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Short Communication

Dehydrated brewery residue for pigs in the growth phase under high temperature conditions[1]

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ABSTRACT - This research was developed to evaluate the nutritional, digestible (DE) and metabolizable (ME) energy values of dehydrated brewery residue (DBR) for growing pigs, as well as to evaluate the performance of these animals, subjected to five levels of DBR inclusion (0, 5, 10, 15 and 20%). The experimental design was of randomized blocks, based on animal weight. In the digestibility assay, 12 male piglets of average weight of 34.8±4.8 kg were utilized, while the performance assay had 40 piglets with average weight of 26.7±3.3 kg. Digestible and metabolizable protein values of dehydrated brewery residue for growing pigs reared in an environment of high temperatures were 22.47 and 22.06%, respectively, whereas digestible and metabolizable energy values of DBR were 3,371 and 3,364 kcal/kg, respectively. Dehydrated brewery residue can be included in diets for growing pigs up to the level of 20%.

Key Words: alternative feedstuffs, barley, digestibility, metabolizability, performance

Introduction

The Brazilian pig farming has held an outstanding position, with production at industrial scale, and appearing among the most developed of the sector. However, pig farmers go through difficulties during a big part of the year, given the fluctuation in the supply of grains, interfering with the production costs and the profitability of this activity. This problem is more meaningful to the northeast region of Brazil, where pig rearing has played relevant social role and, in recent times, established itself as an important economic activity, although, on the other hand, the grain production has not followed this growth.

Alone, pig farming consumes 22% of all the corn produced in Brazil and, along with aviculture, adds up to 69% (Santos Filho et al., 2007). Since the financial success of pig entrepreneurships is intrinsically bound to the price of ingredients utilized at the elaboration of diets, experimenting with new ingredients which aim at the replacement, even partially, of corn and soybean meal - basic components of feed for monogastrics - is viable (Moreira et al., 2002).

Therefore, the search for new feeding alternatives increases, in which products, byproducts and industrial residues have emerged in animal nutrition, especially because of the apparent nutritional value that they present; the high levels of supply, resulting from the lack of definition in the use of these residues; and the perspective of reduction of costs to the producer.

Among the several alternative feedstuffs, brewery residue has stood out due to the abundance of supply because of the increase in the production of beer in Brazil, which rose from 6.6 million tons in 1997 to 7.3 millions in 2007 (FAO, 2009). Regarding the nutritional value, brewery residue presents digestible energy value of 2,100 kcal/kg for pigs, with levels of crude protein, lysine, methionine, tryptophan, calcium and total phosphorus of 26.50%, 1.08%, 0.45%, 0.26%, 0.32% and 0.56%, respectively (NRC, 1998). Higher values were observed by Rostagno et al. (2005) for crude protein (24%) and digestible energy for pigs (3,474 kcal/kg).

This research was developed in order to evaluate the nutritional and the digestible and metabolizable energy values of dehydrated brewery residue, as well as the performance of pigs subjected to five levels of inclusion of this residue: 0, 5, 10, 15 and 20%.

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Material and Methods

The study was developed at the Setor de Suinocultura of the Departamento de Zootecnia of Centro de Ciências Agrárias at Universidade Federal do Piauí, located in the municipality of Teresina, Piauí state, Brazil, whose geographical coordinates, according to the Prefeitura Municipal de Teresina (PMT, 2002), are 5º 05'12" south latitude and 42º48'42" west longitude, located at 72.2 m above the sea level, having hot subhumid tropical climate.

Two assays were carried out: one of digestibility and another of performance. In the digestibility one, 12 castrated male piglets of commercial strain with average initial weight of 34.8±4.8 kg were housed in cages for metabolic studies. Six piglets received the reference diet (Table 1), composed mainly of corn and soybean meal, so as to meet the minimum nutritional requirements of the animals (Rostagno et al., 2005). The six other animals received a test diet, with replacement of 30% by dehydrated brewery residue.

The wet brewery residue was subjected to a sun-drying procedure on brick dryer, during five days; residues were turned over twice daily, in order to facilitate the dehydration process. After dried, the material was ground to be incorporated to experimental diets, and a sample was removed for chemical and bromatological analysis.

Table 1 - Composition of reference diet for pigs in the growth phase and of dehydrated brewery residue

Ingredients	g/kg
Corn	761.70
Soybean meal	200.00
Soybean oil	7.25
Dicalcium phosphate	15.10
Limestone	4.85
Common salt	3.90
Mineral and vitamin pre-mix[1]	4.00
L-lysine HCl	3.20
Total	1,000.00
Calculated values[2]	
Crude protein (g/kg)	153.60
Metabolizable energy (kcal/kg)	3.382
Calcium (g/kg)	7.74
Available phosphorus (g/kg)	4.14
Digestible lysine (g/kg)	9.50
Digestible methionine (g/kg)	2.30
Sodium (g/kg)	1.80
Analyzed values of dehydrated brewery residue	
Dry matter (g/kg)[3]	218.00
Crude protein (g/kg)[4]	284.90
Crude fiber (g/kg)[4]	133.00
Gross energy (kcal/kg)[4]	4,932

[1] Mineral and vitamin pre-mix: Quantities per kilogram: vitamin A - 720,000 UI; vitamin D3 - 146,300; vitamin E - 3,038 mg; vitamin K3 - 160 mg; vitamin B1- 112.5 mg; vitamin B2 - 630 mg; vitamin B6 - 135 mg; vitamin B12 - 2.363 mcg; niacin - 3,600 mg; folic acid - 56.30 mg; pantothenic acid - 2,100 mg; Se - 67.50 mg; growth promoter - 10,000 mg; Ca- 230 g; P - 75 g; Na - 65 g; Fe- 4,000 mg; Cu - 4,500 mg; Mn - 400 mg; Zn - 4,000 mg; I - 30 mg; antioxidant - 2,000 mg.
[2] Rostagno et al. (2005).
[3] On a natural matter basis.
[4] On a dry matter basis.

The experimental period lasted 16 days: six days were destined to adaptation of animals to metabolic cages, three for settlement of the feed in the digestible tract and seven days for collection. Feed was supplied during the experimental period per unit of metabolic size (live weight - $LW^{0.75}$) twice daily, at 8h in the morning and 15h in the afternoon.

The method of total feces and urine collection without marker was utilized (Bayley, 1971). The feces collected, daily, were weighed and homogenized, and an aliquot of 20% was removed from the total content to be conditioned in plastic bag and stored in freezer (-10 ºC). The urine collection was performed utilizing a plastic bucket with screen on the edge. Twenty milliliters of hydrochloric acid were put in each bucket in order to avoid bacterial proliferation and nitrogen loss. The volume of urine was measured, and a sample was also taken and conditioned in identified plastic bottles, then stored in freezer. At the end of the experimental period, collected feces were defrosted and homogenized per cages; a new aliquot was then removed to be submitted to laboratory analyses, performed according to recommendations of the AOAC (1990). The same procedure was utilized for urine.

The calculation of nutrient digestibility was done according to Matterson et al. (1965) and Gomes (1988).

The bromatological composition and metabolizable energy values obtained in the digestibility assay of dehydrated brewery residue were utilized in the performance assay. For the latter, 40 commercial hybrid piglets were used: 20 castrated males and 20 females, with average initial weight of 26.7±3.3 kg.

The experiment was conducted in a randomized block design, based on animal weight, with five treatments and four repetitions, composed of one male and one female, housed in the same masonry shed, which was provided with common brick feeder and automatic nipple drinker.

One of the treatments consisted of a diet composed mainly of corn and soybean meal, supplemented with minerals and vitamins, and the other consisted of inclusion levels of 5, 10, 15 and 20% dehydrated brewery residue (Table 2), formulated so as to meet the minimum nutritional requirements of animals in the growth phase (Rostagno et al., 2005).

Feed was supplied *ad libitum* and replenished twice daily, at 8h and 15h, so that the trough always contained feed.

Ambient temperature and relative air humidity were measured daily by means of digital thermo hygrometer;

Table 2 - Centesimal and calculated composition of experimental diet for pigs in the growth phase

Ingredients	Inclusion level of dehydrated brewery residue (g/kg)				
	0	50	100	150	200
Corn (g/kg)	736.10	707.50	682.60	655.00	623.50
Soybean meal (g/kg)	226.0	208.00	185.90	165.00	146.50
Vegetable oil (g/kg)	7.50	4.50	1.50	0.00	0.00
Mineral/vitamin pre-mix[1]	30.00	30.00	30.00	30.00	30.00
Dehydrated brewery residue (g/kg)	0.00	50.00	100.00	150.00	200.00
L-Lysine HCl (g/kg)	0.40	0.00	0.00	0.00	0.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated values[2]					
Crude protein (g/kg)	158.40	159.00	158.40	158.00	158.30
Crude fiber (g/kg)	23.00	28.30	33.40	38.60	43.80
Metabolizable energy (kcal/kg)	3,235	3,232	3,230	3,229	3,231
Calcium (g/kg)	7.82	7.88	7.94	7.99	8.06
Available phosphorus (g/kg)	3.31	3.38	3.45	3.51	3.57
Digestible lysine (g/kg)	8.67	9.59	10.70	11.80	13.00
Digestible methionine (g/kg)	2.74	2.92	3.09	3.25	3.42
Sodium (%)	2.14	2.22	2.31	2.39	2.48

[1] Mineral and vitamin pre-mix: quantities per kilogram: vitamin A - 720,000 UI; vitamin D3 - 146,300; vitamin E - 3,038 mg; vitamin K3 - 160 mg; vitamin B1 - 112.5 mg; vitamin B2 - 630 mg; vitamin B6 - 135 mg; vitamin B12 - 2.363 mcg; niacin - 3,600 mg; folic acid - 56.30 mg; pantothenic acid - 2,100 mg; Se - 67.50 mg; growth promoter - 10,000 mg; Ca - 230 g; P - 75 g; Na - 65 g; Fe - 4,000 mg; Cu - 4,500 mg; Mn - 400 mg; Zn - 4,000 mg; I - 30 mg; Antioxidant - 2,000 mg.
[2] NRC (1998) utilized for the calculation of ingredients and energy of the brewery residue and Rostagno et al. (2005) for the other nutrients.

animal weighing was performed weekly until the average weight of the animals of each shed reached approximately 60 kg. The performance parameters assessed were: weight gain, feed intake and feed conversion.

The performance results were submitted to variance and regression analyses, regressing them with inclusion levels of dehydrated brewery residue in the experimental diets, according to procedures of SAS (Statistical Analysis System, version 6.11). The study adopted $\alpha = 0.05$.

Results and Discussion

The average temperature during the course of the digestibility assay was 28.6 ºC, and in the performance experiment, 31.1 ºC, while the relative air humidity was 74.3 and 33.6%, respectively. These results demonstrated that the temperatures were above the upper critical temperature of the thermoneutrality zone for pigs (Whittemore, 1980; Ferreira, 2000).

Protein had the best digestibility, probably because the fibrous fraction was well digested, even with the content of 133.00 g/kg of dehydrated brewery residue (Table 3). This elevated protein digestibility coefficient (788.60 g/kg) may be a consequence, according to Scheeman et al. (1982) and Li et al. (1994), of the diminution of the adsorption of amino acid and peptides from the protein of bacterial origin to the fiber matrix. However, Yen (2001) reported that dietary fiber and the resistant amino acids that were not digested in the small intestine go to the interior of the large intestine, where they are exposed to the microbial population for fermentation, affecting the production of digestive secretions, elevating the gastric, biliary and pancreatic secretions, causing reduction in the digestion of other nutrients, because the fiber adsorbs with them. However, the results of the present study show adequate levels of use, both of protein and energy, partially opposing to the observations of Yen (2001), because the replacement level of dry brewery residue of this study promoted approximately 6% crude fiber in the diet, and pigs weighing around 35 kg presented enzymatic system capable of using part of the fiber.

Table 3 - Coefficients of digestibility (CD) and metabolizability (CM) of the crude protein and gross energy of dehydrated brewery residue for pigs in the growth phase

Parameters	CD (g/kg)	CM (g/kg)
Crude protein	788.60	774.20
Gross energy	683.60	682.10

Of the total digestible protein and energy, the values of 18.30 and 2.20 g/kg were excreted in the urine, which characterizes that, once absorbed; a little fraction is eliminated via urine.

The nitrogen balance (Table 4) was positive, both in the control diet (22.58 g/day) and in the test diet (25.44 g/day), indicating that the residue neither interfered with the use of protein ingested, nor contributed to the excretion of endogenous protein. These data of nitrogen balance are consistent with those obtained in the crude protein digestibility and metabolizability assays of the present study.

Table 4 - Nitrogen balance values of control and test diets, of digestible and metabolizable protein and energy of dehydrated brewery residue (DBR) for growing pigs

Parameters	Values
Nitrogen balance of the control diet (g/day)	22.58
Nitrogen balance of the test diet (g/day)	25.44
Digestible protein of the DBR (g/kg)	224.70
Metabolizable protein of the DBR (g/kg)	220.60
Digestible energy of the DBR (kcal/kg)	3,371
Metabolizable energy of the DBR (kcal/kg)	3,364

The crude protein in the dry matter determined in this study was of 284.90 g/kg and the digestible one, 224.70 g/kg; this value was 3.3 superior to the digestible protein of the corn, which is 6.73% (Rostagno et al., 2005). The digestible protein value obtained is inferior to the 23.68 and 25.66% obtained by Capelle et al. (2001) and Depeters & Cant (1992), respectively.

Based on the results, one can verify that even in an environment of high temperatures, the energy value of the dehydrated brewery residue for pigs in the growth phase is very close to 3,460 kcal/kg of the digestible energy of the corn (Rostagno et al., 2005).

There was no effect (P>0.05) of inclusion levels of dehydrated brewery residue on the performance parameters, up to the level of 200 g/kg of inclusion, for the studied phase (Table 5). However, the average daily weight gain with 50 and 150 g/kg inclusion of dehydrated brewery residue was 10.0% and 6.5% superior to the treatment control, although feed conversion worsened in 16.6 and 10.8%. Results similar to this study were observed by Amaefule & Onwudike (2006), analyzing inclusion levels of dehydrated brewery residue for pigs in the starter and growth phases, in which there was no difference in the performance of these animals, except for the amount of protein ingested, although with no reflection on performance; there was also significant decrease in the cost with feeding.

The results obtained for the performance variables are coherent with the study of digestibility of the dry brewery residue nutrients, in which protein and energy digestibility coefficients close to 70% were observed, also with the digestible energy value close to that of corn, main energetic ingredient utilized at the formulation of diets for pigs. The value of 133.00 g/kg crude fiber of the dry brewery residue probably did not interfere with piglet performance, once in experimental diets this level became compatible for the diets of these animals, and also presented values quite inferior to 8%, which is considered acceptable by Cavalcanti (1984). Thus, it is also believed that with the fiber levels utilized in the dehydrated brewery residue in the diets, the peristaltic movements were not affected enough to harm nutrient absorption and consequently, did not interfere negatively with the performance results.

Since the parameters evaluated were not affected by the inclusion of up to 200 g/kg residue in the diets for growing pigs, the dehydrated brewery residue can constitute an important alternative ingredient to be incorporated in the formulation of growing pigs, especially in the offseason of corn and soybean, when there are alterations in the price of these ingredients.

Table 5 - Mean parameters of performance (animal/day) in the growth phase of pigs fed diets containing different levels of dehydrated brewery residue (DBR)

Parameters	Inclusion levels of DBR (g/kg)					CV (%)
	0	50	100	150	200	
Weight gain, kg[1]	0.771	0.848	0.798	0.821	0.784	12.20
Feed intake, kg[1]	1.73	2.15	2.06	2.02	2.12	11.50
Feed conversion[1]	2.22	2.59	2.58	2.46	2.72	13.95

CV - coefficient of variation.
[1] No significant effect (P>0.05).

Conclusions

The digestible and metabolizable protein values of dehydrated brewery residue for growing pigs reared in an environment of high temperature are 224.70 and 220.60 g/kg, respectively, whereas those of digestible and metabolizable energy are 3,371 and 3,364 kcal/kg. Dehydrated brewery residue can be included in diets for growing pigs up to the level of 200 g/kg.

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