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PRODUCTION OF FECES FROM PIGS IN THE FINISHING PHASE FED WITH DIFFERENT LEVELS OF CITRUS PULP WITH OR WITHOUT ENZYME COMPLEX

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Abstract: The objective was to evaluate the feces production of piglets in the finishing phase fed diets with different levels of citrus pulp (PC) inclusion (0, 5, 10 and 15%) with or without the addition of an enzyme complex. A randomized block design was used, in a 4 x 2 factorial scheme, with 8 treatments and nine replications, with treatments being 4 levels of citrus pulp x 2 diets with or without an enzyme complex. 72 pigs, castrated males, of the Topigs lineage, with an initial age of 126 days and weight of 82.75 ± 10.69 kg, were used, with each experimental unit consisting of one animal. The piglets were housed in individual masonry pens, measuring 2.55 m2 each, equipped with semi-automatic feeders and level drinking fountains, of the communicating vessel type. The study was divided into two experiments, in the first using the partial feces collection method, using insoluble acid ash as an indicator. The second method assessed total feces production. At the end of the experiment, it was found that the addition of the enzyme complex decreased the production of feces in relation to the animals in the treatment with 5% inclusion of PC without the enzyme complex in the dry matter, although it increased the production of feces in relation to the animals in the treatment with 15% PC inclusion without enzyme complex in the natural matter. The level of inclusion of citrus pulp determined the amount of feces produced by finishing pigs, with an increase being observed at levels of 5 and 15% inclusion. When using the enzyme complex, there was an interaction with the levels of citrus pulp that influenced the production of feces, mainly at the 5% level.
Keywords: alternative foods, enzymes, feces, fiber

INTRODUCTION

Pork is the third most consumed in Brazil and the country is the fourth largest producer and exporter of this animal protein (ABPA, 2015). The constant intensification and integration of agricultural and livestock systems have made pork more competitive, increasing production and the number of animals housed, which consequently leads to an increase in waste production.

Pig feeding represents around 60 to 80% of total costs in pig production, so the need to look for new alternative foods is necessary with the aim of reducing costs. However, the use of these foods depends on availability, in addition to their nutritional value and the presence of antinutritional factors.

An alternative that can help reduce production costs is the use of exogenous enzymes in the pig diet, since these products can improve the digestibility of nutrients (AMORIM, et al., 2011), and reduce the production of waste generated to the environment.

The importance of environmental impacts is currently being discussed, as there is concern about waste treatment and disposal in nature, which is becoming a bottleneck in pig production. The fact that most producers do not use adequate resources for waste management causes obstacles and embargoes for the export of pork to markets in several countries, mainly developed countries.

Therefore, the present work aimed to evaluate the production of feces in pigs in the finishing phase fed diets with different levels of citrus pulp, with or without an enzyme complex, using two methodologies.

MATERIAL AND METHODS

FACILITIES, ANIMALS AND EXPERIMENTAL DIETS

The trial was conducted in the Pig Farming Sector, Department of Animal Husbandry, Faculty of Agricultural and Veterinary Sciences – UNESP, Jaboticabal Campus. 72 pigs, castrated males, from the Topigs line, with an initial age of 126 days and 82.75 ± 10.69 kg of weight, from a commercial farm, were used. The animals were housed in individual masonry pens, measuring 2.55m2 each, equipped with semi-automatic feeders and level drinking fountains, of the communicating vessel type. At the beginning of the test, the animals were weighed and distributed among the following experimental treatments:

- DC0 - control diet: composed mainly of corn and soybean meal, without enzyme complex;
- DC0E: control diet plus enzyme complex;
- DPC5: diet composed mainly of corn and soybean meal with the inclusion of 5% citrus pulp;
- DPC5E: diet composed mainly of corn and soybean meal with the inclusion of 5% citrus pulp plus the enzyme complex;
- DPC10: diet composed mainly of corn and soybean meal with the inclusion of 10% citrus pulp;
- DPC10E: diet composed mainly of corn and soybean meal with the inclusion of 10% citrus pulp plus the enzyme complex;
- DPC15: diet composed mainly of corn and soybean meal with the inclusion of 15% citrus pulp;
- DPC15E: diet composed mainly of corn and soybean meal with the inclusion of 15% citrus pulp plus the enzyme complex.

The ROVABIO® enzyme complex was composed of xylanase, β-glucanase, cellulase, pectinase and protease, with 5 g/100 kg of feed added.

The diets were isonutritive and met the minimum nutritional requirements recommended by Rostagno et al. (2005), being formulated for the phase from 120 to 134 days of age. The nutritional values used for citrus pulp were:

NDF-23.09%, FDA-18.47%, Starch-4.29%, CP-6.86%, EM-1677 kcal/kg, Ca-1.42% and P-0.40%, according to Amorim et al. (2013). The experimental diets are presented in Table 1.

PARTIAL COLLECTION – METHOD 1

The digestibility of the experimental feeds was evaluated, determining the dry matter digestibility coefficients (DM). The partial feces collection method was used, using insoluble acid ash (CAI) as an indicator. The determinations were carried out at finishing, from 120 to 134 days of age of the animals.

The trial lasted 14 days, with the first eight days being for the animals to adapt to the pens and diets, receiving two meals a day, at 8am and 5pm, and water ad libitum. The following three days were dedicated to regulating the flow of the indicator and the final three days to collecting feces, using the partial collection method.

Initially, the average food consumption of the animals was determined, in two daily meals, so that, during the collection period, the animals consumed all the food provided.

After the period of adaptation and determination of consumption, the supply of controlled feed began, with the addition of 1% of (CAI) as an external indicator in the feed, in order to stabilize its flow in the digestive

Ingredients, %	Citrus Pulp Levels, %			
	0 [1]	5	10	15
Corn	76,703	72,148	66,118	59,826
Soybean meal	19,608	19,828	20,119	20,456
Citrus pulp	-	5,000	10,000	15,000
Dicalcium phosphate	0,818	0,819	0,826	0,834
Calcitic limestone	0,456	0,304	0,098	-
Soy oil	0,100	0,805	1,740	2,760
L – Lysine. HCl (78,4 %)	0,208	0,212	0,217	0,222
DL – Methionine (99,0 %)	0,020	0,033	0,049	0,066
L – Threonine (98,0 %)	0,032	0,041	0,053	0,064
L – Tryptophan (99,0 %)	-	0,002	0,004	0,006
Mineral supplementation [2]	0,050	0,050	0,050	0,050
Vitamin supplementation [3]	0,400	0,400	0,400	0,400
Common salt	0,310	0,308	0,304	0,301
Inert/Enzyme complex [4]	1,285	0,040	0,012	0,005
BHT	0,010	0,010	0,010	0,010
TOTAL	100	100	100	100
Calculated composition [5]				
Metabolizable energy, kcal/kg	3230	3230	3230	3230
Crude protein, %	15,53	15,53	15,53	15,53
Starch, %	50,57	47,77	44,05	40,17
FDN, %	11,80	12,35	12,73	13,09
FDA, %	4,24	5,07	5,86	6,63
Lysine dig.,%	0,81	0,81	0,81	0,81
Methionine dig., %	0,27	0,27	0,28	0,29
Methionine + Cystine dig., %	0,50	0,50	0,50	0,50
Threonine dig., %	0,54	0,54	0,54	0,54
Tryptophan dig,%	0,15	0,15	0,15	0,15
Calcium, %	0,48	0,48	0,48	0,53
Available phosphorus, %	0,25	0,25	0,25	0,25
Potassium, %	0,59	0,61	0,63	0,66
Sodium, %	0,16	0,16	0,16	0,16

Table 1. Proximate and nutritional compositions of experimental diets used in the finishing phase of pigs.

[1] Levels of citrus pulp, with or without enzyme complex. 2 Guarantee levels per kg of feed: Copper – 30 mg, Zinc – 160 mg, Iodine – 1,900 mg, Iron – 100 mg, Manganese – 70 mg, Selenium – 0.075 mg. 3 guarantee levels per kg of feed: Vit. A - 10000 IU, Vit. D3 - 2500 IU, Vit. E – 18.12 mg, Folic acid – 0.75 mg, Calcium pantothenate – 20 mg, Biotin – 6 mg, Niacin – 30 mg, Pyridoxine – 2.50 mg, Riboflavin – 0.70 mg, Thiamine – 2, 50 mg, Vit. B12 – 37.50 mcg, Vit. K3 – 12.5 mg, Choline – 783 mg. 4 5 grams of enzyme complex per 100 kg of feed. 5 Nutritional values of ingredients, proposed by ROSTAGNO et al. (2005), except citrus pulp.

tract.

On the final three days, fecal samples were collected directly from the animals' rectums, twice a day, immediately after meals. Following collection, these samples were placed in plastic bags, duly identified, and then stored in a freezer at -18 °C until analysis.

Feces production was related to the non-digestible fraction of the diet by pigs, and all feces produced by pigs were collected for later comparison with the formula proposed by Berchielli et al. (2005), presented below:

Fecal dry matter excretion (kg) = DM intake (kg) x FI = $\frac{\text{CAI (diet)}}{\text{CAI (feces)}}$

This formula estimates animal fecal excretions based on dry matter. To do this, the animals' diet consumption and the indigestibility factor (IF) are considered, which corresponds to the portion of the diet not used by the animals and excreted in feces. To do this, the content of the insoluble acid gray indicator in the feed was divided by that found in the feces. With this procedure, the total fecal dry matter excretions estimated by the formula were calculated.

TOTAL COLLECTION – METHOD 2

The evaluation of method 2 was in conjunction with method 1, evaluating the total production of feces in the last three days of collection, and calculating the amount of feces collected in method 1. Collection was carried out in each stall, as follows way: on the day before the collection day, in the morning, the stalls were cleaned with pressurized water and on that same day, in the afternoon, the first collection of feces was carried out to be weighed. The next day, in the morning, the feces produced were weighed for the second time and collected for drying in an oven, storage and subsequent laboratory analysis. Thus, the total feces produced in 72 hours per animal was obtained.

The stalls were separated by wooden boards, in order to prevent an animal from defecating into the adjacent stall, through the dividing bars. During collections, care was taken to separate feces that had been contaminated with feed residues from intact feces, so that their weight was taken into consideration. However, its content was not incorporated into the sample to be stored, so as not to alter the nutrient content.

SAMPLE PREPARATION AND CHEMICAL ANALYSIS

After the collection period, feces from both trials were thawed and homogenized to obtain a composite sample from each animal. The feces were then subjected to pre-drying in an oven with forced ventilation at 55°C for a period of 72 hours and were subsequently ground in a stationary mill type Thomas-Wiley, model 4, equipped with a sieve with 1 mm screens.

The analysis of diets and feces was carried out at the Animal Nutrition Laboratory of the Department of Animal Science at FCAV – Unesp, Jaboticabal campus, in accordance with the Association of Official Analytical Chemists (AOAC), with dry matter (DM; process 4.1. 06, AOAC, 2000). CAI determinations in diets and feces from the second trial were carried out using gravimetric determination, according to the method adapted from Van Keulen and Young (1977). To do so, 0.7 g of sample was used, which was weighed in a ceramic crucible, which was placed in a muffle furnace at a temperature of 500°C for 8 hours. After burning in a muffle furnace, the ashes of each sample were transferred to Kjeldahl-type borosilicate flasks, where aliquots of 5 mL of HCl (4 mol/L) were added, under heating in a digester block at 125°C for 45 minutes. After cooling, the samples were filtered using quantitative filter paper. Subsequently, the filters went through a washing, drying and

incineration procedure. Finally, the samples were weighed to obtain the percentage of insoluble acid ash.

STATISTICAL ANALYSIS

A randomized block design was used, in a 4x2 factorial scheme, with four levels of citrus pulp, (0.5, 10 and 15%) with or without the addition of the enzyme complex, with nine replications and one animal constituting the experimental plot. The data were subjected to analysis of variance, using the statistical software R (R Core Team, 2013). The assumptions for the normalities of the residuals were verified using the Cramer-von Mises test.

As there was no adjustment in the regression analysis for the quantitative data of citrus pulp levels and enzyme complex addition classes, a qualitative analysis was carried out for significant interactions (P<0.05), to elucidate the data.

Aiming to compare the different fecal production averages of pigs in the finishing phase fed with different levels of citrus pulp, considering the two methodologies evaluated, the Student's t test was used.

RESULTS AND DISCUSSIONS

FAECES PRODUCTIONS IN NATURAL AND DRY MATTER

Data on fecal production in natural matter (MN) and DM of finishing pigs fed different levels of citrus pulp with or without an enzyme complex are shown in Table 2.

The daily feces production of pigs in the finishing phase, when analyzed in natural matter (MN), demonstrates that at the level of 5% inclusion of citrus pulp in diets without enzyme complex there was greater feces production (P<0.05). However, for the other inclusion levels of citrus pulp (0%, 10% and 15%) they were similar. For diets with the inclusion of an enzyme complex, the citrus pulp inclusion levels of 0%, 5% and 10% had no difference between them, however the 15% level had greater feces production (P<0.05).

When comparing the levels of citrus pulp without and with the addition of the enzyme complex, it was observed that the levels of 5% and 15% had differences (P<0.05), with the level of 5% inclusion without the enzyme complex there was an increase of 1.21 kg of feces in the MN, however for the level of 15% inclusion of citrus pulp, without enzyme complex, there was a reduction of 0.670 kg.

The production of feces in MS when using a diet without an enzyme complex was greater at the inclusion level of 5% citrus pulp, however there was no difference between the other inclusion levels (0%, 10% and 15%). In diets with the addition of the enzyme complex, an increase in fecal production was observed at the level of 15% inclusion of citrus pulp, but it was statistically similar at the level of 5% inclusion. The 5% inclusion level also did not differ from the other inclusion levels studied (0 and 10%). When comparing the differences with or without an enzyme complex, at a level of 5% inclusion of citrus pulp with an enzyme complex, a reduction of 0.350 kg of feces was observed.

At the level of 5 and 15% inclusion of citrus pulp, there was an increase in fecal production, both in MN and MS, this increase is related to the low digestibility of the fibrous portion of the diet, as there was a greater inclusion of citrus pulp, with no adaptation of the animals. Citrus pulp can be used to feed pigs, as long as its inclusion in the diet does not exceed 20% (BAIRD and AMICK, 1966) and as it is classified as a by-product, it has a different energy profile than corn, with lower digestibility, which can be improved with the supplementation of exogenous enzymes (AMORIM et al., 2011).

According to Gomes et al., (2006) diets

		Citrus Pulp Levels (%)			
		0	5	10	15
Natural matter (kg)					
	Without				
CE		4,64b	6,17Aa	4,93b	5,27Ab
	With	4,22b	4,96Bb	4,45b	5,94Ba
CV (%) = 12,84					
Dry matter (kg)					
	Without				
CE		1,30b	1,73Aa	1,38b	1,45b
	With	1,26b	1,38Bab	1,21b	1,57 a
CV (%) = 13,47					

Table 2. Daily fecal production of pigs in the finishing phase fed with different levels of citrus pulp (PC) without and with enzyme complex (EC) in natural matter and dry matter.

Means followed by the same uppercase letter in the column and lowercase letter in the row, within the variables, do not differ from each other using the Tukey test (P<0.05)

rich in fiber are responsible for changes in the processes of ingestion and digestion of nutrients. The inclusion of fibers such as those contained in citrus pulp, mainly pectins, can increase the amount of total solids and the density of feces (RODRIGUES, 2015). What was observed in the present study in the production of feces in MN at levels of 5% without enzyme complex and 15% with enzyme complex.

Moeser and Van Kempen (2002) found a 10.30% decrease in fecal production when they used xylanase supplementation in a diet containing corn, soybean meal and soybean hulls. According to Martinez et al., (2009), higher nutrient digestibility coefficients were observed for diets containing citrus pulp, when an enzyme complex was used, which may justify the data found in the present study, as there was lower production of feces at the level of 5% citrus pulp, when an enzyme complex was used.

In the literature, pigs that received various fiber sources showed apparent digestion ranging between 21% and 92%, therefore, the fiber source is an important point in increasing digestibility and consequently reducing fecal production (STANOGIAS and PEARCE, 1985).

COMPARISONS BETWEEN METHODOLOGIES

When comparing the different means of feces production within each level of citrus pulp inclusion (0, 5, 10 and 15%), both in MN and MS, it was observed that there were differences (P<0.05) between the methodologies in the treatments in which the levels of 5, 10 and 15% were used (Table 3).

These differences in results between the methodologies suggest that some error in conducting the experiments may have occurred, which could be of a sampling or laboratory nature in some of the methodologies used. As methodology 1 is the one commonly used, it can be considered that the greatest possibility of error was when conducting methodology 2.

	Citrus Pulp Levels (%)			
	0	5	10	15
Dry matter	-0,101^{NS}	-0,453*	-0,145*	-0,531*
Natural Matter	-0,320^{NS}	-1,605*	-0,519*	-1,949*

Table 3. Comparison of the different fecal production averages of pigs in the finishing phase fed with different levels of citrus pulp considering the two methodologies evaluated.

NS – Not significant

* T Test (P<0,05)

CONCLUSION

The level of inclusion of citrus pulp affected the amount of feces produced by finishing pigs, with an increase being observed at levels of 5 and 15% inclusion. When using the enzyme complex there was an interaction with levels of citrus pulp, which influenced the production of feces, mainly at the level of 5%.

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