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Whole scrapings of cassava root in diets for broilers from 1 to 21 days of age

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ABSTRACT. The study was conducted to evaluate the effect of including whole cassava root scrapings (WCS) in diets of broilers on performance and the metabolizability of dry matter, crude protein, and gross energy and on nitrogenous balance. Four hundred female and 100 male broilers from Ross strain were used in the performance and metabolism studies, respectively. In both studies, broilers were allotted in completely randomized block design with five treatments and four replicates. The experimental unit was represented for twenty birds per box for performance study and five birds per metabolic cage for metabolism study. The treatments consisted of diets containing 0, 5, 10, 15, and 20% WCS inclusion. Up to 5.1% WCS can be included in the diet of broilers from 1 to 21 without compromising feed conversion and productive efficiency index. Dry matter, crude protein, and gross energy metabolizability and the nitrogen balance of the diets are not influenced by the inclusion of whole cassava root scrapings up to 20% in diets of broilers from 1 to 21 days of age.

Keywords: crude protein, metabolizability, performance.

Raspa integral da raiz de mandioca para frangos no período de 1 a 21 dias

RESUMO. Avaliaram-se diferentes níveis de inclusão da raspa integral da raiz de mandioca (RIM) com o objetivo de avaliar o desempenho produtivo e a metabolizabilidade da matéria seca, da proteína bruta e da energia bruta de frangos de corte, no período de um a 21 dias de idade. No ensaio de desempenho, foram utilizadas 400 aves fêmeas da linhagem Ross e para o de metabolismo, 100 frangos machos da mesma linhagem. O delineamento experimental dos dois ensaios foi o de blocos ao acaso, com cinco tratamentos, quatro repetições e 20 aves alojadas em cada boxe para o ensaio de desempenho. Cinco aves foram alojadas em cada gaiola metabólica, para o estudo de metabolismo. Os tratamentos consistiram de rações contendo 0, 5, 10, 15 e 20% de inclusão de RIM. A RIM mandioca pode ser incluída em até 5,1% na ração de frangos de corte, no período de 1 a 21 dias, sem comprometimento da conversão alimentar e do índice de eficiência produtiva. As variáveis de metabolizabilidade da matéria seca, da proteína bruta, da energia bruta e o balanço de nitrogênio das rações não são influenciadas pelos níveis de inclusão da RIM em até 20%, no período de um a 21 dias.

Palavras-chave: proteína bruta, metabolizabilidade, desempenho.

Introduction

Poultry production occupies a prominent position on the capability to convert plant products on high quality protein compared with other species. However, feeding cost may represent more than 70% of the total cost of production where corn and soybean meal are used as main ingredients.

Corn is the main component of energy in poultry diets and is subjected to large price variations caused by periods between harvests and droughts with a direct impact on supply, and also because corn is widely used in human food, constituting a major problem for poultry producers, particularly those located at northeast of Brazil, where the production of this ingredient is very limited. The inclusion of alternative foods in animal nutrition has been studied in order to lower the costs of production (BASTOS et al., 2007).

Producers and researchers have sought to use alternative feedstuffs in diet formulation of poultry since nutritionists within certain limits recognize that livestock nutritional requirements are related to nutrients (amino acids, calcium, phosphorus, vitamins, etc.) and not to certain foods (ROSTAGNO et al., 2005).

Cassava is an alternative food used in animal feed and can generate various types of byproducts. The energy concentration in whole cassava root is affected by moisture content and features around 1,500 ME kg^{-1}. However, when dehydrated ranges from 3,200 – 3,600 kcal EM kg^{-1} (ROSTAGNO et al., 2005). In general, chemical composition values of whole cassava root scrapings vary depending on climate, soil type, variety and plant age (MONTALDO et al., 1994).

Dehydration is an important process for preserving the quality of the roots after harvest and it facilitates its use in feed formulation and increases the concentration of nutrients besides being one of the most efficient methods to reduce the toxicity present in some varieties. In this scenario, cassava scraps is a promising alternative feed in diets for broilers. According to Rostagno et al. (2005), the energy level of cassava scraps is around 3,138 kcal EM kg^{-1} making possible to use it as a substitute for corn in poultry diets. However, this ingredient has minimal amounts of crude protein, vitamins, and minerals that must be considered and adjusted in diet formulations (ALMEIDA; FERREIRA FILHO, 2005).

Thus, the study was conducted to evaluate the effect of including cassava scraps in diets of broilers on performance (weight gain, feed intake and feed conversion) and on feasibility of broilers production, and also to evaluate dry matter metabolizability (DM), crude protein (CP) and gross energy (GE), from 1 to 21 days of age.

Material and methods

Experiment 1

The study was conducted in the experimental facility at Sector of Aviculturr of the Department of Animal Science (DZO) from the Center for Agricultural Sciences (CCA) of the Federal University of Piauí (UFPI), in Piauí State, using four hundred 1-day old female broilers of Ross strain.

Broilers were allotted in a randomized block design, based on body weight, with five treatments and four replicates. The experimental unit consisted of 20 birds, per pen with wired mash sides and 3 m^2 each. The experimental diets (Tables 1 and 2) were mainly composed of corn and soybean meal, and supplemented with soybean oil, dicalcium phosphate, limestone, salt, vitamins and minerals to meet the nutritional requirements in each stage of growth, according to Rostagno et al. (2005). Treatments consisted of a basal diet and other four diets obtained by adding 5, 10, 15, and 20% WCS in the basal diet replacing corn.

WCS was added to the diets according to the percentages determined for each treatment and

Table 1. Composition of experimental diets according to the level of inclusion of whole cassava root scrapings fed to broilers from 1to 7 days of age.

Ingredient	Whole cassava root scrapings, %				
	0	5	10	15	20
Corn	54.695	48.005	41.576	35.118	28.780
Soybean meal, 45%	38.645	39.627	40.507	41.400	42.275
Soybean oil	2.566	3.215	3.785	4.385	4.873
Whole cassava scrapings	0.000	5.000	10.000	15.000	20.000
Dicalcium phosphate	1.928	1.935	1.950	1.970	1.970
Limestone	0.930	0.905	0.865	0.829	0.809
Salt	0.325	0.325	0.325	0.325	0.325
L-Lysine	0.129	0.119	0.112	0.087	0.072
DL-methionine	0.182	0.269	0.280	0.286	0.296
Mineral and vitamin premix[1]	0.200	0.200	0.200	0.200	0.200
Kaolim	0.140	0.140	0.140	0.140	0.140
Choline Chloride	0.125	0.125	0.125	0.125	0.125
Virginiamycin	0.055	0.055	0.055	0.055	0.055
Coccidiostatic	0.050	0.050	0.050	0.050	0.050
B-hydroxytoluene	0.010	0.010	0.010	0.010	0.010
Enzymes[2]	0.020	0.020	0.020	0.020	0.020
TOTAL	100.000	100.000	100.000	100.000	100.000
Calculated composition[3]					
Metabolizable energy, kcal kg^{-1}	2950	2950	2950	2950	2950
Crude protein, %	22.04	22.04	22.04	22.04	22.04
Digestible lysine, %	1.330	1.330	1.330	1.330	1.330
Digestible Met+Cist, %	0.944	0.944	0.944	0.944	0.944
Digestible tryptophan, %	0.213	0.213	0.213	0.213	0.213
Crude fiber, %	3.04	3.25	3.45	3.66	3.87
Calcium, %	0.94	0.94	0.94	0.94	0.94
Available phosphorus, %	0.47	0.47	0.47	0.47	0.47

[1]Premix composition per kg: Folic Acid – 100 mg, Antioxidant – 125 mg, Copper – 15.000 mg, Coccidiostatic – 25,000 mg, Choline – 50,000 mg, Iron – 10,000 mg, Iodine – 250 mg, Manganese – 24,000 mg, Methionine – 307,000 mg, Niacin – 20,000 mg, Calcium Pantothenate – 2,000 mg, Selenium – 50 mg, Vehicle QSP – 1,000 g, Vitamin A – 300.,00 IU kg^{-1}, Vitamin B1 – 400 g, Vitamin B12 – 4,000 mcg, Vitamin B2 – 1,320 mg, Vitamin D3 – 100,000 IU kg^{-1}, Vitamin E – 4,000 UI kg^{-1}, Vitamin K – 98 mg, Zinc – 20,000 mg, growth promoter – 10,000 mg. [2]Amylase, cellulose, protease, and phytase according to the manufacturer's recommendation. [3]Calculated according to Rostagno et al. (2005).

Table 2. Composition of experimental diets according to the level of inclusion of whole cassava root scrapings fed to broilers from 8 to 21 days of age.

Ingredient	Whole cassava root scrapings, %				
	0	5	10	15	20
Corn	58.556	51.873	45.534	39.104	32.516
Soybean meal, 45%	35.168	36.147	36.990	37.900	38.859
Soybean oil	2.510	3.220	3.720	4.265	4.900
Whole cassava scrapings	0.000	5.000	10.000	15.000	20.000
Dicalcium phosphate	1.795	1.825	1.825	1.825	1.840
Limestone	0.890	0.825	0.825	0.795	0.765
Salt	0.325	0.325	0.325	0.325	0.325
L-Lysine	0.031	0.015	0.005	0.000	0.000
DL-methionine	0.125	0.170	0.176	0.186	0.195
Mineral and vitamin premix[1]	0.200	0.200	0.200	0.200	0.200
Kaolim	0.140	0.140	0.140	0.140	0.140
Choline Chloride	0.125	0.125	0.125	0.125	0.125
Virginiamycin	0.055	0.055	0.055	0.055	0.055
Coccidiostatic	0.050	0.050	0.050	0.050	0.050
B-hydroxytoluene	0.010	0.010	0.010	0.010	0.010
Enzymes[2]	0.020	0.020	0.020	0.020	0.020
TOTAL	100.000	100.000	100.000	100.000	100.000
Calculated compositon[3]					
Metabolizable energy, kcal kg^{-1}	3000	3000	3000	3000	3000
Crude protein, %	20.790	20.790	20.790	20.790	20.790
Digestible lysine, %	1.146	1.146	1.146	1.146	1.146
Digestible Met+Cist, %	0.814	0.814	0.814	0.814	0.814
Digestible tryptophan, %	0.183	0.183	0.183	0.183	0.183
Crude fiber, %	2.919	3.126	3.333	3.542	3.751
Calcium, %	0.884	0.884	0.884	0.884	0.884
Available phosphorus, %	0.442	0.442	0.442	0.442	0.442

[1]Premix composition per kg: Folic Acid – 100 mg, Antioxidant – 125 mg, Copper – 15,000 mg, Coccidiostatic – 25,000 mg, Choline – 50,000 mg, Iron – 10,000 mg, Iodine – 250 mg, Manganese – 24,000 mg, Methionine – 307,000 mg, Niacin – 20,000 mg, Calcium Pantothenate – 2.000 mg, Selenium – 50 mg, Vehicle QSP – 1,000 g, Vitamin A – 300,000 IU kg^{-1}, Vitamin B1 – 400 g, Vitamin B12 – 4,000 mcg, Vitamin B2 – 1,320 mg, Vitamin D3 – 100,000 IU kg^{-1}, Vitamin E – 4,000 UI kg^{-1}, Vitamin K – 98 mg, Zinc – 20,000 mg, growth promoter – 10,000 mg. [2]Amylase, cellulose, protease, and phytase according to the manufacturer's recommendation. [3]Calculated according to Rostagno et al. (2005).

altered the amounts of ingredients in the diets (corn, soybean meal, soybean oil, dicalcium phosphate, limestone, L-lysine and DL-Methionine). However, the chemical composition of the diet was maintained, except for crude fiber.

The WCS was dehydrated, ground, and stored for later use in experimental diets.

Broilers had free access to clean water and feed throughout the experimental period. A heating lamp system was provides during the ten days of age. The lighting program was continued during 24h of the day, and as of 6:30 a.m to 5:30 p.m, natural lighting, and the rest with artificial light with automatic lighting from 5:30 p.m until 6:30 a.m, using fluorescent lamps of 75 watts. Broilers were handled throughout the experimental period according to the Ross manual.

Temperature and humidity inside the facility were monitored by means of a digital hygrometer HM-02 (HIGHMED) with external sensor for maximum and minimum temperatures, placed at an intermediate height in relation to the boxes. The readings of the thermometers were performed daily, and in the periods of the day in which the temperature exceeded the thermal neutral zone, electric fans with capacity of 296 m^3 min.$^{-1}$ and rotation of 538 rpm were used to decrease heat stress.

To determine feed intake (FI) and weight gain (WG) broilers were weighed at the beginning and at the end of the experimental phase. FI was calculated by difference between the amount of feed offered and the leftovers of the experimental diets. Feed conversion (FC) was calculated based on data of FI and WG. The creation viability index (CVI) was calculated by subtracting 100 from the observed value of mortality (%) and the productive efficiency index (PEI) was calculated by the formula: PEI = ((WG x CVI) / (days until the end of the experiment x FC)) x 100 (STRINGHINI et al., 2006).

Experiment 2

The metabolism study was conducted in a metabolism facility at Sector of Aviculturr of the Department of Animal Science (DZO) from the Center for Agricultural Sciences (CCA) of the Federal University of Piauí (UFPI), in Piauí State. Quemical analysis and gross energy determination were performed at the Laboratory of Nutrition DZO-CCA-UFPI using a calorimeter pump (Parr Instrument Company-6300).

Hundred male broilers from 12 to 20 days of age, individually selected by body weight, were allotted in a randomized block design, based on the position of the cages inside the facility, with five treatments and four replicates with five broilers per experimental unit. Broilers were housed in metabolic cages (1.50 x 1.0 x 1.20 m) equipped with feeders, drinkers, and trays for excreta collection. The experiment lasted eight days, the first four days for adaptation to the metabolic cages and experimental diets and the last four days for total excreta collection.

Broilers had free access to feed and water throughout the experimental period. A continuous light program during 24h per day was adopted with natural light from 6:30 a.m to 5:30 p.m and the remaining using 75 watts bulbs.

Two total daily collections of excreta from each experimental unit were performed at 8:00 a.m and 4:00 p.m during four days. Excreta collected were stored in properly identified plastic bags, weighed, homogenized and stored in a freezer at -5°C until the end of the experiment period when laboratory analysis were performed. At the end of the period of total excreta collection, all excreta from the same experimental unit was properly thawed and mixed uniformly. Subsequently, excreta were pre-drying was done in an oven with forced ventilation for 48h at 65°C. Then excreta samples were taken, ground in a ball mill, and packed in jars for later chemical analyzes (SILVA; QUEIROZ, 2002). Calculations of nutrients metabolizability coefficients were performed according to Ramos et al. (2006).

Data were submitted to analysis of variance and regression, according to the procedures of the Statistical Analysis System (SAS, 1998).

Results and discussion

The average temperature during the experimental period in the morning and afternoon were 29.7 ± 1.8ºC and 35.6 ± 0.8ºC, respectively, and the average of relative humidity of the air was 46.6 ± 15.4%. According to Ferreira (2005), the recommended temperature for broilers, layers and breeders ranges from 15 to 28°C, and for the first days of life the temperature should be between 33 - 34°C, depending on the air humidity. Thus, the variation of temperatures observed in our experiment shows that most of the time broilers were subjected to heat stress.

It was found that the levels of inclusion of whole cassava root scrapings (WCS) influenced feed intake (Table 3), according to the equation

$$FI = 1.003 - 0.008X + 0.0016X^2 (R^2 = 0.9813, p < 0.01).$$

The lowest FI occurred at 2.7% inclusion of WCS. Therefore, from this value, the consumption increased proportionally with the increase of WCS in the diets. Freitas et al. (2008) using floor cassava meal did not verified differences on FI of broilers in the initial phase of growth. Carrijo et al. (2010) also found no differences on performance of female free-range broilers with the addition of whole cassava root meal.

By the other hand, Olugbemi et al. (2010) found that inclusion of cassava root scrapings in the diet of broilers during initial phase of growth decreased performance.

Weight gain and production viability (Table 3) were not affected ($p > 0.05$) by the inclusion WCS in the diets. However, feed conversion (FC) and productive efficiency index (PEI) showed a quadratic response, according to the respective equations:

$$FC = 1.6183 - 0.026X + 0.0029X^2 (R^2 = 0.99, p < 0.01)$$

and

$$PEI = 180.48 + 2.507X - 0.246X^2 (R^2 = 0.93, p < 0.05).$$

The lowest value for FC and the highest value for PEI occurred, respectively, at 4.47 and 5.10% inclusion of WCS. Midau et al. (2011) reported a reduction in weight gain with the increase of WCS in the diet of broilers at the initial phase of growth. Sousa et al. (2012) including cassava bagasse in diets of broilers from 1 to 21 days of age found no effect on FC. However, a quadratic effect on weight gain was found up to 4.86% maximum response contrary to what was observed in our study.

Considering the PEI up to 5.1% of WCS can be included in diets of broilers from 1 to 21 days of age, provided diets are properly balanced.

Table 3. Performance of broilers fed diets with different levels of inclusion of whole cassava root scrapings (WCS) from 1to 21 days of age.

WCS, %	Feed intake, kg	Weight gain, kg	Feed conversion	Viability, %	Productive efficiency index
0	1.014	0.622	1.63	97.5	177.41
5	0.965	0.631	1.53	97.5	191.85
10	1.112	0.668	1.67	96.25	184.37
15	1.214	0.645	1.88	93.75	153.14
20	1.462	0.651	2.25	98.75	136.38
CV, %	4.27	4.43	3.62	5.27	9.25
L (p > F)	0.0001	0.1373	0.0001	0.8795	0.0004
Q (p > F)	0.0001	0.2411	0.0001	0.3774	0.0121
Equation	$Y = 1.003 - 0.008X + 0.0016X^2$	-	$Y = 1.6183 - 0.026X + 0.0029X^2$	-	$Y = 180.48+2.50X – 0.246X^2$
R^2	0.98	-	0.99	-	0.93

L: linear, Q: quadratic.

This value is lower than 10.24% maximum response found by Nascimento et al. (2005), who verified a quadratic effect on weight gain and feed conversion with the inclusion of 5, 10, 15, 20, and 25% WCS replacing corn in diets of broilers.

The results of weight gain (WG) obtained in our study are considered low compared to various genetically improved strains of broilers. Souza et al. (2011) verified a linear increase on BW by increasing WCS inclusion in the diet of free-range broilers. It is possible that the low performance of broilers observed in our study was caused by heat stress due to the high temperatures that occurred during the experimental period.

Menezes et al. (2010), identified the average thermoneutral environment temperature for broilers, and found that broilers were kept under heat stress during the experimental period. The ambient temperature is considered the physical factor that has the greatest effect on performance of broilers by influencing feed intake, resulting in a direct effect on weight gain and feed conversion of these animals. Therefore, analyzing the results, it appears that the inclusion of WCS up to 20% in the diet, with the diet properly balanced, does not affect the values of metabolizable dry matter (Table 4).

It was also found no effect ($p > 0.05$) of including WCS on gross energy (GE) intake (kcal day^{-1}), CP excreted (kcal day^{-1}), and on GE metabolizability coefficient (%). These findings indicate that the inclusion of WCS in up to 20% in the diet of broilers does not influence GE metabolization.

It was also verified that CP intake (Table 5) was not affected ($p > 0.05$) by the inclusion of WCS in the diet. However, the CP excreted (CPE) showed a quadratic response, according to the equation:

$$CPE = 6.438 - 0.106X + 0.004X^2 \ (R^2 = 0.3649, p < 0.05).$$

The lowest value of the CP excretion occurred at 12.9% inclusion of WCS. However, the metabolization coefficient, an important parameter that measures the metabolization of nutrients, was not affected ($p > 0.05$) by dietary inclusion of WCS.

The amount of nitrogen (N) consumed and excreted presented the same behavior of CP metabolism (Table 5). Thus, the nitrogen excreted (NE) showed a quadratic response to increasing WCS in the diet, according to the equation:

$$NE = 1.032 - 0.017X + 0.0007 X^2 \ (R^2 = 0.3735, p < 0.05).$$

The lowest nitrogen excretion occurred at 12.1% inclusion of WCS in the diets. However, nitrogen balance, the main parameter that characterizes the use of nitrogen consumed was not affected ($p > 0.05$) by the inclusion WCS in the diet of broilers from 1 to 21 days of age, been positive at all inclusion levels evaluated.

Thus, the inclusion of WCS up to 20%, with the diets properly balanced; do not interfere on

Table 4. Effect of whole cassava root scrapings (WCS) in diets of broilers from 12 to 20 days of age on dry matter metabolism and gross energy.

WCS, %	Dry matter intake, g day^{-1}	Excreta dry matter, g day^{-1}	M. C. DM, %	GE intake, kcal day^{-1}	GE excreted, kcal day^{-1}	M. C., %
0	78.553	21.68	72.4	318.32	82.3	74.15
5	74.483	19.082	74.36	301.94	71.22	76.4
10	74.898	20.062	73.01	302.04	74.36	75.18
15	73.855	20.885	71.67	298.74	75.24	74.82
20	72.745	20.032	72.44	298.69	73.68	75.33
CV (%)	6.95	4.13	2.04	6.93	5.87	1.91
L (p > F)	0.1627	0.2837	0.2867	0.2266	0.0832	0.7423
Q (p > F)	0.6550	0.0557	0.4098	0.4721	0.0655	0.3493

M. C.: metabolizability coefficient. GE: gross energy. L: linear, Q: quadratic.

Table 5. Effect of whole cassava root scrapings (WCS) in diets of broilers from 12 to 20 days of age on crude protein metabolism.

WCS, %	CP intake, g day^{-1}	CP excreted, g day^{-1}	CP Metab. C., %	N intake, g day^{-1}	N excreted, g day^{-1}	N balance, g day^{-1}
0	17.36	6.65	61.678	2.775	1.065	1.712
5	15.302	5.61	63.34	2.45	0.9	1.55
10	17.18	5.72	66.645	2.75	0.915	1.832
15	16.647	6.262	63.308	2.665	1.002	1.662
20	16.235	5.722	64.765	2.597	0.915	1.682
CV (%)	4.34	4.99	2.8	4.33	4.89	6.13
L (p > F)	0.4411	0.0249	0.0937	0.4548	0.0207	0.7540
Q (p > F)	0.5249	0.0243	0.0952	0.5557	0.0235	0.6596
Equation	-	$Y = 6.438 - 0.106X + 0.004X^2$	-		$Y = 1.032 - 0.017X + 0.0007X^2$	-
R^2	-	0.3649	-		0.3735	-

L: linear, Q: quadratic.

the metabolizability of dry matter, crude protein, gross energy, and on nitrogen balance.

Conclusion

Up to 5.1% whole cassava root scrapings can be included in diets of broilers from 1 to 21 days of age without compromising feed conversion and productive efficiency index, as long as diets are properly balanced.

Dry matter, crude protein, and gross energy metabolizability and the nitrogen balance are not influenced by the inclusion of whole cassava root scrapings up to 20% in diets of broilers from 1 to 21 days of age.

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