Flavor preferences conditioned by postingestive effect of sucrose and porcine digestive peptides in postweaning pigs[1]

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ABSTRACT: Pigs can learn to prefer a flavor if it has been previously associated to positive consequences. The aim of this experiment was to study flavor preferences conditioned by the postingestive effect of nutrients in pigs. In total, 240 weanling piglets were allocated in 24 pens (10 piglets/pen) and distributed to 2 groups of animals (12 pens per group). Pigs in Group 1 (G1) were trained during 8 d with one flavor [positive conditioned stimulus (CS+)] into a protein solution [4% porcine digestible peptides (PDP)] on odd days and another flavor [negative conditioned stimulus (CS–)] into 100 mM of monosodium glutamate (MSG) solution on even days (5-L bottle for 24 h). In the second group of pigs [Group 2 (G2)], CS+ was mixed into a 4% sucrose solution in odd days and CS– into 1% sucrose + 0.08% saccharine on even days. Therefore, treatments were defined as CS+, the flavor associated with PDP or sucrose, on odd days, which were assumed to have a higher postingestive effect than MSG or saccharine + sucrose, the ingredients associated to CS–. Concentration of ingredients in the solutions were chosen to ensure that hedonic attraction for PDP and MSG solutions and for sucrose and saccharine + sucrose were similar (checked in previous double-choice studies). The amount of solution offered during training period was prepared to be totally consumed each day to equalize flavors intake. Flavors (0.0375% anise or garlic) were counterbalanced across replicates to act as CS+ or CS–. Double-choice test between flavors dissolved in water (CS+ and CS–) were performed by selecting 2 pigs/pen on days 1, 6, and 8 after the training period. Solution intake was measured after 30 min. Piglets showed higher intakes for CS+ than CS– in G2 [212 vs. 76 mL and 168 vs. 86 mL ($P < 0.05$) and 195 vs. 78 mL ($P = 0.15$)] on days 1, 6, and 8, respectively. Differences between CS+ and CS– consumption were observed in G1 on day 8 (231 vs. 130 mL; $P < 0.05$). In conclusion, weanling pigs can acquire flavor preferences through associative learning between a flavor and postingestive effects of some nutrients.

Key words: conditioning, learning, postingestive

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INTRODUCTION

Pigs are frequently exposed to feed and environmental changes that they have to face in a critical short time and without previous experience. Feed neophobia is a phenomenon commonly associated with those changes (Miller and Holzman, 1981) that may drive pigs to a variable period of underfeeding or anorexia. However, pigs have a high innate preference for sweet, umami, and moderately salty compounds (Hellekant and Danilova, 1999). These compounds have been used to enhance feed palatability but also in other species to facilitate the intake of neutral flavors by an associative learning with their hedonic or postingestive effects (Ackroff and Sclafani, 2011). Both effects may play a different role on the learning process of flavor preferences and can be dissociated by using different techniques to assess their contribution. Warwick and Weingarten (1994) proved in rats that postingestive effects are strong enough by themselves to create flavor preferences by using the match of the hedonic effects of 2 components with different nutritive values. These effects are stronger than flavor–flavor associations and show a higher resistance to extinction (Sclafani,

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2004) and flavors become more palatable (Dwyer et al., 2009). In the present work it was hypothesized that this difference could be even higher in species with a high growing potential such as pigs in which nutrients may act as a powerful positive stimulus to create flavors preferences. The aim was to evaluate if the postingestive effects of protein and sucrose (unconditioned stimulus) are sufficient to establish flavor preferences in pigs because of a previous associative learning between these nutrients and a neutral flavor stimulus (conditioned stimulus).

MATERIALS AND METHODS

The experiment was conducted at the animal research facilities of the Universitat Autònoma de Barcelona (**UAB**). Experimental procedures were approved by Ethical Committee on Animal Experimentation of the UAB (CEAAH 1406).

In total, 240 weaned piglets [(Large White × Landrace) × Pietrain] were weaned at an average of 26 d of age and allocated in 24 pens (10 piglets/pen) inside a room equipped with automatic, forced ventilation and completely slatted floor. During the first week after weaning, animals were pretrained by offering plain water (1600 mL in 2 pans) in each pen from 0900 to 1100 h. All animals had ad libitum access to unflavored feed (prestarter diet for 0 to 14 d and starter diet for 15 to 35 d after weaning). After the pretraining period, pens were equally distributed into 2 groups (12 pens/group). Pens of Group 1 (**G1**) were trained to drink during 8 d (alternate sessions) a flavor as a positive conditioned stimulus (**CS+**) that was mixed with a protein solution [4% porcine digestible peptides (**PDP**); Palbio 62SP; Bioibérica, Palafolls, Spain] on odd days and a different flavor [negative conditioned stimulus (**CS–**)] into 100 mM of monosodium glutamate (**MSG**; Ajinomoto SAS, Paris, France) solution on even days. In pens of Group 2 (**G2**), CS+ was mixed into 4% sucrose solution in odd days and CS– into 1% sucrose + 0.08% saccharine (S1002; Sigma, St. Louis, MO) on even days. We assumed that MSG and 1% sucrose + 0.08% saccharine would provide lower postingestive nutrients than 4% PDP and 4% sucrose (positive stimulus), respectively. On the other hand, we tried to match the hedonic attraction for PDP and MSG solutions and for sucrose and saccharine + sucrose in a previous double-choice tests (**DCHT**; 30 min) by evaluating different concentrations of MSG vs. a fix 4% PDP and different concentrations of saccharine + 1% sucrose vs. 4% of sucrose. Thus, flavors CS+ were associated with a higher postingestive but the same hedonic value than flavors CS–. The total amount of solution offered during training session was prepared to be absolutely consumed each day to equalize flavor intake (5-L bottle for 24 h). Flavor products used as conditioned stimulus (0.0375% anis or garlic; Lucta SA, Montornès del Vallès, Spain) were counterbalanced in each group across replicates to act as CS+ or CS– (i.e., half of the pens in G1 associated anise or garlic to PDP on odd days to act as CS+ and consequently garlic or anise as CS– to MSG on even days). After training sessions, flavor preferences were evaluated by using a DCHT with the CS+ and CS– flavors both presented in water (unreinforced tests) and selecting 2 pigs/pen on days 1 (Test 1), 6 (Test 2), and 8 (Test 3) after the training period. In these tests, 2 pans containing 800 mL of the CS+ and CS– flavors were placed in the front of each pen and consumption was measured after 30 min. Left and/or right positions of the CS+ and CS– pans were counterbalanced across subjects and tests days. Solution intakes during DCHT between CS+ and CS– was analyzed by group (1 and 2) and test day (1, 2 and 3) with ANOVA by using the GLM procedure of SAS (SAS Institute Inc., Cary, NC) taking into account the solution intake (CS+ or CS–) and the flavor (anise or garlic), and the pen was the experimental unit. The mean values are presented as least square means adjusted by Tukey. The α level used for the determination of significance was 0.05.

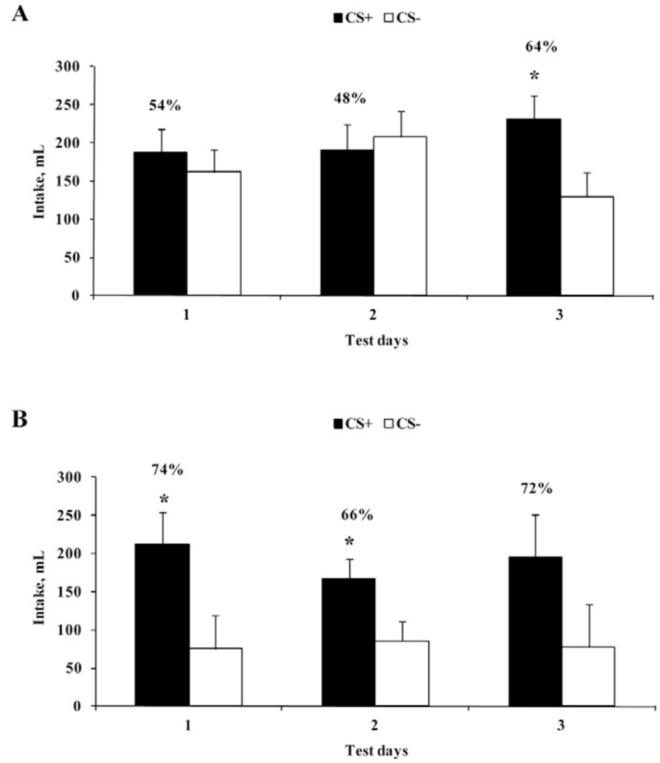

Figure 1. Intake of flavored solutions [positive conditioned stimulus (CS+) and negative conditioned stimulus (CS–)] during the choice tests (tests 1, 2, and 3; 30 min) of a group of pigs previously trained with a flavor (CS+) mixed with porcine digestible peptides (PDP; 4%) and other flavor (CS–) mixed with monosodium glutamate (MSG; 100 Mm) solutions (A) and of a second group of pigs previously trained with a flavor (CS+) mixed with sucrose (4%) and other flavor (CS–) mixed with saccharine (0.08%) + sucrose (1%) solutions (B). Asterisks indicate that CS+ intake is different than CS– intake (*$P < 0.05$). Flags indicate ±1 SEM.

RESULTS

Piglets from G1 had a higher ($P < 0.05$) total solution intake during the choice tests than piglets from G2 (370 vs. 270 mL; SE = 30.8). Although differences were not observed in G1 (Figure 1A) between CS+ and CS– during the first 2 tests, intake of the CS+ solution was higher ($P < 0.05$) on day 8 for CS+ than CS– (231 vs. 130 mL; SE = 31.6). On the other hand, piglets of G2 (Figure 1B) had a higher ($P < 0.05$) intake for CS+ than CS– solutions during Test 1 (212 vs. 76 mL; SE = 42.6) and 2 (168 vs. 86 mL; SE = 26.1) but differences were not observed for Test 3.

DISCUSSION

Our results confirm that piglets can acquire flavor preferences through an associative learning with the postingestive effects of sucrose. However, PDP failed to establish flavor preferences at the first 2 tests. Postingestive effects of MSG may also have a positive association with the flavor (CS–), making differences between flavors less visible (Ackroff and Sclafani, 2011). Moreover, the attraction for CS– flavor may have been enhanced by the hedonic attraction of MSG solution when a flavor is simultaneously added (Rolls, 2009). In this way the previous hedonic match between PDP and MSG could have been unbalanced. However, preferences conditioned by hedonic effects have a short extinction time because they evoke the palatability of the previous association (Dwyer et al., 2009). This could be the reason of finding a preference for the CS+ flavor at the last choice test when CS– attraction likely tended to be extinguished. In conclusion, pigs learn to select nutritious fluids by associating the flavor of consumed substances with their postingestive consequences. Learned flavor preferences may be used as a strategy to enhance voluntary intake and reduce neophobia during critical periods, such as weaning.

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