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## 1 Effects of trial and error and social learning on flavour palatability in nursery pigs

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## 18ABSTRACT

19The acquisition of behaviours that enhance the acceptability of new feeds could improve the  
20performance and animal welfare in the pig industry. Pigs may learn individually by trial and error  
21and/or by social learning to consume and prefer new flavoured feeds. However, there is little  
22information regarding the effects of learning on the palatability of those flavours. This study aimed  
23to investigate possible changes in pigs' hedonic responses, estimated by the mean consumption time  
24per approach (CT/A), for flavours previously learnt through individual experiences (Experiment 1)  
25and socially by a brief interaction with an experienced conspecific (Experiment 2). A total of 96  
26nursery pigs were used to study their preference, acceptability and palatability for flavours  
27previously conditioned. Flavours were associated with 4% sucrose (Experiment 1) or with a  
28demonstrator that recently consumed the flavour (Experiment 2). Those flavours or positive  
29conditioned stimulus (CS+) were compared with control flavours that were not positively  
30conditioned (CS-). In experiment 1, pigs preferred ( $P = 0.010$ ) and tended to accept more ( $P =$   
310.069) of the CS+ than CS- in water solutions. Nevertheless, no palatability differences were found  
32( $P = 0.875$ ). In experiment 2, observer animals had a higher intake of CS+ following interaction  
33with demonstrators that consumed the same flavoured feed ( $P = 0.041$ ). Snout to snout interaction  
34time between those demonstrators and observers tended to present a positive correlation with CT/A  
35( $r = 0.497$ ,  $P = 0.1$ ). Thus both individual trial and error learning, and social learning, increased pigs  
36acceptance of, and preference for, food flavours. However, only social Learning modified the  
37pattern of consumption with the observation of a correlation between changes in the CT/A ratio and  
38the degree of snout to snout contact time between demonstrators and observers. Thus the  
39mechanisms and effects of social and individual learning appear to differ at least partially.  
40Regardless of mechanism, the fact that associative learning can increase food flavour consumption  
41suggests that interventions based on associative learning may be beneficial for addressing welfare  
42problems in pig production linked to low consumption, in particular with respect to weaning where  
43the low consumption may relate to the inexperience of the animals.

44**Keywords:** associative learning; feeding behaviour; palatability; pigs; social learning; trial and  
45error learning

46

#### 471. **Introduction**

48 Learning plays a significant role in food selection through the acquisition of individual  
49preferences for associated sensory cues that predict oral and post-oral rewards of food (Sclafani,  
502004). When animals learn to consume new foods by trial and error learning, flavours associated  
51with those foods may act as conditioned stimuli. The flavour of the food is associated with the  
52positive or negative consequences of consumption (unconditioned stimuli), generating a future  
53attraction or rejection for the associated flavours (Ackroff and Sclafani, 2010). However,  
54environment exploration requires expenditure of time and energy, exposing animals to potential  
55predators or toxins (Laland, 2004). In contrast, social learning facilitates the acquisition of highly  
56adaptive food information, typically from conspecifics, thereby minimizing the costs implied by  
57trial and error learning (Nicol, 1995). Animals can learn to consume foods through imitation,  
58monitoring of the consumption site or joining other more experienced animals during a  
59consumption episode (Galef and Laland, 2005). Thus, through social learning animals can learn  
60flavour preferences (Galef and Whiskin, 2008), the location of food sources (Held et al., 2000), and  
61to avoid noxious foods (Laland, 2004).

62 Under commercial conditions, pigs are faced by nutritional challenges that may affect their  
63subsequent productive performance (Main et al., 2004). At weaning, pigs are reluctant to eat new  
64feeds, often resulting in a period of underfeeding or anorexia with consequent diarrhoea and poor  
65growth, resulting in reduced welfare (Oostindjer et al., 2014). Learning about foods before weaning  
66could be a useful strategy to reduce these detrimental effects by improving the acceptability of new  
67feeds or flavours. Previous experiments have shown that pigs prefer flavours learned by both  
68individual trial and error (Clouard et al., 2012; Figueroa et al., 2012a) and by social learning (Held  
69et al., 2000; Figueroa et al., 2013). However, learnt flavour preferences could be explained by many

70changes, including motivation or by changes in the pleasure perception or palatability of that  
71flavour at the time of consumption (Dwyer, 2008, 2009).

72 Experiments in rats have evaluated palatability through orofacial reactions at the time of  
73consumption (Grill and Norgren, 1978), short-term consumption (Boughter et al., 2002), and  
74analysis of lick cluster size (Davis and Smith, 1992; Dwyer, 2008). Palatability has been studied in  
75pigs through the analysis of consumption patterns (Figuroa et al., 2019), analogous to lick cluster  
76size analysis in rats, where the consumption time (CT) divided by the number of approaches (A) to  
77the site of consumption is assessed (CT/A). However, little information exists regarding the effects  
78of learning on the palatability of a flavour in pigs (Forbes, 2010; Clouard et al., 2014). Experiments  
79in rats demonstrate that when a flavour is associated with carbohydrates, such as sucrose or  
80maltodextrins, the palatability of the associated cues increases (Forestell and LoLordo, 2003;  
81Dwyer, 2008). However, there is little information about the effect of social learning on flavour  
82palatability. Recently, Figuroa et al. (2020a) did not find hedonic changes in rats' flavour  
83perception after interacting with a conspecific that recently consumed a flavoured solution.

84 The aim of this study was to investigate possible changes in pigs' responses (in terms of  
85preference, acceptability and palatability) for flavours previously learnt during a training period by  
86individual trial and error experiences (Experiment 1) and socially by a brief interaction (30 min)  
87with a conspecific that recently consumed those flavours (Experiment 2).

88

## 892. **Materials and methods**

90 Experiments were conducted at the nursery unit of Pontificia Universidad Católica de Chile pig  
91facilities. The experimental procedures were approved by the Ethical Committee on Animal  
92Experimentation of the Facultad de Ciencias Veterinarias y Pecuarias at the Universidad de Chile,  
93certificate N° 252014.

94

### 952.1 ***Experiment 1: Flavour conditioned palatability after individual trial and error learning***

### 972.1.1 Animals and housing

98 A total of 32 castrated male and female nursery pigs were used (PIC® genetics, Hendersonville,  
99Tennessee, USA). Animals (weaned at 21 days;  $6.094 \pm 0.148$  kg) were transported from a  
100commercial pig farm (Metropolitan de Santiago region, Chile) to the swine experimental facilities  
101experimental nursery facilities belonging to the university. They had been offered an unflavoured  
102creep-feed diet during the suckling period from day 10 using a commercial pan feeder at the  
103commercial farm. On arrival at the experimental facility, animals were individually identified using  
104numbered plastic ear tags and were randomly allocated into 16 fully slatted pens (2 pigs/pen; 1.28  
105m x 1.8 m x 0.7 m). The pens had full walls, therefore the animals in each pen had no visual or  
106tactile contact with the animals from other pens during the whole experimental procedure. The  
107nursery room was equipped with automatic forced ventilation and controlled environment  
108temperature ( $27.3 \pm 2.70^\circ$  C). The animals had ad libitum access to a commercial powder feed  
109offered with a hopper feeder with 3 feeding spaces according to their nutritional requirements  
110(NRC, 2012) and water provided by stainless steel nipples. Hanging steel chains were used as  
111environmental enrichment during the nursery period but there were removed during the  
112experimental period. Before experimental procedures started, pigs were acclimated for one week to  
113the new environment and management conditions.

114

### 1152.1.2. Experimental procedure

116 After the acclimation period, animals were trained to drink during 8 days (alternate sessions) a  
117flavoured solution (CS+Suc) that was mixed with 4% sucrose and a different flavoured solution  
118(CS-) mixed in water. Flavour products used as CSs (garlic or aniseed, 0.075%; Floramatic ®,  
119Santiago, Chile) were selected because of their similar preferences in naive animals and were  
120balanced across pens to act as CS+ or CS- flavours. Thus half of the pens (Group 1, 8 pens) were  
121trained to drink garlic flavoured solutions mixed with 4% sucrose during sessions 1, 3, 6 and 8,

122 while the remaining pens (Group 2, 8 pens) were exposed to the garlic flavour solution without  
123 sucrose at those sessions. During the other 4 sessions (days 2, 4, 5 and 7), half of the pens (Group 2,  
124 n8) were trained to drink an aniseed flavoured solution mixed with 4% sucrose, while the remaining  
125 pens (Group 1, n8) were exposed to aniseed flavoured solution without sucrose. Training sessions  
126 involved giving one experimental pan with 800mL of the respective CS solution at 10:00 am at the  
127 front of each pen for 30 min/day. Animals were feed and water restricted for 1 hour before sessions  
128 and no feed or water was available during the training. Consumption was measured by calculating  
129 the difference between the initial and final weight of the pans.

130 Flavour preference, acceptability and palatability for CS+ and CS- flavours were estimated in  
131 each pen on days 10 and 11. Flavour preferences were assessed using a two-choice test. Pig pairs  
132 were exposed for 30 min to two equidistant pan-feeders simultaneously placed in the front of each  
133 pen containing the CS+ and CS- flavoured solutions without sucrose. The right-left position of the  
134 CS+ and CS- flavours was balanced across subjects and days: half of the pens of each group  
135 received the garlic solutions at the right position the first day and aniseed solutions at the left  
136 position. In the other half of pens of each group, aniseed solutions were at the right position and  
137 garlic solutions at the left position. The flavour positions were swapped on the second test day.  
138 Subsequently, the acceptability of that flavours (CS+ and CS-) was estimated on two consecutive  
139 days (experimental days 12 and 13), where the animals received a single pan placed in the front of  
140 each pen containing one of the flavoured solutions (without sucrose) for 30 min, balancing the  
141 flavours (CS+ and CS-) between animals and days. One hour of feed and water restriction was  
142 applied before each test and no feed or water was available during the test.X

143 Intake was measured by calculating the difference between the initial and final weight of the  
144 pans during each preference and acceptability test. Usually, solution spillage was not significant and  
145 was not accounted when measuring consumption. Additionally, the behaviour of the pigs in term of  
146 consumption time and number of approaches to the pan was recorded simultaneously during the  
147 first 10 min of the acceptability test by focal continuous sampling using one video camera (IR

148Outdoor Cameras 700tv1 1/3 cmos Sony, SENKO SA, Santiago, Chile) placed in a central position  
149on the ceiling of each pen. The CT/A was estimated based on study of Figueroa et al. (2019) as the  
150total time in which the animal drinking at the pan (i.e. consumption time) divided by the number of  
151times the pan was approached with a consumption result (i.e. number of approaches). For each pen,  
152one video camera was used. Additionally, analyses of the first (0 to 5 min) and the final (6 to 10  
153min) half of the period were performed to examine whether these sub-periods of the session would  
154be more sensitive than the session as a whole in estimating palatability.

155

### 1562.1.3. Statistical analysis

157Consumption from each pen (pair of pigs) during the training sessions and at the preference,  
158acceptability and palatability tests after training were analysed by mixed linear models with the  
159MIXED procedure of the statistical package SAS 9.4 (SAS Inst. Inc., Cary, NC), taking into  
160account for training sessions the solution consumed (CS+Suc or CS-), the flavour consumed (garlic  
161or aniseed), the training session (1-4) and the interaction between factors. For preference and  
162acceptability test the main factors considered were the solution consumed (CS+ or CS-), the flavour  
163consumed (garlic or aniseed) and their interaction. Finally, to estimate palatability, CT/A were  
164analysed for the total period (0 to 10 min) and in each sub-period (0 to 5 min and 6 to 10 min),  
165considering as the main factors the solution consumed (CS+ or CS-) and the flavour consumed  
166(garlic or aniseed) and the interaction between factors. Interactions that were not significant were  
167removed from the final model. Pen was included as a random effect. Each pair of pigs were  
168considered as an experimental unit. Prior to ANOVA analysis, normality and homoscedasticity of  
169dataset were analysed by using the UNIVARIATE procedure with the Shapiro Wilk and O'Brien's  
170test, respectively. As no significant p-values were obtained for any of the specific factors, the  
171original hypothesis for normality and homogeneity of variance were accepted ( $P > 0.10$ ). Results are  
172presented as LSMeans  $\pm$  SEM, considering a significance level of 5% adjusted by Tukey. A trend in  
173the data was defined as  $0.05 \leq P \leq 0.1$ .



## 1742.2 *Experiment 2: Flavour conditioned palatability after social learning*

175

### 1762.2.1 **Animals and housing**

177 A total of 64 castrated male and female nursery pigs (PIC® genetics, Hendersonville, Tennessee,  
178USA), weaned at 21 days of life and weighing  $6.088 \pm 0.209$  kg were used. The origin of animals,  
179transport, identification and husbandry conditions were the same as in Experiment 1 with the  
180exception that pigs were allocated in groups of 4 to the 16 nursery pens.

181

### 1822.2.2 **Experimental Procedure**

183 Experimental procedures are summarized in **Figure 1**. After the acclimation period, two pigs  
184from each pen (16 pig-pairs) were randomly selected to act as demonstrators (DEM) and were  
185temporary removed and allocated to 16 pens (identical to their home pens in a neighbouring room).  
186DEM were then *ad libitum* fed with a flavoured commercial diet (0.075% aniseed or garlic flavours  
187(Floramatic ®, Santiago, Chile)) for 30 min; eight pairs were exposed to garlic flavour and the  
188remaining eight to aniseed in order to balance the experimental design.

189 DEM pigs were returned to their original pens to interact with pigs that remained there  
190(observers; OBS) for 30 minutes. After the interaction period between DEM and OBS, DEM pigs  
191were removed again and OBS were exposed to a pan-feeder with garlic feed for 30 minutes placed  
192in the front of each pen. This was repeated 24 and 48h later in order to estimate the extinction of the  
193expected change in observers' feeding behaviour. Before each test, animals underwent one hour of  
194feed and water restriction. No commercial feed or water was available during the test. Feed intake  
195was estimated by calculating the difference between the initial and final weight of the pans for each  
196acceptability test. Feed waste was not significant and was not accounted when measuring  
197consumption. As in experiment 1, OBS pigs were video recorded (16 Video-cameras, IR Outdoor  
198Cameras 700tvl 1/3 cmos Sony, SENKO SA, Santiago, Chile) during the first 10 min. of their  
199exposure to garlic diets and behaviour was analysed by focal continuous sampling in order to

200 estimate CT/A (Figuroa et al., 2019). This was used as a possible indicator of changes in the  
201 hedonic perception for the flavoured food. Additionally, analyses of the initial (0 to 5 min) and the  
202 final (6 to 10 min) half of the period were performed to examine whether these sub-periods of the  
203 session would be more sensitive than the session as a whole to estimate palatability. Moreover, the  
204 time spent on oro-nasal contact between DEM and their respective OBS during the interaction  
205 period was measured to study possible correlations between interaction time and the magnitude of  
206 the expected effect on OBS feeding behaviour, reflected in animals' CT/A, consumption time and  
207 number of approaches during the complete period of the test (0-10 min), the initial (0 to 5 min) and  
208 the final (6 to 10 min) half of the test. In order to assess the time of oro-nasal contact more  
209 accurately between DEM and OBS, the video-cameras were installed on ceiling of each pen to  
210 capture from an upper view the physical contact between animals. The oro-nasal contact was  
211 defined when an observer pig touched the end of the snout of the demonstrator pig with the end of  
212 its own snout and vice versa.

213

### 214 2.2.3. Statistical analysis

215 Consumption data of each DEM and OBS pairs and the palatability measures of OBS pairs were  
216 analysed by mixed linear models with the MIXED procedure of the statistical package SAS 9.4  
217 (SAS Inst. Inc., Cary, NC), taking into account in the case of DEM consumption the flavoured feed  
218 consumed (garlic or aniseed feed), and in the case of OBS consumption the flavoured feed  
219 consumed by their respective DEM (garlic or aniseed feed), the test day (1, 2 or 3) and the  
220 interaction between those factors. Finally to estimate OBS palatability, CT/A were analysed for the  
221 total period (0 to 10 min) and in sub-periods (0 to 5 min and 6 to 10 min), taking into account as the  
222 main factors the flavoured feed consumed by their respective DEM (garlic or aniseed feed), the test  
223 day (1, 2 or 3) and the interaction between those factors. Moreover, Spearman correlations were  
224 calculated between the oro-nasal interaction time of DEM and their respective OBS, and the CT/A  
225 and their components (consumption time and number of approaches to the pan) of those OBS

226during the complete period of the test and sub-periods. Before ANOVA analysis, normality and  
227homoscedasticity of dataset were analysed by using the UNIVARIATE procedure with the Shapiro  
228Wilk and O'Brien's test, respectively. As no significant p-values were obtained for any of the  
229specific factors, the original hypothesis for normality and homogeneity of variance were accepted  
230( $P > 0.10$ ). Results are presented as LSMeans  $\pm$  SEM, considering a significance level of 5%  
231adjusted by Tukey. A trend in the data was defined as  $0.05 \leq P \leq 0.1$ .

232

### 2333. Results

234

#### 2353.1 Results Experiment 1: Trial and error learning

236

##### 2373.1.1 Training sessions

238 Animals increased their solution intake as the days increased [ $F(3, 15) = 21.29, P < 0.001$ ].  
239Overall intake was higher for CS+Suc than CS- solutions [ $F(1, 15) = 16.44, P = 0.001$ ]. Intakes of  
240CS+Suc and CS- during the training sessions are shown in **Figure 2**. There was an interaction  
241between testing days and solutions [ $\text{Day} \times \text{CS}, F(3, 15) = 8.24, P = 0.002$ ], where the intake of  
242CS+Suc increased over training sessions exceeding the consumption of CS- only in session 4 ( $P =$   
2430.004; days 7 and 8) but not in the first 3 sessions, where a trend to consume more CS+Suc was  
244observed in sessions 2 ( $P = 0.078$ ) and 3 ( $P = 0.109$ ) and no differences between solutions intake  
245were observed during the first session ( $P = 0.228$ ). The flavour used also had an effect on  
246consumption ( $P < 0.001$ ) irrespective of whether the solutions included sucrose [ $F(1, 15) = 28.39, P$   
247 $< 0.001$ ]. Pigs drank more when garlic was added into solutions (292 vs. 210 g; SEM 15.36 g) The  
248differences between flavour consumption also increased with time, reflected in a significant  
249interaction between flavour and session day [ $F(3, 15) = 20.75, P < 0.001$ ].

250

##### 2513.1.2 Flavour preference, acceptability and palatability

252 The preference, acceptability and palatability for CS+ and CS- solutions after training are  
253 summarized in **Figure 3**. According to the preference test, pigs preferred the CS+ over the CS-  
254 [F(1, 15) = 8.60, P = 0.010] (**Figure 3a**). Moreover, when pigs were offered only one CS option  
255 (CS+ or CS- on different days), they consume more CS+ than CS- solutions [F(1, 14) = 6.69, P =  
256 0.022], (**Figure 3b**). Nevertheless, no differences were found between the CS+ and CS- CT/A [F(1,  
257 15) = 0.01, P = 0.913] (**Figure 3c**), at any of periods analysed (P > 0.05). Finally, the flavour tested  
258 (garlic or aniseed) had an effect on pigs acceptability [F(1, 14) = 6.58, P = 0.022] and preferences  
259 [F(1, 15) = 48.87, P < 0.001] observing a higher consumption of garlic over aniseed. Palatability  
260 was not affected by the flavour tested [F(1, 15) = 0.03, P = 0.856].

261

### 262 3.2 Results Experiment 2: Social learning

263

#### 264 3.2.1 Flavour acceptability

265 The acceptability of garlic and aniseed flavoured feed by the DEM did not differ [137 vs. 166g,  
266 SEM 22.9g; F(1, 15) = 0.77, P = 0.394]. **Figure 4a** shows the acceptability of the garlic feed by the  
267 OBS on day 1, 2 and 3 according to the flavour consumed by their DEM. After the interaction with  
268 DEM pigs, the general consumption of garlic feed was higher in OBS pigs that had interacted with  
269 DEM who had consumed garlic [F(1, 13) = 5.12, P = 0.041]. Consumption did not show differences  
270 between days [F(2, 13) = 1.07, P = 0.371]. The interaction between the flavour consumed by the  
271 DEM and the day of the test did not have an effect on the consumption of garlic flavoured feed by  
272 the OBS [F(2, 13) = 0.13, P = 0.878].

273

#### 274 3.2.2 Flavour palatability

275 Palatability of observers for the garlic flavoured feed, expressed by CT/A is presented in **Figure**  
276 **4b**. No effect of the flavour consumed by demonstrators (garlic or aniseed) [F(1, 13) = 0.69, P =  
277 0.421], day of the test [F(2, 13) = 2.13, P = 0.159] or the interaction of these factors [F(2, 13) =

2780.23,  $P = 0.796$ ] were observed. The day of the test had an effect on CT/A in the first half of the test  
279(0 – 5 min) [ $F(2, 13)=5.19, P = 0.022$ ], increasing with time. However, no effect was observed  
280during the second half of the test (6-10) [ $F(2, 13)=0.48, P = 0.629$ ]. Finally, palatability was not  
281affected by DEM flavour consumed or by the interaction between the day of the test and the flavour  
282consumed by the DEM in any of the periods analysed ( $P > 0.05$ ).

283

### 2843.2.3 Snout to snout interactions

285 The correlation between snout to snout interaction time between DEM and their respective OBS,  
286and OBS' approaches, consumption time and CT/A for garlic feed during the sub-periods are shown  
287in **Table 1**. This analysis was performed separately for the garlic and aniseed DEM groups. Most  
288interestingly, when looking at the correlation between CT/A (palatability) and the DEM-OBS  
289interaction, a positive but moderate correlation for observers that interacted with demonstrator that  
290consumed garlic feed, over the first 5 min of the sessions (and a trend to the same effect over the  
291whole 10 min analysis period ), was observed. Critically, this relationship was entirely absent in  
292observers interacting with demonstrators that consumed the aniseed flavour which was not used  
293during the test sessions. Although not significant, results suggest that the correlation between DEM-  
294OBS interaction times and CT/A (consumption time/number of approaches) was driven by both a  
295positive correlation with consumption time and a negative correlation with number of approaches  
296(**Figure 5**).

297

## 2984. Discussion

299 Pigs are able to acquire new flavour preferences by trial and error and social learning, allowing  
300them to anticipate future oral and post-oral rewards. This was confirmed in Experiments 1 and 2,  
301which also extended the analysis to the palatability of the learnt solutions. On the other hand, our  
302results gives certain evidence for a change in palatability, finding little evidence of changes due to  
303individual learning, but a suggestion of changes in palatability associated to social learning.

304

#### 3054.1 *Individual trial and error learning*

306 As in previous experiments, in the present study nursery pigs preferred flavours previously  
307conditioned with energy compounds such as sucrose (4%). Results suggest that both the palatable  
308taste and post-ingestive effects of sucrose contributed to the conditioned CS+ preference and  
309acceptability, reflecting how attractive the sucrose is to pigs (Glaser et al., 2000). Figueroa et al.  
310(2012b) associated a flavoured solution with sucrose (4%) observing that sucrose post-ingestive  
311effect by itself may condition flavour preferences, noting a higher intake than flavours conditioned  
312with the same sweetness but a minor energy level (1% sucrose + 0.08% saccharine). Similar results  
313have been observed in pigs when other concentrations of sucrose (10%) or carbohydrates as  
314maltodextrin (2.25%) were used as a reinforcement (Clouard et al., 2012). This could indicate that  
315post-ingestive effects might be sufficient to condition flavour preferences as several experiments  
316showed in rats (Lucas et al., 1997; Ackroff and Sclafani, 2010). Figueroa et al., 2012a also reported  
317protein-based flavour preference conditioning in pigs, where animals associated protein  
318concentrates (> 60% CP) with artificial flavours during nursery. They showed a clear preference  
319when those flavours were presented later in water solutions or commercial feed. Regarding  
320acceptability of previously conditioned flavours, in the present study we observed that animals  
321present a higher consumption of those flavours when only one option was offered. Despite the  
322existence of evidence in rats (Pérez et al., 1998), previous experiments in pigs did not explore the  
323effect of learning on flavour acceptability. This information could be useful to extrapolate to real  
324commercial conditions where only one feed option is provided. However, the possible learning  
325extinction and long-term effect of flavour consumption still needs to be explored.

326 Experiments in rats support that flavours conditioned by the post-ingestive effects of nutrients  
327not only are better preferred and accepted, but also are perceived as more pleasant (Myers and  
328Sclafani, 2001). Diverse measures correlated with the palatability of a solution or feed, such as  
329licking pattern, appetitive facial expressions and consumption in a brief period of time observing an

330increase when flavours are previously associated with the benefits of sucrose or maltodextrins  
331(Forestell and LoLordo, 2003; Dwyer, 2008). However, palatability in pigs to date has not been  
332systematically studied. Clouard et al. (2014) observed changes in behavioural activities,  
333motivational responses and microstructure of CS intake in nursery pigs after they had been  
334conditioned with 16% sucrose. Added to this, a non-significant higher duration of drinking episodes  
335and a smaller number of drinking episodes were observed. This information could be extrapolated  
336to lick cluster size analysis in rats (Davis and Smith, 1992) or CT/A in pigs (Figueroa et al., 2019),  
337suggesting the importance of oral perception of the unconditioned stimulus (US) during training for  
338possible hedonic changes for the CS+ in pigs. However, no changes in palatability were observed in  
339the present experiment after conditioning flavours with 4% sucrose. A possible explanation could  
340be that rather than acquiring the hedonic tone of the US, the CS+ acquires the incentive value of the  
341US (perhaps because of the low concentration of sucrose used). This can maintain an elevated  
342intake, reflected in preferences and acceptability even in the absence of enhanced palatability  
343(Myers and Sclafani, 2001). However, there is also evidence from rats that conditioned changes in  
344palatability are relatively short-lived (e.g. Dwyer et al., 2009). Thus, learned changes in flavour  
345palatability may have extinguished before because the palatability tests followed preference tests  
346delivered without sucrose.

347

#### 3484.2 *Social learning*

349 The changes in pigs' feeding behaviour induced by social learning through brief interactions  
350have been previously studied in terms of preferences (Figueroa et al., 2013, 2020b). The present  
351study explored the effects of social learning on pigs' flavour acceptability and palatability,  
352highlighting the importance of oro-nasal contact in the acquisition of new feeding patterns, which  
353has been previously reported by Galef and Stein (1985) in rats. Results show that, similar to rats, the  
354acceptability of a flavoured feed increases after a brief contact with a familiar demonstrator that  
355previously consumed that feed. This phenomenon could involve learning, establishing the

356 acquisition of new feeding behaviours in the population that could remain dependent on the  
357 immediate reinforcement generated by the consumption of that flavoured feed, other consumption  
358 alternatives and population dynamics (Galef and Laland, 2005). Social learning could be a key  
359 strategy in productive stages where pigs exhibit feed neophobia, such as at weaning (Pluske et al.,  
360 2007). The interaction of the test day and flavour consumed by the DEM pigs did not show an  
361 effect on the acceptability of the flavoured food, therefore, no extinction of learning was observed,  
362 but rather, this was maintained (Galef and Whiskin, 1998).

363 Regarding palatability, although changes have been described after associative learning in  
364 several species (Dwyer, 2008, 2009), little information exists on changes in feed palatability after a  
365 brief social contact (Figueroa et al., 2020a). In the present experiment interesting results were  
366 obtained when analysing the first half of the test, similar to results observed by Figueroa et al.  
367 (2019). This suggests that the first 5 minutes of exposure to a feed is most sensitive in assessing  
368 hedonic reactions after associative learning. Palatability, contrary to acceptability, showed no  
369 overall changes when the DEM consumed the same flavour as presented to the OBS (garlic  
370 flavour), and it did change according to the test day, increasing over the days. The latter could be  
371 attributed to the fact that neophobia modulates palatability, due to both a habituation effect and the  
372 perception of feed as familiar and safe (Lin et al., 2012).

373 While there was no reliable change in overall palatability due to social learning, a correlation  
374 between palatability and the amount of snout to snout contact between OBS and DEM animals was  
375 observed. According to Galef (for a summary see Galef, 2012) an OBS rat acquires a new feeding  
376 behaviour by having a brief contact with an experienced DEM through its breath (Galef et al., 1988;  
377 Munger et al., 2010). Based on this, interaction between individuals, more specifically the time and  
378 number of oro-nasal interactions, is essential to generate changes in feed preferences in rats (Galef  
379 and Stein, 1985). Although the specific components of pigs' breath were not isolated in the present  
380 experiment, when studying the oro-nasal contact time between DEM and OBS, it was found that it  
381 was positively correlated with the CT/A. Critically, this was only seen when the OBS animals were



382 tested with the same flavour as consumed by the DEM animals (and thus the correlation cannot be  
383 due to animal temperament factors that would affect both snout to snout contact times and CT/A in  
384 the same way). This implies that the longer the oro-nasal contact time between OBS and DEM, the  
385 greater the subsequent palatability of the flavoured feed. This suggests that in pigs there would also  
386 be chemical compounds from their oro-nasal cavity that, in a given context (flavoured feed and  
387 presence of a conspecific), would be responsible for the changes in feeding behaviour described in  
388 this experiment. However, further studies are required to clarify the responsible mechanism of these  
389 changes in pigs' feeding behaviour.

390

### 3915. Conclusions

392 Learning based on individual experience or social exposure can change the feeding behaviour of  
393 pigs, presumably on the basis that previously novel flavours come to be associated with positive  
394 events such as calories or social interaction. We conclude from our experiments that trial and error  
395 and social learning are important contributors to pigs' preferences and acceptability for flavours  
396 learnt. Nevertheless, only social learning modified the hedonic perception of flavours, with an  
397 interesting correlation between snout to snout contact time between DEM and OBS and the  
398 magnitude of OBS changes in their hedonic perception for those flavours. Therefore, the  
399 mechanisms that are involved in the oro-nasal-contact mediated social interaction in pigs, have to  
400 be further explored to better understand the changes of feeding behaviour observed in this study.  
401 Regardless of the exact mechanism of learning, it is clear that associative learning (based on either  
402 individual or social experiences) can lead in increases in the consumption of, and preference for,  
403 food flavours. Thus interventions based on associative learning about food flavours could be  
404 beneficial to implement on pig farms to help increase food consumption. This would be especially  
405 true around periods of change in the production stages (in particular weaning) because these are  
406 particularly stressful and associated with reductions in feed intake and welfare.

407

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410

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412

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415

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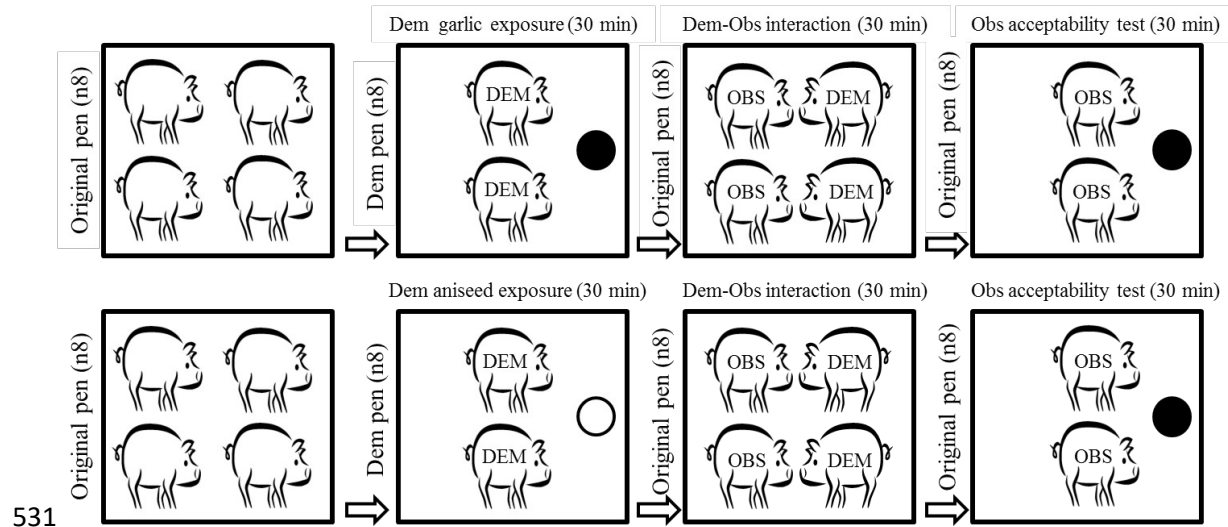
523 **Table 1.** Spearman's correlation between snout to snout interaction time of demonstrators (DEM)  
 524 pigs that previously consumed garlic or aniseed flavoured feed with their respective observers and  
 525 consumption time (CT), the number of approaches (A), and CT/A of those observers against garlic  
 526 flavoured feed analysed during the complete period of the observer test (0-10 min), the first half (0-  
 527 5 min) and the last half (6-10 min).

528

	<b>Garlic DEM</b>		<b>Aniseed DEM</b>	
	<b>r</b>	<b>p</b>	<b>r</b>	<b>p</b>
<b>Consumption time (CT, s)</b>				
0-5 min period	0.388	0.211	0.151	0.638
6-10 min period	0.302	0.334	-0.129	0.688
0-10 min period	0.410	0.185	0.000	1.000
<b>Number of approaches (A)</b>				
0-5 min period	-0.475	0.118	0.390	0.210
6-10 min period	-0.227	0.477	0.529	0.076
0-10 min period	-0.518	0.084	0.422	0.172
<b>CT/A</b>				
0-5 min period	0.626	0.029	0.000	1.000
6-10 min period	0.388	0.211	-0.259	0.416
0-10 min period	0.497	0.100	-0.194	0.545

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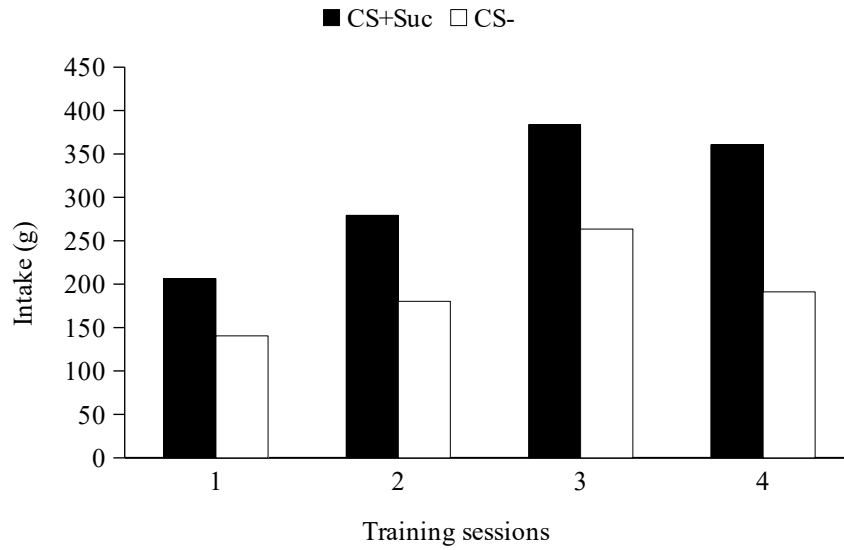
530



533 **Figure 1.** Experiment 2: Layout of the social learning procedures between observers (OBS) and  
 534demonstrators (DEM) pigs. Closed circles represent the garlic flavoured feed given to half of  
 535demonstrators (8 pig pairs) and the open circles the aniseed flavoured feed given to the other half of  
 536demonstrators (8 pig pairs). Observer animals were tested with an acceptability test where they  
 537were offered garlic flavoured feed.

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539

540**Figure 2.** Experiment 1: Mean solution intake (+ SEM) of nursery pigs' pairs after 30 min. during  
 541training session for flavoured solutions (garlic or aniseed; 0.075%) with the inclusion of 4% of  
 542sucrose (CS+Suc) or without sucrose inclusion (CS-). No feed or other fluids were available during  
 543training sessions. †P < 0.1; \*P < 0.05.

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553**Figure 3.** Experiment 1: Mean intake of CS+ and CS- solutions (+ SEM) during 30 min. non-  
554reinforced two-choice test (a), during 30 min. non-reinforced one-pan acceptability test (b), and  
555palatability estimated during the first 10 minutes (c) [consumption time (CT)/number of approaches  
556(A)]. No feed or other fluids were available during the tests. \*P < 0.05.

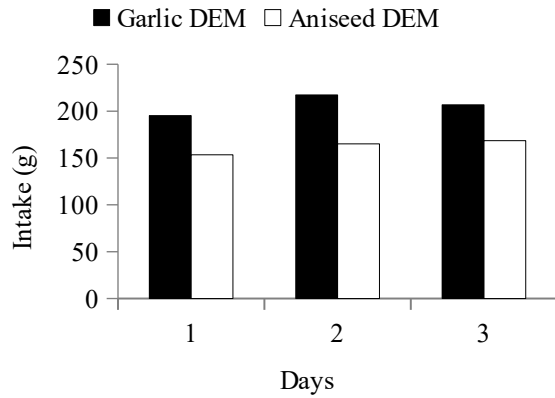
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563**Figure 4.** Mean consumption for garlic flavoured feed by observer nursery pigs that previously  
 564interacted during 30 min. with demonstrators (DEM) that consumed garlic (Garlic DEM) or aniseed  
 565(Aniseed DEM) flavoured feed (a) and palatability estimated during the first 10 minutes (c)  
 566[consumption time (CT)/number of approaches (A)]. Results are expressed by the day of the test.  
 567Flags: + SEM.

568

569

$r = -0.518$   
 $p = 0.084$

571 **Figure 5.** Experiment 2: Scattergrams of the number of approaches (a), consumption time (b) and  
572 consumption time per approach (c) of observers with garlic flavoured feed after interaction with  
573 demonstrators that previously consumed garlic flavoured feed, against snout to snout interaction  
574 times.

575