EUROPEAN ACADEMIC RESEARCH
Vol. VIII, Issue 6/ September 2020

ISSN 2286-4822
www.euacademic.org

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

Yam flour (*Dioscorea trifida,* L.) in the feeding of pigs in the finishing phase

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Abstract

This study aimed to evaluate the effects of the inclusion of 15 and 30% of yam seed (Dioscorea trifida, L.) in the diet of pigs in the finishing, through the digestibility of the diets and the metabolic profile of the animals. In the digestibility trial had as a method to total fecal collection of 15 barrows beam "tricross" (large white x landrace x duroc) with initial live weight (60 to 70 Kg) and age of 120 days, distributed in a completely randomized blocks, with 3 levels of inclusion of yam flour in the diet and 5 repetitions each. We used the statistical package SAS LAB for analysis of the data of digestibility of nutrients and metabolic profile. The analysis of variance was performed using PROC GLM of SAS. The results showed a significant effect (p < 0.05) with decreasing linear responses of the coefficients of digestibility (EB, MS, MO, MM AND LIP) in relation to the control diet, where it was observed the behavior of decrease (EDap, PDap And LDap), according to the increase of the levels of yam feed. In the metabolic profile, there were significant differences (p < 0.05) in serum levels, where these parameters showed a linear effect increasing the levels of inclusion of yam flour. In this way, it is recommended that the completion of the experiment of animal performance, carcass evaluation and economic viability, in order to determine the best levels of inclusion of this ingredient in the diets of pigs in the finishing phase.

Keywords: digestibility; Inclusion; Metabolism; alternative feed; Amazonia

1. INTRODUCTION

The Brazilian pig farming has grown significantly in recent years. It should be noted that growth when they are analyzed the various social and economic indicators, such as production volume, participation in the world market, the number of jobs and others (Gonçalves and Palmeira 2006). In this sense, the same has an supporting role in animal production in the state of Amazonas, with a growth and increased its importance in the economy of the state, having a relevant importance to the family agriculture, in which the creation occurs as a form of acquisition of protein and increase in family income in riverside. The Amazon region has a wide diversity in food resources that can be used to integrate a list of ingredients in the formulation of diet for animals, such as pigs in terminating, acting as alternative feature in animal feed, and may exercise role as protein source, efficiency or additive, such as yam (Dioscorea spp.), among others. The yam (*Dioscorea trifida,* L.) is a tuber with potential alternative to animal feed. From a nutritional point of view, it is rich in B complex vitamins (thiamine, riboflavin, niacin, vitamin A, vitamin C (ascorbic acid) and carbohydrates (starch), which is the main energy reserve of plants and the main source of carbohydrates in the human diet, in addition to significant levels of protein and fats (Oliveira et al. 2007, 73-76).

In the Amazon region, it is an excellent crop that grows well in the conditions of agroecosystem of solid ground, being observed its cultivation on a large scale by family farmers in the Lower Solimões River where this crop is the main source of income and consumption.

The Amazon region has a huge range of foods that can be studied and they are potential ingredients in the diets of pigs. This diversity used in feed formulation is essential for studies of nutritional values and energy, aiming at its best utilization and use of more rational way, being necessary the values of chemical composition, energy and digestibility of nutrients, to seek a cost reduction in supply and an increase in productivity. So that remains a competitive market serving the consumers and the laws of trade, at the same time that maintains the sustainability of the pig sector and the environment (Jafari et al. 2006, 618-622; Lopes et al. 2011, 2431-2438).

In this context, this study aimed to evaluate the inclusion of yam feed in the diets of pigs in the finishing phase through the digestibility of the diets and the metabolic profile of the animals.

2. MATERIAL AND METHODS

2.1. Ethics in Animal Research

The methodological procedures were approved by the Ethics Committee on Animal Use (CEUA) at the Amazonas Federal University (UFAM, under protocol no. 059/2018.

2.2. Study Development Site

The experiment of digestibility was performed in the period from 21 February to 04 March 2018 at the premises of the pig sector of an Experimental Farm (FAEXP) at the Amazonas Federal University (UFAM), located in the municipality of Manaus - AM, between the coordinates 2º38'20"S 2º39'10"S 60º40'W 60º30'W, at km 38 of the BR-174 38 left margin, meaning Manaus - Boa Vista. (Figure 1). According to the classification proposed by the Koeppen climate is classified as tropical, hot and humid, with average annual rainfall of 2286 mm and average temperature between 27 to 29 ℃ (INMET 2017).

Figure 1. Map of the Experimental Farm of the UFAM

Physical-chemical analysis of raw materials collected were performed in conjunction to the Laboratory of Technology of Agricultural Products, Fish Technology Laboratory and Laboratory of forage and grassland (LAFOPAST) of the Faculty of Agricultural Sciences (FAS) of the UFAM, Bromatology and at the Laboratory of the Faculty of Veterinary Medicine and Animal Science of the Paulista State University Júlio de Mesquita Filho, Botucatu, São Paulo, Brazil.

2.3. The acquisition, processing and physical-chemical analysis of raw material

The raw material used for the preparation of yam flour was acquired in natura, in a single batch, through a cooperative in the municipality of Caapiranga located 133 Km from the capital, being transported immediately to the LAPA/UFAM. In the Laboratory of Anatomy and Physiology Animal - LAPA, the raw material was selected in order to discard foreign objects and materials in decomposition. Were performed cleaning and washing of the raw material, was then forwarded to LAFOPAST. The selected raw material was subjected to drying in forced air oven at 60°C for 72 uninterrupted hours and (Figure 2), subsequently, crushed to become homogeneous, thus obtaining the product called yam flour (*D. trifida,* L.) (Figure 3). The product obtained was identified, bagged and stored in a dry and ventilated in order to be used for the composition of the experimental diets.

Figure 2. Drying the yam.

Figure 3. Yam flour.

Before the completion of the field experiment was determined on the centesimal composition of the yam flour according to the methodology proposed by Silva & Queiroz (2002), for all the main parameters of evaluation of the centesimal composition according to the weende system (Dry Matter - MS, lipids - LIP, ether extract - EE, crude protein - PB, Mineral matter - MM) and Van Soest (neutral detergent fiber - Neutral detergent fiber and acid detergent fiber (FDA).

2.4. Dimensions and management of experimental facilities

The experimental shed used had leaked semi-open sides (part protected by a metallic screen), right foot of 3.0 meters in height, coverage, with earthenware tiles, collective stalls (1.2 x 1.2 meters = 1,4m²/animal) (EMBRAPA 1997, 5-21), and concrete walls, furthermore, was positioned in the direction east-west and presented natural ventilation, as a result of afforestation around the installation, softening the heat to the animals housed in the bay.

Each stall had the runner-type feeders and drinkers kind pacifier, where he was offered food and water *ad libitum* during the entire experimental period. The feeders and drinkers were supplied daily (3 times a day). The cleanliness of the pens were performed daily (2 times a day) through the withdrawal of feces with tap water.

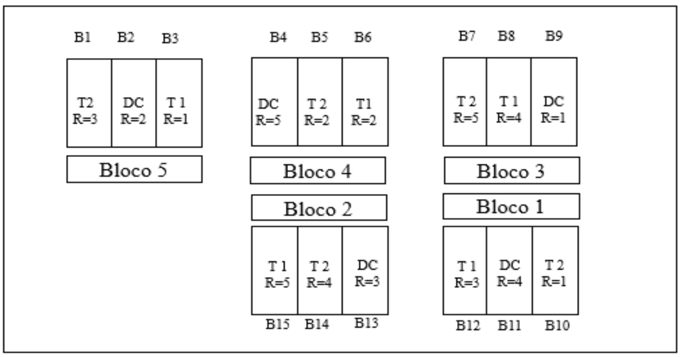
2.5. Digestibility trial of yam feed (*D. Trifida,* L.) in diets for pigs in the finishing phase

In the digestibility trial were used 15 barrows, resulting from crossing "tricross" (Large White x Duroc, Landrace x) on termination, with approximately 100 to 120 days of life, and weight ranging between 60 and 70 kg. The animals were housed individually in bays (Figure 4 A-B), distributed in a completely randomized block design (DBC) (Figure 5) as a function of the initial weight of animals, with 3 treatments (0, 15 and 30% inclusion of yam flour), five replications (blocks) and one animal per experimental unit (Bay).

We adopted the method of total collection of feces (Sakomura and Ferreira 2007), using 2% ferric oxide ($Fe3O2$) as a marker of the beginning and end of the period of collections. The experiment lasted 12 days, 07 days for adaptation of animals to the experimental environment (metabolic cages) and the experimental diets and five days intended for total fecal collection.

Figure 4. Experimental unit (A) and stall used in experiment (B).

Figure 5. Sketch of the experimental design of the digestibility trial.



B= number of stall, DC= control diet, T1= Treatment with 15% inclusion of lenz of yam, T2= Treatment with 30% inclusion of lenz of yam (*D. trifida,* L and R= repetition.

All the rations were formulated through the computational software SUPERCRAC in attendance to the nutritional requirements of animals and according to the values of the ingredients provided by the Brazilian Tables for Poultry and Swine (Ferreira et al. 2005), with the exception of the composition of the yam flour, which was used the values obtained in the physico-chemical characterization of the product (Table 1).

The total feces were collected several times a day, packed in plastic bags and stored in a freezer at -10 °C freezers. At the end of the experiment, the stool samples were homogenized and sampled (20% of the total collected), dried in forced ventilation (60 °C for 72 hours) and milled for further analysis.

Table 1. Composition and calculated values of diets containing levels (0, 15 and 30%) of yam flour as Substituent for energy pigs in the finishing phase of the experiment of digestibility

Consumables	Levels of yam feed (*Dioscorea trifida, L.*) (%)		
	Control	15	30
Maize 7.88%	76.54	59.95	43.57
45% soy bran	12.75	20.15	20.41
Yam flour	-	15.00	30.00
Soybean oil	7.00	1.96	1.06
Precipitated phosphate	1.2218	1.1875	1.2224
Limestone	1.1859	0.9090	0.8906
Premix Vit/MinF3[1]	0.5000	0.5000	0.5000
Common salt	0.6049	0.3375	0.3446
L-Lysine	0.2147	-	-
Total	100.0000	100.0000	100.0000
Nutrients	Nutritional Levels		
Linoleic acid %	5.2553	2.3572	1.5983
Calcium %	0.8000	0.7000	0.7000
Energy Metabolized Kcal/kg	3548	3350	3350
Crude fiber %	1.9995	2.4905	2.6771
Fosforo available %	0.3000	0.3000	0.3000
Fosforo total %	0.4887	0.4824	0.4575
Lysine Total %	0.7000	0.7000	0.7000
Met+Cys Total %	0.4157	0.4557	0.4212
Methionine Total %	0.1989	0.2168	0.1998
Crude protein %	12.0000	14.2148	13.9557
Soda %	0.2580	0.1500	0.1500
Threonine Total %	0.4718	0.5505	0.5238
Total tryptophan %	0.1262	0.1629	0.1617

1quantities per kg of feed: vit. A - 2520 IU; vit. D3 - 540 IU; vit. And - 9.9 IU; vit. K3 - 0.72 mg; thiamine - 404 mcg; RIBOFLAVIN - 1.98 mg; PYRIDOXINE - 404 mcg; vit. B12 - 8.1 mcg; folic acid - 225.2 mcg; pantothenic acid - 6.3 mg; NIACIN - 12.6 mg; growth promoter - 10 mg; Se - 0.24 mg. [2] Quantities per kg of feed: Cu - 9 mg; Fe - 81 mg; I - 0.9 mg; Mn - 54 mg; Zn - 135 mg.

The animals were housed and exposed to solid fasting for 24 hours, after this period was held the individual weighing of animals. The 15 pigs received 500g of experimental ration according to each treatment. From the first to the seventh day of adaptation, the water supply was *ad libitum* and the ration supplied gradually, always obeying the voluntary intake of each animal within each block, because the controlled consumption had as objective to estimate the consumption restricted to total fecal collection.

Within seven days following that completed the adaptation phase, the animals received the ration twice a day (8pm and 16 pm) and the supply of water *ad libitum*. The feed was weighed daily in plastic bags and supplied in accordance with the animal consumption of each block. Scans were performed in all cages to detect the presence of leftovers, which were collected with the aid of a sponge to ensure complete removal of residues. Then, these leftovers were packed in plastic bags, identified according to the number of stalls, and treatments, weighed in precision scale and made the record.

At the end of the adaptation phase, from the record of the average consumption of ration of each animal in the period, it was possible to estimate the amount of ration offered to animals during the five days following, i.e., during the days of total fecal collection (Table 2).

Table 2. Calculation of the restricted consumption of ration for the experiment of digestibility of diets containing the inclusion of yam flour for pigs in the finishing phase

Stall	Block	Trat.	No of the animal	Live weight (Kg)	Metabólicoa Weight	Feed consumption (Kg)	b Index	Power Consumption Restritoc (Kg)
1	B1	T3	30	75.0	25.4857	2.500	0.0981	2.50
2	B1	T1	32	74.0	25.2304	2.500	0.0991	2.50
3	B1	T2	43	72.0	24.7172	2.500	0.1011	2.50
4	B2	T1	7	68.5	23.8105	2.300	0.0966	2.30
5	B2	T3	12	68.5	23.8105	2.300	0.0966	2.30
6	B2	T2	31	68.2	23.7322	2.300	0.0969	2.30
7	B3	T3	33	68.0	23.6800	2.200	0.0929	2.20
8	B3	T2	34	65.0	22.8921	2.100	0.0917	2.10
9	B3	T1	52	63.0	22.3617	2.100	0.0939	2.10
10	B4	T1	40	62.0	22.0950	2.100	0.0950	2.10
11	B4	T2	10	62.0	22.0950	2.100	0.0950	2.10
12	B4	T3	13	61.3	21.9076	2.000	0.0913	2.00
13	B5	T3	38	58.4	21.1256	2.000	0.0947	2.00
14	B5	T1	42	57.0	20.7447	2.000	0.0964	2.00
15	B5	T2	29	57.0	20.7447	2.000	0.0964	2.00

The Metabolic Weight = live weight $^{0.75}$

B = Consumption Index / metabolic weight

C restricted metabolic consumption = weight x smaller index

The following calculations were performed.

$$CRR = I \times \text{metabolic Weight}$$

Where:

CRR = restricted consumption of ration (Kg)

I = average consumption of five days (Kg) / metabolic Weight

Metabolic Weight (Kg) = (live weight)$^{0.75}$

The index (I) was calculated for all animals (Table 2), however, was adopted the lowest value of (I) found for the calculation of (CRR).

On day 80 of the experiment of digestibility, the animals began to receive the amount of ration to meet the restricted consumption according to each block (Table 2), the amount of ration was divided into two portions, being provided daily at 8pm and 15pm during the five days for total fecal collection.

The feces were collected several times a day, with the use of two spatulas, paper towel and plastic bags, identified, quantified in precision scale and frozen.

At the end of the period of collection of feces volume produced per animal was placed in a plastic bucket, thawed, homogenised individually in accordance with each repetition of each treatment, placed in a tray of aluminum, identified and brought to the emissions of air forced circulation to be dried at a temperature of 65 ºC for a period of 72 hs.

After a period of 72 hs, the samples were removed from the oven and re-weighed in precision scale to obtain the dry weight of the samples. In the sequence, the dried samples were finely ground in Willey type mill, groping in sieve riddled with 1 mm of diameter and sent to laboratory analyzes. Was performed to collect samples of the experimental rations (0, 15 and 30%) for the inclusion of yam flour for performing similar analyzes of the fecal samples carried out in accordance with the Association of Official Analytical Chemists (AOAC 2005).

With the achievement of the outcome of the bromatological analysis it was possible to perform the calculation of the coefficient of digestibility (CD) for the total collection method using the following equation.

$$\text{CD\%} = 100 \text{ x } \frac{(Amounts\ of\ feed\ nutrients - amount\ of\ nutrients\ in\ the\ feces)}{Amount\ of\ feed\ nutrients}$$

From the results of total consumption of ration based on dry matter and bromatological analysis it was possible to calculate the apparent digestible energy of rations using the equation proposed by Matterson et al. (1965, 3-11).

$$\text{ED ration} = \frac{\text{EB ing - EB exc feces}}{\text{MS ing}}$$

Where: ED ration = digestible energy of the ration
EB ing = Gross Energy Consumed
EB exc feces = Gross Energy excreted in feces
MS ing = dry matter ingested

2.6. Serum metabolic profile of pigs in the finishing

2.6.1. Collection of blood samples

The blood collection was performed by venipuncture of the veins located in the ear with the use of syringes of 10 ml with needles 25/8, and stored and identified in the Vacutainer tube containing fluoride for analysis of glucose and in tubes without anticoagulant for obtaining the serum.

To perform this procedure, 15 animals were used, being 05 animals per treatment. The blood was collected from each animal, without prior fasting, by means of puncture of the marginal vein of the ear with hypodermic needles

40x16. After collection, the samples were stored in vials of 10 mL without anticoagulant, for obtaining the serum, and in 5 mL vials containing sodium fluoride, for obtaining the plasma. The sampling were carried in thermal box containing recyclable ice for cooling and conservation of the material to the Laboratory of Veterinary Clinic Pet Stop Animal Care located in the municipality of Manaus-AM, where he held the biochemical analyzes with the use of automated equipment using commercial kits, following the manufacturer's recommendations.

2.6.2. Processing of analyzes:

After the samples were collected at rest under refrigeration the time needed to complete the coagulation and separation of the serum. Afterwards, they were centrifuged for five minutes of 1,500 to 2,000 rpm for clarification and complete separation of the whey, which was pipetted and transferred to other tubes and subsequently, frozen.

Were analyzed by automated equipment and checked the blood components such as serum levels of total protein (refractometry method), albumin (bromocresol green method), globulins (calculated by the difference between thetotal p roteína and albumin), urea - glucose - cholesterol - triglycerides (enzymatic colorimetric method-human *in vitro*), calcium (automated test equipment electrolytes), phosphorus (enzymatic method human *in vitro*) and magnesium (enzymatic method human *in vitro*).

2.7 Statistical analysis

For data analysis of the experiment of digestibility and blood collection for the determination of the metabolic profile was used for the statistical package SAS® Lab to verify the adequacy of the data to the linear model. Then, it was performed the analysis of variance by the PROC GLM of SAS®. In addition, it was performed the decomposition of the degrees of freedom of the factor level in its individual components (linear and quadratic regression), through the orthogonal polynomials.

3. Results and Discussion

3.1. Experiment of digestibility of diets

3.1.1. Centesimal composition of ingredients and diets

In Table 3 are expressed in the values of the composition of ingredients and diets used in this experiment.

Table 3. Centesimal composition of ingredients and rations that were provided in the experiment to pigs in the finishing phase

Consumables	MS (%)	MO (%)	MM (%)	PB (%)	LIP (%)	Ndf (%)	FDA (%)	EB (Kcal/kg)	ED (Kcal/kg)
Yam flour	88.60	83.63	8.48	2.00	2.76	32.33	24.06	3740	3360
Maize	87.00	86.0	0.94	6.62	2.90	12.3	3.31	3865	3415
Soy Bran	89.60	83.90	5.66	45.4	1.95	13.6	7.76	4118	3437
Control diet	89.73	96.05	4.40	15.90	3.22	29.77	18.81	3823	
15% treatment	89.07	95.26	5.33	15.40	3.10	51.37	14.99	3330	
Treatment 30 %	89.03	94.84	5.79	12.00	2.95	54.09	15.19	3336	

For yam flour, the values found showed significant differences in relation to the NDF (32.33 %) and the FDA (24.06 %) which in the present study, the values were higher than those found by Feijó et al. (2016, 413-423), which evaluated the yam flour in poultry feeding lightweight posture obtained the following values in the chemical composition of 95.5% of MS; 2.65% PB; 2.69 % of FB; 7.45% NDF 3.64% FDA; 3.2 % of MM; 86.6 % of ENN; 3730,73 Kcal/kg of EB and 3489,81 Kcal/kg.

The variation of the values of the chemical composition was already expected, this is due to the processing of the ingredient test, where the alternative foods are subject to variation in their chemical-bromatological composition (Nunes et al. 2001, 785-793; Gomide et al. 2016, 157-163).

3.1.2. Total fecal collection

In the digestibility trial was performed a total fecal collection according to the methodology proposed by Sakomura and Ferreira (2007), enabled the record of the quantity of feed consumed per animal for each treatment in blocks, as well as the quantity of feces excreted (Table 4) during the five days intended to that collection.

Table 4. Total consumption of ration (Kg) and the total production of feces with values expressed in dry matter (DM) of diets containing levels of yam feed for pigs in the finishing phase.

Animal	Trat.	Total consumption of ration (Kg)	Total consumption of raçãoa (Kg/MS)	Total production of feces (Kg)	Total production of fezesb(Kg/MS)
1	T2	12.50	11.1283	5.66	1.9009
2	DC	12.50	11.2164	1.54	0.4847
3	T1	12.50	11.1335	5.00	1.2601
4	DC	11.50	10.3191	3.72	0.9465
5	T2	11.50	10.2381	6.17	1.4922
6	T1	11.50	10.2428	4.80	1.4779
7	T2	11.00	9.7929	5.97	1.5581
8	T1	10.50	9.3521	4.03	1.2434
9	DC	10.50	9.4218	2.00	0.6391
10	DC	10.50	9.4218	6.28	1.8290

11	T1	10.50	9.3478	4.72	1.7704
12	T2	10.00	8.9068	5.22	1.4169
13	T2	10.00	8.9027	4.83	1.3514
14	DC	10.00	8.9731	3.57	1.1278
15	T1	10.00	8.9068	4.67	1.1488
Average		11.00	9.8203	4.5433	1.3098
CVc %		8.59	8.59	30.70	30.91

Total aConsumo FODDERS= total consumption of ration x % of MS in the ration
Total fecal bProdução= feces production x % of MS of feces
CCoeficiente of variation (CV%)

In Table 4, it is observed that the quantity of feed consumed varies, this fact is due to the provision of pre-defined diet by calculating the restricted consumption of ration. The quantity of feces excreted varied within each treatment and between treatments. As there was a difference in the weights of the animals and the treatments was the variation of consumption and production of fecal matter. Corroborate with this statement Souza et al. (2008, 219-224), in asserting that the quantity produced of fecal wastes a lot depends on the weight and age of the animals. The characteristics of the residue are also affected by factors such as the physiology of the animal and the composition of rations (Souza et al. 2008, 219-224).

The result of the bromatological analysis of fecal samples of 15 castrated male pigs used in the experiment of digestibility fed diets containing levels of inclusion of (0, 15 and 30%) of yam flour are shown in Table 5.

Table 5. Centesimal composition of feces of fifteen castrated male pigs in the finishing phase used in the digestibility trial

Animal	EB (Kcal/kg)	MS (%)	MO (%)	MM (%)	PB (%)	LIP (%)	Ndf (%)	FDA (%)
1	3882	31.58	83.54	22.76	27.8	12.46	57.71	65.24
2	4254	25.18	83.10	19.97	23.96	14.52	59.02	33.69
3	4279	33.58	85.68	16.2	23.97	15.48	50.8	34.94
4	4137	25.44	82.28	21.52	24.17	13.71	57.89	43.61
5	4380	30.79	81.10	20.85	20.98	10.54	59.11	45.15
6	4369	24.18	80.40	22.19	22.77	13.37	60.97	31.97
7	4401	32.04	83.76	17.53	21.67	17.48	56.92	31.18
8	4263	30.89	84.72	18.19	22.9	17.33	50.4	38.77
9	4291	26.12	81.48	19.97	22.96	15.24	47.45	33.68
10	4278	29.12	84.73	16.62	23.03	14.58	43.11	38.13
11	4149	27.17	81.49	20.77	22.15	11.67	45.49	35.8
12	4275	37.55	82.05	19.46	23.32	14.23	44.15	36.03
13	4058	31.64	84.04	18.14	24.74	11.19	42.8	50.34
14	4227	24.60	83.95	18.99	23.11	13.88	43.16	53.99
15	3961	27.98	82.58	19.5	22.14	12.96	42.38	49.6
Average	4213,6	29.19	82.99	19.51	23.31	13.91	50.76	41.47
CVb	3.57	13.13	1.84	9.95	6.82	14.47	14.05	23.45

* **Coefficient of variation*values of dry matter after pre- drying of samples, bCoeficiente of variation

With obtaining the data in Table 6, it was possible to obtain average values of apparent digestible energy of gross energy (EDA-EB), crude protein apparent digestibility (EDA-PB) and apparent digestible lipids (EDA-EE) of all 15 animals in each treatment and the results of statistical analysis are shown in Table 7.

Table 6. Apparent digestible energy of gross energy (EDA-EB), crude protein apparent digestibility (EDA-PB) and apparent digestible lipids (EDA-EE).

Animal	EDA-EB	PB Dap	LIP Dap %
1	3477	9.50	2.11
2	2948	13.29	1.80
3	2951	13.73	1.56
4	3454	9.83	2.00
5	2937	13.56	2.15
6	2943	13.83	1.75
7	3431	10.05	1.66
8	2947	13.38	1.54
9	2950	13.82	1.58
10	3442	9.93	1.92
11	2957	13.45	2.05
12	2952	13.78	1.67
13	3461	9.77	2.22
14	2950	13.36	1.85
15	2980	13.89	1.79
Average	3118	12.34	1.84
*CV%	7.85	15.09	12.16

*Coefficient of variation

Table 7 shows the mean values of digestible energy apparent (EDap), digestible protein apparent (PDap) And Lipids digestivel apparent (LDAP), diets containing the inclusion of yam flour (*D. trifida*, L) determined negative linear responses ($p < 0.05$) on the evaluated parameters, the values of digestible energy apparent (3453, 2498, 2955), the apparent digestible protein (13.82; 13.41; 9.82) and apparent digestible lipids (2.0; 1.85; 1.67) of pigs fed with 15 and 30% inclusion of yam flour showed an inversely proportional negative. This behavior can be explained as the chemical composition of the yam flour where their values of EB apparent, PB digestible and LIP digestible are smaller in relation to the maize. In Table 3 are the values of EB and observed that the levels of EB of maize are higher than the levels that EB the yam flour, where the energy is the product generated by the transformation of nutrients in the diet.

The increase in the fiber content is also a factor to be considered in the use of energy, because as it increased in rations, the levels of inclusion of yam flour concomitantly increased the levels of levels of fiber, the use of gross energy contained in food depends on several factors, for example, the fiber content present, method of processing, the level of food intake by the animal in accordance with its weight and age (Souza et al. 2008, 219-224).

Table 7 - average values of digestible energy apparent (EDap), digestible protein apparent (PDap) And Lipids digestivel apparent (LDap) of diets containing the inclusion of yam flour (*D. trifida sp*)

Variables	Yam flour (*D. trifida, L*)			Regression		CV, %
	0	15	30	L	Q	
ED ap.	3453	2948	2955	<0.05	NS	0.44
PD ap. (%)	13.82	13.41	9.82	<0.05	NS	1.11
LD ap. (%)	2.0	1.85	1.67	<0.05	NS	10.46
	The regression equations					R2
ED ap.	Y= 3453,0 - 50.7667 x2 + 1,1391x					0.99
PD ap. (%)	Y= 13.820 - 0.3458 x2 - 0,0071x					0.99
LD ap. (%)	Y= 1.9820 - 0,0035x2 - 0,00023X					0.36

*Coefficient of variation, P value - Coefficient of probability. Effect. NS - not significant.

Table 8 shows the values of the coefficients of digestibility of nutrients of 15 animals, and with the obtaining of them it was possible to obtain average values of the coefficients listed above for each treatment. The results of statistical analysis are shown in Table 9.

In Table 9, are the averages of the coefficients of digestibility of nutrients of the treatments. It was observed that the inclusion of yam feed obtained negative linear response ($p < 0.05$) on the coefficients of digestibility of gross energy (90.2; 84.97; 80.35), coefficient of digestibility of dry matter (91.04; 88.24; 84.29), coefficient of digestibility of organic matter (92.17; 89.78; 86.49), coefficient of digestibility of mineral matter (62.12; 56.24; 48.24) and digestibility coefficient of lipids (61.53; 49.06; 25.02) of pigs fed with 15 and 30% inclusion of yam flour, which showed a negative inverse proportion. These results may have occurred due to the nutritional imbalance of the diets resulting from the replacement of corn by flour ingredient test (yam). Second Kunrath et al. (2010, 1172-1179), the increasing level of substitution of the ingredient test can influence negatively the digestibility of nutrients in the diet.

Table 8. Values of the coefficients of digestibility of nutrients of the diets containing the inclusion of yam flour

Animal	CD-EB (%)	CD- MS (%)	CD-MO (%)	CD- MM (%)	CD-PB (%)	CD-LIP (%)	CD-NDF (%)	CD-FDA (%)
1	95.61	95.68	96.24	77.65	89.97	83.28	91.62	70.48
2	85.54	88.68	90.13	57.59	82.44	46.99	87.00	74.56
3	78.09	82.92	84.57	52.21	74.22	10.36	83.96	60.71
4	90.87	91.56	92.77	58.73	82.98	64.07	83.59	61.47
5	82.54	86.73	88.70	48.07	81.96	54.87	84.72	60.02
6	82.44	86.59	88.63	48.61	80.77	39.23	84.89	71.78

7	93.44	94.30	95.03	77.3	89.69	69.07	89.11	81.4
8	85.70	88.83	90.07	61.89	83.44	37.57	89.04	71.12
9	81.99	86.00	87.97	51.71	79.76	27.67	87.72	68.95
10	81.75	83.69	85.61	38.40	68.65	26.16	76.39	34.89
11	84.14	87.27	89.11	50.41	81.74	52.09	88.73	69.61
12	79.61	84.09	86.24	46.53	76.64	23.26	87.02	62.27
13	89.33	89.95	91.20	58.55	79.24	65.06	85.55	47.00
14	86.90	89.68	90.91	63.24	84.56	53.8	91.33	62.83
15	79.61	82.83	85.05	42.17	76.06	24.56	86.55	43.93
Average	85.17	87.92	89.48	55.54	80.81	45.2	86.48	62.73
*CV	6.11	4.44	3.85	20.39	6.84	45.31	4.3	19.87

*Coefficient of variation

The fineness of the product analyzed may be a factor that must be considered in this behavior of reduction of coefficients of digestibility of nutrients, because the yam flour had a particle size too low (powder), in consequence may have been an increase in the rate of passage that influence the absorption of nutrients by the small intestine villi, because the increase of speed of passage rate also reduces the digestibility of nutrients (Oliveira 2001).

The decrease of CD-EB, CD-MS, CD-MO, CD-MM and CD-LIP may have been influenced by another factor, due to the expensive yam flour during the processing of the ingredients have been used for the whole tuber, with bark, this factor may have increased the levels of NDF and ADF. When observing the Table 3 there is an increase of approximately 50% in fiber (NDF and ADF) of animal tests (which contains the yam flour) in relation to the control diet. In this way the NDF may have influenced the decrease of the digestibility of nutrients, because the fiber is one of the factors that contributes to reducing the digestibility of ingredients used in diets for pigs (Noblet and Perez 1993, 3389-3398).

Table 9. The average values of the coefficient of digestibility of gross energy (CD-EB), coefficient of digestibility of dry matter (CD-MS), coefficient of digestibility of organic matter (CD-MO) and coefficient of digestibility of crude protein (CD-PB) of diets containing increasing levels of yam flour in the diet.

Variables (%)	Yam flour			Regression		CV, %
	0	15	30	L	Q	
CD-EB	90.20	84.97	80.35	<0.05	NS	3.89
CD-MS	91.04	88.24	84.49	<0.05	NS	3.25
CD-MO	92.17	89.78	86.49	<0.05	NS	2.94
CD-MM	62.12	56.24	48.24	<0.05	NS	15.57
CD-PB	82.11	82.33	77.49	NS	NS	6.44
CD-LIP	61.53	49.06	25.02	<0.05	NS	33.57
CD-Ndf	85.23	88.16	88.17	NS	NS	4.43
CD-FDA	59.05	67.63	63.34	NS	NS	18.981
		The regression equations				R2

CD-EB	Y= 90.200 - 0.3697 x2 + 0.0013 x	0.77
CD-MS	Y= 91.036 - 0.1547 - 0.0021 x x2	0.69
CD-MO	Y= 92.170 - 0.1288 - 0.0020 x x2	0.66
CD-LIP	Y= 61.5280 - 0,4448x2 - 0,0257x	0.69
CD-MM	Y= 62.1260 - 0,3221x2 - 0,0046x	0.67

CV - Coefficient of variation. P value - Coefficient of probability. Effect. NS - Not significant

In studies carried out by Oliveira (1999), in a metabolic test to analyze the effects of the addition of traditional coffee husk in rations for growing and finishing pigs, we observed a linear reduction ($p < 0.05$) in all studied variables: MSD CDPB, CDFDN, RN, gross energy and digestible energy and metabolizable energy. The author considers various factors that may have contributed to these results, especially the increasing quantities of fiber in the diets containing coffee husk (0, 5, 10 and 15%).

Other authors have demonstrated that the digestibilities of DM, EB (Nortey et al. 2008, 3450-3464), CP, NDF and ADF (Gomes et al. 2007, 483-492) are affected negatively by the increase- of the content of crude fiber in the diets of growing pigs.

With respect to fiber, the pigs digest better the hemicellulose than the cellulose, but is the degree of lignification that exerts the greatest influence on the digestibility of fiber. The fiber can negatively affect the use of some nutrients, consequently occurring to the reduction of the digestibility of dry matter, the ethereal extract and crude protein by increasing the rate of passage of food through the gastrointestinal tract of the pig (Souza et al. 2008, 219-224).

This effect of reduction of coefficients of digestibility was observed by Oliveira (2001) where the coefficients of digestibility of the diets of pigs ranged between 70 and 90%, and that this coefficient is greatly reduced when using raw materials with high levels of fiber (Noblet and Perez 1993, 3389-3398). Even with the inclusion of yam feed digestibility coefficients remained with values between 70 and 90% for the majority of the nutrients, demonstrating that the yam flour has a good digestibility, even with the presence of fiber is less digestible, contributes to the reduction of the digestibility of other nutrients, such as protein, fat and minerals.

3.2. Serum biochemical profile

The mean values of serum concentrations of protein metabolisms, energy and mineral of the finishing phase are shown in Table 10.

The results observed in serum concentrations of protein metabolism showed significant differences ($p < 0.05$) with positive linear response ($p < 0.05$) for the serum levels of total protein (4.46; 6.75; 7.20) and Albumin (2.01; 2.65; 3.75). All serum parameters evaluated are within the values referenced by the literature. For the protein metabolism serum levels of total protein increased significantly ($p < 0.05$) in animals fed with the flour of yam, when compared to values obtained from animals in the control treatment, indicating the consumption of a diet with good protein content and amino acid balance, which resulted in a good maintenance of serum levels of urea.

The serum levels of albumin is the most abundant protein in the plasma (Lehninger 1999), being synthesized in the liver and acting as the carrier of metabolites and in control of the osmotic pressure. The alteration of its blood concentration is given by various means, among which include liver damage, food deficit of protein, dehydration, among others, but a marker extremely stable, suffering changes only after long periods (González and Silva 2006).

The concentration of urea in the blood is of great importance to assess the metabolic activity of animal protein, urea is derived from the catabolism of amino acids, where this metabolite is directly related with the intake of protein in feed. It is a sensitive indicator and immediate protein intake, having regard to the protein levels in the diet, renal function and the energy-protein ratio in the diet (González and Silva 2006). However, this metabolic high value may be indicative of excess of protein in feed or an energy deficit, there should be a balanced balance between energy and protein in the animal body.

Table 10. Mean values of serum levels of total protein (g/dl), albumin (g/dl), globulin (g/dl), urea (mg/dl), glucose (mg/dl), cholesterol (mg/dl), triglycerides (mg/dl), Calcium (mg/dl), Fosforo (mg/dl), Magnesium (mg/dl) of animals of yam flour (*D. trifida,L*) in the diet.

Variables	Inclusion of yam flour (*D. trifida*, L)			Regression		CV1 (%)	Reference parameters for pigs2
	0%	15%	30%	L	Q		
	Protein metabolismo						
Total protein (g/dl)	4.46	6.35	7.20	0.05	NS	25.17	5.2 - 8.3
Albumin (g/dl)	2.01	2.65	3.75	0.05	NS	29.78	1.9 - 4.2
Globulin (g/dl)	2.49	3.70	3.45	NS	NS	31.02	
Urea (mg/dl)	30.00	33.5	30.50	NS	NS	10.23	24.7 - 85.7
	Energy Metabolism						
Glucose (mg/dl)	92.04	106.5	125.00	0.05	NS	15.56	4.0 - 8.1
Cholesterol (mg/dl)	28.05	30.5	43.00	0.05	NS	28.10	13.7 - 31.8
Triglycerides (mg/dl)	11.20	14.5	19.00	0.05	NS	20.20	
	Mineral metabolismo						
Calcium (mg/dl)	5.50	4.90	5.20	NS	NS	17.50	2.16 - 8.76

Fosforo (mg/dl)	4.90	5.30	7.28	NS	NS	22.36	2.25 - 8.81
Magnesium (mg/dl)	2.30	3.13	3.65	0.05	NS	15.71	1.90 - 3.85

	The regression equations	R2
Total protein (g/dl)	Y= 4.06 + 0.00233 x2 - x 0.0001	0.74
Albumin (g/dl)	Y= 1.98 + 1.33227 x2 - x 2.9606	0.50
Glucose (mg/dl)	Y= 92.0 + 0.10000 x2 + 0.0022 x	0.70
Triglycerides (mg/dl)	Y= 11.0 + 0.25495 x2 + 0.0081 x	0.68
Magnesium (mg/dl)	Y= 2.10 + 0.0425 x2 + 0.0014 x	0.65

[1]CV = coefficient of variation; 2reference values provided by Embrapa (1997).

The metabolic profile in animals can be used to monitor the metabolic adaptation, diagnose imbalances in the homeostasis of nutrients and reveal the causes that are behind the manifestation of a nutritional or metabolic disease (González 2000; Oliveira et al. 2007, 73-76).

In the energy metabolism observed significant effect ($p < 0.05$). The serum levels of glucose (92.04; 106.5; 125.0), cholesterol (28.05; 30.5; 43.00) and triglycerides (11.20; 14.50; 19.00) showed increasing linear effect, as the increase in the levels of inclusion of yam flour in diets. It was expected that the glucose levels rise, because as the yam flour is a starchy source, its composition is 70% of carbohydrates and have the starch as main component, this behavior is related to greater availability of this nutrient for the body of the animal, and it also influenced the levels of cholesterol and triglycerides, respectively, as the main means of energy storage is in the form of lipids.

The cholesterol present in the body of mammals is from diet and endogenous synthesis that occurs in the cytosol and in the endoplasmic reticulum of all nucleated cells of the body from the acetyl-CoA, this acetyl-CoA is a consequence of the excess of carbohydrate metabolism from glycolysis and the Krebs cycle. The increase in the rate of cholesterol (hypercholesterolemia) can be explained by the high energetic value of ration offered to animals in termination, besides the fact that they are not in fasting for 12 hours.

In the mineral metabolism showed significant effects ($p < 0.05$) only the serum levels of magnesium (2.30; 3.13; 3.65) as increased levels of inclusion of flour there was a linear increase in the quantity of magnesium, this increase must be related to the possible source of the yam flour, because the yam is a rich source of minerals, especially magnesium, as was the offer of this mineral has increased the quantity found in the animal body. In accordance with the brazilian food tables the raw yam (*D. alata*, L) contains 11 mg of magnesium in 100 grams of the edible part and in the cooked yam (*D. alata*, L) has 15 mg of Mg in 100 g of edible portion (NEPA 2011).

Magnesium is a mineral that has a relevant importance in regulating muscle contraction, which has effects on the myosin regulatory protein (troponin), adenosine triphosphate, in endoplasmic reticulum and in other points of storage of calcium. The Mg inhibits the release of acetylcholine, responsible for the beginning of the muscular contraction (González 2000).

3.3. Costs per kg of feed

We calculated the price of rations according to the values of the ingredients during the period that the experiment was performed. The price of feed the control diet, diet of treatment 15% and 30% treatment were, respectively, R$1.78; R$ 1.60 and R$ 1.47 on the price of kg of feed. Where the price of 1 kg of feed suffered a decrease of 13% in the feed containing 15% of yam in relation to feed the control diet, whilst the diets with inclusion of 30% had a reduction of 20% in relation to the reference feed.

According to Martins (2010), cost is an expenditure made by the entity in the purchase of a good or service for use in the production of other goods or services, and can be classified as to its ownership of the products and their behavior in relation to the volume produced.

The knowledge and control of the costs of production of pigs becomes important, because the production of pigs has a relevant role in the Brazilian economy, since participation in the GDP in its development in the production chain up to the generation of employment and income (ABCS 2011, 11-50).

Among the main factors that are fundamental for the survival of a company, the profitability presents itself as being one of the most important, because nobody will make an investment in a sector that is in decline or that is not profitable.

In Table 11, are contained the average values of the cost prices of each kilogram live weight gain for each treatment during the experiment of digestibility, it is observed that the price of the cost preview the greatest value was the control diet that 1 kg of live weight had a cost of R$ 7.53; since their diet was the most expensive and resulted in the rise in the cost per live weight, since the treatment with 15% of inclusion was the one that had the lowest cost per 1 kg of live weight gain.

Table 11. The average values of the cost of each kilogram live weight gain during the experiment of digestibility

Treatments	Price of PV (R$)	CV %
Control diet	7.53	22.08
15% treatment	5.53	28.62
30% treatment	5.84	40.90

1CV = coefficient of variation

4. CONCLUSION

The yam flour presents itself as a potential ingredient in feed for pigs on termination, once that showed good values in the centesimal composition and a digestible energy of 3360 Kcal/kg.

The metabolic profile of animals evaluated not suffered deleterious changes in serum parameters and remained within the levels recommended by the literature.

In this study, the yam flour had a particle size too low, in consequence may have been an increase in the rate of passage that influence the absorption of nutrients by the small intestine villi, with a reduction in the digestibility of nutrients.

The inclusion of yam flour to 15% allowed satisfactory result in the values of the coefficients of digestibility when compared to the inclusion of 30% of yam feed. In this way, it is recommended that the completion of the experiment of animal performance, carcass evaluation and economic viability, in order to determine the best levels of inclusion of this ingredient in the diets of pigs in the finishing phase.

Acknowledgments

We thank the Amazonas Federal University (UFAM), the Amazonas Research Support Foundation (FAPEAM), the Core of Food Security and Nutrition (NUSAN), the direction of the UFAM experimental farm, Albejamere Pereira de Castro, and, in particular, to the director of the Faculty of Agrarian Sciences, Marco Antônio de Freitas Mendonça, for the support given to the accomplishment of this work.

BIBLIOGRAPHICAL REFERENCES

1. ABCS. Associação Brasileira de Criadores de Suínos. 2011. *Manual brasileiro de boas práticas agropecuárias na produção de suínos*. Brasília, DF: ABCS; MAPA; Concórdia: Embrapa Suíno e Aves.
2. AOAC. Official methods of analysis of the Association Analytical Chemists. 2005. 18. ed. Gaithersburg, Maryland.
3. EMBRAPA. Empresa Brasileira de Pesquisa Agropecuária. 1997. *Procedimentos básicos na produção de suínos*. EMATER/RS; Embrapa Suíno e Aves.
4. Feijó, J.C.; Cruz, F.G.G.; Melo, R.D.L.; Rufino, J.P.F.; Damasceno, J.L.; Costa, A.P.G.C.; Negreiros. T. de J.N. 2016. "Farinha de cará (*Dioscorea trifida L.*) sobre o desempenho, qualidade do ovo e bioquímica sérica de poedeiras comerciais leves'. *Rev. Bras. de Saú. Prod. Ani.*, 2016. http://dx.doi.org/10.1590/S1519-99402016000300008.

5. Garcia Gonçalves, R.; Mauch Palmeira, E. 2006. "Suinocultura Brasileira". *Observatorio de la Economía Latinoamericana*. 2006. http://www.eumed.net/cursecon/ecolat/br.
6. Gomes, J.D.F.; Putrino, S.M.; Grossklaus, C; Utiyama, C.E.; Oetting, L.L.; Souza, L.W. de O.; Fukushima, R.S.; Fagundes, A.C.A.; Sobral, P.J. do A,; Lima, C.G. de. 2007. "Efeitos do incremento de fibra dietética sobre a digestibilidade, desempenho e características de carcaça: I. suínos em crescimento e terminação". *Semina: Ciências Agrárias*, 2007.
7. Gomide, E.T.; Saraiva, L.H.G.; Moura, J.P.; Fausto, M.C. 2016. "Avaliação da qualidade de subprodutos utilizados na alimentação de suínos, através da determinação do índice de acidez e peróxido". *Revista Científica Uni Viçosa*, 2016.
8. González F.H.D. *Uso de perfil metabólico para determinar o status nutricional em gado de corte*. 2000. In: González FHD, Barcellos JO, Ospina H, Ribeiro LAO. (Eds). Perfil Metabólico em ruminantes: seu uso em nutrição e doenças nutricionais. Porto Alegre: Gráfica da Universidade Federal do Rio Grande do Sul.
9. González F.H.D.; Silva, S.C. 2006. *Introdução à bioquímica clínica veterinária*. Porto Alegre: Gráfica da Universidade Federal do Rio Grande do Sul.
10. INMET. Instituto Nacional de Meteorologia. 2017. "Prognóstico Climático do Verão". Acesso em 31 de maio de 2020. http://www.inmet.gov.br/portal/index.php?r=noticia/visualizarNoticia&id=120
11. Jafari, M.; Pirmohammadi, R.; Bampidis, V. 2006. "The use of dried tomato pulp in diets of laying hens". *International Journal of Poultry Science*, 2006.
12. Kunrath, M.A.; Kessler, A. de M.; Ribeiro, A.M.L.; Vieira, M. de M.; Silva, G.L. da S.; Peixoto, F.D. 2010. "Metodologias de avaliação do valor nutricional do farelo de arroz desengordurado para suínos". *Pesquisa Agropecuária Brasileira*. 2010. DOI: 10.1590/S0100-204X2010001000017.
13. Lehninger, A.L. 1999. *Princípios de Bioquímica*. São Paulo: Ed. Sarvier.
14. Lopes, I.R.V.; Freitas, E.R.; Lima, J.R.; Neto, J.L.V.; Bezerra, R.M.; Lima, R.C. 2011. "Desempenho e qualidade dos ovos de poedeiras comerciais alimentadas com rações contendo farelo de coco tratado ou não com antioxidante". *Revista Brasileira de Zootecnia*, 2011.
15. Martins, E. 2010. *Contabilidade de Custos*. 10. ed. São Paulo: Atlas.
16. Matterson, L.B.; Potter, L.M.; Stutz, M.W.; Singsen, E.P. 1965. "The metabolizable energy of feed ingredients for chickens". *Res. Rep.* 1965.
17. NEPA. Núcleos de Estudos e Pesquisas de Alimentação. 2011. *Tabela brasileira de composição de alimentos*. Campinas, SP: UNICAMP; NEPA, 2011. http://www.cfn.org.br/wpcontent/uploads/2017/03/taco_4_edicao_ampliada_e_revisada.pdf
18. Noblet, J.; Perez, J.M. 1993. "Prediction of digestibility of nutrients and energy values of pig diets from chemical analysis". *Journal of Animal Science* 71 (12): 3389-3398.

19. Nortey, T.N.; Patience, J.F.; Sands, J.S.; Trottier, N.L.; Zijlstra, R.T. 2008. "Effects of xylanase supplementation on the apparent digestibility and digestible content of energy, amino acids, phosphorus, and calcium in wheat and wheat by-products from dry milling fed to grower pigs". *Journal of Animal Science* 86: 3450-3464. DOI: 10.2527/jas.2007-0472.
20. Nunes, R.V.; Rostagno, H.S.; Albino, L.F.T.; Gomes, P.C.; Toledo, R.S. 2001. "Composição Bromatológica, Energia Metabolizável e Equações de Predição da Energia do Grão e de Subprodutos do Trigo para Pintos de Corte". *Revista Brasileira de Zootecnia*. 2001.
21. Oliveira, A.P.; Barbosa, L.J.N.; Pereira, W.E.; Silva, J.E.L.; Oliveira, A.N.P. 2007. "Produção de túberas comerciais de inhame em função de doses de nitrogênio". *Horticultura Brasileira*, 2007.
22. Oliveira, S.L. 2001. "Avaliação da casca de café melosa em rações para suínos em terminação". Mestrado, Universidade Federal de Lavras.
23. Oliveira, V. 1999. "Casca de café em rações isoenergéticas para suínos em crescimento e terminação (Digestibilidade e Desempenho)". Mestrado, Universidade Federal de Lavras.
24. Rostagno, H.S.; Albino, L.F.T.; Donzele, J.L.; Gomes, P.C.; Oliveira, R.F. de; Lopes, D.C.; Ferreira, A.S.; Barreto, S.L. de T. 2005. *Tabelas Brasileiras para Aves e Suínos; Composição de Alimentos e Exigências Nutricionais*. 2. ed. Viçosa: UFV, Imprensa Universitária.
25. Sakomura, N.K.; Rostagno, H.S. 2007. *Métodos de pesquisa em nutrição de monogástricos*. Funep: São Paulo.
26. Silva, D.J.; Queiroz, A.C. 2002. *Análise de alimentos: métodos químicos e biológicos*. 3.ed. Viçosa, MG: UFV/Imprensa Universitária.
27. Souza, C. de F.; Campos, J.A.; Santos, C.R. dos; Bressan, W.S.; Mogami, C.A. 2008. "Produção volumétrica de metano: dejetos de suínos". *Ciências Agrotécnica. Lavras*, 2008.