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Influence of flavored drinking water on voluntary intake and performance of nursing and post-weaned piglets

Kariny F. da Silva[a], Bruno A.N. Silva[a,*], Simon Eskinazi[c], David V. Jacob[d], Wagner A.G. Araujo[b], Ronaldo L.S. Tolentino[a], Flavio I.G. Rebordões[a], Mateus F. Gonçalves[a], Valesca R. Lima[a], Iara Q. Ataíde[a]

[a] Institute of Agricultural Sciences/ ICA, Universidade Federal de Minas Gerais (UFMG), 39404-547, Montes Claros, Minas Gerais, Brazil
[b] Animal Science Unit, Instituto Federal de Educação, Ciência e Tecnologia Norte de Minas Gerais (IFNMG), 39480-000, Januária, Minas Gerais, Brazil
[c] Adisseo (Nutriad Ltd.) 1 Telford Court, Chester Gates, Chester CH1 6LT, England
[d] Adisseo (Nutriad Nutrição Animal Ltda. Brazil), José Bonifácio Coutinho Nogueira 214, 13091-611, Campinas, São Paulo, Brazil

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ABSTRACT

Water is an absolute requirement in the daily needs of the pig. It has been suggested that when sows have a limited milk production, piglets may not consume enough water which will impact on their hydration. Eighty mixed parity sows of a high prolificacy genetic line were used to evaluate the impact of a flavor added to the drinking water for piglets on the voluntary water intake and performance during nursing phase and first week post-weaning. Sows and their respective litters were distributed in a completely randomized experimental design among the four treatments according to parity order and body weight 24 h post-farrowing. The treatments represented by control where piglets received standard water (T1) and other three levels of flavor inclusion in the water (T2 = 100 ppm; T3 = 200 ppm and T4 = 400 ppm). Piglets were allowed free access to water treatments via a semi-automatic water dispenser from d 3 until weaning (approx. 21 day). At weaning a total of 936 piglets were weighed, selected and distributed in a completely randomized experimental block design among treatments in the nursery pens according to weight (light, moderate and heavy), sex (male and female) and previous lactation treatment. The piglets were housed in the nursery facilities and were continuously offered the same four treatments that were used during the lactation phase until 7-day post-weaning. The flavor added to the drinking water significantly increased the piglets water ($P = 0.047$) and creep feed ($P = 0.001$) intake, which impacted positively on piglet average daily gain, and piglet weaning weight during the nursing phase. Treatments also influenced piglets' nursery voluntary total water ($P = 0.0001$) and total feed consumption ($P = 0.002$). Also the piglets' total average weight gain ($P = 0.042$), and pen daily gain ($P = 0.003$) and final weight ($P = 0.0001$) were influenced by the water flavor. In conclusion, this experiment has demonstrated that the inclusion of flavor compounds in the drinking water of the piglets during nursing and post-weaning phases has the potential to improve piglet performance. Our findings lead us to believe that the strategic use of a water flavor to manipulate the sensorial properties of water is a viable strategy to increase the piglet's voluntary water and feed intake and as a consequence improve litter performance at weaning and during the first week post-weaning all of which can help prepare the animal for the negative effects of the weaning process.

1. Introduction

Like other nutrients, such as energy and amino acids, water is an absolute requirement in the daily needs of the pig. It is involved in several biochemical reactions and nutrient, waste product and hormone transportation throughout the body. Water helps to maintain constant body temperature and constant acid-base balance (Brooks et al., 1984). Water makes up about 80% of total body weight of the piglet and 50% in adult swine because of the lower water content in fat as compared to muscle tissue. In addition, in sows that have milk production limited by external factors (i.e. heat stress), piglets may not consume the daily needed amount of water which will impact in their hydration. According to Legagneur and Fevrier (1956), the inclusion of sucrose in pigs' diets increased total feed intake. A threshold for sucrose ranging from 5 to 10mM is highly preferred by piglets, as well as glucose (10 – 30mM) or even artificial compounds like saccharin (5 – 10mM)

* Corresponding author.
E-mail address: BrunoSilva@ufmg.br (B.A.N. Silva).

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compared to water.

Supplying water to the piglets in the farrowing unit can be an alternative, where sow milk production is limited by environmental factors (under heat stress conditions or highly prolific sows). It is commonly known that providing water to piglets encourages higher creep feed intake and improves nutrient absorption, with a positive impact on weight gain and on post-weaning feed intake adaptation, decreasing problems caused by the transition phase from the farrowing unit to the nursery (Ogumbameru et al., 1991). In this sense, adding flavors that are related to pig preference (i.e. sodium saccharin and thaumatin; Legagneur and Fevrier, 1956) could enhance performance during stages of the pig's life.

The present study aimed to evaluate the impact of a commercial flavor added to the drinking water for piglets on the voluntary water intake and performance during nursing phase and first week post-weaning.

2. Material and methods

2.1. Animals and experimental procedure

All methods involving animal handling were realized in accordance with the regulations approved by the Institutional Animal Welfare and Ethics/Protection committee from the Universidade Federal de Minas Gerais (UFMG) under the protocol n. 131/2015.

The study was performed in the facilities of a commercial sow unit, located in the South-eastern part of Brazil, and was performed during tropical summer conditions, covering the period between December 2015 and February of 2016. According to Köppen (1948) classification, the climate of the region is Cwa (hot, temperate, rainy, and with dry winters and hot summers).

A total of 80 mixed parity sows of a commercial genetic line (Topigs Norsvin® TPS20®) were used, divided into 4 treatments with 20 replicates each, were each sow and its litter were considered as an experimental unit. Sows were distributed in a completely randomized experimental design among the four treatments according to parity order (1st; 2nd; 3rd; >4th parity) and body weight 24 h post-farrowing.

The treatments represented by control were pigs received a standard water (T1) and other three levels of flavor inclusion in the water (T2 - 100 ppm, T3 - 200 ppm, T4 - 400 ppm) (i.e. Optisweet™ Nutriad Ltd, Chester, UK). Optisweet ™ is proprietary mixture of chemically defined aldehydes, ketones and esters with sodium saccharin and thaumatin, to impart a sweet fruit flavor to the water. Piglets were allowed free access to water treatments via an automatic water dispenser (Model MAXI 10 L capacity storage, PlasDog Pet, Santo André, SP, Brazil) from d 3 until weaning (approx. 21 days).

On 110 days of gestation, sows were transferred to a farrowing unit and housed in individual open-fronted farrowing pens (2.1 × 2.2 m) on a slatted metal floor and fed 2 kg d^{-1} of a standard lactation diet (14.4 MJ ME kg^{-1}, 10 g SID lysine kg^{-1}, 9.8 g Ca kg^{-1}, 4.5 g available phosphorus kg^{-1}) formulated to meet the requirements of these animal categories according to Rostagno (2011) until the day of farrowing. Variations in ambient temperature, relative humidity (RH), and photoperiod closely followed outdoor conditions. Sows were then submitted to a step-up manual feeding regime to stimulate a gradual feed intake increase up to day 7 post-farrowing, starting with 2 kg on day 1 post-farrowing and reaching 8 kg on day 7. The allowance increased by 1 kg each day. This feeding management was applied to avoid overconsumption at the beginning of lactation and agalactia problems (Silva et al., 2009). After day 7 to 21 postpartum, sows were manually fed an amount of 2 kg + 0.5 kg/ piglet/ day, which lead to an average feed allowance of 8 kg/ day. Every morning, feed refusals were collected, and all fresh feed was immediately distributed once per day between 0700 and 0900 h. Feed consumption was determined as the difference between feed allowance and the refusals collected on the next morning (Silva et al., 2009). The feeding troughs used were regular commercial models with a holding capacity of 10 kg of feed. Sows had ad libitum access to water throughout all the experimental period via an individual nipple. Sow water consumption was not measured during lactation.

After birth, the piglets were managed according to the farm regular procedures: teeth-clipping, umbilical cord treatment and tail docking. On day 3 they received a 200 mg iron dextran intramuscular injection. The litters were standardized as necessary until the first 48 h after birth, the standard being 12 piglets/ sow. Male piglets were castrated on day 10. During lactation, from day 7 until weaning and during the first week post-weaning, piglets were offered a standard creep feed (containing: SID Lys. 1.5 g/kg; 3.6 Mcal ME/kg; 16 g/kg lactose; 0.7 g/kg Ca and 0.55 g/kg available P).

At weaning (i.e. 20.5 ± 0.73 days), a total of 936 weaned piglets were weighed, selected and distributed in a completely randomized experimental block design among treatments in the nursery pens according to weight (light = 4.620 ± 0.332 kg; moderate = 5.405 ± 0.207 kg; and heavy = 6.875 ± 0.596 kg), sex (male = 468 piglets with average 5.355 ± 0.824 kg and female = 468 piglets with average 5.333 ± 1.002 kg) and previous lactation treatment. The piglets were housed in the nursery facilities and were continuously offered the same four treatments that were used in the lactation phase until day 7 post-weaning. Treatments consisted of 9 repetitions and 26 piglets in each (13 males and 13 females). During the post-weaning phase, piglets received the same creep feed diet that was given during the nursing phase. Feed intake was measured on a daily basis and piglets were again weighed on day 7 post-weaning.

2.2. Measurements and collected parameters

The variations in ambient temperature, relative humidity, and photoperiod were followed indoor, using a thermometer placed 1 m above the floor in the centre of the barn. The sows were weighed when moved to the farrowing unit, 24 h after farrowing and at weaning. The following parameters were collected at farrowing: total number of piglets born, born alive, stillborn, and mummies. Piglets were individually weighed using a digital scale (Líder Balanças Ltda., Mod. B150. Araçatuba, SP, Brazil) at birth, at 48 h and at weaning to determine the daily weight gain during lactation.

To determine the effects of treatments on water intake during the experimental period, water was made available by using an automatic water dispenser that had a trough (18.0 × 14.0 × 0.5 cm) adapted to a 10 litre water container. Each container was identified by pen, treatment group and a scale (100 mL) to record the water level. Every day or whenever the container was empty, fresh water (temperature was on average 24.0°C ± 1.23) was provided to the piglets, according to the treatment group and the amount recorded. The solution was prepared by mixing the calculated dosage of the product together with the fresh water directly in the container. This mixture was then stirred manually with a metallic spoon during 05 minutes. After this procedure the container was again fitted into the trough. Water consumption was determined by the difference between the water level that was provided and was leftover in the next measurement.

2.3. Statistical calculations and analyses

Maximum and minimum temperatures, their variability and relative humidity were calculated and analysed for the entire experimental period. Data were submitted to normality Shapiro-Wilk test and analysed using the generalized linear model procedure (GLM) of SAS statistical package (SAS Inst., Inc, Cary, NC; version 9.2), using the adjustment for Multiple Comparisons of the Tukey-Kramer test. Each sow and its litter were considered as an experimental unit during the lactation (n = 20/ treatment). During the nursery phase the pen was considered as an experimental unit (n = 9/ treatment). When the parameter was significant, a regression model was applied using the treatments increasing levels as main effects. The effects of treatments during lactation and the nursery phase were included in the statistical model. For the lactation analysis, the effects of treatment, batch, parity number, and their interactions on performance of sows and litters were considered as main effects in the model. As for the nursery analysis, piglet and pen weight and number of piglets per pen at start were used as covariables in the statistical model.

3. Results

3.1. Lactation phase

Average maximum and minimum temperatures and relative humidity levels measured during the experimental period were 30.6 and 21.6 °C, and 80.2 and 66.7%, respectively. According to the experimental design, there was no difference in parity order between treatments. There was no difference in experimental lactation duration between treatments (17.5 days on average; Table 2). Treatments had no influence (P = 0.379) on sow voluntary feed intake (7.05 kg/ d on average; Table 2). Percentage and absolute variation in the sow body weight were not different between treatments and averaged -3.19% (P = 0.855) and -5.4 kg (P = 0.747), respectively (Table 1). Litter size, piglet and litter weight at start (72 h post-farrowing) were not influenced (P = 0.127) by the treatments (12.0, 1.92 kg and 22.8 kg on average, respectively; Table 2). As for the litter size at weaning, no significant effect was observed (11.8 on average; P = 0.106; Table 1).

The flavor added to the drinking water significantly increased (P = 0.029; Table 1) water intake by the piglets during the lactation phase. T4 litters consumed on average, 8.3 L more water than T3 and 14.8 L more than T2 and T1 (P = 0.045; Table 1). The T3 litters consumed on average 7 L more than T2 and T1 (P = 0.045; Table 1). During the entire experimental period, on average, this represented a total water intake of 6.8; 6.2; 5.8 and 5.5 L/ piglet for T4, T3, T2 and T1, respectively (P = 0.047; Table 1).

Treatments influenced linearly (P = 0.001) piglet weaning weight, where T4 piglets showed a higher weaning weight when compared to the other treatments (6.53; 5.53; 4.83; 4.58 kg, respectively for T4, T3, T2 and T1; Table 1). The average daily gain of piglets was also influenced (P = 0.001) by treatments, whereas T4 piglets showed a daily gain on average 26% higher than T3 and 64% higher than T2 and T1 (Table 1). As for T3 piglets, they showed a 30% higher daily gain when compared to T2 and T1.

There was a linear effect of treatments (P = 0.001) on litter final weight where T4 and T3 litters showed a higher weight when compared to T2 and T1 (78.3 and 66.4 kg vs. 57.4 and 54.1 kg, respectively; Table 1). Treatments also had a linear influence (P = 0.001) on litter daily gain, whereas T4 litters showed a higher daily gain when compared to T3, T2 and T1 (3.13; 2.49; 1.98; 1.78 kg/ day respectively; Table 1). As for T3 litters, they showed a 32% higher average daily gain when compared to T2 and T1.

Table 1
Evaluation of the use of water flavor on the stimulation of voluntary water intake and performance of piglets and litter from day 3 until 21 (Least Square Means)[1]

Parameters	T1	T2	T3	T4	RSD[1]	P Value[2]
Number of litters[3]	20	20	20	20	-	-
Phase duration (day 3 –21), day	17.5	17.5	17.4	17.6	0.8	0.254
Sow body weight, kg						
At farrowing (24 h)	171.8	173.7	171.9	176.9	19.1	0.864
At weaning	166.9	169.3	166.5	169.5	18.2	0.918
Weight variation, kg	-4.9	-4.7	-5.6	-6.5	4.7	0.747
Weight variation, %	-2.92	-2.80	-3.37	-3.70	2.80	0.855
Average sow feed intake, kg/ day	7.02	7.14	7.17	7.05	0.26	0.379
Number piglets at day 3	12.0	12.0	12.0	12.0	0.3	0.127
Number weaned piglets	11.8	11.8	12.0	11.9	0.4	0.106
Piglet performance (day 3–21)						
Average weight start, kg	1.94	1.91	1.92	1.92	0.09	0.269
Average weight end, kg	4.581a	4.830ab	5.533b	6.533c	0.93	0.001
Average total gain, kg	2.641a	2.923a	3.612b	4.611c	0.97	0.001
Average gain, g/ day	151a	166a	207b	261c	55	0.001
Litter performance (day 3–21)						
Average weight start, kg	22.8	22.8	23.0	22.8	8.3	0.738
Average weight end, kg	54.12a	57.46a	66.43b	78.32c	11.6	0.001
Average total gain, kg	31.35a	34.63a	43.44b	55.51c	12.7	0.001
Average gain, kg/ day	1.781a	1.982a	2.490b	3.130c	0.67	0.001
Litter total feed intake, g	851a	876a	1086b	1056b	262	0.016
Piglet total feed intake, g	72a	74a	90b	88b	21	0.029
Litter total water intake, L	66.12a	69.54a	74.33b	82.61b	17.2	0.046
Piglet total water intake, L	5.52a	5.80a	6.23b	6.82b	1.4	0.048

[1] RSD= residual standard deviation. [2] Obtained by analysis of variance and regression analysis (GLM including the effects of treatment (T) and linear effect (L)). T1- Control; T2- 100 ppm, T3- 200 ppm, T4- 400 ppm. [3]Sow and its litter were considered as an experimental unit.

3.2. Nursery phase

Average maximum and minimum temperatures and relative humidity levels measured during the experimental period in the nursery barns were 31.5 and 22.1°C, and 84.3 and 78.1%, respectively. The daily water and feed intake data of piglets were collected from day 1 post weaning until day 7 in the nursery barns. At weaning the piglets were on average 21 days old. As piglets were redistributed among treatments after weaning, the individual piglet weight and the pen weight at the beginning of the nursery phase did not differ among the treatments (5.4 kg and 142.2 kg on average, respectively; P = 0.814 and P = 0.734; Table 2).

Treatments influenced nursery water intake, whereas, on average, T4 and T3 piglets showed a 5.1 L higher water intake than T2 and T1 piglets. On average, this water intake was 14.7, 14.3, 10.9 and 8.0 L/ piglet, respectively, for T4, T3, T2 and T1 (P = 0.001; Table 2) during the first week after weaning. The animals also showed a higher voluntary feed consumption (3.83, 3.32, 2.49 and 2.25 kg/ piglet, respectively, for T4, T3, T2 and T1; P = 0.001; Table 2).

Treatments had a linear influence (P = 0.042) on the piglets' total average weight gain, whereas T4 piglets had a higher weight gain when compared to other treatments (2.92; 2.84; 1.79 and 1.56 kg/ piglet, respectively, for T4, T3, T2 and T1; Table 2). Average piglet daily weight gain was also influenced (P = 0.041) by the treatments, where T4 and T3 piglets showed a daily weight gain 72% higher, on average, than T2 and T1 (Table 2).

Treatments had an effect (P = 0.001) on the pens final weight where T4 and T3 showed on average a higher weight when compared to T2 and T1 (212.4 vs. 186.5 kg respectively; Table 2). Treatments also influenced (P = 0.003) the pens daily gain, where T4 and T3 had a higher daily gain when compared to T2 and T1 (10.1 vs. 6.3 kg/ day respectively; Table 2).

4. Discussion

4.1. Lactation phase

The effect of high temperature on the performance of lactating sows is widely reported in the literature (Black et al., 1993), with negative effects on performance and behaviour when environmental temperature is above the sow's evaporative critical temperature, that is, 22°C (Quiniou and Noblet, 1999). Under our tropical humid conditions, the observed average temperature (26.1°C) frequently exceeded 22°C. In our experimental conditions, the lactating females were under heat stress most of the time.

Table 2
Evaluation of the use of water flavor on the stimulation of voluntary water intake and performance of piglets and litter during post-weaning period from 24 to 31 days of age (Least Square Means)[1]

Parameters	T1	T2	T3	T4	RSD[1]	P Value[2]
Number of replicates/treatment[3]	9	8	8	9	-	-
Piglets performance						
Initial average weight, kg[2]	5.35	5.16	5.33	5.77	1. 23	0.814
Final average weight, kg	6.910a	6.952a	8.172b	8.691b	1.41	0.004
Total average weight gain, kg	1.563a	1.792a	2.841b	2. 923b	1.11	0.042
Average gain, g/ day	222a	256a	406b	417b	158	0.041
Litter performance						
Average weight start, kg	142.40	142.50	142.50	141.40	18.3	0.734
Average weight end, kg	181. 82a	191.24a	209.70b	215.22b	27.5	0.001
Average total gain, kg	39.41a	48.73a	67.22b	73.80b	27.6	0.003
Average gain, kg/ day	5.622a	6.950a	9.601b	10.544b	3.93	0.002
Total feed intake litter, kg	58.31a	61.94a	81. 82b	89.73b	20.1	0.002
Total feed intake piglet, kg	2.253a	2. 493a	3.326b	3.834b	0.91	0.001
Total water intake litter, L	222a	265a	333b	341b	62	0.001
Total water intake piglet, L	8.00a	10.91a	14.30b	14.70b	3.4	0.001

[1] RSD = Residual Standard Deviation. [2] Obtained by variance analysis and regression analysis (GLM including the effects of treatment (T) and linear effect (L)). T1-Control; T2- 100 ppm, T3- 200 ppm, T4- 400 ppm. [3]Pen was considered as an experimental unit.

According to Quiniou and Noblet (1999), Gourdine et al. (2006) and Silva et al. (2009b), milk production is reduced under high temperatures. Milk is one of the main sources of nutrients and hydration for piglets in the farrowing unit. The reduction in milk production due to the heat stress has a negative impact on the piglets growth rates, as the water and nutrients intake is not adequate (Silva et al., 2009a). In addition, the increase in milk production is directly related to an increase in nutrients available for its production. As no difference was observed in the sows voluntary feed intake and weight loss during lactation between treatments, we can suggest that the differences observed in the piglet and litter performance during the lactation phase are related to the effect of the water flavor treatments.

Water is one of the most important nutrients for animals. Piglets should always have access to water both during lactation and immediately after weaning. Compared to other animals, pigs have a highly sensitive olfactory system, able to recognize several non-volatile compounds, the sweet taste being the most acceptable. According to Jones et al. (2000), five odourised foods which are categorized by humans as sweet (i.e. almond oil, peach, raspberry, vanilla and strawberry) have a good acceptance by pigs. These same authors examining the effects of a range of 15 odourised visible foods in growing pigs observed that vanilla and raspberry flavors did not influence negatively feed intake. The findings presented by the previous authors are consistent with the pig preference values for sweeteners observed by Glaser et al. (2000). Therefore, we can infer that in our study, the use of a sweet-tasting flavor agent added to the drinking water stimulated the oronasal sensing mechanisms and improved piglet feeding behaviour, increasing voluntary water intake.

Recent studies have indicated that a higher water intake can have a positive impact on feed intake (Roura and Tedó, 2009). In our study the highest flavored water level improved voluntary water intake by 24% (i.e. +1.3 L/ piglet) in relation to the control, and these same piglets also showed an improved creep feed consumption of 22% (i.e. +205 g/ litter) when compared to control. Similar to our findings, Van Enckevort (2001) who evaluated the impact of providing additional flavored water on feed intake of piglets during nursing phase, reported that although the piglets in the flavor treated group had on average a lower birth weight, they still showed a higher feed intake throughout the lactation phase when compared to the control group. Still in this same study, the author´s findings indicated on average a voluntary intake of 1.02 L of water/ piglet in the flavored water treatment. In our study, piglets benefited from a higher water and creep feed intake, resulting in an additional daily gain of 110 g/ d/ piglet and additional +1.95 kg/ piglet at weaning for the animals receiving the highest flavor level when compared to control. Similarly, Van Enckevort (2001) also observed that the piglets that received the flavored water also showed and improved daily gain, resulting on an additional 400 g of weight at weaning. The differences observed in gains between our findings and the previous author could be related to piglet weight at start of the trial, as our piglets were heavier and where more uniform or even the level of inclusion or composition of the water flavor that was used in the study.

The supply of flavored water in the farrowing unit can benefit suckling piglets under various circumstances, one of the most important being the improvement in renal functioning and also in diarrhoea processes, stimulating solid diet intake, hydrating the animal, favouring physical-chemical breakdown of feed, increasing feed palatability. The result is a higher intake when compared to animals with water restriction in the farrowing unit (Torrey et al., 2008). With a higher water intake and supplementation of solid feed, animals show an improved weight gain and probably a better intestinal maturation, which could help decreasing the critical effects of post-weaning transition.

4.2. Nursery phase

Weaning is one of the most stressful times in the pig production cycle, and is associated with adverse effects during this stage: the separation from the mother, a change of environment, the mixing with animals from different litters and the change of the diet, among other factors. All these produce a negative stress in the piglet and a neophobia to the feed that results in a low feed intake at the weaning.

As piglets are generally weaned much earlier than in natural conditions, an early learning experience can be specially interesting for this species, because the increase in the preference for a certain type of flavors can help motivate the piglets to drink water and consume solid food at weaning, and therefore improve their welfare, reduce the early weight loss and the diarrhea incidence. Post-weaning diarrhea is a common problem, due to the fact that the gastrointestinal tract is still under maturation process (Quadros et al., 2002). Diarrhea can reduce weight gain and, in some cases, damages the gastrointestinal villi. All these changes and stressors during the transition phase in the early life of the piglet can have a negative impact on performance during the nursery phase (Boudry et al., 2004). Therefore, to help the animals through this stressful period, nutritional support and care are essential. According to Roura and Tedó (2009), the imprinted preference for certain flavoring compounds are long lasting in piglets, therefore, using sensory imprinting (precocious learning) strategies could allow to create a preferential effect through the tastes and flavors of the diet or water. Several authors (Roura and Tedó, 2009) have demonstrated the benefits of pre- and post-natal associated with post-weaning exposure to a flavor on piglet behaviour via using feed flavors in the sow´s diet or even in the piglet´s creep feed. Nevertheless, the use of water flavor during nursery or even associated with a sensory imprinting link with post-weaning has never been attempted, therefore our findings are novel information. In addition, there is a lack of scientific data on voluntary water intake in piglets during nursery and initial post-weaning phase. Brooks et al. (1984) demonstrated that it can be difficult for piglets to find water and feed in the first hours after weaning and this intake tends to improve only 2 days after weaning. Transition from a liquid diet to a totally solid diet involves a series of physiological alterations. When the sow's milk is withdrawn as the main source of nourishment there is a decrease in the animal's nutritional intake (Mellor, 2000). The increase in feed intake as a result of higher water intake is an important source of nutrients for the animal, improving growth rates during the transition period.

The peripheral senses particularly the smell, the taste and the oral somatosensing interpret those stimuli relevant to feed and water location and nutritional value (Dulac, 2000; Forbes, 1998; Roura et al., 2008a). According to Roura and Tedó (2009), the taste system is defined as the oral chemosensory system that recognises a diverse repertoire of non-volatile compounds. Not less than five different tastes have been defined and are widely accepted: sweet, umami, salty, sour and bitter. Sweet taste is related to carbohydrates such as sugars (Roura and Tedó, 2009). Sweetness is associated with a pleasurable taste in pigs (Drewnowski et al., 2012). Legagneur and Fevrier (1956) showed increases in feed consumption after dietary inclusion of 3 or 5% of sucrose. In the same direction, Kennedy and Baldwin (1972) studied taste preferences to sweet solutions. According the authors findings, pigs responded to sucrose, glucose and sodium saccharin in water. The threshold preference ranged from 0.005 to 0.01M for sucrose, from 0.01 to 0.03M for glucose and from 0.01 to 0.10M for sodium saccharin. For these substances piglets showed consistent preferences. The threshold preference was between 0.005 to 0.01M but pigs never showed preferences higher than 90%. Therefore, the addition of water flavor compounds may increase voluntary water and consequently stimulate feed consumption and help alleviate post-weaning stress and improve nutrient intakes (Frederick and van Heugten, 2006). Our findings agree with this statement, where piglets from the high level inclusion of flavor in the water ingested on average 5.1 L more water than the other piglets during the first week post-weaning. This higher water intake also stimulated a higher voluntary feed intake (+50%) which reflected on piglet performance (+72% piglet average daily gain). The improvement in these piglets' weight gain can be a direct influence of hydration and nutrient intake on intestinal villi length development and increase in the crypts depth improving feed efficiency usage. Feed absorption is higher with the higher production of digestive enzymes and more cells are produced, increasing enterocytes renewal on the villi (Pluske et al., 1996). These factors resulting from an increased water and feed intake contribute to the nutrition and maintenance of a healthier microbiota.

5. Conclusion

In conclusion, it might be safely deducted from the above that the inclusion of flavor compounds in the drinking water of the piglets during nursing and post-weaning phases has the potential to improve piglet performance. Our findings lead us to believe that the strategic use of a water flavor to manipulate the sensorial properties of water is a viable strategy to increase the piglet's voluntary water and feed intake and as a consequence improve litter performance at weaning and during the first week post-weaning all of which can help prepare the animal for the negative effects of the weaning process.

Author statement

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this material or similar material has not been and will not be submitted to or published in any other publication before its appearance in the Livestock Science Journal.

Authors' contribution

Category 1

Conception and design of study: Bruno A. N. Silva; Simon Eskinazi; David V. Jacob;

Acquisition of data: Kariny F. da Silva; Ronaldo L. S. Tolentino; Flavio I. G. Rebordões; Mateus F. Gonçalves; Valesca R. Lima; Iara Q. Ataíde; Bruno A. N. Silva;

Analysis and/or interpretation of data: Bruno A. N. Silva; Wagner A. G. Araujo; Simon Eskinazi; David V. Jacob;

Category 2

Drafting the manuscript: Kariny F. da Silva; Bruno A. N. Silva;

Revising the manuscript critically for important intellectual content: Bruno A. N. Silva; Simon Eskinazi; David V. Jacob;

Category 3

Approval of the version of the manuscript to be published:
Kariny F. da Silva;
Bruno A. N. Silva;
Simon Eskinazi;
David V. Jacob;
Wagner A. G. Araujo;
Ronaldo L. S. Tolentino;
Flavio I. G. Rebordões;
Mateus F. Gonçalves;
Valesca R. Lima;
Iara Q. Ataíde.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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Supplementary materials

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