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Effect of a long-term exposure to concentrated sucrose and maltodextrin solutions on the preference, appetence, feed intake and growth performance of post-weaned piglets

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HIGHLIGHTS

- Piglets initially showed preference for 2% sucrose over 2% animal plasma solutions.
- They were then offered concentrated carbohydrate solutions in addition to the diet.
- 16% sucrose and 16% maltodextrin solutions reduced feed intake and weight gain.
- Exposure to 16% sucrose or 16% maltodextrin reversed the preference for 2% sucrose.
- Exposure to 16% sucrose or 16% maltodextrin reduced the appetence for 2% sucrose.

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ABSTRACT

Commercial pigs display an innate attraction for sweet taste compounds. However, the impact of long-term availability to supplementary carbohydrate solutions on their general feeding behavior has not been examined. In this work we assess the effect of 12-days exposure to 16% sucrose and 16% maltodextrin solutions on the feed intake and growth performance of piglets, and on their preference and appetence for sweet or protein solutions. The innate preference of piglets was assessed by an initial choice test between 2% sucrose and 2% animal plasma solutions for a period of three minutes. Piglets showed higher intake and preference for 2% sucrose than for 2% animal plasma. In Experiment 1, piglets were then free-offered a 16% sucrose solution as a supplement to the diet, showing a higher intake of it than water and a reduction in feed intake and weight gain. A similar situation occurred during the last days of free-exposure to a 16% maltodextrin solution in Experiment 2. The choice test between 2% sucrose and 2% animal plasma solution was repeated after the exposure to the concentrated solutions. In both experiments, a reduction in the initial preference for 2% sucrose was observed. Similarly, piglets that had previous access to the 16% sucrose and 16% maltodextrin solutions showed a decrease in the appetence for 2% sucrose in comparison with that for 2% animal plasma, as measured by a one-pan test at the end of the experiments. It is concluded that long-term exposure to concentrated sucrose and maltodextrin solutions reduces feed intake and growth in weanling piglets, and also reverses their innate preference and appetence for dilute sweet over protein solutions.

1. Introduction

The omnivorous diet of the pig in wild conditions shares significant similarities with human dietary habits not seen in other omnivorous species, such as the rat or the mouse [1]. Dietary preferences are intimately linked to taste perception mechanisms, which are also shared and similar between pigs and humans [2]. Among the currently accepted basic tastes, sweet and umami compounds are strongly pleasurable for pigs. Sugars, including different types of carbohydrates, polyols and sweeteners, are recognized by the T1R2/T1R3 heterodimeric receptor into the oral cavity and gastrointestinal tract of pigs [3,4]. Pigs show an innate attraction and preference for solutions of sucrose, glucose, lactose and sodium saccharin when compared in short-term preference tests against water [5,6]. The attraction is similar to that showed by humans, reflecting a trait that has probably evolved through years to signal highly caloric carbohydrate-rich nutrients [7]. From Glaser et al.

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(2000), it is known that sucrose and fructose response intensities are identical in both species, sucrose being the most strongly preferred carbohydrate for pigs [8]. These compounds added in-feed at levels of around 50 g/kg also increased feed intake and weight gain of weanling animals [9]. However, there is no conclusive literature concerning how and in which intensity pigs sense other oligosaccharides or more complex carbohydrates, such as maltodextrin. In a recent study [10], Roura et al. showed that the hedonic intensity of maltodextrin solutions in pigs is lower than that reported for sucrose, because the preference threshold for maltodextrin (3%) was higher than that for sucrose (0.5%–1%) when tested against plain water. This is potentially important because humans report far lower taste intensities for maltodextrin solutions than for sugar solutions [11]. This is in stark contrast to rats which show a preference for maltodextrin over sucrose-solutions at low concentrations and also detect maltodextrin at lower concentrations than sucrose [12].

Kennedy and Baldwin (1972) observed in a 12-hour choice test against water that young pigs showed increases in sucrose solution intake of concentrations of approximately 0.3% to 7.7% with concomitant decreases in water intake — but there was no assessment of sucrose availability on feed intake [13]. Since that study, no other report has evaluated the possible effects of a long-term availability to a highly hedonic and more concentrated supplementary carbohydrate solution on the feeding behavior of pigs. In humans, there is a general concern about the detrimental impact on public health of a long-term consumption of caloric drinks [14–16]. This phenomenon has been well studied in laboratory rodents. Thus, when offered a highly palatable 32% sucrose solution as a supplement to their nutritionally complete diet, adult rats overeat and gain excessive weight, which has been described as obesity by choice [17–19]. In the present work, in order to further explore the hedonic motivation of piglets we used a concentrated sucrose solution (16%, Experiment 1) to expose the animals with a highly hedonic sweet compound which also has considerable caloric post-ingestive effects. The aim was to assess whether a long-term exposure (12 days) might alter feed intake and growth of piglets, as well as modify their preference and appetence for sweet (2% sucrose) and protein (2% animal plasma) solutions. Subsequently, in order to discriminate between the influence of sweetness and the contribution of the caloric load on the response, a low dextrose equivalent 16% maltodextrin solution was used (Experiment 2). It was hypothesized that, similar to rodents, pigs may show a high-affinity pattern towards a palatable solution if it is freely offered as a supplement to the diet, based on their innate attraction with sweet taste compounds. In addition, the long-term exposure to solutions that are hedonically preferred to the growing feed may have a negative effect on the feed intake of the animals, and may also reduce their preference for less hedonically valuable low-concentration sweet solutions as compared to protein solutions.

2. Material and methods

All procedures described in this study were conducted at the animal research facilities of the Universitat Autònoma de Barcelona (UAB). Experimental procedures were approved by the Ethical Committee on Animal Experimentation of the UAB (CEAAH 1406).

2.1. Animals, diets and housing

In total, 108 male and female piglets (Pietrain × [Landrace × Large White]) from 14 to 35 days post-weaning were selected to be used in three experiments, with 36 piglets in each.

During lactation, piglets were supplemented with a milk replacer feed from 10 days of age until weaning in order to familiarize the animals with solid feed as early as possible. Then, piglets were weaned at 28 days of age. In Experiments 1 and 2, at the beginning of the starter period on Day 14 after weaning piglets were distributed according to their body weight and were further allocated into 12 pens of three piglets per pen. In Experiment 3, on Day 35 after weaning piglets were similarly allocated into 12 pens of three piglets per pen. In all experiments, piglets were fed a single, commercial starter diet (Table 1) formulated to provide a complete and equilibrated nutrient content in order to maximize growth potential of animals, according to NRC [20]. This diet was offered ad libitum in mash form.

The weaning room had automatic, forced ventilation and completely slatted flooring. Each pen (3.2 m^2 in floor area) was equipped with a feeder with three feeding spaces and an independent and automatic water supply to ensure ad libitum feeding and freshwater access.

2.2. Experimental designs

2.2.1. Experiments 1 and 2: Long-term solution exposure in piglets

These experiments were designed to evaluate the effect of a long-term free availability of an extra sucrose or maltodextrin solution on the preference and appetence of piglets for sweet and protein solutions, and also on their feed intake and growth performance. The experimental design included an initial choice test on Day 14 after weaning, an ad libitum solution exposure period from Days 14 to 26 during which feed intake and growth were recorded, a final choice test on Day 26, and one-pan test on Days 27 and 28 after weaning.

2.2.1.1. Initial and final choice test. During the first two weeks after weaning, piglets were familiarized to the weanling room and pre-trained with two pans containing 800 mL of tap-water in each pen for 30 min. The preference of piglets for sweet or protein water-based solutions was assessed at the beginning of the experimental period (Day 14 after weaning) by using a single choice test for 3 min. This test was also repeated at the end of the experimental period (Day 26 after weaning). The test was performed for the 3 piglets of each pen, with 2 pans placed in the front of the pens containing 800 mL of either 2% of porcine animal plasma (AP820, APC; Ankeny, USA) as protein solution (0.014 g crude protein, 0.324 kJ digestible energy/mL) or 2% of commercial sucrose as carbohydrate solution (0.335 kJ digestible energy/mL). The rationale

Table 1
Composition and estimated nutrient content of the starter diet used in the experiments.

	g/kg DM
Ingredients	
Maize	350.0
Barley	187.1
Wheat	180.0
Extruded soybean	109.0
Soybean meal 44% crude protein	58.9
Fishmeal LT	50.0
Whey powder 50% fat	25.0
Commercial nucleus[a]	10.0
Monocalcium phosphate	8.8
Calcium carbonate	7.0
L-Lysine-HCl	5.2
L-Threonine	2.2
DL-Methionine	1.8
L-Tryptophan	0.5
Salt	4.5
Estimated nutrient content	
Dry matter	890.6
Net energy (MJ/kg)	10.4
Crude protein	179.8
Crude Fiber	31.5
Fat	59.3

[a] Supplied per kg of feed: 3060 μg of retinol, 52.5 μg of cholecalciferol, 39.9 mg of α-tocopherol, 3 mg of menadione, 2 mg of thiamin, 3 mg of riboflavin, 3 mg of pyridoxine, 0.025 mg of cyanocobalamin, 20 mg of calcium pantothenate, 60 mg of nicotinic acid, 0.1 mg of biotin, 0.5 mg of folic acid, 150 mg of Fe, 156 mg of Cu, 0.5 mg of Co, 120 mg of Zn, 49.8 mg of Mn, 2 mg of I, 0.3 mg of Se.