *Community Dentistry and Oral Epidemiology* 32(5), pp. 319-321.

Pheasant, S. and Haslegrave, C. 2006. *Bodyspace, Anthropometry, Ergonomics and the design of work*. London, UK: Taylor and Francis.

Phelan, J. and Rees, J. 2003. The erosive potential of some herbal teas. *Journal of Dentistry* 31(4), pp. 241-246.

Plattig, K. H., Kobal, G. & Thumfart, W. 1980. The chemical senses of smell and taste in the course of life - changes of smell and taste perception. *Gerontology* 13(2), pp. 149-157.

Popper, R. and Kroll, J. J. 2003. Conducting sensory research with children. *Food Technology* 57(5), pp. 60-65.

Poutanen, R., Lahti, S., Tolvanen, M. & Hausen, H. 2006. Parental influence on children's oral health-related behavior. *Acta Odontologica Scandinavica* 64(5), pp. 286-292.

Powell, L. M. and Chaloupka, F. J. 2009. Food prices and obesity: evidence and policy implications for taxes and subsidies. *Milbank Q* 87(1), pp. 229-257.

Prentice, A. M. and Jebb, S. A. 2003. Fast foods, energy density and obesity: a possible mechanistic link. *Obesity Reviews* 4(4), pp. 187-194.

Prescott, J. 1998. Comparisons of taste perceptions and preferences of Japanese and Australian consumers: Overview and implications for cross-cultural sensory research. *Food Quality and Preference* 9(6), pp. 393-402.

Privitera, G. J. and Wallace, M. 2011. An assessment of liking for sugars using the estimated daily intake scale. *Appetite* 56(3), pp. 713-718.

Public Health England. 2007. *Obesity and Health* [Online]. Available at: http://www.noo.org.uk/NOO_about_obesity/obesity_and_health [Accessed: 15 March 2016]

Public Health England. 2012. *National Diet and Nutrition Survey: Results from Years 1-4 (combined) of the Rolling Programme (2008/2009 – 2011/12)* [Online]. Available at : https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/310997/NDNS_Y1_to_4_UK_report_Executive_summary.pdf [Accessed*:* 15 March 2016].

Public Health England. 2014. *Changes in children's body mass index between 2006/07 and 2013/14: NCMP* [Online]. *Available at: http://www.noo.org.uk/securefiles/160324_0905//NCMP_Trends_Report_Nov_2014.pdf* [Accessed: 15 March 2016].

Public Health England. 2015. *Sugar Reduction, The evidence for action* [Online]. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/470179/Sugar_reduction_The_evidence_for_action.pdf [Accessed*:* 20 March 2016]

Purves, D., Augustine, G., Fitzpatrick, D., Katz, L., Lamantia, A., Mcnamara, J. & Williams, M. 2001. *Neuroscience*. USA: Sainauer Associates.

Qi, Q., Li, Y. F., You, Y. & Liao, F. L. 2009. The criteria for evaluating shear stress measuring range and the lowest measurable shear stress of rotational viscometer. *Clinical Hemorheology and Microcirculation* 42(1), pp. 71-73.

Rame, E. 1997. The interpretation of dynamic contact angles measured by the Wilhelmy plate method (vol 185, pg 245, 1997). *Journal of Colloid and Interface Science* 189(2), pp. 383-383.

Royal College of Peadiatrics and Child Health. 2012. *UK School Age Growth Charts and Resources* [Online]. Available at: http://www.rcpch.ac.uk/improving-child-health/public-health/uk-who-growth-charts/school-age-2-18-years/school-age-charts-an [Accessed 15 March 2016].

Redfearn, P. J., Agrawal, N. & Mair, L. H. 1998. An association between the regular use of 3,4 methylenedioxy-methamphetamine (ecstasy) and excessive wear of the teeth. *Addiction* 93(5), pp. 745-748.

Reed, D. R. and McDaniel, A. H. 2006. The human sweet tooth. *BMC Oral Health* 6 Suppl 1, p. S17.

Reed, D. R., Tanaka, T. & Mcdaniel, A. H. 2006. Diverse tastes: Genetics of sweet and bitter perception. *Physiology Behaviour* 88(3), pp. 215-226.

Rees, J., Loyn, T. & Gilmour, A. 2006. Does low acid orange juice equal low erosion? *Dental Update* 33(4), pp. 242-244.

Rees, J. S. 2004. The role of drinks in tooth surface loss. *Dental Update* 31(6), pp. 318-320.

Reidpath, D. D., Burns, C., Garrard, J., Mahoney, M. & Townsend, M. 2002. An ecological study of the relationship between social and environmental determinants of obesity. *Health and Place* 8(2), pp. 141-145.

Reijden, W. A., Buijs, M. J., Damen, J. J., Veerman, E. C., Ten Cate, J. M. & Nieuw Amerongen, A. V. 1997. Influence of polymers for use in saliva substitutes on de- and remineralization of enamel in vitro. *Caries Research* 31(3), pp. 216-223.

Reverdy, C., Chesnel, F., Schlich, P., Koster, E. P. & Lange, C. 2008. Effect of sensory education on willingness to taste novel food in children. *Appetite* 51(1), pp. 156-165.

Ricketts, C. D. 1997. Fat preferences, dietary fat intake and body composition in children. *European Journal of Clinical Nutrition* 51(11), pp. 778-781.

Roberts, B. P., Blinkhorn, A. S. & Duxbury, J. T. 2003. The power of children over adults when obtaining sweet snacks. *International Journal of Paediatric Dentistry* 13(2), pp. 76-84.

Robinson, T. N. 2001. Television viewing and childhood obesity. *Pediatric Clinics of North America* 48(4), pp. 1017-1025.

Robinson, T. N., Borzekowski, D. G., Matheson, D. M. & Kraemer, H. C. 2007. Effects of fast food branding on young children's taste preferences. *Archives of Pediatrics and Adolescent Medicine* 161(8), pp. 792-797.

Robyn, R. L., Robert, J. M. & John, D. R. 2008. Pucker up: the effects of sour candy on your patients' oral health. A review of the dental erosion literature and pH values for popular candies. *Northwest Dentistry* 87(2), pp. 20-29.

Rodriguez, J. M. and Bartlett, D. W. 2010. A comparison of two-dimensional and three-dimensional measurements of wear in a laboratory investigation. *Dental Materials* 26(10), pp. e221-225.

Rogers, A. H. 1976. Bacteriocinogeny and the properties of some bacteriocins of Streptococcus mutans. *Archives of Oral Biology* 21, pp. 99-104.

Rovner, A. J., Nansel, T. R., Wang, J. & Iannotti, R. J. 2011. Food sold in school vending machines is associated with overall student dietary intake. *Journal of Adolescent Health* 48(1), pp. 13-19.

Rozin, P. 1976. Acquisition of food preferences and attitude to food. *International Journal of Obesity* 4, pp. 356-363.

Rugg-Gunn, A. J., Maguire, A., Gordon, P. H., Mccabe, J. F. & Stephenson, G. 1998. Comparison of erosion of dental enamel by four drinks using an intra-oral applicance. *Caries Research* 32(5), pp. 337-343.

Ruxton, C. H. S., Gardner, E. J. & Mcnnulty, H. M. 2010. Is sugar consumption detrimental to health? A review of the evidence. *Critical Reviews in Food Science and Nutrition* 50(1), pp. 1-19.

Ruxton, C. H. S. and Kirk, T. R. 1996. Relationships between social class, nutrient intake and dietary patterns in Edinburgh schoolchildren. *International Journal of Food Sciences and Nutrition* 47(4), pp. 341-349.

Rytomaa, I., Meurman, J. H., Koskinen, J., Laakso, T., Gharazi, L. & Turunen, R. 1988. In vitro erosion of bovine enamel caused by acidic drinks and other foodstuffs. *Scandinavian Journal of Dental Research* 96(4), pp. 324-333.

Salvy, S. J., De La haye, K., Bowker, J. C. & Hermans, R. C. 2012. Influence of peers and friends on children's and adolescents' eating and activity behaviors. *Physiology Behaviour* 106(3), pp. 369-378.

Savage, J. S., Fisher, J. O. & Birch, L. L. 2007. Parental Influence on Eating Behavior: Conception to Adolescence. *Journal of Law, Medicine and Ethics* 35(1), pp. 22-34.

Schaad, P., Thomann, J.-M., Voegel, J.-C. & Gramain, P. 1994. Adsorption of Neutral and Anionic Polyacrylamides on Hydroxyapatite and Human Enamel: Influence on the Dissolution Kinetics. *Journal of Colloid and Interface Science* 164(2), pp. 291-295.

Schaefer, T. 2014. Fluid Dynamics and Viscosity in Strongly Correlated Fluids. *Annual Review of Nuclear and Particle Science* 64 (2), pp. 125-148.

Schiffman, S. S. 1993. Perception of Taste and Smell in Elderly Persons. *Critical Reviews in Food Science and Nutrition* 33(1), pp. 17-26.

Schulz, K. F. and Grimes, D. A. 2002. Generation of allocation sequences in randomised trials: chance, not choice. *Lancet* 359(9305), pp. 515-519.

Schweizer-Hirt, C. M., Schait, A., Schmid, R., Imfeld, T., Lutz, F. & Muhlemann, H. R. 1978. Erosion and abrasion of the dental enamel. Experimental study. *Revue mensuelle suisse d'odonto-stomatologie / SSO* 88(5), pp. 497-529.

Schwendicke, F., Dorfer, C. E., Schlattmann, P., Foster Page, L., Thomson, W. M. & PARIS, S. 2015. Socioeconomic inequality and caries: a systematic review and meta-analysis. *Journal of Dental Research* 94(1), pp. 10-18.

Scientific Advisory Committee on Nutrition. 2015. *SACN Carbohydrates and Health Report* [Online]. Available at: https://www.gov.uk/government/publications/sacn-carbohydrates-and-health-report [Accessed: 15 March 2016].

Selwitz, R. H., Ismail, A. I. & Pitts, N. B. 2007. Dental caries. *Lancet* 369(9555), pp. 51-59.

Shang, J., Flury, M., Harsh, J. B. & Zollars, R. L. 2008. Comparison of different methods to measure contact angles of soil colloids. *Journal of Colloid and Interface Science* 328(2), pp. 299-307.

Shaw, L., AL-Dlaigan, Y. H. & Smith, A. 2000. Childhood asthma and dental erosion. *ASDC Journal of Dentistry for Children* 67(2), pp. 102-106, 182.

Sheiham, A. and Watt, R. G. 2000. The common risk factor approach: a rational basis for promoting oral health. *Community Dentistry and Oral Epidemiology* 28(6), pp. 399-406.

Shellis, R. P. 1988. A microcomputer program to evaluate the saturation of complex solutions with respect to biominerals. *Computer Applications in Bioscience* 4(3), pp. 373-379.

Shellis, R. P. 1996. A scanning electron-microscopic study of solubility variations in human enamel and dentine. *Archives of Oral Biology* 41(5), pp. 473-484.

Shellis, R. P., Finke, M., Eisenburger, M., Parker, D. M. & Addy, M. 2005. Relationship between enamel erosion and liquid flow rate. *European Journal of Oral Science* 113(3), pp. 232-238.

Shellis, R. P. and Wilson, R. M. 2004. Apparent solubility distributions of hydroxyapatite and enamel apatite. *Journal of Colloid and Interface Science* 278(2), pp. 325-332.

Shimizu, D. and Macho, G. A. 2008. Effect of enamel prism decussation and chemical composition on the biomechanical behavior of dental tissue: a theoretical approach to determine the loading conditions to which modern human teeth are adapted. *Anatomical Records (Hoboken)* 291(2), pp. 175-182.

Shore, R. C., Backman, B., Elcock, C., Brook, A. H., Brookes, S. J. & Kirkham, J. 2010. The structure and composition of deciduous enamel affected by local hypoplastic autosomal dominant amelogenesis imperfecta resulting from an ENAM mutation. *Cells Tissues Organs* 191(4), pp. 301-306.

Sijtsema, S. J., Reinders, M. J., Hiller, S. R. C. H. & Guardia, M. D. 2012. Fruit and snack consumption related to sweet, sour and salty taste preferences. *British Food Journal* 114(6-7), pp. 1032-1046.

Silva, A. E. et al., Menezes, A. M., Demarco, F. F., Vargas-Ferreira, F. & Peres, M. A. Obesity and dental caries: systematic review. *Rev Saude Publica* 47(4), pp. 799-812.

Sims, W. 1985. Streptococcus mutans and vaccines for dental caries: a personal commentary and critique. *Community Dental Health* 2, pp. 129-147.

Sinclair, S. and Winkler , T. 2009. *The School Fringe, From Research to Action - Policy Options Nutrition Policy Unit* London Metropolitan University [Online]. Available at: http://www.londonmet.ac.uk/library/r28842_3.pdf [Accessed: 10 March 2016].

Singh, S. and Jindal, R. 2010. Evaluating the buffering capacity of various soft drinks, fruit juices and tea. *Journal of Conservative Dentistry* 13(3), pp. 129-131.

Skinner, A. and Woods, A. 1984. An investigation of the effect of maltose and sucrose in the diet on the microbiology of dental plaque in man. *Archives of Oral Biology* 29, pp. 323-326.

Skinner, J. D., Carruth, B. R., Wendy, B. & Ziegler, P. J. 2002. Children's food preferences: a longitudinal analysis. *Journal of the American Dietetic Association* 102(11), pp. 1638-1647.

Skotowski, M. C., Hunt, R. J. & Levy, S. M. 1995. Risk factors for dental fluorosis in pediatric dental patients. *Journal of Public Health Dentistry* 55(3), pp. 154-159.

Smith, B. G. and Knight, J. K. 1982. Dental erosion due to anorexia nervosa with bulimia. *British Dental Journal* 152(6), p. 187.

Smith, S. A. and Norris, B. J. 2004. Changes in the body size of UK and US children over the past three decades. *Ergonomics* 47(11), pp. 1195-1207.

Socransky, S. S. and Haffajee, A. D. 2005. Periodontal microbial ecology. *Periodontology* 38(20), pp. 135-187.

Sodamade, A. 2014. Assessment of Sugar Levels in Different Soft Drinks: A Measure to Check National Food Security. *International Journal of Science and Research* 3(12), pp. 567-569.

Sodexho. 2005. *The Sodexho School Meals and Lifestyle Survey 2005* [Online]. *Available at:* *http://www.thehealthwell.info/node/33004?source=relatedblock&content=resource&member=6744&catalogue=none&collection=none&tokens_complete=true* [Accessed: 15 March 2016]

SollbGhmer, K. P. and May, M. A. 1995. Force microscopical investigation of human teeth in liquids. *Thin Solid Films* 264(2), pp. 176-183.

Sousa, S. M. and Silva, T. L. 2005. Demineralization effect of EDTA, EGTA, CDTA and citric acid on root dentin: a comparative study. *Brazilian Oral Research* 19(3), pp. 188-192.

Sovik, J. B., Skudutyte-Rysstad, R., Tveit, A. B., Sandvik, L. & Mulic, A. 2015. Sour sweets and acidic beverage consumption are risk indicators for dental erosion. *Caries Research* 49(3), pp. 243-250.

Spence, I., Wong, P., Rusan, M. & Rastegar, N. 2006. How color enhances visual memory for natural scenes. *Psychological Science* 17(1), pp. 1-6.

Spielman, A. I. 1990. Interaction of saliva and taste. *Journal of Dental Research* 69(3), pp. 838-843.

Srivastava, N. and Burns, M. A. 2006. Analysis of non-Newtonian liquids using a microfluidic capillary viscometer. *Analytical Chemistry* 78(5), pp. 1690-1696.

St-Onge, M. P., Keller, K. L. & Heymsfield, S. B l. 2003. Changes in childhood food consumption patterns: a cause for concern in light of increasing body weights. *American Journal of Clinical Nutrition* 78(6), pp. 1068-1073.

Staat, R. H., Gawronski, T. H., Cressey, D. E., Harris, R. S. & Folke, L. E. 1975. Effects of dietary sucrose levels on the quantity and microbial composition of human dental plaque. *Journal of Dental Research* 54, pp. 872-880.

Stewart, K. F., Fairchild, R. M., Jones, R. J., Hunter, L., Harris, C. & Morgan, M. Z. 2013. Children's understandings and motivations surrounding novelty sweets: a qualitative study. *International Journal of Paediatric Dentistry* 23(6), pp. 424-434.

Story, M. and French, S. 2004. Food Advertising and Marketing Directed at Children and Adolescents in the US. *International Journal of Behavioral Nutrition and Physical Activity* 1(3), pp. 1-17.

Story, M., Neumark-Sztainer, D. & French, S. 2002. Individual and environmental influences on adolescent eating behaviors. *Journal of the American Dietetic Association* 102(3 Suppl), pp. S40-51.

Stuck, B. A. 2010. Smell and taste - the chemical senses. *HNO* 58(7), p. 643.

Sullivan, R. E. and Kramer, W. S. 1983. Iatrogenic erosion of teeth. *ASDC Journal of Dentistry for Children* 50(3), pp. 192-196.

Suvan, J., D'Aiuto, F., Moles, D. R., Petrie, A. & Donos, N. 2011. Association between overweight/obesity and periodontitis in adults. A systematic review. *Obesity Reviews* 12(5), pp. e381-404.

Szmukler, G. I. 1985. The epidemiology of anorexia nervosa and bulimia. *Journal of Psychiatric Research* 19(2-3), pp. 143-153.

Taji, S. and Seow, W. K. 2010. A literature review of dental erosion in children. *Australian Dental Journal* 55(4), pp. 358-367; quiz 475.

Tanzer, J. M., Livingston, J. & Thompson, A. M. 2001. The microbiology of primary dental caries in humans. *Journal of Dental Education* 65(10), pp. 1028-1037.

Te Morenga, L., Mallard, S. & Mann, J. 2013. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *British Medical Journal* 346, pp. e7492-e7510.

Ten Bosch, J. J. and Angmar-Mansson, B. 1991. A review of quantitative methods for studies of mineral content of intra-oral caries lesions. *Journal of Dental Research* 70(1), pp. 2-14.

Ten Bruggen Cate, H. J. 1968. Dental erosion in industry. *British Journal of Industrial Medicine* 25(4), pp. 249-266.

Theuns, H. M., Driessens, F. C., Van Dijk, J. W. & Groeneveld, A. 1986. Experimental evidence for a gradient in the solubility and in the rate of dissolution of human enamel. *Caries Research* 20(1), pp. 24-31.

Thomann, J. M., Voegel, J. C. & Gramain, P. 1990. Kinetics of dissolution of calcium hydroxyapatite powder. III: pH and sample conditioning effects. *Calcified Tissue International* 46(2), pp. 121-129.

Tilston, C. H., Gregson, K., Neale, R. J. & Douglas, C. J. 1990. Dietary awareness of primary school children. *British Food Journal* 93, pp. 25–29.

Tong, J. and D'Alessio, D. 2011. Eating disorders and gastrointestinal peptides. *Current Opinion in Endocrinology, Diabetes and Obesity* 18(1), pp. 42-49.

Toogood, J. H. 1990. Complications of topical steroid therapy for asthma. *American Review of Respiratory Disease* 141(2 Pt 2), pp. S89-96.

Tredwin, C. J., Scully, C. & Bagan-Sebastian, J. V. 2005. Drug-induced disorders of teeth. *Journal of Dental Research* 84(7), pp. 596-602.

Troiano, R. P. and Flegal, K. M. 1998. Overweight children and adolescents: description, epidemiology, and demographics. *Pediatrics* 101(3 Pt 2), pp. 497-504.

Turow, J. 2003. Family Boundaries, Commercialism, and the Internet: A Framework for Research. *Journal of Applied Developmental Psychology 73(22)*, pp. 25-43.

Twetman, S. 2015. The evidence base for professional and self-care prevention-caries, erosion and sensitivity. *BMC Oral Health* 15 Suppl 1, p. S4.

Twetman, S. et al. 2003. Caries-preventive effect of fluoride toothpaste: a systematic review. *Acta Odontologica Scandinavica* 61(6), pp. 347-355.

Unicef UK. 2007. *United Nations Covention on the Rights of the Child* [Online]. Available at: *http://www.unicef.org.uk/Documents/Publication-pdfs/UNCRC_summary.pdf* [Accessed: 12 March 2016].

Unicef UK. 2014. *The United Nations Convention on the Rights of the Child* [Online]. Available at: http://www.unicef.org.uk/Documents/Publication-pdfs/UNCRC_PRESS200910web.pdf [Accessed: 12 March 2016].

Valkenburg, P. M. 2000. Media and youth consumerism. *Journal of Adolescent Health* 27(2 Suppl), pp. 52-56.

Van Houte, J. 1980. Bacterial specificity in the etiology of dental caries. *International Dental Journal* 30, pp. 305-326.

Van Houte, J. 1994. Role of microorganisms in careis etiology. *Journal of Dental Research* 73, pp. 672-681.

Van Jaarsveld, C. H. and Gulliford, M. C. 2015. Childhood obesity trends from primary care electronic health records in England between 1994 and 2013: population-based cohort study. *Archives of Disease in Childhood* 100(3), pp. 214-219.

Van Landuyt, K. L., Peumans, M., FIEUWS, S., De Munck, J., Cardoso, M. V., Ermis, R. B., Lambrechts, P. & Van Meerbeek, B. 2008. A randomized controlled clinical trial of a HEMA-free all-in-one adhesive in non-carious cervical lesions at 1 year. *Journal of Dentistry* 36(10), pp. 847-855.

Vanhala, M., Vanhala, P., Kumpusalo, E., Halonen, P. & Takala, J. 1998. Relation between obesity from childhood to adulthood and the metabolic syndrome: population based study. *British Medical Journal*, pp. 317, 319–320.

Ventura, A. K. and Mennella, J. A. 2011. Innate and learned preferences for sweet taste during childhood. *Current Opinion in Clinical Nutrition and Metabolic Care* 14(4), pp. 379-384.

Ventura, E. E., Davis, J. N. & Goran, M. I. 2011. Sugar content of popular sweetened beverages based on objective laboratory analysis: focus on fructose content. *Obesity (Silver Spring)* 19(4), pp. 868-874.

Vereecken, C. A., Keukelier, E. & Maes, L. 2004. Influence of mother's educational level on food parenting practices and food habits of young children. *Appetite* 43(1), pp. 93-103.

Vereecken, C. A., Todd, J., Roberts, C., Mulvihill, C. & Maes, L. 2006. Television viewing behaviour and associations with food habits in different countries. *Public Health Nutrition* 9(2), pp. 244-250.

Vitale, G. C., Cheadle, W. G., Patel, B., Sadek, S. A., Michel, M. E. & CUSCHIERI, A. 1987. The effect of alcohol on nocturnal gastroesophageal reflux. *Journal of the American Medical Association* 258(15), pp. 2077-2079.

Wagoner, S. N., Marshall, T. A., Qian, F. & Wefel, J. S. 2009. In vitro enamel erosion associated with commercially available original-flavor and sour versions of candies. *Journal of American Dental Association* 140(7), pp. 906-913.

Walker, R. W., Dumke, K. A. & Goran, M. I. 2014. Fructose content in popular beverages made with and without high-fructose corn syrup. *Nutrition* 30(7-8), pp. 928-935.

Walker, R. W. and Goran, M. I. 2015. Laboratory Determined Sugar Content and Composition of Commercial Infant Formulas, Baby Foods and Common Grocery Items Targeted to Children. *Nutrients* 7(7), pp. 5850-5867.

Walsh, L. M. M., Toma, R. B., Tuveson, R. V. & Sondhi, L. 1990. Color Preference and Food Choice among Children. *Journal of Psychology* 124(6), pp. 645-653.

Wang, P., Lin, H. C., Chen, J. H. & Liang, H. Y. 2010. The prevalence of dental erosion and associated risk factors in 12-13-year-old school children in Southern China. *BMC Public Health* 10, p. 478.

Wansink, B. 2004. Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annual Review of Nutrition* 24, pp. 455-479.

Wardle, J., Herrera, M. L., Cooke, L. & Gibson, E. L. 2003. Modifying children's food preferences: the effects of exposure and reward on acceptance of an unfamiliar vegetable. *European Journal of Clinical Nutrition* 57(2), pp. 341-348.

Wells, L., Nelson, M. 2005. The National School Fruit Scheme produces short-term but not longer-term increases in fruit consumption in primary school children. *British Journal of Nutrition* 93(4).

Welsh Government. 2012. *Welsh Network of Healthy School Schemes* [Online]. Availanle at:
http://wales.gov.uk/topics/health/improvement/schools/schemes/?lang=en
[Accessed: 15 March 2016]

Wen Ng, S., Mhurchu, C., Jebb, S. A. & Popkin, B. M. 2012. Patterns and trends of beverage consumption among children and adults in Great Britain, 1986 –2009. *British Journal of Nutrition* 108, pp. 536–551.

Wendell, S., Wang, X., Brown, M., Cooper, M. E., Desensi, R. S., Weyant, R. J., Crout, R., Mcneil, D. W. & Marazita, M. L. 2010. Taste genes associated with dental caries. *Journal of Dental Research* 89(11), pp. 1198-1202.

Wendin, K., Allesen-Holm, B. H. & Bredie, W. L. P. 2011. Do facial reactions add new dimensions to measuring sensory responses to basic tastes? *Food Quality and Preference* 22(4), pp. 346-354.

Werner, S. L., Phillips, C. & Koroluk, L. D. 2012. Association between childhood obesity and dental caries. *Pediatric Dentistry* 34(1), pp. 23-27.

West, N. X., Hughes, J. A. & Addy, M. 2000. Erosion of dentine and enamel in vitro by dietary acids: the effect of temperature, acid character, concentration and exposure time. *Journal of Oral Rehabilitation* 27(10), pp. 875-880.

West, N. X., Hughes, J. A., Parker, D. M., Newcombe, R. G. & Addy, M. 1999. Development and evaluation of a low erosive blackcurrant juice drink. 2. Comparison with a conventional blackcurrant juice drink and orange juice. *Journal of Dentistry* 27(5), pp. 341-344.

West, N. X., Maxwell, A., Hughes, J. A., Parker, D. M., Newcombe, R. G. & Addy, M. 1998. A method to measure clinical erosion: the effect of orange juice consumption on erosion of enamel. *Journal of Dentistry* 26(4), pp. 329-335.

West, T. 2006. Sweet and Sour – The only sour thing about sugar confectionery is the flavours that are so popular with today's kids. *Forecourt Trader*, p. page 25.

White, D. J., Tsakos, G., Pitts, N. B., Fuller, E., Douglas, G. V., MURRAY, J. J. & STEELE, J. G l. 2012. Adult Dental Health Survey 2009: common oral health conditions and their impact on the population. *British Dental Journal* 213(11), pp. 567-572.

White, D. J., Faller, R. V. & Bowman, W. D. 1992. Demineralization and remineralization evaluation techniques-added considerations. *Journal of Dental Research* 71 Spec No, pp. 929-933.

Whitehead, S. A., Shearer, A. C., Watts, D. C. & Wilson, N. H. 1995. Comparison of methods for measuring surface roughness of ceramic. *Journal of Oral Rehabilitation* 22(6), pp. 421-427.

Wilson, G. and Wood, K. 2004. The influence of children on parental purchases during supermarket shopping. *International Journal of Consumer Studies* 24(4), pp. 329–336.

WIMD. 2011. *Welsh Goverment, Welsh Index of Multiple Deprivation (WIMD)* [Online]. Available at: http://www.cdcymru.org/SiteAssets/publications/WIMD%2011%20technical.pdf [Accessed: 15 March 2016].

WIMD. 2014. Welsh Goverment, Welsh Index of Multiple Deprivation (WIMD) [Online]. *Availaable at: http://gov.wales/statistics-and-research/welsh-index-multiple-deprivation/?lang=en* [Accessed: 15 March 2016].

Woodward, D. R., Cumming, F. J., Ball, P. J., Williams, H. M., Hornsby, H. & Boon, J. A. 1997. Does television affect teenagers' food choices? *Journal of Human Nutrition and Dietetics* 10(4), pp. 229-235.

World Health Organization. 2013. *World Health Organization, Obesity and Overweight* [Online]. Available at: *http://www.who.int/mediacentre/factsheets/fs311/en/* [Accessed 15 March 2016].

Wu, D., Yang, J., LI, J., Chen, L., Tang, B., Chen, X., Wu, W. & Li, J. 2013. Hydroxyapatite-anchored dendrimer for in situ remineralization of human tooth enamel. *Biomaterials* 34(21), pp. 5036-5047.

Wyatt, S. B., Winters, K. P. & Dubbert, P. M. 2006. Overweight and obesity: prevalence, consequences, and causes of a growing public health problem. *American Journal of the Medical Sciences* 331(4), pp. 166-174.

Xie, B., Gilliland, F. D., Li, Y. F. & Rockett, H. R. 2003. Effects of ethnicity, family income, and education on dietary intake among adolescents. *Preventive Medicine* 36(1), pp. 30-40.

Xie, G., Chain, P. S. G., Lo, C.-C., Liu, K.-L., Gans, J., Merritt, J. & Qi, F. 2010. Community and gene composition of a human dental plaque microbiota obtained by metagenomic sequencing. *Molecular Oral Microbiology* 25, pp. 391-405.

Yabuno, H., Higashino, K., Kuroda, M. & Yamamoto, Y. 2014. Self-excited vibrational viscometer for high-viscosity sensing. *Journal of Applied Physics* 116(12).

Yabuno, H., Seo, Y. & Kuroda, M. 2013. Self-excited coupled cantilevers for mass sensing in viscous measurement environments. *Applied Physics Letters* 103(6).

Yaseen, E. I., Herald, T. J., Aramouni, F. M. & Alavi, S. 2005. Rheological properties of selected gum solutions. *Food Research International* 38(2), pp. 111-119.

Young, A. and Tenuta, L. M. 2011. Initial erosion models. *Caries Research* 45 Suppl 1, pp. 33-42.

Youravong, N., Teanpaisan, R., Noren, J. G., Robertson, A., Dietz, W., Odelius, H. & Dahlen, G. 2008. Chemical composition of enamel and dentine in primary teeth in children from Thailand exposed to lead. *Science of the Total Environment* 389(2-3), pp. 253-258.

Yu, C. W. and Abbott, P. 2007. An overview of the dental pulp: its function and responses to injury. *Australian Dental Journal* 52(1 Suppl), pp. S4-S16.

Zandstra, E. H. and de Graaf, C. 1998. Sensory perception and pleasantness of orange beverages from childhood to old age. *Food Quality and Preference* 9(1-2), pp. 5-12.

Zero, D. T. 1996. Etiology of dental erosion-extrinsic factors. *European Journal of Oral Science*104(2 (Pt 2)), pp. 162-177.

Zero, D. T. and Lussi, A. 2005a. Erosion--chemical and biological factors of importance to the dental practitioner. *International Dental Journal* 55(4 Suppl 1), pp. 285-290.

Zero, D. T. and Lussi, A. 2005b. Erosion - chemical and biological factors of importance to the dental practitioner. *International Dental Journal* 55(4), pp. 285-290.

Zheng, J., Xiao,F, Qian,L & Zhou,Z. 2009. Erosion behavior of human tooth enamel in citric acid solution. *Tribology International* (42), pp. 1558–1564.

Zheng, S., Deng, H. & Gao, X. 1997. The study on chemical composition and crystalline structure of hypoplastic primary dental enamel. *Zhonghua Kou Qiang Yi Xue Za Zhi* 32(6), pp. 366-368.

Zimmerman, F. J., Christakis, D. A. & Meltzoff, A. N. 2007. Television and DVD/video viewing in children younger than 2 years. *Archives of Pediatrics and Adolescent Medicine* 161(5), pp. 473-479.

Appendices

8 Appendices

8.1 Appendix 1. Search strategy

Search was made in 16 October 2012 and updated in March 2016 using Medline via Ovidsp, PubMed, web of science and Scopus.

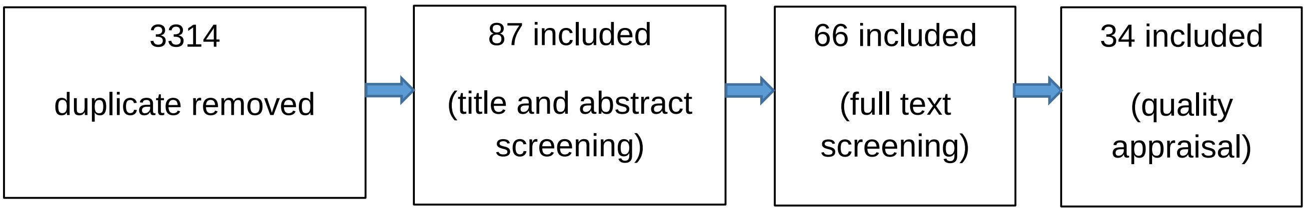
The search was undertaken from 1970-2016.

Search strategy

The following keywords and subject headings (where available) were used:

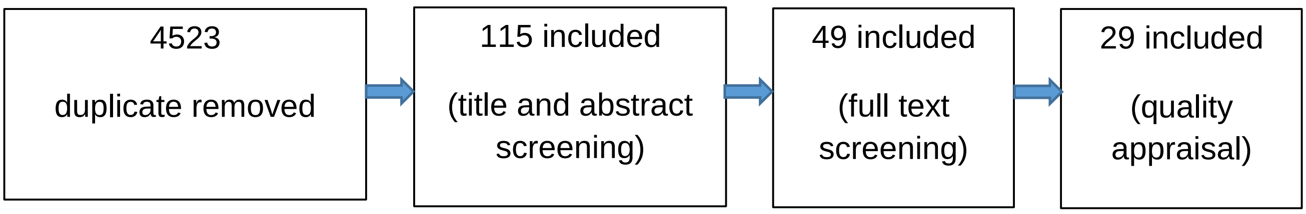
Search 1

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR childhood OR adolescent) AND (novelty sweet OR sour sweet OR sugar OR confectionary)



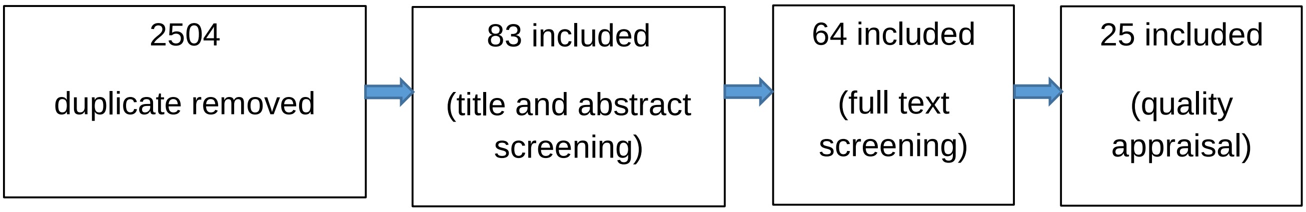
Search 2

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (marketing OR advertising OR advertizing OR media or television)



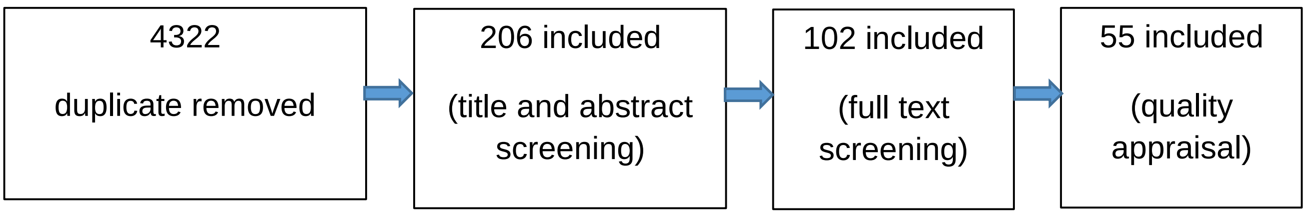
Search 3

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (eating habit* or consumer behavio?r)



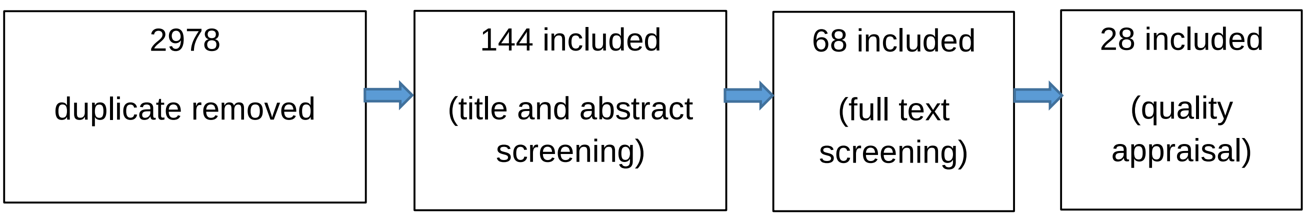
Search 4

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (prevalence) AND (tooth surface loss OR tooth wear OR erosion)



Search 5

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (aetiology OR etiology) AND (tooth surface loss OR tooth wear OR erosion)



Search 6

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (obesity OR overweight) AND (prevalence)

6422 duplicate removed	→	283 included (title and abstract screening)	→	98 included (full text screening)	→	39 included (quality appraisal)

Search 7

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (obesity or overweight) AND (aetiology OR etiology)

5542 duplicate removed	→	236 included (title and abstract screening)	→	122 included (full text screening)	→	36 included (quality appraisal)

Search 8

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (decay OR caries) AND (aetiology OR etiology)

6634 duplicate removed	→	345 included (title and abstract screening)	→	156 included (full text screening)	→	33 included (quality appraisal)

Search 9

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (decay OR caries) AND (prevalence)

1432 duplicate removed	→	88 included (title and abstract screening)	→	41 included (full text screening)	→	24 included (quality appraisal)

Search 10

(Tooth OR teeth OR enamel OR dentin*) AND (structure OR composition)

6314 duplicate removed	→	243 included (title and abstract screening)	→	122 included (full text screening)	→	54 included (quality appraisal)

Search 11

(Tooth surface loss OR tooth wear OR erosion OR erosive potential) AND (Method* OR in vivo OR in vitro OR In situ OR laboratory)

4314 duplicate removed	→	347 included (title and abstract screening)	→	169 included (full text screening)	→	64 included (quality appraisal)

Search 12

(Contact angle* OR wettability OR surface tension) AND (technique* OR method* OR Measurement*)

7314 duplicate removed	→	177 included (title and abstract screening)	→	111 included (full text screening)	→	38 included (quality appraisal)

Search 13

(Sugar content*) AND (Technique* OR Method* OR Measurement*) AND (Food* OR Drink*)

2817 duplicate removed	→	67 included (title and abstract screening)	→	46 included (full text screening)	→	19 included (quality appraisal)

Search 14

(Viscosity) AND (Technique* OR Method* OR Measurement*) AND (Food* OR Drink*)

2314 duplicate removed	→	79 included (title and abstract screening)	→	64 included (full text screening)	→	34 included (quality appraisal)

Search 15

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (Focus group*) AND (Questionnaire*)

2123 duplicate removed → 57 included (title and abstract screening) → 31 included (full text screening) → 9 included (quality appraisal)

Search 16

(Child* OR pediatric* OR peadiatric* OR school children OR preschool children OR adolescent) AND (sensory taste* OR taste threshold*) AND (Basic tastes*)

4114 duplicate removed → 115 included (title and abstract screening) → 86 included (full text screening) → 16 included (quality appraisal)

N.B.

"*= truncation of term with all possible endings"

(e.g. Child*= children, childhood).

"?= truncation of term with possibility of presence of letters "

(e.g. Behavi?or= behavior, behaviour).

8.2 Appendix 2. Data collection sheet for scoping visits

Data collection sheet

Shop number: ☐ **Level of Deprivation:** ☐

Number of available novelty sweets: ☐

Name of available novelty sweet(s)	Price per pack (in £)	Notes about display (location, height of shelves in m)	Proximity of sweets to checkout (in m)

8.3 Appendix 3. Ethical approval for scoping visits

Ethical approval and forms for Scoping study to identify the most available novelty sweets in the Cardiff area

School of Dentistry
Dean Professor Michael A O Lewis
Ysgol Am Deintyddiaeth
Deon Yr Athro Michael A O Lewis

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Cardiff University
College of Biomedical and Life Sciences
School of Dentistry
Heath Park
Cardiff CF14 4XY
Tel Ffôn +44(0)29 2074 2470
Fax Ffacs +44(0)29 2074 8274
E-mail E-bost
Dentaldean@cardiff.ac.uk
Prifysgol Caerdydd
Coleg y Gwyddorau Biofeddygol a Bywyd
Ysgol am Deintyddiaeth
Mynydd Bychan
Caerdydd CF14 4XY

Reference: 15/41a

11th September 2015

Dr A AlJawad
Cardiff University Dental School
Heath Park
Cardiff

Dear Ayman

Scoping study to identify the most available novelty sweets in the Cardiff area.

Thank you for your email of 10th September 2015 and accompanying documentation. On behalf of the Dental School Research Ethics Committee I am pleased to confirm a favourable Ethical Opinion for your project.

Documents Considered

Document	Version	Document Date
Ethical Approval Form		6th July 2015
Project Protocol	Version 3	22nd June 2015
Participant Information Sheet	Version 3	8th September 2015
Shop's Letter	Version 4	8th September 2015
Thank You Note	Version 2	22nd June 2015
Data Collection Form	Version 3	8th September 2015

Conditions of Approval

The Dental School Research Ethics Committee requires that any modifications to the approved protocol be notified to the Committee.

Athena SWAN Bronze Award

8.4 Appendix 4. Participant information sheet for scoping visits

Study title

Scoping study to assess the availability of novelty sweets in Cardiff

Background

Your shop is invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask us if there is anything that is not clear or if you would like more information. Please take time to decide whether you want to take part.

Thank you for reading this.

What is the purpose of this study?

Cardiff University Dental School are investigating a group of sweets called novelty sweets, which can cause acid erosion in children. Acid erosion of teeth seems to affect some children more severely than others and we think that this may be related to some children having a higher taste threshold for tasting sweet and sour tastes.

Why have I been chosen?

Your shop has been chosen as it is located in the Cardiff area due to geographic proximity to schools or located in city centre.

Do I have to take part?

It is up to you whether you agree to take a part as taking part in this research is entirely voluntary. If you do decide to take part you will be given this information sheet to keep and you will be asked to sign a consent form.

The data generated from this study will be anonymised on collection. Once data has been collected from your shop you will not be able to withdraw from the study because we will not be able to identify your shop from the anonymous data.

What will happen to me if I take part?

If you agree to allow the researcher to see the available sweets, the availability of novelty sweets, prices and location in shops will be assessed. Data recording forms will be used to write down the notes. The scoping visit will last approximately 5-10 minutes.

What about confidentiality?

The data will be stored in a secure University drive. Neither video nor photos of the shop will be taken. The drive that contains the data is password protected so that only the researcher has access to the data.

What do participants have to do?

Participants are only required to agree to a visit where the researcher assesses the availability, price and colours of novelty sweets.

What will happen to the results of the research study?

This research will form part of a PhD being undertaken by the specialist dentist undertaking this study. It is also very likely that the results will be published in an academic report and verbal conferences but your shop will not be identified in the PhD or the academic report in any way. We will also be able to let you know the findings of the study by email.

Who is organising and funding the research?

The research is being undertaken and funded by Cardiff University Dental School

Contact for further information?

Specific information about this research project can be obtained from the project lead

Professor Jeremy Rees

Professor of Restorative Dentistry,

Cardiff University School of Dentistry,

Heath Park, Cardiff CF14 4XY

Email: reesjs1@cardiff.ac.uk   Tel: 02920 746 557

8.5 Appendix 5. Consent form for scoping visits

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Consent form

Scoping study to assess the availability of novelty sweets in Cardiff

Dear Shop Manager /Authorised person,

You are invited to take part in a research study to understand more about the availability and presentation of novelty sweets in the city.

The study will look at the types, prices and locations in shops.

This scoping visit is part of an ongoing wider research which aims to gain a better understanding of the oral health implications of novelty sweets. This research is being undertaken by personnel from the Cardiff University School of Dentistry.

The scoping study will involve a single visit by a researcher. The researcher will collect information about the types of novelty sweets available for purchase in your store, noting the names and prices of products and details of where they are located in the store. Data will be recorded in a data recording forms. No store personnel will be asked any questions during the visit.

Novelty sweets can be categorised into three main groups,

(i) Those that combine a sweet with a toy, for example 'Wrist Licker' and 'Hose Nose',

(ii) Re-sealable lollipops such as 'Flic n Lic' and

(iii) Liquids, including sprays, for example 'Juicy Drop Pop' and 'Brain Licker'.

Novelty sweets are attractive to children as they resemble or can be used as toys, are brightly coloured, often with striking imagery, and are sold at pocket money prices. They are a potential a cause for concern because they contain sugar which may affect the health of children's teeth.

Any information collected during the visit will be anonymised, and the research will be presented in a way that does not identify your shop.

Participation in this scoping study is entirely optional.

………………………………………………………………………………………………
……………………………………………..

Please tick the appropriate response

- I give my consent for the novelty sweets scoping visit to take place ☐
- I do **<u>not</u>** give my consent for the novelty sweets scoping visit ☐

Manager /Authorised person's name:
……………………………………………………………

Signature: ……………………………………… Date
…………………………………

8.6 Appendix 6. Thank you note for scoping visits

Thank you

Thank you for your participation in this study. The results of this study will be used as part of a wider study investigating novelty sweets.

We will be summarising the results of the study anonymously. Analysis will take at least one year. If you are interested in receiving a written summary of the results of this study, please email Dr. Aljawad on aljawadaa@cf.ac.uk. A copy of the findings will be sent to you.

8.7 Appendix 7. Ethical approval for focus group work, Cardiff University

Ethical approval and forms of the focus group to inform the assessment of the taste recognition thresholds in 11-16 year old children, Cardiff University and Cardiff Metropolitan University.

School of Dentistry
Dean Professor Michael A O Lewis
Ysgol Am Deintyddiaeth
Deon Yr Athro Michael A O Lewis

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Cardiff University
College of Biomedical and Life Sciences
School of Dentistry
Heath Park
Cardiff CF14 4XY
Tel Ffôn +44(0)29 2074 2470
Fax Ffacs +44(0)29 2074 8274
E-mail E-bost
Dentaldean@cardiff.ac.uk
Prifysgol Caerdydd
Coleg y Gwyddorau Biofeddygol a Bywyd
Ysgol am Deintyddiaeth
Mynydd Bychan
Caerdydd CF14 4XY

DSREC Reference: 14/22a

17 June 2014

Dr Ayman Al Jawad
School of Dentistry
Cardiff University
Cardiff

Dear Dr Jawad

A FOCUS GROUP TO INFORM THE ASSESSMENT OF THE TASTE RECOGNITION THRESHOLDS IN 11-16 YEAR OLD CHILDREN

Thank you for your email of 16 June 2014 and accompanying documentation. On behalf of the Dental School Research Ethics Committee I am pleased to confirm a favourable Ethical Opinion for your project.

Documents Considered

Document	Version	Date Received
Ethical Approval Form	Version 1	14 January 2014
Project Protocol	Version 1	14 January 2014
Patient Information Sheet	Version 1	14 January 2014
Consent Form	Version 2	11 June 2014
Letter to Parents/Carer	Version 2	11 June 2014

Conditions of Approval

The Dental School Research Ethics Committee requires that any modifications to the approved protocol be notified to the Committee.

It should be noted that Ethical Approval is valid for a period of 2 years from the date it was approved by the Dental School Research Ethics Committee. After this time, if the project has not commenced you should reapply to the Dental School Research Ethics Committee.

Athena SWAN
Bronze Award

Registered Charity, 1136855 Elusen Gofrestredig

8.8 Appendix 8. Ethical approval for focus group work, Cardiff Metropolitan University

Cardiff Metropolitan University | Prifysgol Metropolitan Caerdydd

Tuesday, 04 November 2014

cshs-srec/ethics /approved/nht/6262

Fairchild, Ruth
Staff Research
Cardiff School of Health Sciences

Dear Applicant

Re: Application for Ethical Approval: A focus group to inform the assessment of the

taste recognition thresholds in 11-16 yr old children

SREC Project Reference Number : 0046-SREC-2014(02)

Your ethics application, as shown above, was considered by the School Research Ethics Committee (SREC) on 10/29/2014.

I am pleased to inform you that your application for ethical approval was **APPROVED,** subject to the conditions listed below – *please read carefully.*

Conditions of Approval

Your Ethics Application has been given a Project Reference number as above. This **MUST** be quoted on all documentation relating to the project (E.g. consent forms), together with the full project title.

A full **Risk Assessment** must be undertaken for this proposal, as appropriate, and be made available to the Committee if requested.

Any changes in connection to the proposal as approved, must be referred to the Panel/Committee for consideration ***without delay quoting your Project Reference Number***. Changes to the proposed project may have ethical implications so must be approved.

Any untoward incident which occurs in connection with this proposal must be reported back to the Panel ***without delay***.

This approval is valid for 12 months from the date of approval. Please set a reminder on your Outlook calendar or equivalent if you need to continue beyond this approval date. It is your responsibility to reapply / request extension if necessary.

Yours sincerely

Arthur Tatham

Prof. Arthur Tatham
Chair of School Research Ethics Committee (SREC)
Cardiff School of Health Sciences

Tel : 029 2041 7125
E-mail : atatham@cardiffmet.ac.uk

Cc: .

PLEASE RETAIN THIS LETTER FOR REFERENCE

Cardiff School of Health Sciences
Western Avenue,
Cardiff, CF5 2YB
Ysgol Gwyddorau Iechyd Caerdydd
Rhodfa'r Gorllewin,
Caerdydd, CF5 2YB

Telephone Ffôn
+44(0)29 2041 6070
Fax Ffacs
+44 (0)29 2041 6982

www.cardiffmet.ac.uk

8.9 Appendix 9. Parents letter for focus group work

Parent's letter

Project Title

A focus group to inform the assessment of the taste recognition thresholds in 11-16 year old children

Cardiff Metropolitan University Visit – Food & Nutrition Workshops

Dear Parent/Carer

The pupils studying Food Technology have been invited to attend a cookery workshop which will take place in Cardiff Metropolitan University on day/month/year. They will learn new skills and develop their knowledge of the functions of ingredients. The workshop will directly benefit their Controlled Assessment tasks and give them a better insight into the higher education courses available at the University.

As an optional part of the day children will also involve be invited to take part in a discussion about novelty sweets, which will be led by our good colleagues from the School of Dentistry. This is part of an ongoing research project about novelty sweets, the children will be asked about their knowledge and understanding of novelty sweets and the session will be recorded for further analysis.

Pupils will register as normal on the day and attend periods one and two. We will leave at 10.50 am and return in time for normal school transport. Children must wear school uniform and bring a packed lunch. However, if your son/daughter is in receipt of Free School Meals, one will be provided. There is no charge for the trip and any equipment required will be provided by the University.

Goody bags containing toothpaste and toothbrushes will also be provided as a thank you.

This is an excellent opportunity for our pupils and I hope that they will be able to attend. Please complete and return the reply slip as soon as possible.

8.10 Appendix 10. Participant information sheet for focus group work

Participant information sheet

Study title

A focus group study to inform the assessment of taste recognition thresholds in children

Background

Your son or daughter is being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask us if there is anything that is not clear or if you would like more information. Please take time to decide whether you want your son/daughter to take part.

Thank you for reading this.

What is the purpose of this study?

Cardiff University Dental School are investigating a group of sweets called novelty sweets, which can cause acid erosion in children. Acid erosion of teeth seems to affect some children more severely than others and we think that this may be related to some children having a higher taste threshold for tasting bitter and acids tastes.

This study is a preliminary study that will look at children's attitudes towards buying and eating these novelty sweets. This will help us develop a questionnaire that we will use in our next study which will test the taste recognition thresholds of a group of children.

Why have I been chosen?

Your child has been chosen as they are going to attend an open day at Cardiff Metropolitan University within the next few weeks.

Do I have to take part?

It is up to you whether you agree to let your child take part as taking part in this research is entirely voluntary. If you do decide to let your child take part you will be given this information sheet to keep and you and your child will be asked to sign a consent form. If you do decide to allow your child to take part then you or your child are still free to withdraw your consent at any time and without giving a reason.

The data generated from the focus group will be anonymised on collection and from this point you or your child will not be able to withdraw from the study as we will not be able to identify individual participants from the anonymous data.

What will happen to me if I take part?

If you agree to allow your child to take part during the open day visit at some point during the day they will be 'interviewed' in a group of 6-8 children. This interview will be conducted by a specialist dentist from Cardiff University Dental School who is undertaking this research as part of his PhD.

During this interview the children will be asked various questions about whether they know what a novelty sweet is, whether they have ever bought them, what types of these sweets they like and how much they cost. They will also be shown pictures of the various types of novelty sweets to help the process. The group interview will last for 60 minutes and will be recorded.

As a small thank you for taking part we will give all children a dental pack containing age appropriate toothpaste and tooth brushes.

What about confidentiality?

Only the audio of the group interviews will be recorded onto the laptop of the researcher undertaking this project. No video of the group interviews will be taken. The laptop that contains the audio recordings is password protected so that only the researcher has access to the recordings. At the end of the study the recordings will be deleted and destroyed.

What do participants have to do?

Your son or daughter will just need to contribute to a discussion about the types of sweets they like to eat which will be led the researcher. This will be a group discussion involving around 6-8 children.

What will happen to the results of the research study?

This research will form part of a PhD being undertaken by the specialist dentist undertaking this study. It is also very likely that the results will be published in an academic report but your son or daughter will not be identified in the PhD or the academic report in any way. We will also be able to let you know the findings of the study via your son or daughters school. We will contact each of the class teachers with the results of the study so that these can be disseminated to the children that have taken part.

Who is organising and funding the research?

The research is being undertaken and funded by Cardiff University Dental School

Contact for further information?

Specific information about this research project can be obtained from the project lead

Professor Jeremy Rees

Professor of Restorative Dentistry,

Cardiff University School of Dentistry,

Heath Park, Cardiff CF14 4XY

Email: reesjs1@cardiff.ac.uk Tel: 02920 746 557

8.11 Appendix 11. Consent form for focus group work

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

Cardiff Metropolitan University

CONSENT FORM

Project Title: A focus group to inform the assessment of the taste recognition thresholds in 11-16 year old children

- **Parent need to tick all they agree with:**

Do you understand what this project is about?	☐ Yes	☐ No
Have you asked all the questions you want?	☐ Yes	☐ No
Have you had your questions answered in a way you understand?	☐ Yes	☐ No
Do you understand it's OK to stop taking part at any time?	☐ Yes	☐ No
Are you happy for your child to take part?	☐ Yes	☐ No

- **If <u>any</u> answers are "no" or you don't want your child to take part, don't sign your name**

- If you **<u>do</u>** want **your child** to take part, you can write your name below

Print Name ……………………………………………………

Relationship to child…………………………………………..

Sign ……………………………………………………………..

Date ………………………………………………………………

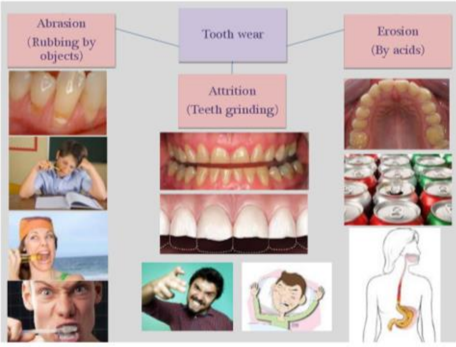
Researcher:

Print Name ……………………………………………………

Sign ………………………………………………………..

Date ……………………………………………………………

8.12 Appendix 12. Dental Health talk for participating children

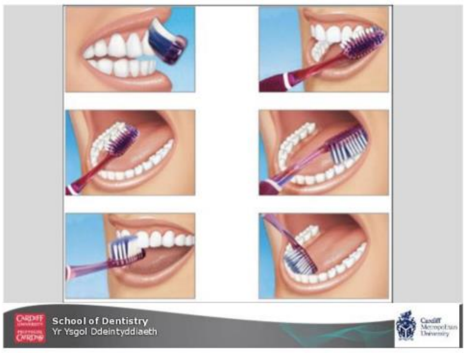


What can we do to keep acidic food/drinks from harming your teeth?

- Decrease number of times you drink or eat acidic food or drinks (no more than once per day).
- Replace other times by drinking water.
- Replace acidic foods and drinks with non-acidic e.g. cheese, milk , sugarless chewing gum.
- Don't brush immediately , delay brushing by 30 min-1 h.

Brushing and Flossing

School of Dentistry
Yr Ysgol Ddeintyddiaeth


School of Dentistry
Yr Ysgol Ddeintyddiaeth


versus
School of Dentistry
Yr Ysgol Ddeintyddiaeth


School of Dentistry
Yr Ysgol Ddeintyddiaeth


Dental floss
School of Dentistry
Yr Ysgol Ddeintyddiaeth


School of Dentistry
Yr Ysgol Ddeintyddiaeth


With braces
School of Dentistry
Yr Ysgol Ddeintyddiaeth


School of Dentistry
Yr Ysgol Ddeintyddiaeth


School of Dentistry
Yr Ysgol Ddeintyddiaeth

School of Dentistry
Yr Ysgol Ddeintyddiaeth

Cardiff Metropolitan University

Thank you for taking part in this study

School of Dentistry
Yr Ysgol Ddeintyddiaeth

Cardiff Metropolitan University

8.13 Appendix 13. Thank you note for focus group discussion

Thank you

Your opinion and view about these sweets are helpful. They will be used to design questionnaire for children like yourselves to seek more views on this topic from a larger group.

We will be summarizing your views anonymously, but this will take a little time. If you are interested in receiving a written summary, please email Dr.Aljawad on aljawadaa@cf.ac.uk who will keep a list of whom interested and send a copy once prepared.

8.14 Appendix 14. The compositional structure of themes

Theme	Subtheme	Focus Group (11-14 years old)	Focus Group (12-16 years old)	Main findings and discussion
1. Variety of sweets amongst children	1.1. Familiarity of sweets consumed by children	10 (BOY 11) "Jelly babies" 11 (BOY 9) " Chewits" 12 (BOY 9) "Wine gums" 13 (BOY 11) "Fruit pastilles" 14 (GIRL 3) "Marshmallows" 17 (BOY 10) "Lindor balls" 18 (BOY 11) "I like Guylan shells" 19 (BOY 9) "Aero bubbles" 20 (BOY 11) "Galaxy caramel" 21 (BOY 9) "Dairy milk" 23 (BOY 11) "Tangfastics" 24 (BOY 9) "Mentos" 29 (BOY 10) "Maltesers" 30 (BOY 11) "Galaxy counters" 32 (BOY 9) "Snickers" 38 (BOY 10) "Munchies"	22 (BOY 12) "Haribo" 23 (BOY 13) "Haribo" 24 BOY 14: Lots of Haribos 27 BOY 15: Is the chocolate considered a sweet? **28 RF: Of course it is.** 29 BOY 15: Cadbury 30 BOY 16: skittles 31 BOY 7:Haribos 32 BOY 18: Haribo 33 GIRL 19:Haribos 34 GIRL 20: Jelly Babies sweets especially Haribos, Midget gems 35 BOY 21: do Tic Tacs count as sweet? **36 RF: of course it is.** 37 GIRL 19: Tic Tacs, the fruit one. 45 BOY 22: Galaxy and Dairy milk	In both groups' children, various group of confectionary were mentioned. For example, chocolate (in Red), Jelly (In Pink), chewable (in Blue), lollipop in (dark blue), grey were sour/sweet confectionary and marshmallows (in yellow). One child (BOY 24: Sour sweets

		39 (BOY 11) "Minstrels" 41 (BOY 8) "Walkers" 42 (BOY 8) "Twix" 43 (BOY 10) "Mars bar" 44 (BOY 7) "Skittles" 45 (BOY 10): Sherbet banana 46 (BOY 9) "Jelly Tots"	46 GIRL 23: Haribos and Tangfastics 47 BOY 24: Sour sweets and snickers 53 GIRL 20: I like one European chocolate Its name is Yorkie. 54 BOY 24: I like M&M's 55 BOY 13: I like Lindor 59 GIRL 19: I like also M&M's and Skittles. 61 BOY 12: I like Mars bar and Tootie Fruity 62 BOY 15: Jelly tots 63 BOY 16:I like Yorkie cookies 64 BOY 7: I love Reeses pieces 65 BOY 18: Chuppa Chups lollies 66 GIRL 19: Marvellous Creations 67 GIRL 20: I've had hostess Twinkies? before and they are really nice 73 BOY 22: Maltesers Chewetts and Aero. I eat Percy pig's as well. 77 GIRL 23: Thorntons	
	1.2. Familiarity of novelty	**After the actual presentation of novelty sweets to children,**	**After the actual presentation of novelty sweets to children,**	It was clearly observed that all children have seen at least one of the top ten novelty (most of children

	sweets amongst children	**AA: Have you seen sweets before?** 75 All Children: (in group): yes **78 MM: Do you like them?** 79 BOY 11: yes. I like them, but I don't like Toxic Waste. Only for a challenge because It is too sour. **80 AA: can everyone tell us which type of these they like?** 81 BOY 11: Vimto 82 BOY 10: Tango 83 BOY 9: Tango and Brain Licker	**AA: Have you seen sweets before?** All Children: (in group): yes 155 Children: I like them. 156 BOY 24: I had these ages ago 157 GIRL 23: I really love them. 165 GIRL 4: I've seen all of them When I go with my sister to buy sweets. 166 TM: only seen Toxic Waste and I've tried it. 167 BOY 18: I've seen them behind the counter and I thought they're not a normal type of sweet because the guy is hiding them. 169 RF: why they were behind the counter? 170 BOY 18: At that time I was thinking is this guy is crazy but now I know that because there is a lot of sugar in them. 172 BOY 22: I've seen them all before and I eat all of these. 173 GIRL 19: I've seen the Brain Licker one and Lickedy Lips and Toxic Waste and push pop. 175 GIRL 19: I never seen the Big Baby bottle 176 BOY 22: I've seen that	seen all of them sweets) which supported that the list sweets were widely available. It was mentioned by one of the children that shopkeepers were keeping some of the products less accessible by hiding them behind the counter." I've seen them behind the counter and I thought they're not a normal type of sweet because the guy is hiding them" (BOY 18) Another interesting sentence was mentioned by BOY 11 which showed that because of the high level of sourness of these sweets, he eats them only for a challenge" yes. I like them, but I don't like toxic waste. Only for a challenge

			227 BOY 22: I've had most of them I've just like half of them.	
2. The routine natures of novelty sweets consumption		**AA: How often do you eat them?** 48 BOY 9: Not every day 49 BOY 11, BOY 10: everyday 51 BOY 11: Well. I go to the shop, if I have enough money I buy a lot of sweets to eat, if I don't have money, I don't buy any sweets. It depends on the money I got. Usually everyday. 55 BOY 10: it is like every 2 days I go to the shop. 56 BOY 9: It's like every Friday 57 BOY 8: Every other day. 58 BOY 7: Every Friday 62 GIRL 5: Every day. 63 GIRL 4: Every day 64 GIRL 3: I have it every week. 65 GIRL 2: Every day. 66 GIRL 1: Twice a week.	**AA: How often do you eat them?** 90 BOY 12: 3-4 times a week 91 BOY 13: 3 times a week 92 BOY 14: 2 times a week 93 BOY 15: once a week 94 BOY 16: everyday 95 BOY 7: Probably about 3-4 times a month 96 BOY 18: Once a week except during our journey to Southampton, I have sweets for the whole weekend. 100 GIRL 19: Twice every three weeks. Sometimes after my dinner, not full. 101 BOY 21: About 4-5 times a week. 102 BOY 22: 4-5 times a day, all in the afternoon. 4-5 different times in the afternoon. 103 GIRL 23: Once a week. 104 BOY 24: Once a week.	Children in both groups mentioned various frequency of consumption. Weekly or daily More than weekly 2 children mentioned three striking sentences. BOY 11 said "I go to the shop, if I have enough money I buy a lot of sweets" which showed that money might be a factor which may influence the frequency of buying and eating of sweets. In addition BOY 18 said "once a week except during our journey to Southampton, I have sweets for the whole weekend." Which showed that transportation may influence the frequency. Furthermore GIRL 19 said "twice every three weeks. Sometimes after my dinner, not full" Which showed that children might consider sweets as a substitution of other types of food if needed.

3. Availability of accessibility of novelty sweets to children		**AA: From where do you buy these sweets?** 92 BOY 11, BOY 10: Shops. 94 BOY 11, BOY 10, BOY 9: shops near school. Like Costcutter and the post office. 265 BOY 11: If you don't go to the shop you can just buy them from a friend. 188 BOY 10: in shop we can be free to mix different types of sweets **227 MM: Are they easy accessible for you to pick them up from the shelves?** 228 Children: yes **256 AA: Do you usually buy these sweets before or after school?** 257 Children: after 258 BOY 9: sometimes before, but mostly after **259 RF: do you buy them at the weekend as well?** 260 Some children: yes 262 BOY 10: I buy them before school to make me awake in boring lessons like in maths lessons. **AA: When do you eat them?**	**AA: From where do you buy these sweets?** 265 Children: From corner shop and supermarkets. Big shops like Tesco and Asda. Supermarkets like Tesco and Asda. 267 GIRL 19: I got most of these from different shops but mainly local shops to school and home. **283 AA: are these sweets available in shops around the school?** 284 Children: yes. 285 Children: Co- Op, Omar's close to school **286 AA: so when do go to the shops to buy them are these sweets easily accessible for you?** 284 Children: Yeah. **289 AA: Where do you usually find them?** 290 BOY 24: Sweet aisle 291 GIRL 19: When I do with my family to one little shop, the sweet aisle is full of sweets but I cannot reach the top shelf. 293 BOY 18: I usually find them behind the counter. One time the guy in the shop who wants to buy them: are you sure you want	Assessment of the accessibility of children to sweet identified various elements. The first element is from where children buy the novelty sweets. Children provide a lot of information about this aspect. They mentioned (highlighted in blue) that the bought novelty sweets from shops near schools and local school and homes which give a great importance to the school fringe as an important source of such types of sweets. In addition, children also mentioned that they bought these sweets from supermarkets and from city centre (Highlighted in pink and orange respectively). Children mentioned that these sweets are easy accessible in shops (highlighted in yellow) except for two children who mentioned that they were displayed behind the counter and in the top shelf (highlighted in grey). Another element of the accessibility of children to novelty sweets was the time when can buy and eat these sweets. Some children buy them before and/or after school (Highlighted in blue). Some children buy them in the weekend or Friday (Highlighted in green).

		233 BOY 10: Whenever 239 GIRL 3: I usually share them around at school or to give it to my sister if I don't like them. 243 GIRL 3: When I feel tired or when I don't do anything. 108 BOY 9: My mum allows me to buy them only for treat.	these? And he gave it to the guy and said take it on your own risk. 296 GIRL 20: I find them at the end of the sweet aisle 297 BOY 21: I find them as soon as I walk into the shop 298 BOY 22: In the 3rd aisle 299 TM: Usually around the counter there are a lot of sweets 300 BOY 12: Around the counter and in sweet aisle 301 BOY 7: Sweets are available all over the shop 271 GIRL 19: Sometimes with my family from supermarkets. Sometimes with the girls from the city centre. 278 BOY 15: Buy them with myself from shops on my way to school 279 BOY 14: Buy them with my sister from local shops. 280 BOY 13: I do usually from supermarkets that we visit on the weekend. GIRL 20: There is an all American sweet shop in town which sells all of these sweets.	Another aspect is the timing of eating. Children mentioned that they eat them whenever possible, during lessons, after tea and when they are tired (Highlighted in yellow). Some children said that they take the whole sweet at once while other children said that they eat it at more frequent manner by closing it and keep it for later. Children mentioned that the novelty sweets were displayed in different locations in shops which included sweet aisle, around the counter, first when enter the shop, all over the shop (highlighted in red) All these elements confirm that these sweets were widely available and children were familiar with them. Another way of accessibility to the novelty sweets was mentioned by two children. They mentioned novelty sweets were given as a treat.

			320 BOY 12: Before school and after school and in the weekend 321 BOY 13: I see people eating them after school 322 BOY 15: In the weekend 323 BOY 16: By them before them to eat them during classes. 326 GIRL 19: I usually buy them with my parents in the weekend or Fridays if I don't, after school 328 GIRL 20: After school around 3:30 in my way home 331 BOY 22: I buy them in in odd times like when the school ends earlier like before the end of the term, I buy them like at 1:10 pm. Or on my way home. 343 BOY 16: I normally have them in my pocket to eat them during lessons 336 BOY 12: I normally eat a little bit at time, like after tea. Then to keep it for later. 338 BOY 12: Sometimes I keep eating it for 3-4 days. 339 BOY 14: All at one time. 340 BOY 13: When I eat it I eat a couple of sweets or one a day. 342 BOY 15: All at the same time	

			344 BOY 18: Generally for all sweets, trying keeping them for later is physically and mentally challenging, so I take it all at the same time. 346 GIRL 19: I try keeping them but then I try hiding them so my brother cannot eat them but he finds and eats them. 351 BOY 21: Sometimes I keep them for later sometimes I eat them all at once. 436 BOY 22: My mum and grandma buy them and give them to my brother as a treat but not to me and other brothers. I think apparently if you are young, my mum and dad think if you are young then giving sweets to 3 and half years will be fine.	
4. Children's belief about to which age/gender these sweet are aimed for?		**130 MM: What age group/gender these sweets aimed for?** 132 BOY 11, BOY 10: Younger 133 GIRL 1: younger 134 BOY 7: Our age group 135 GIRL 3: It says in the label not for children under 3. Because may be for any younger than 3 it will be hard to digest because they are sour. So for anybody older than 3. 137BOY 10: That's for girls (Lickedy lips) and the green one (brain licker for boys). 138 BOY 9 (class 9): I'd still have it.	**130 MM: What age group/gender these sweets aimed for?** 365 GIRL 23: Boys and girls, high school. 366 BOY 22: I think boys 10-15 years. 367 BOY 24: Boys and girls, a year 4- year 13 depends on personality and characteristics of the person. Because I see some people in year 11 and they look too young. 369 BOY 21: Both boys and girls, age similar to BOY 24 from year 4 to late teens. 370 GIRL 19: For toxic waste, it says it needs to be 3 years or over. When I think about it, I think about it, it is seriously wrong. I think it should be like year 9 plus.	When children were asked about the age group theses sweets aimed for, children of both groups had different opinions regarding the age and gender. Nine children mentioned that these sweets aimed for both boys and girls (Highlighted in green). Three children said that some types novelty sweets are suitable for girls only (highlighted in purple). With regards to age, children mentioned different age groups, which can be applied, on both boys and girls (Highlighted in yellow). GIRL 20 said that boys could eat sweets with strong sour taste more than girls of the same age. BOY 24

			Because I tried it before and I am not eating that again ever. 374 GIRL 20: It is too strong for me personally but for BOY 7 (male) it is not. 375 BOY 21: I would think that they are mainly aimed at both genders. Because I've seen boys in their late teens eat them and girls in same age eat them. I think people until 20 still eat them if they really like them. But normally around 11-12 till year 11. 379 BOY 18: It the same like what he said but there are some sweets are mainly for girls like Lickedy lips. You cannot put on your lips or even look at that as a boy. Age, I don't think that you should be eating them before the age of 8 years. **382 RF: so do you thing people under 8 shouldn't eat them?** 383 BOY 18: Yeah 384 BOY 7: I think there is a myth. That the older you go, it will be more boys. So the old people you get you will find more boys eating them and it is sort of from 8-20 year old will eat them. And I think 15 and above it will be about 75% boys eating them. 388 BOY 16: I think they are for both boys and girls. And the age from 7-18. 389 BOY 15: I think it is like most of these are for boys but couple of these for	said that it's not only the age or gender which allows the child to eat the sweets; it's the personality (Highlighted in pink). BOY 24 also said that more girls in primary schools eat these sweets while more boys eat these at later years (Highlighted in red). Same idea mentioned by BOY 7 but she called it a myth (Highlighted in dark green). GIRL 20 said that children older than 15 years (year 10) will start eat more from other types of sweets (other than novelty sweets.) (Highlighted in blue). Interestingly, one of the children (GIRL 20) read the label on one of the novelty sweets and found that these sweets contained citric acid and written that this sweet is suitable for 3 years and above which considered by this child to be unsuitable.

			example are aimed at girls only like Lickedy lips and big baby [pop]. 391 BOY 13: I think the age would be from 6 -20 so from late childhood to early adults. 392 BOY 12: I think they are aimed at both boys and girls I think it's for younger children like from 8-15 394 BOY 24: When you look at the primary schools in year 6 and 7, I think it will be more girls eat them than boys, but when you go older to later years to the end of high school it will be more boys. 397 GIRL 20: I think for children in year 8-9 and 10 they like to eat these types of sweets but when they get older they will eat other sweets like Haribos more than these. 241 GIRL 20: there is one thing I don't like about these sweets. It contains citric acid in it which wears down teeth. (The child read the labels) and it says that it is not suitable for children under 5 years old and contains citric acid.	

4. Reasons of like/dislike of novelty sweets	4.1 Taste and flavour of novelty sweets	**AA: Why do you like/dislike theses sweets?** 85 BOY 10: They are nice and sweet and tasty. 98 GIRL 2: They taste nice. 101 GIRL 1: They are sweet. 205 BOY 10: When you eat something sweet and then it turns to sour, it tastes really nice. 79 BOY 11: Yes. I like them, but I don't like Toxic Waste. Only for a challenge because It is too sour. 103 BOY 11: Toxic Waste is different because it hurts your tongue. 135 GIRL 3: It says in the label not for children under 3. Because may be for any younger than 3 it will be hard to digest because they are sour. **125 AA: What happens if you eat any one of these at once?** 126 BOY 9: I feel sick 127 BOY 8: I Rush 128 GIRL 2: too sickly 270 BOY 10: because they are sugary 271 BOY 8: and fuzzy.	**AA: Why do you like/dislike theses sweets?** 182 BOY 12: I like them because they are sweet and sour. 193 BOY 15: I like those one cuz I normally I like sour stuff cuz I know I can handle it 198 BOY 15: But the sweet stuff I've never been a fan of stuff like sweet 203 GIRL 19: I like When I eat toxic waste they're like really sour but then they go sweet, I used to hate them but then people started like videoing people like eating them and things 228 GIRL 23: I've had them all and liked them all especially toxic waste because I don't normally have sweets so when I have them I like them. 160 GIRL 19: I don't like toxic waste. **161 RF: Why?** 162 GIRL 19: because it is really really sour. 109 BOY 14: They're sour 205 BOY 7: I've had a Toxic Waste and the big toe thing and I preferred the big toes 206 BOY 7: because the toxic waste is really sour	The analysis of the factors which influence the consumption of novelty sweets by children, various factors were identified. Taste is one of these factors is the taste of the novelty sweets. It was mentioned by many children that these sweets are nice, sweet and tasty. BOY 15 (highlighted in yellow) mentioned that he likes sour stuff not the sweet stuff. GIRL 19 (highlighted in red) mentioned that he likes one type of sweet which has a sour taste and turns into sweets taste. BOY 10 (highlighted in green) also found it really nice to eat smoothing sweet and turns to sour. That shows that combination of sour and sweet may be liked by some children. Taste may be a reason for not eating some types of these sweets. Children mentioned that they don't like the types of novelty sweets or it's hard to eat because they are too sour. Two children (highlighted in yellow) mentioned that because of the strong sourness of Toxic waste, they eat it only for challenge. Children mentioned that they feel sick, rush, sickly, funny feeling in the teeth, fuzzy and the nerve goes

		266 RF: So when eat a lot of them what do you feel? Sick or something rubbing your teeth. 267 Children: Both 81 GIRL 19: I cannot eat full bar of chocolate. I feel it's too sickly for me. 268 BOY 11: When you eat a lot of them you feel your teeth become fuzzy and your nerve goes up. **190 RF: Is there any flavour in these sweets you would like to make?** 191 Children: Strawberry, raspberry, blackcurrant, cherry, chocolate, bubble gum, tropical, apple 192 Orange+apple **193 RF: Where are you getting these ideas of flavours from?** 194 Children: From fruit juices **217 RF: Do you like pineapple on pizza?** 218 BOY 9: Yes. 219 BOY 10: Yes **250 MM: Are they sweet or sour (Sport drinks)?**	208 BOY 18: I hate sour things but I hate sour things and I remember my friends used to give them to me to see my reaction because when I eat sour thinks I kinda have like a really spasm Now Erm I really do not like toxic waste cuz again in primary [school] when they bought loads in someone opened all of them in one thing and chucked them in their mouth then had to go to hospital cuz their tongue, something happened to their tongue. **AA: What happens if you eat any one of these at once?** 355 BOY 21: Some of them make my teeth feel funny 356 GIRL 23: I feel sick 357 BOY 13: feel sick 358 GIRL 19: I feel funny feeling in my teeth. **RF: Is there any flavour in these sweets you would like to make?** 448 BOY 12: I like lemon, spicy pasta. 480 Children: love mangos, grapes, strawberries, raspberry, 481 GIRL 19: I don't like strawberry because it has a lot of seeds in it. 483 BOY 24: I eat fruits every day.	up in the teeth when eating these sweets at once. Children said that they like to have more flavour of these sweets available in the market. They like to have them in single flavour or mixed of flavours. The ideas of these flavours came from the like and dislike of the flavours of the fruits. Some children also expressed their likeness to the sourness of the some fruits. Some children mentioned that they like the sweet and sour taste in different types of food and drinks (highlighted in yellow). GIRL 1 mentioned that the sport drinks that they drink are sour and sweet and some of them taste like the novelty sweets (highlighted in green).

		251 BOY 11: Both, they are fizzy drinks and isotonic and give you a push 252 (BOY 11) I really like the taste **254 MM: Do they taste sour like these sweets?** 255 AP: some of them yes 205 BOY 10: When you eat something sweet and then it turns to sour, it tastes really nice. 198 BOY 10: Lemon and sugar on pancake 215 BOY 10: I like Anko Rice which is sweet and sour. 202 GIRL 3: I do the basic cup cake and I add a lemon juice. It is really nice. **203 RF: So when you add sour and sweet it taste really good?** 204 GIRL 3: yes.	486 BOY 21: I love mango so much. I actually have a pack of strawberry a day and apple. 489 BOY 7: I love to have strawberry and sugar and I dip the strawberry in the sugar. 490 BOY 16: I do a lot of fruit because I play a lot of sports. 492 GIRL 20: I really Really Really like mangos. I am Kind of get addicted so whenever it is in summer, I have mangos. But other than mangos, I like watermelon. 496 BOY 18: I personally have an addiction to apples. 499 BOY 12: The only sweet fruit I prefer is strawberry and that's it. **501 RF: Do you like the sourness?** 502 BOY 12: Yeah. I like banana and banana sandwiches. BOY 16: I like grapes, apple and melon. BOY 15: I really really really like apples. BOY 13: I like grapes, apple and fruits juices from concentrate. 503 BOY 16: I like grapes, apple and melon. 504 BOY 15: I really really really like apples.	

			505 BOY 13: I like grapes, apple and fruits juices from concentrate. 508 GIRL 23: Everyone in my family eats fruit and fruit juices **AA: Do you like other sweet and sour food?** 449 BOY 13: I hate sweet main courses. I hate sweet chilli or sweet chicken. I like sweet lemon juice and fizzy water. 446 BOY 12:I like sour and hot spicy 451 BOY 14: In terms of desserts, I like sweet things but I don't like any sweet main courses. I like cake. 453 BOY 15: I really really love sour food and sweets. 454 BOY 16:I love sweet food 455 BOY 7: I really like things like sweet and sour and sweet chilli chicken and things like that. 457 BOY 18: When we talk about sweet and sour, I have to mention sweet and sour chicken. 471 BOY 21: I love sour food and I love sweet chilli and sauce all over my food. 475 BOY 24: I love KFC so any type of sweet and sour chicken I like that. I like Indian, Chinese food I love everything.	

			There is nothing like I don't eat because my mum eats everything.	
	4.2 Packaging criteria of novelty sweets	**AA: Why do you like/dislike theses sweets?** 86 BOY 11: Comes in different shapes. 103 BOY 11: They are different, the one you can lick (brain licker), these you can spray (vimto, tango and mega mouth) and sucky like toxic waste is different because it hurts your tongue. 86 BOY 11: And they are re-sealable. 88 BOY 9: You can save it for later instead of buying another one. 102 GIRL 2: They last longer. 122 BOY 9: I save them for later. 86 BOY 11: Comes in different shapes, colours	**AA: Why do you like/dislike theses sweets?** 236 GIRL 20: I like the sprays more because it's like a variety type things and mostly you have to literately chew because they're sweet 222 BOY 21: Erm, I haven't tried brain licker this and the lickedy lips, the rest I have and I liked, liked them all **224 AA: And why you do like that?** 225 BOY 21: I like sour sweet and I seem to like ignore the sour part and just take the sweetness in. 238 BOY 13: I like the chewy one 239 BOY 7: I think the spray one is not as bad for your teeth and you will have a lot of it at the end.	Another factor is the way of eating of these sweets. The way of eating these sweets are variable because they come in different shapes and consistency (pop, spray, sherbet, …) . BOY 11 (highlighted in green) mentioned that he likes them because they are different and way of eating is variable. Interestingly, one of the children (highlighted in pink) said that he ignores the sour part of these types of sweets and take only the sweet part of it during the licking these sweets (lickedy lips and brain licker). This may shows the ability of some children of unpairing the paired taste and enjoying only the

		140 RF: Is there any colour of these sweets you like? 141 BOY 11: Red 142 BOY 10: Red, Blue 103 BOY 11: Sucky toxic waste is different because it hurts your tongue.	244 BOY 22: I like the spray one better than all of them. I think it doesn't contain a lot of sugar. 207 BOY 18: I kinda've like whatever is sucky 362 BOY 21: I can keep it closed and sealed until I think to eat it. 363 BOY 14, LD: It gives you the option to close it 336 LD: I normally eat a little bit at time, like after tea. Then to keep it for later. 338 BOY 12: sometimes I keep eating it for 3-4 days. 256 BOY 13: I like the colour of this sweet (toxic waste). **257 RF: why do you like it?** 258 BOY 13: I like the bright colours. **259 RF: Is it the colour of the package or the sweets inside?** 260 BOY 13: Both. Like these bright yellow, pink and green. It appeals to my sight. 206 BOY 7: I'm not so big on sucky sweets as well 238 BOY 13: I don't like the sucky one or the spray one	taste they prefer and ignoring the other tastes. Another interesting statement which was mentioned by Boy 22 (highlighted in red) who believes that novelty sweets which comes in spray form has less sugar. BOY 11 (highlighted in yellow) found the spray types less powerful than the sherbet type. Re-sealability of the novelty sweets was found to be advantageous by many children. It gives the chance for them to close the sweet and save it for later. Colour seems to have an impact on the level of consumption or/and selection of the novelty sweets (highlighted in pink). BOY 13 (highlighted in red) mentioned that she likes the bright yellow colour of both the package and the sweet. She mentioned that the colour appeals her sight. BOY 11 said he likes the red colour while BOY 10 said that he likes the red and blue colours.

				Some children don't like some types of novelty sweets which are a sucky sweets. BOY 11 (highlighted in yellow) found the sucky toxic waste hurts the tongue. These aspects may be important to look at in the items marketed to children.
5. independency of children purchasing decision (influence of pocket money)		**How much these sweets cost?** 149 BOY 10: these are cheaper than Haribo 153 BOY 11: these are for a pound Brain licker and lickedy lips. 154 GIRL 5: This is for 89p,	**How much these sweets cost?** 303 BOY 24: I know that the brain licker is about £1.80 304 GIRL 23: It costs 99p 305 BOY 22: About a pound 306 GIRL 20: I don't really know how much it costs because I just put them in the basket. 307 GIRL 19: I depends how big the sweet is. That like that one (big baby pop) around 70-80p but stuff like the tango about £1.50 309 BOY 21: In different shops they are different prices. Toxic Waste would be around 80p 311 BOY 16: I buy Toxic Waste for abound £1.89 312 BOY 15: most of these cost between 50p and £1.	Many children seem to have good background about the price range of the novelty sweets. As conclusive answer of the children in-group, they mentioned that they don't cost a lot of money (highlighted in green). BOY 12 (highlighted in yellow) found that it is worth to buy toxic waste by £1 and having 10 pieces inside the package. This packaging/pricing aspect may be important to look at in the items marketed to children. Pocket money seems to play an important role in buying these sweets. Children mentioned that the price of these sweets doesn't considered to be a lot of money (highlighted in green). BOY 11 mentioned that the amount of novelty sweets he buys depends

			314 BOY 12: Normally about 50p to £1. **315 RF: Is that a lot of money?** 316 Children: no 317 BOY 12: When I buy Toxic Waste for a pound, it worth it because you will have 10 pieces in it.	on the amount of money available with him. Apparently children can independently buy and consume these sweets without their parents' knowledge or
6. Parent's awareness about novelty sweets		**105 AA: What do parents think about these sweets? Do they agree for you to buy them?** 107 All Children (in group): No. 108 BOY 9: My mum allows me to buy them only for treat. 110 BOY 10: They say don't eat too much. 113 GIRL 1: They say they are bad for your teeth. 119 BOY 11: My mom doesn't allow me to buy anything from these sweets. 120 BOY 10: I put some of these sweets by trolley loading. **231 (MM) if you buy one of these, when do you have them?** 232 BOY 11: When my mum is not around. 235 BOY 11: Because she hates these sweets.	**AA: What do parents think about these sweets? Do they agree for you to buy them?** 400 BOY 24: They dispose them I suppose. 404 GIRL 23: Some parents wouldn't mind if it is once in a while but most of parents wouldn't like. 406 BOY 22: Parents actually hate them and that's why children take them secretly. 410 GIRL 19: They don't know how it is exactly tastes and when they eat sweets like chocolate they don't enjoy themselves because of that they don't like when we buy stuff, we hide it. 415 BOY 18: To the parent, 100% of all sweets like these are like spawn of the devil. 418 BOY 7: parents don't like them very much. Because they these are not good for our health. 420 BOY 16: My mum and dad don't like them because I gave Toxic Waste to them	It can be obviously seen that parents do not allow their children to eat these types of sweets. They tried to prevent or limit the consumption of these types of sweets. Children mentioned that their parents think that these sweets are bad for their health. However, children buy during the trolley loading in the supermarkets (highlighted in pink). Parents may allow eating these sweets only for small amount (highlighted in green). BOY 22 mentioned that "parents actually hate them and that's why children take them secretly" which shows that children could overcome the obstacle of parents opinions of these sweets and take them secretly.

		74 BOY 13: you eat a lot of sweets 75 TS: My dad won't be happy.	after I dropped it, they didn't know what it was. 422 BOY 15: I think parent thinks that they are all right in small amounts. Because it's like everything is quite good in small amounts. 424 BOY 14: I don't think parents approve of this kind of things at all. They might do everything they can to stop you eating them. 426 BOY 13: My dad has a serious sweet tooth. He loves every kind of chocolate and cake. He doesn't like sweets but my mum really likes to eat sweets. 428 BOY 12: My mum approves some sweets because sometimes I have some sweets beside my bed and when mum come and see them they will eat them. **434 RF: Does he buy them himself?** 135 BOY 22: No. By trolley loading My mum and grandma buy them and give them to my brother	
7. Influence of peers and friends on novelty sweets consumption		265 BOY 11: if you don't go to the shop you can just buy them from a friend. 133 GIRL 3: I usually share them around at school or to give it to my sister if I don't like them	445 Boy 22: Some friends sell them at school but they cost us more than the shops. 165 GIRL 4: I've seen all of them When I go with my sister to buy sweets. 279 BOY 14: Buy them with my sister from local shops.	Children mentioned that they share novelty sweets around at school or at home. They also mentioned that they can purchase novelty sweets from friends at school when they did not buy them from shops. Furthermore, children also

			271 GIRL 19: Sometimes with my family from supermarkets. Sometimes with the girls from the city centre.	purchase and share novelty sweets with peers and friends

8.15 Appendix 15. Questionnaire for sensory testing

CARDIFF UNIVERSITY PRIFYSGOL CAERDYD

An assessment of the taste recognition thresholds in children

Cardiff Metropolitan University

Participant Initials: **Age:** **Gender:** **M** ☐ **F** ☐

1- Please, tick the appropriate answers for each of the following sweets.

Sweet	Have you ever bought it?	Have you tried it?	If yes, Do you like it/ dislike it?
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it

Questionnaire V 1 09.2.15 1

Sweet	Have you ever bought it?	Have you tried it?	If yes, Do you like it/ dislike it?
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it
	☐ Yes ☐ No ☐ Somebody bought it for you (specify):	☐ Yes ☐ No	☐ I Like it ☐ I do not like it

2- How often do you eat the types of sweets shown above? (please tick one box only)

☐	Less than once per month	☐	**2-3 per day**
☐	1-3 per month	☐	4-5 per day
☐	1 per week	☐	6 or more per day
☐	2-4 per week	☐	Once a year
☐	5-6 per week	☐	Less than once a year
☐	1 per day	☐	Never

3- If you Like/Dislike any of these types of sweets shown above, please let us know what do you like/dislike about them (please select as many options which apply to you).

Like		Dislike	
Sweet taste	☐	Sweet taste	☐
Sour taste	☐	Sour taste	☐
Resealable	☐	Resealable	☐
Prices are affordable	☐	Prices are **not** affordable	☐
Easily available in shops	☐	Uneasily available in shops	☐
Way of eating it (lollipop, spray,..)	☐	Way of eating it (lollipop, spray,..)	☐
Toy comes with it	☐	Toy comes with it	☐
Other reason (specify):		Other reason (specify):	

4- Have you ever tried any of the following sweet/sour foods and drinks? Do you like/dislike them? (Please underline the appropriate food/drink and select the appropriate answer)

Foods/ drinks	If yes, Do you like it/ dislike it?	Are they:
Underline if you have tried: Fruit, Fruit Juice/ smoothie, Fruit dessert	☐ I Like it ☐ I do not like it	☐ Sour ☐ Sweet ☐ Sweet and sour
Underline the fruit, fruit juice/ smoothie, dessert that you have tried: Pineapple, Orange, Lemon, Apple, Strawberry, Raspberry, Cherry, Blackcurrant, Mango, Grapes Other (specify):	☐ I Like it ☐ I do not like it	☐ Sour ☐ Sweet ☐ Sweet and sour
Mixture of more than one of the above fruits or other fruits? Specify:	☐ I Like it ☐ I do not like it	☐ Sour ☐ Sweet ☐ Sweet and sour
Underline if you have tried: • Sport drinks, Flavour: • Carbonated drinks: Coca Cola, Pepsi,Dr Pepper, Fanta, Tango. • Other drinks (specify):	☐ I Like it ☐ I do not like it	☐ Sour ☐ Sweet ☐ Sweet and sour
Sweet and sour chicken	☐ I Like it ☐ I do not like it	☐ Sour ☐ Sweet ☐ Sweet and sour

8.16 Appendix 16. Ethical approval for sensory testing, Cardiff University

School of Dentistry
Dean Professor Michael A O Lewis
Ysgol Am Deintyddiaeth
Deon Yr Athro Michael A O Lewis

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

Cardiff University
College of Biomedical and Life Sciences
School of Dentistry
Heath Park
Cardiff CF14 4XY
Tel Ffôn +44(0)29 2074 2470
Fax Ffacs +44(0)29 2074 8274
E-mail E-bost
Dentaldean@cardiff.ac.uk

Prifysgol Caerdydd
Coleg y Gwyddorau Biofeddygol a Bywyd
Ysgol am Deintyddiaeth
Mynydd Bychan
Caerdydd CF14 4XY

DSREC Reference: 15/13a

11 March 2015

Dr Ayman AlJawad
University Dental Hospital
Heath Park
Cardiff
CF14 4XT

Dear Dr AlJawad

AN ASSESSMENT OF THE TASTE RECOGNITION THRESHOLDS IN 11-16 YEAR OLD CHILDREN

Thank you for your email of 11 March 2015 and accompanying documentation. On behalf of the Dental School Research Ethics Committee I am pleased to confirm a favourable Ethical Opinion for your project.

Documents Considered

Document	Version	Date Received
Ethical Approval Form		
Project Protocol	Version 1	9 February 2015
Methodology	Version 1	9 February 2015
Participant Information Sheet	Version 2	10 March 2015
Consent Form	Version 2	10 March 2015
Questionnaire	Version 1	9 February 2015

Conditions of Approval

The Dental School Research Ethics Committee requires that any modifications to the approved protocol be notified to the Committee.

It should be noted that Ethical Approval is valid for a period of 2 years from the date it was approved by the Dental School Research Ethics Committee. After this time, if the project has not commenced you should reapply to the Dental School Research Ethics Committee.

Athena SWAN Bronze Award

8.17 Appendix 17. Ethical approval for sensory testing, Cardiff Metropolitan University

Cardiff Metropolitan University | Prifysgol Metropolitan Caerdydd

Tuesday, 24 November 2015
cshs/ethics /approved - iterim/

Dr. Ayman Aljawad
PhD
Cardiff School of Health Sciences

Dear Applicant

Re: Application for Ethical Approval: An assessment of the taste recognition thresholds in 11-16 year old children

Ethics Reference Number : 7315

Your ethics application, as shown above, was considered by the Health Care and Food Ethics Panel on 12/11/2015.

I am pleased to inform you that your application for ethical approval was **APPROVED,** subject to the conditions listed below – *please read carefully.*

Standard Conditions of Approval

- Your Ethics Application has been given a Project Reference number as above. This **MUST** be quoted on all documentation relating to the project (E.g. consent forms, information sheets), together with the full project title.
- All documents must also have the approved University Logo and the Version number in addition to the reference and project title as above.
- A full **Risk Assessment** must be undertaken for this proposal, as appropriate, and be made available to the Committee if requested.
- Any changes in connection to the proposal as approved must be referred to the Panel/Committee for consideration ***without delay quoting your Project Reference Number***. Changes to the proposed project may have ethical implications and so must be approved.
- Any untoward incident which occurs in connection with this proposal must be reported back to the Panel/Committee ***without delay***.
- If your project involves the use of **samples of human origin**, your approval is given on the condition that you or your supervisor **notify the School** of your intention to work with such material by **completing Part One** of the form entitled *"Notification of Intention to Work with Human Relevant Material or Human Bodily Material"* which **must** be obtained from the PD (Sean Duggan), **BEFORE** any activity on this project is undertaken.

This approval expires on **12/11/2016.** . Please set a reminder on your Outlook calendar or equivalent if you need to continue beyond this approval date. It is your responsibility to reapply / request extension if necessary.

Yours sincerely

Arthur Tatham

Cardiff School of Health Sciences
Western Avenue,
Cardiff, CF5 2YB
Ysgol Gwyddorau Iechyd Caerdydd
Rhodfa'r Gorllewin,
Caerdydd, CF5 2YB

Telephone/Ffôn
+44(0)29 2041 6070
Fax/Ffacs
+44 (0)29 2041 6982

www.cardiffmet.ac.uk

8.18 Appendix 18. Participant information sheet for sensory testing

An assessment of the taste recognition thresholds in 11-16 year old children

Background

Your son or daughter is being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask us if there is anything that is not clear or if you would like more information. Please take time to decide whether you want your son/daughter to take part. Thank you for reading this.

What is the purpose of this study?

Cardiff University Dental School are investigating a group of sweets called novelty sweets, which can cause acid erosion in children. Acid erosion of teeth seems to affect some children more severely than others and we think that this may be related to some children having a higher taste threshold for tasting sweet and sour tastes.

This study will assess the taste recognition thresholds of the novelty sweet target consumer group which are 11-16 year old school children. This will be carried out in the Sensory Analysis Suite, Food Industry Centre, Cardiff Metropolitan University using a well-established basic sensory threshold assessment.

Why have I been chosen?

Your child has been chosen as they are going to attend an open day at Cardiff Metropolitan University within the next few weeks.

Do I have to take part?

It is up to you whether you agree to let your child take part as taking part in this research is entirely voluntary. If you do decide to let your child take part you will be given this information sheet to keep and you and your child will be asked to sign a consent form. If you do decide to allow your child to take part then you or your child are still free to withdraw your consent at any time and without giving a reason.

The data generated from the tasting panel and accompanying brief questionnaire will be anonymised on collection and from this point you or your child will not be able to withdraw from the study as we will not be able to identify individual participants from the anonymous data.

What will happen to me if I take part?

If you agree to allow your child to take part during the open day visit at some point during the day, the schoolchildren begin with a talk led by Cardiff Metropolitan University that sets out the organisation of the day. On the day of the study the schoolchildren will undertake the taste threshold testing in groups of 10 within the Sensory Analysis Suite.

During the visit the children will be asked various questions about whether they know what a novelty sweet is, whether they have ever bought them, what types of these sweets they like and how much they cost. They will also be shown pictures of the various types of novelty sweets to help the process and answer questions related to each picture.

As a small thank you for taking part we will give all children a dental pack containing age appropriate toothpaste and tooth brushes.

What about confidentiality?

The computer that contains the data is password protected so that only the researcher has access to the data in a university drive.

What do participants have to do?

Your son or daughter will just need to take part in taste threshold test of two types of “Taste” which will be led the researcher. Students will be asked to taste 2 sets of sweet and sour solutions. This will be involving around 46 children.

This will be included in the day visit to Cardiff Metropolitan University. This visit will include the following.

1- **9:35 -9:50 am:** talk will be given by staff member of the Cardiff Metropolitan University that sets out the organisation of the day.
2- **10:00 -10:15 am:** a simple dental public health talk (incorporating fundamental oral hygiene and dietary messages) will be given by member staff of Cardiff University, Dental School.
3- **10:20- 10:40 am:** students will be asked to complete a questionnaire specifically related to the sensory testing
4- **10:45-11:30 am:** each student will taste a series of sweet and sour solutions to know the threshold of each student. All these concentrations are maintained at safe levels.
5- **11:35- 11:45 am:** At the end of the day the children, whether they have taken part in the sensory testing or not, will be given a dental pack free of charge. These will contain a child’s toothbrush and age appropriate toothpaste.

What will happen to the results of the research study?

This research will form part of a PhD being undertaken by the specialist dentist undertaking this study. It is also very likely that the results will be published in an academic report but your son or daughter will not be identified in the PhD or the

Who is organising and funding the research?

academic report in any way. We will also be able to let you know the findings of the study via your son or daughters school. We will contact each of the class teachers with the results of the study so that these can be disseminated to the children that have taken part.

The research is being undertaken and funded by Cardiff University Dental School

Contact for further information?

Specific information about this research project can be obtained from the project lead

Professor Jeremy Rees

Professor of Restorative Dentistry,

Cardiff University School of Dentistry,

Heath Park, Cardiff CF14 4XY

Email: reesjs1@cardiff.ac.uk   Tel: 02920 746 557

Patient info sheet Version 1   09.2.15

8.19 Appendix 19. Consent form for sensory testing

CONSENT FORM

Project Title: An assessment of the taste recognition thresholds in 11-16 year old children

- **Parent need to tick all they agree with:**

Do you understand what this project is about?	☐	Yes	☐	No
Have you asked all the questions you want?	☐	Yes	☐	No
Have you had your questions answered in a way you understand?	☐	Yes	☐	No
Do you understand it's OK to stop taking part at any time?	☐	Yes	☐	No
Are you happy for your child to take part?	☐	Yes	☐	No

- **If any answers are "no" or you don't want your child to take part, don't sign your name**

- If you **do** want **your child** to take part, you can write your name below

Print Name ………………………………………………………

Relationship to child……………………………………………..

Sign ……………………………………………………………..

Date ……………………………………………………………

Researcher:

Print Name ……………………………………………………

Sign ……………………………………………………………..

Date ……………………………………………………………

8.20 Appendix 20. Sensory taste tables for sweet and sour thresholds

Participant Initials: **Age:** **Gender:** **M** ☐ **F** ☐

Solutions Group A

- **Taste the following solutions in the order A1 through to A13.**
- **Solution A1 is water.**
- **Put an x in the box of the first solution that you think tastes different from water.**
- **Write sweet or sour in the comments box on the line for the first solution that you think tastes sweet or sour.**
- **Taste the next solution and confirm the solution tastes sweet or sour by writing sweet or sour in the comments box again.**

SOLUTIONS	COMMENTS
A1	
A2	
A3	
A4	
A5	
A6	
A7	
A8	
A9	
A10	
A11	
A12	
A13	

Solutions Group B

- **Taste the following solutions in the order B1 through to B13.**
- **Solution B1 is water.**
- **Put an x in the box of the first solution that you think tastes different from water.**
- **Write sweet or sour in the comments box on the line for the first solution that you think tastes sweet or sour.**
- **Taste the next solution and confirm the solution tastes sweet or sour by writing sweet or sour in the comments box again.**

SOLUTIONS	COMMENTS
B1	
B2	
B3	
B4	
B5	
B6	
B7	
B8	
B9	
B10	
B11	
B12	
B13	

8.21 Appendix 21. Thank you note for sensory testing

Thank you

Your opinion about these sweets and participation in this study are helpful.

We will be summarizing all the data anonymously, but this will take a little time. If you are interested in receiving a written summary, please email Dr.Aljawad on aljawadaa@cf.ac.uk who will keep a list of whom interested and send a copy once prepared.

8.22 Appendix 22. Raw data of sensory testing and questionnaire

1= "Yes"

2= "No"

3= "No response"

Participant No	Age	Gender	Like sweet taste?	Like sour taste?	Resealability?	Prices?	Availability?	Ways of eating?	Toy?	How often?
1	12	F	1	2	1	2	1	1	3	2
2	12	M	1	1	1	1	1	1	2	1
3	14	F	1	1	1	2	1	1	2	1
4	12	M	1	2	1	1	3	1	3	1
5	12	M	3	1	1	1	3	3	3	1
6	14	F	3	3	1	2	2	3	1	1
7	14	M	1	1	1	1	1	1	2	1
8	13	M	1	1	3	2	1	1	3	1
9	14	M	1	1	3	1	1	1	1	1
10	14	M	1	2	1	1	1	2	1	2

11	14	F	3	1	1	2	3	1	1	1
12	14	F	1	1	3	3	3	1	2	1
13	14	F	1	2	1	1	1	2	2	2
14	14	F	1	1	1	1	1	1	2	2
15	13	F	1	1	1	1	1	1	1	2
16	14	F	1	1	1	2	1	1	1	1
17	14	F	1	2	1	3	1	1	3	1
18	14	F	1	1	3	3	3	1	3	1
19	13	M	1	1	1	3	1	1	2	1
20	15	M	2	2	3	1	1	1	2	1
21	12	M	1	1	1	2	1	1	2	2
22	13	F	1	1	1	1	1	2	2	1
23	12	M	1	2	2	1	1	1	1	2
24	14	M	3	3	3	3	3	3	3	3
25	12	M	1	1	3	3	3	1	3	3
26	11	M	1	2	1	3	1	2	2	3
27	12	M	1	1	1	1	3	2	3	3

28	16	F	1	2	1	3	1	1	3	2
29	16	M	3	1	1	1	3	2	3	2
30	16	F	1	2	1	3	3	3	3	2
31	16	F	1	2	1	1	1	3	3	2
32	16	M	1	1	1	2	1	1	2	1
33	14	F	3	1	3	1	1	3	3	2
34	14	M	1	1	1	1	1	2	2	2
35	16	F	1	1	1	1	1	1	2	2
36	16	M	1	1	1	1	1	1	1	1
37	15	F	3	3	1	3	3	1	3	3
38	15	F	1	2	1	1	1	2	2	2
39	15	F	1	2	1	1	1	1	2	2
40	15	F	1	1	3	1	3	2	3	2
41	15	F	1	1	1	1	1	1	2	2
42	16	F	1	1	1	2	1	1	2	2
43	16	M	1	1	1	1	1	1	2	2
44	16	F	1	1	1	1	2	1	2	2

45	16	M	1	1	1	1	1	3	3	1
46	16	F	1	2	3	3	3	3	3	1

Participant No	Single fruit tried?	Single fruit Like?	Single fruit sweet?	Single fruit sour?	Single fruit sweet/sour?	Mixed fruits tried?	Mixed fruits Like?	Mixed fruits sweet?	Mixed fruits sour?	Mixed fruits sweet/sour?
1	1	1	2	1	2	1	1	2	1	2
2	1	1	2	2	2	1	1	2	1	2
3	1	1	2	1	2	1	3	2	1	1
4	1	1	1	1	2	1	1	2	1	2
5	1	1	1	1	2	1	1	1	1	2
6	1	1	1	2	2	3	3	3	3	3
7	1	1	2	2	1	3	3	3	3	3
8	1	1	2	2	1	1	3	2	2	1
9	1	1	2	2	1	3	3	3	3	3
10	1	1	2	1	2	3	3	3	3	3

11	1	1	2	2	1	1	1	2	1	2
12	1	1	2	2	1	3	3	3	3	3
13	1	1	2	2	1	1	1	2	1	2
14	1	1	2	2	1	1	2	2	1	2
15	1	1	2	2	1	1	1	2	1	2
16	1	1	2	2	1	3	3	3	3	3
17	1	1	2	1	2	1	1	2	1	2
18	1	1	2	2	1	1	1	2	1	2
19	1	1	2	2	1	3	3	3	3	3
20	1	1	2	1	2	1	1	2	2	1
21	1	1	1	2	2	1	1	2	1	2
22	1	1	2	2	1	1	2	2	1	2
23	1	1	2	2	1	1	1	2	2	1
24	1	1	2	2	1	1	1	2	1	2
25	1	1	2	1	2	1	3	3	3	3
26	1	1	2	2	1	1	3	3	3	3
27	1	1	1	1	2	3	3	3	3	3

28	1	1	2	1	2	1	1	1	2	2
29	1	1	2	1	2	3	3	3	3	3
30	1	1	2	2	1	1	1	2	1	2
31	1	1	2	1	2	1	1	2	1	2
32	1	2	2	1	1	1	1	2	1	2
33	1	1	2	2	1	3	3	3	3	3
34	1	1	2	1	2	1	1	2	1	2
35	1	1	2	1	2	1	1	2	1	2
36	1	1	2	2	1	1	1	2	1	2
37	1	1	2	1	2	1	1	2	1	2
38	1	1	2	1	2	3	3	3	3	3
39	1	1	2	1	2	1	1	2	1	2
40	1	1	2	1	2	1	1	2	1	2
41	1	1	2	1	2	1	1	2	2	1
42	1	1	1	2	2	3	3	3	3	3
43	1	1	2	2	1	1	1	2	2	1
44	1	1	2	2	1	1	1	2	2	1

45	1	1	2	2	1	3	3	3	3	3
46	1	1	2	1	2	3	3	3	3	3

Particip ant No	Tried sports drinks?	Tried carbonated drinks?	Like Drinks?	Drinks sweet?	Drinks sour?	Drink sweet/sour ?	Like sweet/sour chicken?	Chicken sweet?	Chicken sour?	Chicken sweet/sour?
1	1	1	1	2	1	2	2	2	1	2
2	2	1	1	2	1	2	3	2	2	1
3	1	1	1	1	2	2	1	2	2	1
4	1	1	1	2	1	2	1	2	2	1
5	1	1	1	1	2	2	1	2	2	1
6	1	1	1	2	1	2	2	2	2	1
7	1	1	1	2	1	2	1	2	2	1
8	1	1	1	2	1	2	1	2	1	2
9	1	1	1	2	1	2	1	2	2	1

10	1	1	1	2	1	2	1	2	2	1
11	1	1	1	2	1	2	1	2	2	1
12	1	1	1	2	2	1	3	3	3	3
13	2	1	2	2	1	2	2	2	1	2
14	1	1	1	2	2	1	1	2	1	2
15	1	1	1	2	2	1	1	2	1	2
16	1	1	1	2	2	1	1	2	2	1
17	1	1	1	2	1	2	2	2	2	1
18	1	1	1	2	1	2	1	2	1	2
19	1	1	1	2	1	2	1	2	2	1
20	1	1	1	2	1	2	2	1	2	2
21	1	1	1	2	1	2	2	1	2	2
22	1	1	1	2	1	2	2	3	3	3
23	1	1	1	2	1	2	1	2	2	1
24	2	1	2	1	2	1	1	2	2	1
25	1	1	1	2	1	2	1	2	2	1
26	2	1	1	2	2	1	1	2	2	1

27	2	1	2	2	1	2	3	3	3	3
28	1	1	1	2	1	1	1	2	2	1
29	1	1	1	2	1	1	2	2	1	2
30	1	1	1	2	1	2	1	2	1	2
31	1	1	1	2	1	1	1	2	2	1
32	1	1	1	2	2	1	2	3	3	3
33	1	1	1	2	2	1	2	2	2	1
34	1	1	1	2	1	2	2	2	2	1
35	1	1	1	2	1	2	1	2	2	1
36	1	1	1	2	1	1	1	2	2	1
37	1	2	1	2	1	2	1	2	1	2
38	1	1	1	2	1	2	1	2	1	2
39	1	1	1	2	1	1	1	2	1	2
40	1	1	1	2	1	1	2	2	2	1
41	1	1	1	2	1	1	1	2	2	1
42	1	1	1	1	2	2	1	2	1	1
43	1	1	1	2	1	2	2	2	1	1

44	1	1	1	2	1	2	2	3	3	3
45	2	1	1	2	1	2	1	1	1	2
46	1	1	1	2	1	2	1	2	2	1

Participant No	Sweet absolute threshold	Sweet recognition threshold	Sour absolute threshold	Sour recognition threshold
1	none	none	B6	B7
2	A10	A10	B7	B7
3	A12	A13	B3	B10
4	A12	A13	B7	B8
5	A6	A12	B3	B5
6	A5	A8	B7	B7
7	A8	A8	B2	B2
8	A3	A7	B3	B7
9	A11	A13	B8	B9

10	A12	A12	B7	B7
11	A9	A12	B7	B12
12	A9	A12	B2	B7
13	none	none	B7	B7
14	A13	A13	B8	B8
15	A12	A12	B6	B6
16	A7	A7	B5	B5
17	A12	A12	B7	B8
18	A8	A9	B3	B6
19	A13	A13	B3	B8
20	A3	A8	B10	B10
21	A12	A12	B7	B7
22	A8	A12	B2	B12
23	A12	A13	B4	B7
24	A13	A13	B4	B8
25	A9	A9	B3	B7
26	A2	A9	B2	B6

27	A12	A13	B4	B7
28	A5	A11	B3	B6
29	A12	A13	B6	B7
30	A3	A11	B4	B7
31	A4	A4	B4	B4
32	A5	A13	B2	B8
33	A5	A6	B6	B7
34	A13	none	B6	B6
35	A6	A6	B7	non
36	A4	A4	B5	B5
37	A3	A5	B5	B6
38	A5	A6	B2	B3
39	A5	A5	B7	B7
40	A3	none	B2	B5
41	A7	A7	B7	B7
42	A5	A7	B6	B8
43	A5	A13	B6	B7

44	A13	A13	B7	non
45	A7	A7	B3	B3
46	A6	A6	B4	B4

8.23 Appendix 23. Ethical approval to obtain human extracted teeth

Application for Human Extracted Teeth from Cardiff School of Dentistry Tooth Bank

Part 1: PRE STUDY Application

Name of Cardiff PI: Prof Jeremy Rees
Email: reesjs1@cardiff.ac.uk
Phone:02920 746 557
Brief CV Attached (2 page maximum)**:** YES

Names of Co-investigators: N/A
Research Student (if applicable): Ayman AlJawad (Clinical PhD student)
Collaborative researchers outside of Cardiff (if applicable): N/A

Project start date: 1/6/13
Estimated finish date: 1/10/13

Project Title: A laboratory assessment of the erosive potential of 10 popular novelty sweets
Aims and Objectives (300 words maximum): To assess the ability in vitro of 10 different novelty sweets to cause surface enamel loss caused by erosion and sub-surface enamel softening with and without saliva.

Outline of methodologies (300 words maximum)(Include in the methodology details of any statistical validation of sample number to demonstrate that sample numbers are neither inadequate or excessive)**:**

See attached sheet

Details of project funding (including costs of transferring tissue samples or part of to external collaborating researchers if applicable)**:** Funded internally through PhD student bench fees

Number of teeth required:

Posterior teeth to obtain 280 enamel specimens

I wish to apply for samples from the Cardiff School of Dentistry Tooth Bank as described above. I undertake to return residual samples to the Tooth Bank on completion of the above studies, at my cost. I will provide a brief report of the outcome of the study in conforming to the aims and principles of Tooth bank and of publications (including pending publications, conference abstracts, thesis chapters published via ORCA) or of IP potential arising from this work to the Tooth Bank governance committee. I will acknowledge the Tooth Bank and ethical number as the source of samples on publication of the data.

Signed: J S Rees **Date: 1/5/13**

Part of the research infrastructure for Wales funded by the National Institute for Social Care and Health Research, Welsh Government.
Yn rhan o seilwaith ymchwil Cymru a ariannir gan y Sefydliad Cenedlaethol ar gyfer Ymchwil Gofal Cymdeithasol ac Iechyd, Llywodraeth Cymru

NISCHR

Gwasanaeth Moeseg Ymchwil | RES | Research Ethics Service

South East Wales Research Ethics Committee
Sixth Floor, Churchill House
17 Churchill Way
Cardiff CF10 2TW

Telephone : 029 2037 6823

E-mail : jagit.sidhu@wales.nhs.uk
Website : www.nres.nhs.uk

South East Wales Research Ethics Committee - Panel D

22 October 2012

Professor Rachel Waddington
School of Dentistry
Tissue Engineering and Reparative Dentistry
School of Dentistry, Cardiff University
Heath Park, Cardiff
CF14 4XY

Dear Professor Waddington

Title of the Research Tissue Bank:	**Cardiff School of Dentistry Tooth Bank**
REC reference:	**12/WA/0289**
Designated Individual:	**Professor Jonathan Bisson**

Thank you for your letter of 16 October 2012, responding to the Committee's request for further information on the above research tissue bank and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Alternate Vice-Chair.

__Confirmation of ethical opinion__

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion of the above research tissue bank on the basis described in the application form and supporting documentation as revised.

The Committee has also confirmed that the favourable ethical opinion applies to all research projects conducted in the UK using tissue or data supplied by the tissue bank, provided that the release of tissue or data complies with the attached conditions. It will not be necessary for these researchers to make project-based applications for ethical approval. They will be deemed to have ethical approval from this committee. You should provide the researcher with a copy of this letter as confirmation of this. The Committee should be notified of all projects receiving tissue and data from this tissue bank by means of an annual report.

GIG Cymru NHS Wales | Bwrdd Iechyd Addysgu Powys | Powys Teaching Health Board

Cynhelir Cydweithrediad Gwyddor Iechyd Academaidd y Sefydliad Cenedlaethol ar gyfer Ymchwil Gofal Cymdeithasol ac Iechyd gan Fwrdd Addysgu Iechyd Powys

The National Institute for Social Care and Health Research Academic Health Science Collaboration is hosted by Powys Teaching Health Board

Ariennir gan Llywodraeth Cymru
Funded by Welsh Government

8.24 Appendix 24. Raw data of pH at body temperature

Subject	pH 1	pH 2	pH 3	pH 4	pH 5	pH 6	pH 7	pH 8	pH 9	pH 10	Average pH	SD
Brain Licker	2.05	2.08	2.1	2	2.05	2.08	2.1	2	2.05	2.05	2.056	0.033
Push Pop	3.15	3.17	3.14	3.15	3.15	3.17	3.17	3.15	3.14	3.15	3.154	0.01
Toxic Waste	1.95	2.01	1.89	1.9	1.94	1.95	1.93	1.93	1.95	1.88	1.933	0.03
Lickedy Lips	2.05	2	1.92	2.04	2.05	2.02	2.05	2.05	2	1.97	2.015	0.041
Tango	3.22	3.19	3.17	3.25	3.2	3.23	3.23	3.22	3.22	3.22	3.215	0.021
Vimto	2.47	2.45	2.48	2.45	2.45	2.47	2.46	2.46	2.45	2.5	2.464	0.015
Brain Blasterz	2.3	2.31	2.32	2.32	2.3	2.3	2.31	2.31	2.32	2.3	2.309	0.008
Orange Juice	3.82	3.82	3.8	3.8	3.83	3.82	3.8	3.82	3.81	3.8	3.812	0.01
Big Baby (powder)	2.35	2.4	2.37	2.37	2.37	2.41	2.38	2.35	2.35	2.37	2.372	0.019
Big Baby Pop (pop)	3.21	3.2	3.2	3.2	3.1	3.2	3.2	3.15	3.15	3.2	3.181	0.033

Mega Mouth	1.9	2.01	1.95	1.92	1.93	1.93	1.95	1.9	1.92	1.9	1.931	0.033
Juicy Drop (pop)	3.15	3.21	3.18	3.15	3.15	3.15	3.17	3.15	3.17	3.2	3.168	0.021
Juicy Drop (Liquid)	2.36	2.3	2.34	2.3	2.3	2.33	2.34	2.34	2.34	2.35	2.33	0.02

8.25 Appendix 25. Raw data of pH at room temperature

Subject	pH 1	pH 2	pH 3	pH 4	pH 5	pH 6	pH 7	pH 8	pH 9	pH 10	Average pH	SD
Brain Licker	1.91	1.95	1.9	1.92	1.91	1.95	1.9	1.95	1.91	1.95	1.925	0.021
Push Pop	3.09	3.08	3.12	3.1	3.15	3.15	3.14	3.1	3.11	3.11	3.115	0.023
Toxic Waste	1.84	1.81	1.87	1.8	1.8	1.88	1.82	1.84	1.85	1.83	1.834	0.026
Lickedy Lips	1.91	1.88	1.92	1.89	1.9	1.9	1.92	1.92	1.88	1.87	1.899	0.017
Tango	3.19	3.17	3.16	3.2	3.21	3.22	3.15	3.17	3.21	3.2	3.188	0.022
Vimto	2.42	2.45	2.42	2.43	2.45	2.44	2.43	2.4	2.41	2.45	2.43	0.016
Brain Blasterz	2.3	2.31	2.32	2.3	2.3	2.3	2.31	2.33	2.3	2.3	2.307	0.01
Orange Juice	3.75	3.78	3.8	3.75	3.75	3.75	3.77	3.81	3.77	3.78	3.771	0.02
Big Baby (powder)	2.33	2.34	2.36	2.33	2.32	2.33	2.35	2.33	2.34	2.34	2.337	0.011
Big Baby Pop (pop)	3.21	3.2	3.2	3.2	3.2	3.2	3.22	3.2	3.31	3.31	3.225	0.042
Mega Mouth	1.83	1.83	1.85	1.85	1.85	1.83	1.83	1.84	1.83	1.85	1.839	0.042
Juicy Drop (pop)	3.1	3.11	3.15	3.11	3.12	3.13	3.1	3.1	3.13	3.15	3.12	0.018

Juicy Drop (Liquid)	2.26	2.24	2.24	2.25	2.25	2.26	2.25	2.25	2.25	2.24	2.249	0.007

8.26 Appendix 26. Raw data of neutralisable acidity at room temperature

Subject	Acidity 1	Acidity 2	Acidity 3	Acidity 4	Acidity 5	Acidity 6	Acidity 7	Acidity 8	Acidity 9	Acidity 10	Average Neutralisable Acidity	SD
Brain Licker	48.5	48.7	48.9	48.9	48.8	48.8	50	48.9	48.7	48.6	48.9	0.43
Push Pop	9.0	9.1	9.2	9	9.2	9.2	9.1	9	9	9.1	9.08	0.08
Toxic Waste	93.0	92.0	95.0	93	93.5	93	93.3	95	94.5	93.5	93.6	0.71
Lickedy Lips	40.0	40.5	40	40.5	40	40	40.3	40.5	40	40	40.2	0.23
Tango	40.8	41.0	42.0	42	42.1	42	42	41.5	41	41	41.6	0.45
Vimto	69.5	69.0	70.0	70	69.5	69	70	70	69.5	70	69.7	0.36
Brain Blasterz	29.0	29.0	28.9	29	29.2	29.3	29	28.8	29.1	29	29.05	0.14
Orange Juice	27.0	28.5	29.0	27.8	28	28.3	29	28.5	29	27.9	28.3	0.46
Big Baby (powder)	10.5	10.4	10.3	10.3	10.5	10.5	10.5	10.4	10.2	10.5	10.4	0.11
Big Baby (pop)	10.3	9.8	10.25	10.1	10.4	10.1	9.9	10	10.3	10.3	10.1	0.16

Mega Mouth	95.0	95.0	95.2	95	95	95	95.2	95	95.1	95	95.04	0.16
Juicy Drop (pop)	10.0	9.4	10.0	9.7	10.1	10	10	10	9.6	10	9.9	0.17
Juicy drop (Syrup)	202.0	201.0	200.0	202	201.5	202	200	200	202	202	201.3	0.87

8.27 Appendix 27. Raw data of Neutralisable acidity at body temperature

Subject	Acidity 1	Acidity 2	Acidity 3	Acidity 4	Acidity 5	Acidity 6	Acidity 7	Acidity 8	Acidity 9	Acidity 10	Average Neutralisable Acidity	SD
Brain Licker	48.3	48.5	48.7	48.4	48.6	48.6	48.5	48.7	48.3	48.5	48.51	0.13
Push Pop	9.4	9.1	9.2	9.2	9.2	9.4	9.2	9.1	9.1	9.4	9.23	0.11
Toxic Waste	93.5	94	95	94.5	94.4	94	94.5	93.8	93.7	94	94.14	0.42
Lickedy Lips	41	40.5	40	40.6	40.9	41.2	41.2	40.5	40	41	40.69	0.42
Tango	41	42.2	42	42	41.5	41	41.9	42.1	41.5	41.3	41.65	0.42
Vimto	71.5	70.5	70	71	70.5	70.7	70.7	71.2	70.8	70.2	70.71	0.42
Brain Blasterz	29.5	29	29.8	29.2	29	30	29.5	29.5	30	29.4	29.49	0.34
Orange Juice	27.8	28.5	29.2	27.5	28.5	28.7	27.9	29.2	28.9	28.6	28.48	0.55
Big Baby (Powder)	10.5	10.4	11	10.7	10.9	10.5	10.5	10.3	10.7	10.5	10.6	0.2
Big Baby (Pop)	10.5	10	10.4	10.5	10.3	10.4	10.4	10.5	10.5	10.5	10.4	0.14

Mega Mouth	95.5	95	94.8	95	95.5	95.5	95.7	95.7	95	95.5	95.32	0.14
Juicy Drop (Pop)	10.5	9.8	10.4	10	10.5	10.2	10.4	10.4	9.9	10.2	10.23	0.24
Juicy Drop (Syrup)	202	202	203	202.5	202	202	203	203	202.5	202	202.4	0.43

8.28 Appendix 28. Raw data of contact angle

Material/sample	1	2	3	4	5	6	7	8	9	10	**Average**	**S.D**
Water												
Contact angle	74.79	75.88	72.92	77.82	74.32	70.58	75.32	72.8	79.22	71.88	**74.553**	**2.657969359**
Orange												
Contact angle	76.52	77.35	73.33	78.12	76.83	70.93	76.64	73.72	81.12	72.89	**75.745**	**2.999152658**
Tango												
Contact angle	73.99	74.63	73.57	73.79	74.58	74.82	73.21	73.56	74.66	75.45	**74.226**	**0.705521084**
Mega Mouth												
Contact angle	86.59	88.52	85.53	89.33	85.42	83.5	86.72	84.62	86.26	88.44	**86.493**	**1.844156236**
Brain Licker												
Contact angle	93.48	93.79	97.82	95.77	97.65	98.3	94.12	95.73	96.3	99.57	**96.253**	**2.065978649**

Vimto												
Contact angle	75.32	75.93	73.57	78.31	75.92	71.82	76.52	73.42	78.73	74.83	**75.437**	**2.154220921**
Toxic Waste												
Advancing Angle	75.48	76.52	72.95	78.93	75.57	71.12	75.92	73.37	76.25	77.93	**75.404**	**2.347245194**
Lickedy Lips												
Contact angle	95.38	97.58	94.77	98.18	97.12	97.75	93.73	97.24	99.37	102.98	**97.41**	**2.589504457**
Big Baby (Powder)												
Contact angle	81.62	83.28	79.72	85.55	89.24	83.81	84.72	82.57	83.42	89.77	**84.37**	**3.148562282**
Big Baby (pop)												
Contact angle	76.85	77.54	74.28	79.33	80.66	73.5	76.14	73.44	75.42	81.79	**76.895**	**2.935045902**
Juicy Drop (Syrup)												

Contact angle	102.25	104.32	101.38	108.44	110.48	102.78	104.24	102.77	107.79	106.55	**105.1**	**3.047016756**
Juicy Drop (pop)												
Contact angle	77.54	76.88	75.69	79.58	75.75	74.33	77.57	74.35	77.49	82.29	**77.147**	**2.420408827**
Brain Blasterz												
Advancing Angle	75.62	76.74	74.32	74.92	75.78	70.93	75.57	73.35	78.33	79.12	**75.468**	**2.356422901**
Push Pop												
Contact angle	80.87	82.48	83.35	84.56	83.92	78.55	83.4	83.82	86.32	88.92	**83.619**	**2.810335883**

8.29 Appendix 29. Raw data of viscosity

Material	Water	Orange Juice (Tropicana smooth)	Tango	Lickedy Lips	Brain Licker	Juicy Drop Syrup	Vimto	Mega Mouth
Viscosity 1	1	3	2	79	66.7	594.8	1.7	12.7
Viscosity 2	0.97	2.9	1.9	78.8	66.8	594.7	1.8	12.8
Viscosity 3	0.95	3.1	2	78.7	66.9	594.7	1.8	12.7
Viscosity 4	0.97	3	2	78.8	66.8	594.7	1.8	12.7
Viscosity 5	0.95	2.9	2	78.8	67.2	594.9	1.8	12.7
Viscosity 6	0.95	2.96	2	78.8	67	594.8	1.8	12.9
Viscosity 7	1	2.98	2	78.6	66.9	594.9	1.8	13
Viscosity 8	1	3	1.97	79	66.9	595	1.7	13
Viscosity 9	1	3	1.98	79	66.9	594.9	1.8	13
Viscosity 10	1	3	2	78.7	66.8	594.7	1.8	13
Average	**0.979**	**2.984**	**1.985**	**78.82**	**66.89**	**594.81**	**1.78**	**12.85**
SD	**0.02**	**0.05**	**0.03**	**0.13**	**0.13**	**0.1**	**0.04**	**0.13**

8.30 Appendix 30. Raw data of sugar content

Material	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	AVEREGE	SD
Water	0	0	0	0	0	0	0	0	0	0	0	0
Orange Juice (Tropicana smooth)	12	12	12	12	12.5	12.5	12	12	12	12	12.1	0.2
Juicy Drop (pop)	65	65.5	65	67	65	65.5	65	65	65	65	65.3	0.6
Juicy Drop (syrup)	74	73.5	74	74	73	73.5	73.5	74	74	74	73.75	0.33
Big Baby (powder)	68.5	68	68	68	68.5	68.5	68	68	68	68	68.15	0.22
Big Baby (pop)	65	66	65	65.5	65	65	65.5	66	66	65	65.4	0.43
Mega Mouth	55	55.5	55	55	55.5	56	56	55	55	55	55.3	0.4
Push Pop	70	72	72	71	70	70	72	72	71.5	71.5	71.2	0.84
Brain Blasterz	73	73.5	74	74	74	73.5	74	73.5	74	74	73.75	0.33
Toxic Waste	60	61	60	62	61	61	62	62	62	62	61.3	0.78
Vimto	32	32	32	33	33	32	32	31	32	32	32.1	0.53
Tango	31	31	31	31	31	31	32	32	32	31	31.3	0.45
Lickedy Lips	63	63.5	63	64	64	64	64	63	63	64	63.55	0.47
Brain Licker	64	64	63.5	63.5	63	63.5	63.5	63	64	64	63.6	0.37

8.31 Appendix 31. Raw data of surface enamel loss with saliva

Material/sample	1	2	3	4	5	6	7	8	9	10	**Average**	**S.D**
Water (pre)	0.212	0.292	0.258	0.163	0.232	0.063	0.177	0.208	0.256	0.243		
	0.217	0.283	0.28	0.172	0.245	0.075	0.183	0.224	0.263	0.25		
	0.182	0.275	0.239	0.155	0.256	0.077	0.167	0.232	0.234	0.222		
	0.203666667	0.283333333	0.259	0.163333333	0.244333333	0.071666667	0.175666667	0.221333333	0.251	0.238333333	**0.211166667**	**0.061543972**
Water (post)	0.243	0.289	0.221	0.172	0.23	0.165	0.21	0.222	0.26	0.244		
	0.257	0.28	0.279	0.182	0.253	0.127	0.169	0.242	0.267	0.248		
	0.261	0.282	0.231	0.21	0.246	0.17	0.186	0.253	0.235	0.211		
	0.253666667	0.283666667	0.243666667	0.188	0.243	0.154	0.188333333	0.239	0.254	0.234333333	**0.228166667**	**0.039035992**
											Total E loss	**0.017**
Orange Juice (pre)	0.135	0.158	0.087	0.206	0.212	0.116	0.232	0.142	0.206	0.233		

	0.132	0.143	0.077	0.176	0.232	0.093	0.221	0.153	0.211	0.254		
	0.165	0.163	0.107	0.17	0.221	0.132	0.252	0.148	0.192	0.243		
	0.144	0.15466 6667	0.09033 3333	0.184	0.22166 6667	0.11366 6667	0.235	0.14766 6667	0.203	0.24333 3333	**0.17373 3333**	**0.05201 2771**
Orange Juice (post)	3.92	4.68	3.35	3.62	3.68	3.42	3.43	3.543	3.72	4.62		
	3.75	4.72	3.63	3.48	3.79	3.65	3.68	3.73	3.517	4.32		
	3.53	4.73	3.44	3.45	3.9	3.74	3.72	3.61	3.432	4.123		
	3.73333 3333	4.71	3.47333 3333	3.51666 6667	3.79	3.60333 3333	3.61	3.62766 6667	3.55633 3333	4.35433 3333	**3.7975**	**0.40698 161**
											Total E loss	**3.62**
Tango (pre)	0.2	0.176	0.109	0.242	0.18	0.164	0.283	0.235	0.219	0.123		
	0.189	0.205	0.08	0.254	0.155	0.198	0.266	0.223	0.276	0.176		
	0.21	0.172	0.091	0.262	0.185	0.18	0.247	0.215	0.278	0.152		
	0.19966 6667	0.18433 3333	0.09333 3333	0.25266 6667	0.17333 3333	0.18066 6667	0.26533 3333	0.22433 3333	0.25766 6667	0.15033 3333	**0.19816 6667**	**0.05385 2852**

Tango (post)	8.55	7.25	7.76	7.43	8.16	8.52	7.44	7.22	7.33	8.11		
	8.42	7.38	7.26	7.73	8.29	8.46	7.52	7.36	7.72	8.32		
	8.31	7.25	7.45	7.58	8.22	8.68	7.82	7.47	7.55	8.44		
	8.426666667	7.293333333	7.49	7.58	8.223333333	8.553333333	7.593333333	7.35	7.533333333	8.29	**7.833333333**	**0.481427917**
											Total E loss	**7.63**
Mega Mouth (pre)	0.132	0.283	0.164	0.159	0.159	0.288	0.17	0.284	0.188	0.223		
	0.185	0.279	0.147	0.157	0.163	0.272	0.185	0.222	0.182	0.198		
	0.142	0.263	0.153	0.198	0.149	0.264	0.219	0.283	0.2	0.212		
	0.274	0.275	0.154666667	0.171333333	0.157	0.274666667	0.191333333	0.263	0.19	0.211	**0.2162**	**0.050599419**
Mega Mouth (post)	5.23	5.44	4.53	5.16	5.32	5.2	4.64	4.68	5.63	4.32		
	5.32	5.76	4.66	5.24	5.56	5.22	4.72	4.53	5.36	4.51		
	5.11	5.84	4.78	5.33	5.43	5.13	4.57	4.38	5.54	4.76		

	5.22	5.68	4.656666667	5.243333333	5.436666667	5.183333333	4.643333333	4.53	5.51	4.53	**5.063333333**	**0.43476402**
											Total E loss	**4.84**
Lickedy Lips (pre)	0.11	0.157	0.285	0.069	0.2	0.142	0.129	0.144	0.157	0.81		
	0.118	0.179	0.279	0.087	0.234	0.132	0.137	0.154	0.185	0.63		
	0.107	0.156	0.282	0.075	0.186	0.135	0.144	0.13	0.164	0.083		
	0.111666667	0.164	0.282	0.077	0.206666667	0.136333333	0.136666667	0.142666667	0.168666667	0.507666667	**0.193333333**	**0.123623083**
Lickedy Lips (post)	1.85	2.22	2.23	2.32	2.54	1.81	1.93	2.48	1.82	2.56		
	1.53	2.34	2.25	2.15	2.75	1.76	1.88	2.34	1.99	2.55		
	1.78	2.23	2.17	2.23	2.66	1.92	1.79	2.32	1.76	2.54		
	1.72	2.263333333	2.216666667	2.233333333	2.65	1.83	1.866666667	2.38	1.856666667	2.55	**2.156666667**	**0.306644927**
											Total E loss	**1.95**
Vimto (pre)	0.089	0.113	0.143	0.169	0.2	0.232	0.253	0.283	0.158	0.263		

	0.093	0.123	0.213	0.193	0.19	0.256	0.244	0.244	0.173	0.276		
	0.078	0.134	0.201	0.177	0.183	0.266	0.258	0.253	0.167	0.232		
	0.086666667	0.123333333	0.185666667	0.179666667	0.191	0.251333333	0.251666667	0.26	0.166	0.257	**0.195233333**	**0.06009664**
Vimto (post)	9.33	9.22	9.14	9.2	9.54	10.45	9.96	9.93	9.21	9.11		
	9.15	9.49	9.26	9.16	9.15	10.76	9.32	9.53	9.12	9.29		
	9.25	9.31	9.39	9.24	9.2	10.82	9.73	9.69	9.33	9.32		
	9.243333333	9.34	9.263333333	9.2	9.296666667	10.676666667	9.67	9.716666667	9.22	9.24	**9.486666667**	**0.457462135**
											Total E loss	**9.3**
Toxic Waste (pre)	0.179	0.215	0.183	0.183	0.256	0.205	0.188	0.185	0.285	0.122		
	0.215	0.211	0.195	0.169	0.222	0.185	0.193	0.177	0.276	0.126		
	0.183	0.224	0.2	0.179	0.245	0.167	0.167	0.175	0.256	0.136		
	0.192333333	0.216666667	0.192666667	0.177	0.241	0.185666667	0.182666667	0.179	0.272333333	0.128	**0.196733333**	**0.039238052**

Toxic Waste (post)	15.78	15.08	17.15	17.71	15.29	16.72	15.23	15.13	16.23	15.38		
	15.45	15.21	17.56	17.08	15.33	16.43	15.32	15.23	16.15	15.48		
	15.8	15.28	17.44	17.29	15.57	16.1	15.82	15.3	16.17	15.24		
	15.6766 6667	15.19	17.3833 3333	17.36	15.3966 6667	16.4166 6667	15.4566 6667	15.22	16.1833 3333	15.3666 6667	**15.965**	**0.84245 416**
											Total E loss	**15.77**
Brain Licker (pre)	0.085	0.134	0.223	0.083	0.134	0.192	0.232	0.195	0.221	0.125		
	0.079	0.144	0.265	0.078	0.145	0.189	0.256	0.188	0.232	0.123		
	0.085	0.0156	0.272	0.105	0.158	0.176	0.267	0.178	0.215	0.11		
	0.083	0.09786 6667	0.25333 3333	0.08866 6667	0.14566 6667	0.18566 6667	0.25166 6667	0.187	0.22266 6667	0.11933 3333	**0.16348 6667**	**0.06586 5542**
Brain Licker (post)	3.37	2.38	2.16	2.24	2.62	3.43	2.53	3.16	2.96	3.86		
	3.18	2.21	2.23	2.46	2.54	3.23	2.63	3.23	2.88	3.92		
	3.22	2.45	2.37	2.32	2.77	3.45	2.75	3.25	2.73	4.03		

	3.256666667	2.346666667	2.253333333	2.34	2.643333333	3.37	2.636666667	3.213333333	2.856666667	3.936666667	**2.885333333**	**0.54710055**
											Total E loss	**2.71**
Big Baby (Powder)-pre	0.112	0.237	0.087	0.158	0.235	0.233	0.079	0.205	0.21	0.115		
	0.132	0.22	0.093	0.145	0.198	0.256	0.08	0.221	0.193	0.133		
	0.153	0.232	0.1	0.116	0.211	0.235	0.075	0.178	0.185	0.142		
	0.132333333	0.229666667	0.093333333	0.139666667	0.214666667	0.241333333	0.078	0.201333333	0.196	0.13	**0.165633333**	**0.058110463**
Big Baby (powder)-post	4.27	3.79	5.22	4.21	4.36	4.14	4.17	4.47	4.33	4.76		
	4.52	3.97	5.65	4.35	4.58	4.22	4.3	4.35	4.22	4.45		
	4.63	3.83	5.48	4.55	4.41	4.35	4.53	4.75	4.63	4.67		
	4.473333333	3.863333333	5.45	4.37	4.45	4.236666667	4.333333333	4.523333333	4.393333333	4.626666667	**4.472**	**0.400722188**
											Total E loss	**4.3**

Big Baby (pop) -post	0.156	0.9	0.221	0.263	0.189	0.215	0.192	0.25	0.088	0.22		
	0.143	0.095	0.243	0.27	0.185	0.207	0.188	0.253	0.12	0.198		
	0.124	0.077	0.222	0.276	0.182	0.226	0.195	0.266	0.125	0.233		
	0.141	0.357333333	0.228666667	0.269666667	0.185333333	0.216	0.191666667	0.256333333	0.111	0.217	**0.2174**	**0.068965692**
Big Baby (pop)-Post	8.15	7.22	8.63	7.33	8.47	8.47	8.43	7.53	8.22	8.15		
	8.24	7.41	8.46	7.28	8.58	7.27	8.52	7.32	8.53	8.79		
	8.22	7.58	8.37	7.44	8.62	7.53	8.87	7.59	8.12	8.95		
	8.203333333	7.403333333	8.486666667	7.35	8.556666667	7.756666667	8.606666667	7.48	8.29	8.63	**8.076333333**	**0.52567053**
											Total E loss	**7.85**
Juicy drop (Syrup-)Pre	0.112	0.176	0.224	0.282	0.28	0.067	0.113	0.17	0.184	0.172		
	0.105	0.164	0.253	0.278	0.271	0.092	0.145	0.158	0.189	0.164		
	0.122	0.175	0.255	0.276	0.256	0.086	0.156	0.155	0.2	0.243		

	0.113	0.17166 6667	0.244	0.27866 6667	0.269	0.08166 6667	0.138	0.161	0.191	0.193	**0.1841**	**0.06517 2336**
Juicy drop (Syrup) Post	3.39	3.222	2.28	2.33	2.67	2.66	3.4	2.77	3.2	2.23		
	3.5	3.31	2.42	2.45	2.94	2.72	3.48	2.56	3.11	2.44		
	3.72	3.15	2.17	2.35	3.1	2.54	3.57	2.82	3.3	2.35		
	3.53666 6667	3.22733 3333	2.29	2.37666 6667	2.90333 3333	2.64	3.48333 3333	2.71666 6667	3.20333 3333	2.34	**2.87173 3333**	**0.47112 0461**
											Total E loss	**2.68**
Juicy Drop (pop)-pre	0.122	0.254	0.262	0.198	0.246	0.097	0.258	0.292	0.145	0.234		
	0.156	0.258	0.245	0.2	0.273	0.111	0.255	0.272	0.16	0.238		
	0.159	0.236	0.225	0.21	0.231	0.12	0.222	0.284	0.118	0.235		
	0.14566 6667	0.24933 3333	0.244	0.20266 6667	0.25	0.10933 3333	0.245	0.28266 6667	0.141	0.23566 6667	**0.21053 3333**	**0.05826 3599**
Juicy Drop (pop)-post	7.04	6.75	7.68	6.78	7.42	7.26	8.25	7.15	7.31	7.12		

	7.15	6.47	8.22	6.98	7.36	7.44	8.19	7.22	7.15	7.44		
	7.25	6.31	8.26	6.53	7.61	7.53	7.78	7.32	7.34	7.66		
	7.14666 6667	6.51	8.05333 3333	6.76333 3333	7.46333 3333	7.41	8.07333 3333	7.23	7.26666 6667	7.40666 6667	**7.33233 3333**	**0.48840 8982**
											Total E loss	**7.12**
Brain Blasterz (Pre)	0.223	0.262	0.168	0.129	0.23	0.088	0.187	0.248	0.228	0.292		
	0.212	0.258	0.16	0.122	0.196	0.124	0.172	0.26	0.222	0.285		
	0.211	0.255	0.159	0.111	0.182	0.099	0.176	0.265	0.264	0.279		
	0.21533 3333	0.25833 3333	0.16233 3333	0.12066 6667	0.20266 6667	0.10366 6667	0.17833 3333	0.25766 6667	0.238	0.28533 3333	**0.20223 3333**	**0.06065 243**
Brain Blasterz (post)	12.31	13.21	12.53	12.28	12.53	13.33	12.62	12.12	12.72	13.23		
	12.26	13.34	12.43	12.53	12.24	13.58	12.86	12.24	12.86	13.25		
	13.44	13.42	12.62	12.47	12.46	13.47	12.58	12.28	12.76	13.17		
	12.67	13.3233 3333	12.5266 6667	12.4266 6667	12.41	13.46	12.6866 6667	12.2133 3333	12.78	13.2166 6667	**12.7713 3333**	**0.42365 8959**

											Total E loss	**12.56**
Push Pop (Pre)	0.08	0.123	0.265	0.212	0.092	0.266	0.226	0.25	0.122	0.148		
	0.086	0.133	0.289	0.211	0.1	0.261	0.254	0.244	0.109	0.141		
	0.078	0.138	0.28	0.22	0.112	0.279	0.244	0.231	0.111	0.127		
	0.081333333	0.131333333	0.278	0.214333333	0.101333333	0.268666667	0.241333333	0.241666667	0.114	0.138666667	**0.181066667**	**0.074947521**
Push Pop (post)	3.45	3.12	2.82	3.1	2.87	2.8	2.64	3.12	2.79	3.03		
	3.22	3.33	3.35	2.98	2.55	2.76	2.73	3.24	2.56	3.27		
	3.12	3.51	3.28	2.79	2.78	2.88	2.48	3.35	2.86	3.42		
	3.263333333	3.32	3.15	2.956666667	2.733333333	2.813333333	2.616666667	3.236666667	2.736666667	3.24	**3.006666667**	**0.264896905**
											Total E loss	**2.8**

8.32 Appendix 32. Raw data of surface enamel loss without saliva

Material/sample	1	2	3	4	5	6	7	8	9	10	Average	S.D
Water (pre)	0.212	0.292	0.258	0.163	0.232	0.063	0.177	0.208	0.256	0.243		
	0.217	0.283	0.28	0.172	0.245	0.075	0.183	0.224	0.263	0.25		
	0.182	0.275	0.239	0.155	0.256	0.077	0.167	0.232	0.234	0.222		
	0.203666667	0.283333333	0.259	0.163333333	0.244333333	0.071666667	0.175666667	0.221333333	0.251	0.238333333	**0.211166667**	**0.061543972**
Water (post)	0.213	0.289	0.221	0.172	0.23	0.065	0.18	0.2	0.26	0.244		
	0.215	0.28	0.279	0.165	0.253	0.077	0.179	0.232	0.267	0.248		
	0.191	0.282	0.185	0.16	0.246	0.07	0.16	0.23	0.235	0.211		
	0.206333333	0.283666667	0.228333333	0.165666667	0.243	0.070666667	0.173	0.220666667	0.254	0.234333333	**0.207966667**	**0.059827623**
											Total E loss	**0.03**
Orange Juice (pre)	0.135	0.158	0.087	0.206	0.212	0.116	0.232	0.142	0.206	0.233		

	0.132	0.143	0.077	0.176	0.232	0.093	0.221	0.153	0.211	0.254		
	0.165	0.163	0.107	0.17	0.221	0.132	0.252	0.148	0.192	0.243		
	0.144	0.154666667	0.090333333	0.184	0.221666667	0.113666667	0.235	0.147666667	0.203	0.243333333	**0.173733333**	**0.052012771**
Orange Juice (post)	4.9	5.68	4.35	4.88	4.83	5.42	5.01	4.82	5.3	5.49		
	4.88	5.72	4.63	4.63	4.03	5.53	5.21	4.63	5.17	5.2		
	4.72	5.73	4.01	4.35	3.9	5.32	4.42	4.72	5.22	5.23		
	4.833333333	5.71	4.33	4.62	4.253333333	5.423333333	4.88	4.723333333	5.23	5.306666667	**4.931**	**0.477514268**
											Total E loss	**4.75**
Tango (pre)	0.2	0.176	0.109	0.242	0.18	0.164	0.283	0.235	0.219	0.123		
	0.189	0.205	0.08	0.254	0.155	0.198	0.266	0.223	0.276	0.176		
	0.21	0.172	0.091	0.262	0.185	0.18	0.247	0.215	0.278	0.152		
	0.199666667	0.184333333	0.093333333	0.252666667	0.173333333	0.180666667	0.265333333	0.224333333	0.257666667	0.150333333	**0.198166667**	**0.053852852**

Tango (post)	10.12	9.05	8.76	8.43	8.16	9.32	9.17	9.9	8.33	8.11		
	10.32	9.78	8.66	8.73	8.9	9.56	9.21	10.36	8.72	8.72		
	10.41	9.25	8.45	8.88	8.86	9.88	9.22	10.47	8.55	8.44		
	10.28333333	9.36	8.623333333	8.68	8.64	9.586666667	9.2	10.24333333	8.533333333	8.423333333	**9.157333333**	**0.697874728**
											Total E loss	**8.96**
Mega Mouth (pre)	0.132	0.283	0.164	0.159	0.159	0.288	0.17	0.284	0.188	0.223		
	0.185	0.279	0.147	0.157	0.163	0.272	0.185	0.222	0.182	0.198		
	0.142	0.263	0.153	0.198	0.149	0.264	0.219	0.283	0.2	0.212		
	0.153	0.275	0.154666667	0.171333333	0.157	0.274666667	0.191333333	0.263	0.19	0.211	**0.2041**	**0.049701343**
Mega Mouth (post)	6.23	5.44	6.93	6.16	6.32	5.2	6.6	5.68	5.63	6.95		
	6.52	5.76	6.87	6.24	6.56	5.22	6.83	5.53	5.36	6.41		
	6.11	5.84	6.59	6.33	6.43	5.13	6.93	5.38	5.54	6.32		

	6.286666667	5.68	6.796666667	6.243333333	6.436666667	5.183333333	6.786666667	5.53	5.51	6.56	**6.101333333**	**0.57992805**
											Total E loss	**5.88**
Lickedy Lips (pre)	0.11	0.157	0.285	0.069	0.2	0.142	0.129	0.144	0.157	0.081		
	0.118	0.179	0.279	0.087	0.234	0.132	0.137	0.154	0.185	0.63		
	0.107	0.156	0.282	0.075	0.186	0.135	0.144	0.13	0.164	0.083		
	0.111666667	0.164	0.282	0.077	0.206666667	0.136333333	0.136666667	0.142666667	0.168666667	0.264666667	**0.169033333**	**0.064911992**
Lickedy Lip (post)	2.85	3.22	2.93	2.98	2.54	2.41	1.93	2.48	2.82	2.56		
	2.93	3.34	2.95	3.15	2.75	2.32	1.88	2.34	2.99	2.55		
	2.88	3.23	3.1	3.23	2.66	2.42	1.79	2.32	3.1	2.54		
	2.886666667	3.263333333	2.993333333	3.12	2.65	2.383333333	1.866666667	2.38	2.97	2.55	**2.706333333**	**0.401155138**
											Total E loss	**2.5**
Vimto (pre)	0.089	0.113	0.143	0.169	0.2	0.232	0.253	0.283	0.158	0.263		

	0.093	0.123	0.213	0.193	0.19	0.256	0.244	0.244	0.173	0.276		
	0.078	0.134	0.201	0.177	0.183	0.266	0.258	0.253	0.167	0.232		
	0.086666667	0.123333333	0.185666667	0.179666667	0.191	0.251333333	0.251666667	0.26	0.166	0.257	**0.195233333**	**0.06009664**
Vimto (post)	10.33	9.52	10.14	11.2	11.54	10.45	9.96	9.93	12.1	12.11		
	10.65	9.79	10.26	11.16	11.15	10.76	9.32	9.53	12.12	11.9		
	10.05	9.1	9.89	11	11.2	10.82	9.73	9.69	12.03	12.32		
	10.34333333	9.47	10.0966667	11.12	11.2966667	10.6766667	9.67	9.71666667	12.0833333	12.11	**10.65833333**	**0.968921062**
											Total E loss	**10.463**
Toxic Waste (pre)	0.179	0.215	0.183	0.183	0.256	0.205	0.188	0.185	0.285	0.122		
	0.215	0.211	0.195	0.169	0.222	0.185	0.193	0.177	0.276	0.126		
	0.183	0.224	0.2	0.179	0.245	0.167	0.167	0.175	0.256	0.136		
	0.192333333	0.216666667	0.192666667	0.177	0.241	0.185666667	0.182666667	0.179	0.272333333	0.128	**0.196733333**	**0.039238052**

Toxic Waste (post)	15.78	20.08	17.15	17.71	17.29	16.72	18.23	20.13	10.93	18.38		
	15	19.1	17.56	17.08	17.33	16.43	18.32	20.23	20.15	19.48		
	15.8	20.28	17.44	17.29	17.57	16.1	18.82	20.3	20.17	18.24		
	15.5266 6667	19.82	17.3833 3333	17.36	17.3966 6667	16.4166 6667	18.4566 6667	20.22	17.0833 3333	18.7	**17.8363 3333**	**1.46401 1443**
											Total E loss	**17.64**
Brain Licker (pre)	0.085	0.134	0.223	0.083	0.134	0.192	0.232	0.195	0.221	0.125		
	0.079	0.144	0.265	0.078	0.145	0.189	0.256	0.188	0.232	0.123		
	0.085	0.0156	0.272	0.105	0.158	0.176	0.267	0.178	0.215	0.11		
	0.083	0.09786 6667	0.25333 3333	0.08866 6667	0.14566 6667	0.18566 6667	0.25166 6667	0.187	0.22266 6667	0.11933 3333	**0.16348 6667**	**0.06586 5542**
Brain Licker (post)	3.37	2.78	4.16	2.66	4.12	3.23	2.53	3.46	2.96	3.86		
	2.97	2.51	3.63	2.56	3.94	3.73	2.63	3.33	2.88	3.92		
	3.2	2.58	2.94	2.32	3.77	3.9	2.75	3.29	2.73	4.03		

	3.18	2.623333333	3.576666667	2.513333333	3.943333333	3.62	2.636666667	3.36	2.856666667	3.936666667	**3.224666667**	**0.544945801**
											Total E loss	**3.06**
Big Baby (Powder)-pre	0.112	0.237	0.087	0.158	0.235	0.233	0.079	0.205	0.21	0.115		
	0.132	0.22	0.093	0.145	0.198	0.256	0.08	0.221	0.193	0.133		
	0.153	0.232	0.1	0.116	0.211	0.235	0.075	0.178	0.185	0.142		
	0.132333333	0.229666667	0.093333333	0.139666667	0.214666667	0.241333333	0.078	0.201333333	0.196	0.13	**0.165633333**	**0.058110463**
Big Baby (powder)-post	4.07	3.79	5.22	6.21	4.36	5.24	4.1	5.67	5.33	4.76		
	4.37	3.97	5.65	6.65	4.56	5.2	4.3	6.55	5.55	4.45		
	4.43	4.23	5.78	6.45	5.2	4.85	4.53	6.95	5.63	4.67		
	4.29	3.996666667	5.55	6.436666667	4.706666667	5.096666667	4.31	6.39	5.503333333	4.626666667	**5.090666667**	**0.862257731**
											Total E loss	**4.92**

Big Baby (pop) -post	0.156	0.9	0.221	0.263	0.189	0.215	0.192	0.25	0.088	0.22		
	0.143	0.095	0.243	0.27	0.185	0.207	0.188	0.253	0.12	0.198		
	0.124	0.077	0.222	0.276	0.182	0.226	0.195	0.266	0.125	0.233		
	0.141	0.357333333	0.228666667	0.269666667	0.185333333	0.216	0.191666667	0.256333333	0.111	0.217	**0.2174**	**0.068965692**
Big Baby (pop)-Post	8.15	8.1	8.63	8.33	9.77	8.47	8.43	10.53	10.22	9.15		
	8.24	8.41	8.46	7.98	9.58	8.27	8.52	10.9	10.53	8.79		
	8.22	8.58	8.37	7.94	9.95	8.83	8.87	10.59	10.12	8.95		
	8.203333333	8.363333333	8.486666667	8.083333333	9.766666667	8.523333333	8.606666667	10.67333333	10.29	8.963333333	**8.996**	**0.917656435**
											Total E loss	**8.78**
Juicy drop (Syrup),Pre	0.112	0.176	0.224	0.282	0.28	0.067	0.113	0.17	0.184	0.172		
	0.105	0.164	0.253	0.278	0.271	0.092	0.145	0.158	0.189	0.164		
	0.122	0.175	0.255	0.276	0.256	0.086	0.156	0.155	0.2	0.243		

	0.113	0.17166 6667	0.244	0.27866 6667	0.269	0.08166 6667	0.138	0.161	0.191	0.193	**0.1841**	**0.06517 2336**
Juicy drop (Syrup) Post	3.39	3.78	3.8	2.33	2.67	2.96	3.4	3.77	4.2	4.23		
	3.5	3.58	3.72	2.45	2.94	3.23	3.48	3.56	4.11	4.44		
	3.72	3.05	3.43	2.35	3.1	3.32	3.57	3.82	4.3	4.35		
	3.53666 6667	3.47	3.65	2.37666 6667	2.90333 3333	3.17	3.48333 3333	3.71666 6667	4.20333 3333	4.34	**3.485**	**0.57704 0662**
											Total E loss	**3.3**
Juicy Drop (pop)-pre	0.122	0.254	0.262	0.198	0.246	0.097	0.258	0.292	0.145	0.234		
	0.156	0.258	0.245	0.2	0.273	0.111	0.255	0.272	0.16	0.238		
	0.159	0.236	0.225	0.21	0.231	0.12	0.222	0.284	0.118	0.235		
	0.14566 6667	0.24933 3333	0.244	0.20266 6667	0.25	0.10933 3333	0.245	0.28266 6667	0.141	0.23566 6667	**0.21053 3333**	**0.05826 3599**
Juicy Drop (pop)-post	8.04	8.75	7.68	7.18	8.42	7.26	8.35	7.5	9.11	7.12		

	8.15	8.47	8.22	7.98	8.36	7.93	8.19	7.82	9.05	7.44		
	8.25	8.11	8.26	7.53	8.61	7.53	8	7.2	9.34	7.66		
	8.146666667	8.443333333	8.053333333	7.563333333	8.463333333	7.573333333	8.18	7.506666667	9.166666667	7.406666667	**8.050333333**	**0.554967355**
											Total E loss	**7.84**
Brain Blasterz (Pre)	0.223	0.262	0.168	0.129	0.23	0.088	0.187	0.248	0.228	0.292		
	0.212	0.258	0.16	0.122	0.196	0.124	0.172	0.26	0.222	0.285		
	0.211	0.255	0.159	0.111	0.182	0.099	0.176	0.265	0.264	0.279		
	0.215333333	0.258333333	0.162333333	0.120666667	0.202666667	0.103666667	0.178333333	0.257666667	0.238	0.285333333	**0.202233333**	**0.06065243**
Brain Blasterz (post)	14.88	15.01	12.53	15.78	14.53	13.33	14.2	12.12	13.59	13.23		
	14.86	15.63	12.93	15.53	14.24	13.58	13.86	12.24	13.9	13.25		
	14.48	15.32	12.62	16.47	14.06	13.47	13.8	12.28	13.76	13.17		
	14.74	15.32	12.69333333	15.92666667	14.27666667	13.46	13.95333333	12.21333333	13.75	13.21666667	**13.955**	**1.151220769**

											Total E loss	**13.75**
Push Pop (Pre)	0.08	0.123	0.265	0.212	0.092	0.266	0.226	0.25	0.122	0.148		
	0.086	0.133	0.289	0.211	0.1	0.261	0.254	0.244	0.109	0.141		
	0.078	0.138	0.28	0.22	0.112	0.279	0.244	0.231	0.111	0.127		
	0.081333333	0.131333333	0.278	0.214333333	0.101333333	0.268666667	0.241333333	0.241666667	0.114	0.138666667	**0.181066667**	**0.074947521**
Push Pop (post)	4.45	3.12	3.75	3.1	4.65	2.8	4.44	4.12	3.79	4.73		
	4.33	3.43	3.35	2.98	4.55	2.76	4.23	4.24	3.6	4.57		
	4.12	3.64	3.08	2.79	4.78	2.88	4.48	4.1	3.86	4.42		
	4.3	3.396666667	3.393333333	2.956666667	4.66	2.813333333	4.383333333	4.153333333	3.75	4.573333333	**3.838**	**0.671118837**
											Total E loss	**3.65**

8.33 Appendix 33. Raw data of subsurface enamel loss without and with saliva

Material/sample	1	2	3	4	5	6	7	8	9	10	Average	S.D
Water (0 min)	0.242	0.277	0.246	0.183	0.272	0.243	0.222	0.198	0.252	0.221		
	0.247	0.285	0.252	0.212	0.264	0.26	0.241	0.212	0.235	0.195		
	0.187	0.265	0.233	0.195	0.282	0.232	0.233	0.223	0.243	0.215		
	0.225333333	0.275666667	0.243666667	0.196666667	0.272666667	0.245	0.232	0.211	0.243333333	0.210333333	0.235566667	0.024637844
Water (1h)	0.232	0.278	0.231	0.176	0.245	0.198	0.225	0.247	0.281	0.242		
	0.232	0.291	0.195	0.18	0.263	0.212	0.221	0.234	0.254	0.237		
	0.221	0.277	0.215	0.153	0.255	0.222	0.234	0.244	0.278	0.255		
	0.228333333	0.282	0.213666667	0.169666667	0.254333333	0.210666667	0.226666667	0.241666667	0.271	0.244666667	0.234266667	0.030725957

Orange Juice (0 min)	5.95	6.361	5.887	6.306	5.812	6.231	5.96	6.232	6.212	6.432		
	6.232	6.543	5.727	6.276	6.232	6.136	6.11	6.352	6.333	6.452		
	6.165	6.563	5.607	6.187	6.31	6.411	5.98	6.245	6.523	6.222		
	6.115666667	6.489	5.740333333	6.256333333	6.118	6.259333333	6.016666667	6.276333333	6.356	6.368666667	6.199633333	0.201882499
Orange Juice (1 h)	5.87	5.88	4.45	6.283	4.63	5.12	6.345	5.841	5.433	4.766		
	5.418	5.92	4.33	6.63	4.53	4.95	6.443	5.951	5.343	4.861		
	5.72	5.83	4.91	6.35	4.35	5.212	6.31	6.157	5.552	4.621		
	5.669333333	5.876666667	4.563333333	4.42	4.503333333	5.094	6.366	5.983	5.442666667	4.749333333	5.266766667	0.661704702
Tango (0 min)	12.52	11.676	10.32	10.442	10.58	10.781	10.872	11.213	10.521	10.432		
	12.489	11.405	10.28	10.154	10.285	10.452	10.798	11.333	10.677	10.334		
	12.421	11.372	10.391	10.362	10.185	10.661	10.678	11.554	10.565	10.488		

	12.476 66667	11.484 33333	10.330 33333	10.319 33333	10.35	10.631 33333	10.782 66667	11.366 66667	10.587 66667	10.418	10.874 7	0.6647 34458
Tango (1 h)	10.32	9.35	9.66	9.863	9.716	8.842	10.511	9.866	9.681	8.753		
	10.52	10.028	9.86	9.93	9.39	8.862	10.544	9.926	9.566	8.71		
	10.451	10.125	9.75	10.188	9.186	8.777	10.579	9.84	9.611	8.688		
	10.430 33333	9.8343 33333	8.7566 66667	9.9936 66667	8.8973 33333	8.827	10.544 66667	9.8773 33333	9.6193 33333	8.717	9.5497 66666	0.6652 78689
Mega Mouth (0 min)	8.222	8.216	6.845	8.562	7.927	8.222	6.411	6.384	7.891	8.771		
	8.356	8.476	6.74	8.322	7.822	8.285	6.212	6.05	7.677	8.55		
	8.283	8.522	6.72	8.285	7.842	8.341	6.531	6.227	7.859	8.72		
	8.287	8.4046 66667	6.7683 33333	8.3896 66667	7.8636 66667	8.2826 66667	6.3846 66667	6.2203 33333	7.809	8.6803 33333	7.7090 33333	0.8627 10141
Mega Mouth (1 h)	6.23	5.44	6.93	6.196	7.32	6.432	6.72	6.44	6.895	6.665		

	6.52	5.76	6.87	6.94	7.676	6.81	6.333	6.388	6.566	6.734		
	6.11	5.84	6.59	6.813	7.43	6.44	6.355	6.227	6.362	6.422		
	6.2866 66667	5.68	6.7966 66667	6.2433 33333	7.4753 33333	6.5606 66667	6.4693 33333	6.3516 66667	6.6076 66667	6.607	6.5078 33333	0.4326 80746
Lickedy Lips (0 min)	3.511	4.457	2.885	4.169	4.12	3.321	3.222	3.41	3.421	3.245		
	3.818	4.779	2.749	4.387	4.334	3.234	3.52	3.444	3.211	3.12		
	3.97	4.656	2.982	4.375	4.286	3.222	3.341	3.355	3.471	3.233		
	3.7663 33333	4.6306 66667	2.872	4.3103 33333	4.2466 66667	3.259	3.361	3.403	3.3676 66667	3.1993 33333	3.6416	0.5433 31734
Lickedy Lips (1 h)	3.185	3.022	2.893	3.244	2.654	2.721	2.381	2.531	2.761	2.311		
	3.193	3.134	2.795	3.215	2.575	2.59	2.266	2.44	2.887	2.57		
	3.108	3.223	2.721	3.323	2.626	2.378	2.355	2.412	2.813	2.552		
	3.162	3.1263 33333	2.803	3.2606 66667	5.2366 66666	2.563	2.334	2.461	2.8203 33333	2.4776 66667	3.0244 66667	0.7984 86696

Vimto (0 min)	12.189	12.213	12.443	13.169	12.82	12.321	12.222	12.442	12.642	12.521		
	12.293	12.223	12.513	13.293	12.819	12.33	12.45	12.411	12.586	12.655		
	12.278	12.134	12.421	12.277	12.983	12.214	12.322	12.569	12.477	12.574		
	12.25333333	12.19	12.459	12.913	12.874	12.28833333	12.33133333	12.474	12.56833333	12.58333333	12.49346667	0.235411281
Vimto (1 h)	11.533	11.752	11.214	10.412	11.654	10.544	10.441	10.643	11.921	11.651		
	11.765	11.479	11.326	10.716	11.215	10.445	10.566	10.541	12.321	11.344		
	11.805	11.761	11.289	10.62	11.212	10.557	10.781	10.665	12.42	11.6221		
	11.701	11.664	11.27633333	10.58266667	11.36033333	10.51533333	10.596	10.61633333	12.22066667	11.53903333	11.20717	0.689786142
Toxic waste (0 min)	21.679	20.285	19.106	20.109	19.856	20.776	19.221	19.342	19.781	20.311		
	21.315	21.191	19.895	20.442	19.652	20.995	19.378	19.31	19.611	20.234		

	21.783	22.224	19.32	20.324	19.445	20.876	19.357	19.221	18.699	20.4331		
	21.59233333	21.23333333	19.44033333	20.29166667	19.651	20.88233333	19.31866667	19.291	19.36366667	20.32603333	20.13903667	0.814864891
Toxic Waste (1 h)	18.528	20.328	17.235	17.851	18.651	18.95	19.611	18.345	17.854	19.766		
	18.743	19.92	17.716	17.558	18.483	18.887	19.414	18.334	17.915	19.155		
	18.55	20.58	17.854	17.421	18.711	18.755	19.68	18.225	17.655	19.896		
	18.607	20.276	17.60166667	17.61	18.615	18.864	19.56833333	18.30133333	17.808	19.60566667	18.6857	0.863004705
Brain Licker (0 min)	4.821	3.824	4.523	4.132	4.211	4.657	4.431	5.011	4.653	4.335		
	4.016	3.935	4.321	4.065	4.075	4.625	4.299	4.874	4.622	4.552		
	3.885	3.76	4.325	4.2	4.332	4.459	4.5761	4.9	4.578	4.321		
	4.240666667	3.839666667	4.389666667	4.132333333	4.206	4.580333333	4.435366667	4.928333333	4.617666667	4.402666667	4.37727	0.283526923

Brain Licker (1 h)	3.53	2.88	4.32	2.807	4.2	3.651	4.941	3.432	4.121	4.223		
	3.102	2.721	3.72	2.76	4.234	3.37	4.122	3.389	4.166	4.66		
	3.2	2.802	3.205	2.52	3.97	3.455	4.05	3.355	4.244	4.458		
	3.277333333	2.801	3.748333333	2.695666667	4.134666667	3.492	4.371	3.392	4.177	4.447	3.6536	0.59491026
Big Baby (Powder)-(0 min)	5.532	5.402	6.108	7.523	5.731	6.321	5.871	6.11	6.376	5.984		
	6.132	5.332	6.204	7.834	5.623	6.233	6.121	5.997	6.378	5.845		
	5.933	5.659	6.431	7.324	5.72	6.335	5.955	6.227	6.244	5.8221		
	5.865666667	5.464333333	6.247666667	7.560333333	5.691333333	6.296333333	5.982333333	6.111333333	6.332666667	5.8837	6.14357	0.539891493
Big Baby (powder)-(1 h)	4.213	4.98	5.822	6.352	5.587	5.786	5.112	5.213	4.971	4.77		

	4.52	5.17	5.77	6.87	5.79	5.885	5.321	4.995	5.27	4.825		
	4.213	5.22	6.104	6.57	5.42	5.561	5.224	5.011	5.123	4.822		
	4.315333333	5.123333333	5.898666667	6.597333333	5.599	5.744	5.219	5.073	5.121333333	4.805666667	5.349666667	0.60319993
Big Baby (pop) -(0 min)	10.011	9.77	10.423	9.823	10.76	10.32	10.1	9.911	10.341	10.786		
	10.123	10.234	10.201	9.728	10.522	10.445	9.975	10.218	10.25	10.32		
	10.244	10.321	10.34	9.324	10.324	10.37	9.92	10.59	10.22	10.894		
	10.126	10.10833333	10.32133333	9.625	10.53533333	10.37833333	9.998333333	10.23966667	10.27033333	10.66666667	10.22693333	0.275896752
Big Baby (pop)-(1 h)	9.32	9.132	9.32	9.25	9.26	9.112	9.443	9.533	8.889	9.781		
	9.28	9.22	9.36	9.509	9.012	9.345	9.259	9.44	8.776	9.669		
	9.33	9.29	9.41	9.611	9.787	9.521	9.22	9.511	8.921	9.755		
	9.31	9.214	9.363333333	9.456666667	9.353	9.326	9.307333333	9.494666667	8.862	9.735	9.3422	0.090582375

Juicy Drop (Syrup)-(0min)	5.231	3.725	4.222	4.556	3.728	4.223	4.992	4.222	4.332	4.657		
	5.175	3.964	4.187	4.422	3.623	4.12	5.188	4.112	4.266	4.544		
	5.254	3.864	4.311	4.504	3.657	4.384	5.223	4.2	4.443	4.62		
	5.22	3.851	4.24	4.494	3.669333333	4.242333333	5.134333333	4.178	4.347	4.607	4.3983	0.469161816
Juicy Drop (Syrup)-(1 h)	3.56	3.85	3.87	3.48	2.77	3.51	3.871	4.445	3.786	3.991		
	3.72	3.67	3.95	3.62	3.11	3.417	3.855	4.38	3.65	4.291		
	3.98	3.222	3.65	3.44	3.21	3.382	3.798	4.411	3.557	4.177		
	3.753333333	3.580666667	3.823333333	3.513333333	3.03	3.436333333	3.841333333	4.412	3.664333333	4.153	3.720766667	0.362580782
Juicy Drop (pop)-(0 min)	10.321	10.423	9.768	9.522	10.321	9.891	10.225	9.786	9.661	10.11		
	10.176	10.458	10.243	9.321	10.423	10.244	10.326	9.886	9.754	9.955		

	10.213	10.176	9.651	9.441	10.222	10.226	10.12	9.654	9.877	10.2		
	10.23666667	10.35233333	9.887333333	9.428	10.322	10.12033333	10.22366667	9.775333333	9.764	10.08833333	10.0198	0.282537085
Juicy Drop (pop)-(1 h)	8.231	8.89	8.75	7.358	9.312	8.891	8.334	8.511	8.431	8.976		
	8.122	8.62	8.322	8.188	9.456	8.778	8.442	8.223	8.244	8.845		
	8.352	8.212	8.37	7.73	9.592	8.82	8.29	8.382	8.552	8.866		
	8.235	8.574	8.480666667	7.758666667	9.453333333	8.829666667	8.355333333	8.372	8.409	8.895666667	8.536333333	0.428032579
Brain Blasterz (0 min)	17.31	16.122	14.977	15.321	16.532	16.78	15.321	16.66	15.511	15.812		
	16.876	16.485	15.056	16.821	17.017	16.554	15.35	16.551	15.9	15.78		
	17.018	16.312	14.22	15.234	16.653	16.41	15.223	16.5	15.876	15.85		
	17.068	16.30633333	14.751	15.792	16.734	16.58133333	15.298	16.57033333	15.76233333	15.814	16.06773333	0.67658858

Brain Blasterz (1 h)	15.04	14.213	14.72	14.86	14.68	14.866	14.133	15.437	14.5	15.786		
	14.95	14.721	14.222	14.71	14.57	14.962	14.222	15.23	14.445	15.875		
	14.521	14.48	14.812	14.66	14.223	14.75	14.36	15.275	14.482	15.557		
	14.837	14.47133333	14.58466667	14.74333333	14.491	14.85933333	14.23833333	15.314	14.47566667	15.73933333	14.7754	0.426511998
Push Pop (0 min)	5.123	4.108	4.43	3.233	5.831	4.42	5.121	4.75	3.921	4.889		
	5.231	4.222	4.521	3.62	5.766	4.221	5.222	4.652	4.12	4.568		
	5.421	4.2	4.106	3.421	5.852	4.335	4.964	4.5	3.96	4.856		
	5.258333333	4.176666667	4.352333333	3.424666667	5.816333333	4.325333333	5.102333333	4.634	4.000333333	4.771	4.586133333	0.6519726
Push Pop (1 h)	4.51	3.53	4.692	4.221	3.74	3.66	3.855	4.42	3.99	4.217		
	4.422	3.55	4.441	4.356	3.613	3.721	3.68	4.442	3.87	4.311		
	4.18	3.721	4.332	4.266	3.88	3.81	3.93	4.6221	3.85	4.012		

	4.3706 66667	3.6003 33333	4.4883 33333	4.281	3.7443 33333	3.7303 33333	3.8216 66667	4.4947	3.9033 33333	4.18	4.0614 7	0.3214 23852