CAPÍTULO 2

Non-conventional food plants in addition to pig feedstuff

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ABSTRACT: In pig farming, during the nursery phase, a taste enhancer is added to increase the acceptance of the feedstuff. During the termination phase, food consumption is reduced due to appetite loss due to the changing locations. Therefore, searching for economically sustainable alternatives for feeding these animals is important. was his study aimed to analyze the effect of adding brans made of *Pereskia aculeata* and *Stevia rebaudiana*, which are non-conventional food plants (NCFP), to pig feedstuff on daily weight gain (DWG) and food conversion (FC) in pig nursery and termination phases. At termination, *P. aculeata* bran was added to the feedstuff at 2.5, 5.0, and 10%. In the nursery phase, there were three treatments: *S. rebaudiana* bran - 8 g kg^{-1} (RS); *P. aculeata* bran - 5% (RP); bran *P. aculeata* - 5% and *S. rebaudiana* bran - 8 g kg^{-1} (RPS); control, comprised of feedstuff alone. For the termination phase, adding 5% of P. aculeata bran decreased FC, corresponding to the reduction of 1.60 kg of feedstuff for each kilo of body weight produced by the animals. Although FC did not differ between treatments in the nursery, it was lower in SF, corresponding to 1.5. The NCFPs tested showed potential as an addition to pig feedstuff, both for increased nutritious value, as was the case of *P. aculeata* for animals at the termination phase, and for attracting animals in the nursery phase, as is the case of *S. rebaudiana*.

KEYWORDS: Animal nutrition, *Pereskia aculeata*, *Stevia rebaudiana*, pig farming.

INTRODUCTION

Brazil currently occupies the fourth position in the ranking of pork production and exportation (USDA 2022) with great influence on the Brazilian economy. Therefore, it is important to optimize this activity so that its profitability is enhanced. According to Woloszyn *et al.* (2005), pig production systems are divided into farrow-to-finish (FTF), farrow-to-feeder (FTW), and feeder-to-finish (FTM). In each system, different managements are adopted, which encompass sanitation, ambiance, and nutrition, among others. In the farrow-to-finish system, the animals remain from birth to 28 days old, from 28 to 75 days in the farrow-to-feeder system and from 75 to 190 days in the feeder-to-finish. In these systems, ambiance and nutrition are essential factors for the good development of the animals. Pigs in the nursery phase receive up to three types of feedstuffs, and when they enter the termination phase, they receive up to six different types of feedstuffs so that they are ready for slaughter (Woloszyn *et al.* 2005). The base of these feedstuffs is nearly exclusively limited to maize and soybeans, which increases its cost as these are products with high market value due to the dollar exchange rate and decreases grain production due to adverse climate factors and the high demand for animal production (Ludke *et al.* 2021).

Feedstuff composition comprises proteins, micronutrients, and essential amino acids, among other elements that the animal requires in each life stage. In the feedstuffs of the nursery phase, a taste enhancer is added so that the acceptance of the feedstuff by the pig increases and consumption is encouraged, as weaning is performed early by changing liquid food to solid, and thus, taste enhancer is an important factor to increase the interest of the animal in food. According to Taveira (2017), many industrialized taste enhancers are widely used, from molasses to essences such as vanilla, and they ultimately increase the cost. In the termination phase, transportation and exchanging animals from one system to the other causes stress, even though measures are adopted to mitigate these factors. In termination, consumption is reduced as the animals lose appetite with changes in locations, and consequently, recently accommodated animals lose weight, which delays development (Woloszyn *et al.* 2005).

Therefore, searching for economically sustainable alternatives for feeding these animals is important. However, studies that evaluate the addition of plants other than those traditionally used for animal consumption are scarce. One option to improve weight gain could be the availability of a more tasteful and protein-rich diet. Non-conventional plant foods (NCFP) are poorly explored, have protein potential, and can act as natural taste enhancers, which might improve the quality of the food and reduce production costs. Souza et al. (2020) added *Pereskia aculeata* Mill. (Ora-pro-nóbis) to the feedstuff after it had been dehydrated and milled and increased the nutritional potential of the food as it offered a higher number of proteins and micronutrients. On the other hand, studies showed that recently weaned piglets (Taveira 2017) in the nursery phase, which fed on feedstuff moistened with *Stevia rebaudiana* (Bertoni) Bertoni (Estévia) extract, took less time to eat solid food due to its sweetening power, compared to those which did not eat the feedstuff with the extract. Therefore, the study aimed to evaluate if adding *P. aculeata* and *S. rebaudiana* might increase the nutritious value of conventional pig feedstuff in the nursery and termination phases, improving food conversion.

MATERIALS AND METHODS

Before the experiments began, the project for this study was submitted to the Comissão de Ética no Uso de Animais da Univates (Ceua/Univates) (Ethic Commission for the Use of Animals from Univates) and approved by Protocol numbers 25 and 29.

Stevia rebaudiana (Figure 1) plants were cultivated in a greenhouse with dripping irrigation. Sprouts were periodically cut and maintained in a greenhouse with air circulation (MA/035 model) at 45°C until they reached constant weight (Silva *et al.* 2019). Subsequently, they were ground using an industrial blender and stored in a dry location until they reached 2.5 kg of *S. rebaudiana* bran.

Figure 1. Stevia rebaudiana in pots.

Pereskia aculeata (Figure 2) branches were collected from gardens of private properties in the central region of Rio Grande do Sul (RS), all of which were close to each other. Leaves were collected manually and maintained in a greenhouse for dehydration until they reached constant weight when ground using an industrial blender and stored in a dry location until they reached 36 kg of dry biomass, which was enough to conduct both experiments. Six replicates were conducted using 200 g of green/fresh leaves of *P. aculeata*, which were dried in a cyclone greenhouse at 45-50ºC, to quantify their dry matter. Dry matter (DM) was calculated using this equation: DM = incoming weight of recently collected leaves in the furnace – outgoing weight from the furnace.

Figure 2. Pereskia aculeata flowering in the field.

Chemical characterization and bioaccessibility of *Pereskia aculeata*

Pereskia aculeata bran and pig feedstuffs were submitted to analysis for quantifying protein, ash, moisture, lipids, crude fiber, and carbohydrates, following the methodology of the Adolfo Lutz Institute (2008) (Zenebon *et al.* 2008). To evaluate bioaccessible contents of calcium (Ca), sodium (Na), and potassium (K), these elements were evaluated in the *P. aculeata* bran, in the feedstuff used to feed animals in the tests, and in the mix of feedstuff with *P. aculeata* (5%). This procedure was conducted in the chemical laboratory of Univates, and an in vitro digestion was simulated using alpha-amylase, pepsin, and bile (colic acid and deoxycholic acid) to simulate the digestion stages, following the procedure adapted from Minekus *et al.* (2014).

Effects of the addition of *Pereskia aculeata* to the feedstuff in the termination phase

The first experiment was conducted in Relvado, Rio Grande do Sul (RS), on a pig farm of an integrator company, with a capacity for 400 pigs in the termination phase, the period before the animals go out for slaughter. The pigs used were from the Danbred breed, resulting from Landrace, Yorkshire, and Duroc crossing. The experiment took place in the first two weeks of this system housing, and each animal was adequately numbered and measured (height, length, thorax circumference, and incoming weight, using a metric tape and a digital scale). The test was performed with three *P. aculeata* bran concentrations added to the standard feedstuff of the pigs: (I) 2.5%, 9.2, and 10 g for the 1st and 2nd weeks, respectively; (ii) 5.0%, 18.4, and 20 g; and (iii) 10%, 36.8, and 40 g, comprising three treatments. There was an additional treatment, which was the control (iv), comprised only of standard pig feedstuff made of maize, soybeans, and premix MigPlus® (folic acid and pantothenic acid), biotin, cobalt, copper, choline, iron, phytase, iodine, manganese, niacin, selenium, vitamins A, B1, B12, B2, B6, D3, E, K3, zinc, and flavomycin) for the phase in question.

In the treatments with the addition of bran, it was manually mixed with the standard feedstuff every day and stored in a dry location with no contact with light. Eight animals were used for each treatment: four males and four females, totaling 32 animals. The feedstuff of each treatment was provided daily to the animals for 14 consecutive days, distributed equally in three daily meals. In the first week, 400 g were provided per meal, and in the second week, 437 g were provided. After 14 days of the experiment, all animals were measured and weighed again, returning to their rearing system.

Effects of the addition of *Pereskia aculeata* and *Stevia rebaudiana* to the pig feedstuff in the nursery phase

The second experiment was conducted in Cruzeiro do Sul, RS, on a pig farm of an integrator company, with a capacity for 1000 pigs in the nursery phase, the period before termination. The experiment occurred in the last three weeks of this system's housing. Eight animals were used for each treatment; four males and four females, totaling 32 animals, each one identified according to treatment. As with the first experiment, the incoming and outgoing weights were measured.

Four treatments were established: control (CF), comprised of only feedstuff, feedstuff with *S. rebaudiana* (8.0 g kg^{-1} feedstuff) (SF), feedstuff with *P. aculeata* bran (PB), and feedstuff with *S. rebaudiana* (8 g kg^{-1}) and *P. aculeata* (5%) (OSF). The concentration of *P. aculeata* that triggered the best food conversion was that of the first experiment (5%). *Pereskia aculeata* and *S. rebaudiana* brans were mixed with the standard pig feedstuff. They were provided daily to the animals for 21 consecutive days, corresponding to a mean value of 19.65 kg per day for each animal, repeating the same procedure of mixing and storing as in the first experiment.

Physico-chemical characterization of the pig feedstuff

One portion of the feedstuff with 2.5% and 5% of *P. aculeata*, used in the first experiment, as well as the pure feedstuff, were forwarded to the Animal Nutrition Laboratory of Unianálises (Uni-analysis), Univates, Lajeado, for a physical-chemical analysis. The feedstuff with 10% of *P. aculeata* was not analyzed due to the unsatisfactory result of the test and the high cost of performing it. The analyses followed the methods described in the Brazilian Compendium of Animal Diet (Brasil 2017): Method No. 05 to quantify ash (Mineral Matter); Method No. 41 to determine calcium and total phosphorus; Method No. 18 for crude fiber; Method No. 14 for lipids/fat (extraction); Method No. 46 to quantify crude protein; and Method No. 53 to quantify moisture.

Data analysis

The variables of both experiments were analyzed first using the Shapiro-Wilk test to check data normality, followed by a one-way analysis of variance (one-way ANOVA) and Tukey's test to compare mean values ($p<0.001$ and $p<0.05$) using the statistical program Sigmaplot 14.5.

In the first experiment, the variables food conversion, total weight gain, and daily weight gain did not pass the normality using the Shapiro-Wilk test and were transformed using the equation $\sqrt{(x+0.1)}$ for food conversion and the inverse of $\sqrt{x}$ for the other two variables. The latter, however, are represented by their original values. In the second experiment, however, only food conversion did not pass the Shapiro-Wilk test and was $\log(x/10)$ transformed; again, it is represented by its original values.

RESULTS AND DISCUSSION

Characterization of *Pereskia aculeata bran*

The food-science analysis of *P. aculeata* bran showed that it has 93.18% moisture, 38.46% proteins, 4.34% lipids, 1.42% carbohydrates, 1.91% lipids, and 8.32% crude fiber. When compared to other vegetables, *P. aculeata* has higher nutrient concentrations. Lettuce (*Lactuca sativa* L.), for instance, has higher amounts of ash (0.67%), proteins (1.09%), and total fat (0.16%), and higher amounts of carbohydrates (4.07%) (USDA 2022). Compared to other edible vegetables, such as the bocaiúva fruit, *Acrocomia aculeata* (Jacq.) Lodd, moisture (52%), ash (1.51%), protein (1.51%), and fiber (8.14%) contents are lower. The percentage of lipids in *A. aculeata*, on the other hand, is higher (13%). Additionally, comparing it with other NCFPs, such as *Boehmeria caudata* Sw. (urtiga mansa) (24.15%), *Coronopus didymus* (L.) Sm. (mastruz) (28.175%), *Heteranthera reniformis* Ruiz & Pav. (agriãozinho-do-brejo) (23%), and *Phenax uliginosus* Wedd. (24.15%), (Kinupp & Barros, 2008), *P. aculeata* has the highest protein content. Alternatively, in grains for animal use, such as maize and soybean bran, which comprise the base of animal feedstuff, protein contents are 9.27% and 48.18%, respectively (Veloso *et al.* 2005). Therefore, the high protein value in *P. aculeata* emphasizes its potential to be used as a substitute or supplement to pig feedstuff.

Thus, the addition of *P. aculeata* bran to the feedstuff caused changes in its composition (Table 1), especially in ash and fibers, and this increase was higher at the concentration of 5% bran. However, at this same concentration, there was no variation in protein amount. Lipids and moisture, on the other hand, had higher values in the control feedstuff, and these values decreased slightly with an increased percentage of *P. aculeata* bran.

Pereskia aculeata **bran in the feedstuff**	**Ash**	**Crude ash**	**Total phosphorus**	**Lipids/ Fat**	**Crude protein**	**Moist**
			(%)			
0	4.34	1.6	0.34	7.3	17.5	12.0
2.5	4.66	1.8	0.35	6.8	17.3	11.8
5	5.32	2.1	0.33	6.6	17.3	11.6

Table 1. Characterization of the percent composition of pig feedstuff with different concentrations of *Pereskia aculeata* Mill. bran. Font: Pinós *et al.* (2024).

The protein contents of the treatments were not greatly different, which shows that the protein potential of *P. aculeata* bran can be equivalent to conventional feedstuff.

Bioaccessibility of *Pereskia aculeata*

Total and bioaccessible Ca and K concentrations (Table 2) in the standard feedstuff were 0.26 and 4.48 mg g^{-1}, respectively, and after the in vitro gastrointestinal simulation, bioaccessibility was 16 and 51%. *Pereskia aculeata* bran had total Ca and K of 16.06 and 40.45 mg g^{-1}, respectively, and bioaccessibility of 0 and 24%. The feedstuff with the addition of *P. aculeata*, on the other hand, had total Ca and K of 0.48 and 8.9 mg g^{-1}, respectively, and bioaccessibility of 0 and 56%. The digestion simulation of *P. aculeata* and the measurement of Ca and K bioaccessibility showed that when the NCFP bran was evaluated separately, only K was bioaccessible. The feedstuff had bioaccessible contents of both Ca and K, and the addition of *P. aculeata* bran to the feedstuff enhanced K bioaccessibility while it was unfavorable to Ca.

Sample	Total Ca (mg g^{-1})	CaBio (mg g^{-1})	BioCa (%)	Total K (mg g^{-1})	Kbio (mg g^{-1})	BioK (%)
Standard Feedstuff	0.26	0.042	16	4.48	2.27	51
P. aculeata	16.06	0	0	40.45	10.05	24
Feedstuff + *P. aculeata*	0.48	0	0	8.90	5.04	56

Table 2, Calcium (Ca) and potassium (K) concentrations in the standard feedstuff, of *Pereskia aculeata* Mill. bran, and of the feedstuff with the addition of *P. aculeata* bran (5%) (CaBio= Bioaccessible calcium; BioCa= bioaccessibility of calcium; KBio= bioaccessible potassium; BioK= bioaccessibility of potassium). Font: Pinós *et al.* (2024).

Regarding bioaccessibility, not always the addition of a new ingredient might help increase all minerals, as it depends on chemical forces and interactions related to the sources of minerals when mixing (Cozzolino 2012). This fact was observed in this study, as Ca was not accessible, even when mixed with the standard feedstuff.

Effects of the addition of *Pereskia aculeata* to the pig feedstuff on the termination phase

The difference between the measurements of length, circumference, and height in the animals at the beginning and end of the experiments did not differ between treatments ($p<0.001$) (Table 3). However, the highest height was attained in the treatments with the addition of 5% and 2.5% bran. The largest circumference was obtained in the treatment with 2.5% and the longest length was obtained in the treatment with 5%. There was no significant difference ($p<0.001$) in the variables TWG, DWG, and FC between treatments, either. The best FC was in the 5% treatment, corresponding to the consumption of 1.60 kg of feedstuff for each kilo of weight produced by the animals. In the control, FC was 1.77, while FC was 1.68 with the addition of 2.5% bran. The lowest FC was reported in the 10% treatment (1.95). Fernandes *et al.* (2004) reported that TWG is directly associated with herd yield, and FC represents the efficacy with which the animal converts the food consumed into meat, leading to lower costs in production.

Treatment	TWG	DWG	FC	LG	HG	CG
	(kg)			(cm)		
0	10.02^{ns}	0.72^{ns}	1.77^{ns}	10.25^{ns}	4.63^{ns}	7.13^{ns}
2.5	11.40	0.81	1.68	10.88	5.50	8.75
5	11.32	0.80	1.60	11.25	5.50	6.25
10	9.15	0.65	1.95	10.13	3.88	6.88

ns = not significant (p>0.001), there is no statistical difference between the mean values of all treatments according to ANOVA (p<0.001).

Table 3. Mean total weight gain (TWG), daily total weight gain (DWG), food conversion (CA), length gain (LG), height (HG), and circumference (CG) of pigs in the termination phase (experiment 1) fed with feedstuff containing different concentrations of *Pereskia aculeata* Mill. bran (0 = standard pig feedstuff; 2.5 = standard pig feedstuff with the addition of 2.5% bran; 5 = standard pig feedstuff with the addition of 5% bran; 10 = standard pig feedstuff with the addition of 10% bran). Font: Pinós *et al.* (2024).

Therefore, the results obtained in the 5% treatment show that there will be a reduction of 14.1% compared to conventional feedstuff, which shall correspond to 10.6% in production cost, considering that the expenses with feeding correspond to 75% of the total production of animals (Volpato *et al.* 2015). The pig price must be at least 4.4 times higher than the feedstuff price for the breeder to balance the costs with the animal sale price (Portes *et al.* 2019). Therefore, better food conversion and the best foodstuffs are essential for sustainable activity, which is ensured by the addition of *P. aculeata*, as it promotes better weight gain for the animal and reduces the amount of maize and soybean bran required for feedstuff composition.

The best FC obtained in experiment 1, with the addition of *P. aculeata* bran, is related to the higher amount of bioavailable K, as K is one of the most abundant minerals in the pig's body. According to the National Research Council (2012), K is involved in electrolytic balance and neuromuscular function. In an experiment conducted with pigs in the growing phase with different levels of addition of Cl^- and K to the feedstuff, an increase of 0.03% to 0.6% in dietary Cl^- reduced young pig growth rate when the diet contained 0.1% K, but increased growth when the diet had 1.1 % of dietary K (Golz & Crenshaw 1990).

On the other hand, an increase in crude fiber, according to Paternoster *et al.* (2021), favors the digestion of food and improves the physiological maintenance of the intestine, favoring and increasing the absorption of food by the animals. However, there is the risk of increasing the pass ratio and decreasing food energy, and it is thus necessary to avoid having too high levels of fiber in the diet (Lee *et al.* 2022). This did not occur in this experiment, as no change in the texture of the animal feces was observed, and neither was in the physical appearance of the pigs; their measurements were calculated and did not differ from each other, and there was improved FC in the animals.

Effects of the addition of *Pereskia aculeata* and *Stevia rebaudiana* to pig feedstuff in the nursery phase

In the nursery phase, experiment 2 showed higher TWG and DWG values in the control treatment (13.88 kg and 0.66 kg, respectively) (Table 4). Therefore, this treatment only significantly differed ($p<0.001$) from the SF treatment, as its mean value was lower (9.63 kg and 0.46 kg, respectively). Thus, the lowest values of the two variables occurred in SF. However, with the addition of *S. rebaudiana* (OFS), the values slightly increased, and they only increased even more when *S. rebaudiana* was added (SF). Although the values in SF were lower than in CF, the comparison between PF and OFS shows that *S. rebaudiana* improved feedstuff palatability, inducing consumption and reducing feedstuff waste. The cause is probably the animals' rejection of feedstuff with PF due to the low palatability caused by adding P. aculeata bran since the animals in this phase prefer sweeter tastes (Martinez 2012). According to Budiño *et al.* (2014), after fifty-one days of life, the piglets already did not need much encouragement to consume the food, and the taste-enhancer could be gradually reduced. This suggests that in the early nursery phases, palatability should be enhanced. Young piglets have a more selective taste and are more sensitive to less sweet

Treatment	TWG	DWG	FC
	(kg)		
CF	13.88 a	0.66 a	1.60^{ns}
SF	11.75 ab	0.56 ab	1.53
PF	9.63 b	0.46 b	1.74
OSF	11 ab	0,52 ab	1.84

*Means followed by different letters in the same column differed according to Tukey's test at a level of 1% of error probability; ns=not significant.

Table 4. Mean values of total weight gain (TWG), daily weight gain (DWG), and food conversion (FC) in pigs in the nursery phase with the addition of *Stevia rebaudiana* (Bertoni) Bertoni and *Pereskia aculeata* Mill. brans (CF = only standard pig feedstuff; SF = feedstuff with the addition of *S. rebaudiana* bran; PF = feedstuff with *P. aculeata* bran; OFS = feedstuff with *P. aculeata* and *S. rebaudiana* bran). Font: Pinós *et al.* (2024).

On the other hand, although there was a significant difference in FC between treatments ($p<0.001$), it was better in SF (1.53 kg). The difference in FC between SF and CF was 0.07 kg less feedstuff used per live weight gained, with a reduction of 9.37% in feedstuff consumption and 7.03% in production cost. This shows that *S. rebaudiana* can be used as a potential natural taste enhancer, and it might contribute to an economically sustainable activity.

CONCLUSION

Pereskia aculeata bran has nutritious potential and is an additive for nutritional supplementation of feedstuffs in the termination phase. Its addition improves the food conversion performance of animals, reaching the best result with up to 5% of standard pig feedstuff. We believe that adding *S. rebaudiana* bran to the standard feedstuff improves palatability, resulting in improved FC of piglets in the nursery phase.

The tested NCFPs showed potential for addition to pig feedstuff for nutritional increase, both for animals in the termination phase, as is the case of *P. aculeata*, and for animals in the nursery phase, as is the case of *S. rebaudiana*. However, further studies are required to analyze longer feeding times, different pig rearing phases, further analyses for nutrient specifications, and evaluation of different pig species to provide further information to breeders and consumers.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The study conception and design were performed by Rodrigo Nis Pinós, Lucélia Hoehne and Elisete Maria de Freitas. Material preparation, data collection and analysis were performed by Rodrigo Nis Pinós, Amanda Pichani Primaz, Mathias Hofstätter, Ani Caroline Weber, Aline Viana, Guilherme Schwingel Henn, Sabrina Grando Cordeiro, Bruno Eduardo da Silva, Cristina Jardim Cezar Mariano, Amanda Pastório Borges, Julia Gastmann and Mara Cíntia Winhelmann. Data curation, data validation and project supervision were performed by Lucélia Hoehe and Elisete Maria de Freitas. The first draft of the manuscript was written by Rodrigo Nis Pinós and all authors commented on previous versions of the manuscript. All authors read and approved of the final manuscript.

REFERENCES

BARBOSA, K. A.; GENOVA, J. L.; PAZDZIORA, M. L.; AZEVEDO, L. B.; WENDT, G. N.; RUPOLO, P. E.; RODRIGUES, G. A.; CARVALHO, S. T.; SILVA, L. F. C.; COSTA, L. B.; SARAIVA, A.; CARVALHO, P. L. O, 2022 - Effects of combined feed additives in diets to support growth performance and intestinal health profile in nursery piglets. *Livestock Science*, 266: 105121. Doi: https://doi.org/10.1016/j.livsci.2022.105121

BRASIL, 2017 - Ministério da Agricultura Agropecuária e Abastecimento. Sindicato Nacional da Indústria de Alimentação Animal. Associação Brasileira da Indústria de Alimentação Animal. Colégio Brasileiro de Nutrição Animal. *Métodos analíticos.* In: Compêndio Brasileiro de Alimentação Animal. São Paulo.: Sindirações. 263p.

BUDIÑO, F. E. L.; LUCCHESI, L.; OTSUK, I. P., 2014 - Uso de edulcorante como palatabilizante na dieta de leitões desmamados. *Boletim de Indústria Animal*, 71: 58-62. Doi: https://doi.org/10.17523/bia.v71n1p58

COZZOLINO, S. M. F., 2012 - *Biodisponibilidade de Nutrientes.* 4. ed. Barueri: Manole Ltda. 910p.

FERNANDES, H. J.; PAULINO, M. F.; MARTINS, R. G. R.; VALADARES FILHO, S. C.; TORRES, R. A.; PAIVA, L. M.; MORAES, G. F. B. K., 2004 - Ganho de peso, conversão alimentar, ingestão diária de nutrientes e digestibilidade de garrotes não-castrados de três grupos genéticos em recria e terminação. *Revista Brasileira de Zootecnia*, 3: 2403-2411. Doi: https://doi.org/10.1590/S1516-35982004000900029

GOLZ, D. I.; CRENSHAW, T. D., 1990 - Interrelationships of dietary sodium, potassium and chloride on growth in young swine. *Journal of Animal Science*, 68: 2736-2747. Doi: https://doi.org/10.2527/1990.6892736x

KINUPP, V. F.; BARROS, I. B. I., 2008 - Teores de proteína e minerais de espécies nativas, potenciais hortaliças e frutas. *Ciência e Tecnologia de Alimentos*, 28: 846-857. Doi: https://doi.org/10.1590/S0101-20612008000400013

LEE, G. I.; HEDEMANN, M. S.; JØRGENSEN, H.; BACH KNUDSEN, K. E., 2022 - Influence of dietary fiber on nutrient digestibility and energy utilization in growing pigs fed diets varying in soluble and insoluble fibers from co-products. *Animal: The International Journal of Animal Biosciences*, 16. Doi: https://doi.org/10.1016/j.animal.2022.100511

LUDKE, J. V.; BERTOL, T. M.; CARMO, M. R.; LUDKE, M. DO C. M. M., 2021 - Alternativas para redução dos custos com a alimentação dos suínos. *Suinocultura Industrial*, (4): 18-23.

MARTINEZ, J. F., 2012 - *Palatabilizantes em dietas de leitões recém-desmamados.* Pirassununga: Faculdade de Zootecnia e Engenharia de Alimentos, Universidade de São Paulo. 72p. (Dissertação em Qualidade e Produtividade Animal).

MINEKUS, M.; ALMINGER, M.; ALVITO, P.; BALLANCE, S.; BOHN, T.; BOURLIEU, C.; CARRIÈRE, F.; BOUTROU, R.; CORREDIG, M.; DUPONT, D.; DUFOUR, C.; EGGER, L.; GOLDING, M.; KARAKAYA, S.; KIRKHUS, B.; LE FEUTEUN, S.; LESMES, U.; MACIERZANKA, A.; MACKIE, A.; MARZE, S.; MCCLEMENTS, D. J.; MÉNARD, O.; RECIO, I.; SANTOS, C. N.; SINGH, R. P.; VEGARUD, G. E.; WICKHAM, M. S. J.; WEITSCHIES, W.; BRODKORB, A. A., 2014 - Standardized static in vitro digestion method suitable for food – an international consensus. *Food and Function*, 5: 1113-1124. Doi: https://doi.org/10.1039/C3FO60702J

NATIONAL RESEARCH COUNCIL, 2012 - *Nutrient requirements of swine: Committee on Nutrient Requirement of Swine Board on Agriculture and Natural Resources Division on Earth and Life Studies.* 156. ed. Washington: The National Academies Press. 424p.

PATERNOSTRE, L.; BOEVER, J. D.; MILLET, S., 2012 - Interaction between fat and fiber level on nutrient digestibility of pig feed. *Animal Feed Science and Technology*, 282. Doi: https://doi.org/10.1016/j.anifeedsci.2021.115126

PORTES, J. V.; LACERDA, V. V. DE; BRACCINI NETO, J.; SOUZA, A. R. L., 2019 - Análise dos custos da cadeia produtiva de suínos no Sul do Brasil. *Custos e @gronegócio on line*, 15: 18-41.

SILVA, M. L. T.; BRINQUES, G, B.; GURAK, P. D., 2019 - Utilização de farinha de subproduto de brotos para elaboração de massa alimentícia fresca. *Brazilian Journal of Food Technology*, 22. Doi: https://doi.org/10.1590/1981-6723.06318

SOUZA, R. I. DE; RADIS, A. C.; BARBOSA, J. F., 2020 - Substituição do Farelo de Trigo por Farelo de Ora-pro-nóbis (*Pereskia aculeata*) em dietas para frango de corte. In: *Congresso Brasileiro de Agroecologia*, 11., Sergipe, Anais. Sergipe: UFS.

TAVEIRA, V. M., 2017 - *Uso de palatabilizante para matrizes suínas lactantes* e *para os leitões recém desmamados.* Curitiba: Universidade Federal do Paraná. 55p. (Dissertação em Nutrição de Monogástricos).

USDA, 2022 - U.S. Departament of Agriculture. Agricural Researsh Service - National Nutrient Database. Available at: https://fdc.nal.usda.gov/. Accessado em Novembro 16, 2022.

VELOSO, J. A. F.; MEDEIROS, S. L. S.; AROUCA, C. L. C.; RODRIGUEZ, N. M.; SALIBA, E. O. S.; OLIVEIRA, S. G., 2005 - Composição química, avaliação físico-química e nutricional e efeito da expansão do milho e do farelo de soja para suínos em crescimento. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, 57: 623-633. Doi: https://doi.org/10.1590/S0102-09352005000500008

VOLPATO, R. M.; OLIVEIRA, V. DE; GEWEHR, C. E.; PEREZ NETO, D., 2015 - Coprodutos da agroindústria na alimentação de leitões. *Ciência Rural*, 45: 86-91. Doi: https://doi.org/10.1590/0103-8478cr20130391

WOLOSZYN, N., 2005 - *Procedimento básico para a produção de suínos nas fases de reprodução, maternidade e creche.* 100.ed. Concórdia: Embrapa Suínos e Aves. 61p.

ZENEBON, O.; PASCUET, N. S.; TIGLEA, P., 2008 - *Normas Analíticas para análise de alimentos.* Métodos físico-químicos para análises de alimentos – edição IV. 1. ed. São Paulo: Instituto Adolfo Lutz. 1020p.