Effects of feeding cassava bagasse to slow-growing broilers

Bagaço de mandioca na alimentação de frangos de crescimento lento

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ABSTRACT
The aim was to determine the energy and nutritional value of cassava bagasse (CB) and to evaluate its use for feeding slow-growing broilers. Two experiments were conducted. In the first experiment, a digestibility assay was performed to determine the apparent metabolizable energy (AME) and apparent metabolizable energy corrected for nitrogen balance (AMEn), as well as the apparent metabolizability coefficients of dry matter, crude protein and ether extract. The CB had 88.46% dry matter (DM); 1.26% crude protein (CP); 3.86% ether extract (EE); 1.06% ash and 3565 kcal/kg of gross energy. The determined values of AME and AMEn were 2508.74 kcal/kg and 2465.30 kcal/kg, respectively. The coefficients were 69.15%; 53.59% and 84.55% for DM, CP and EE; respectively. The second experiment was performed to evaluate the performance, biometry of the digestive tract and blood parameters of slow-growing broilers fed different inclusion levels (0%, 10%, 20% and 30%) of CB. In the starter phase, the inclusion of CB negatively affected feed intake (FI), weight gain (WG), whereas feed conversion (FC) had a quadratic response, with the best estimated conversion at 10.39%

of CB. Blood parameters in the starter phase were not influenced by CB inclusion. In the growing phase, the inclusion of CB negatively affected the WG, FC and final weight (FW). In the finishing phase, CB did not affect performance regardless of its inclusion, except for the final weight and carcass yield that were negatively affected. Relative to biometry, there was only an effect on the relative weight of the small intestine, which increased linearly. Glucose, triglycerides and cholesterol in the growing and finishing phases were not influenced by the CB levels. On the other hand, there was a quadratic effect for total protein with a maximum level of 4.74 g/dL at 10% inclusion in the growing phase, whereas uric acid increased as CB inclusion increased in the finishing phase. Based on the results of performance, biometry and blood parameters, CB can be added to slow-growing broilers diets in the starter phase up to 10.39%. The inclusion of CB in growing diets is not recommended, whereas it can be used up to the 30% without affecting the performance of slow-growing broilers in the finishing phase.

Keywords: nutrition, performance, poultry, residue

RESUMO

O experimento foi conduzido com o objetivo de avaliar a inclusão do bagaço de mandioca na alimentação de aves de crescimento lento na fase inicial, crescimento e final. Foram utilizados 280 pintos de crescimento lento, machos, distribuídos em 20 unidades experimentais. O delineamento experimental utilizado foi o inteiramente casualizado com quatro tratamentos, 0, 10, 20 e 30% de inclusão do bagaço de mandioca nas rações experimentais. Foram avaliados o consumo de ração, ganho de peso, conversão alimentar, peso final, rendimento de carcaça, tamanho do intestino delgado e pesos relativos do intestino delgado, coração, fígado e moela além dos parâmetros sanguíneos com a determinação de níveis de glicose, triglicerídeos, colesterol, ácido úrico e proteínas totais. Na fase inicial, a inclusão do bagaço de mandioca afetou negativamente o consumo de ração, ganho de peso e a conversão alimentar apresentou um comportamento quadrático. O peso relativo do intestino delgado aumentou de forma linear. Os parâmetros de glicose, triglicerídeos, colesterol, ácido úrico e proteínas totais não apresentaram alterações significativas pela inclusão do bagaço de mandioca. Na fase de crescimento a inclusão do bagaço de mandioca afetou negativamente o ganho de peso, conversão alimentar e peso final. O peso relativo do intestino delgado aumentou linearmente, seguindo os níveis de inclusão do bagaço e o peso relativo da moela apresentou um comportamento quadrático, aumentando até 14,24% de inclusão do bagaço, diminuindo nos níveis subsequentes. Na fase final, os níveis de inclusão do bagaço de mandioca não afetaram as variáveis de desempenho, com exceção do peso final e rendimento que foram afetados negativamente. Quanto à biometria, houve efeito apenas sobre o peso relativo do intestino delgado, que aumentou linearmente. Os parâmetros de glicose, triglicerídeos e colesterol nas fases de crescimento e final não foram influenciados pelos níveis de inclusão do bagaço, já para proteínas totais, houve efeito quadrático, com o teor máximo de 4,74 g/dL com 10% de inclusão do BM na fase de crescimento, e o ácido úrico, na fase final, aumentou com a inclusão do BM. Com base nos resultados acima, o bagaço de mandioca pode ser incluído nas rações de aves de crescimento lento na fase inicial até o nível de 10,39%, não se recomenda a inclusão nas rações de crescimento, enquanto que este pode ser utilizado até o nível de 30% sem afetar o desempenho de aves de crescimento lento na fase final.

Palavras-chave: avicultura, desempenho, nutrição, subproduto

1 INTRODUCTION

In poultry production, feed is one of the most representative expenses, mainly comprised of corn and soybean meal. The availability of these grains fluctuates depending on the region and year, directly affecting the poultry industry. The use of agroindustrial residues in animal nutrition minimizes the environmental impacts that the disposal of these materials would generate and reduces production costs.

The industry of cassava starch produces as a residue the cassava bagasse (M*anihot esculenta Crantz*). To obtain the starch, the cassava is peeled, ground and the starch is extracted. Then, the cassava bagasse, composed of the root fibrous material, is the residue of the starch extraction after drying (RAUPP et al. 1999). According to Cereda (1994), this residue had on average 88.18% of dry matter, 1.98% of crude protein, 16.57% of crude fiber and up to 75% of residual starch, then characterized as an energy feed.

Cassava and its residues can be partially or totally included in animal feeds in substitution to cereals as an energy source, taking into consideration its significant production and abundance in all regions of Brazil, with emphasis on the North region (FIORDA et al., 2013; HOLANDA et al., 2015).

The use of cassava bagasse was evaluated in broiler diets by Sousa et al. (2012) at increasing levels (5, 10, 15 and 20%). The authors reported that in the starter phase (1 to 21 days of age), broilers had a reduction in weight gain after 4.84% cassava bagasse inclusion and a linear reduction in feed intake, although feed conversion has not been affected. Broilers fed diets with up to 20% cassava bagasse in the finishing phase (22 to 40 days of age) had no productive losses in regarding to feed intake, weight gain and feed conversion. The authors state that the main issue related with the use of cassava bagasse is its high-fiber content, which generally limits its use.

There are few studies on cassava residues, although several authors have studied the use of whole cassava meal (WCM) in poultry nutrition. Campelo et al. (2009), studying backyard poultry fed diets with increasing levels of WCM (0, 18, 36 and 53%) in substitution to corn, observed that the increase in WCM adversely affects the final weight of broilers.

Carrijo et al. (2010), evaluating the performance and carcass yield of broilers fed diets based on whole cassava root meal (WCRM) at 0, 15, 30 and 45%, reported that there were no differences between groups on the variables studied.

Souza et al. (2011) evaluated WCRM levels (0, 20, 40, 60%) and observed that in the starter phase there was an increase in the weight gain and final weight of broilers. After the total rearing period, they concluded that the residue can be used up to 60% inclusion without affecting the performance, carcass and cut yields.

The aim of this study was to determine the best dietary inclusion of cassava bagasse for slow-growing broilers in the growing (29 to 56 days) and finishing phases (57 to 84 days), considering the productive performance, biometry of the intestinal tract and blood parameters of broilers.

2 MATERIAL AND METHODS

Two trials were conducted at the Poultry Research Centre of the School of Veterinary Medicine and Animal Science, Federal University of Tocantins. The study was conducted in accordance with the rules of the Ethics Committee on Animal Use, Federal University of Tocantins (CEUA-UFT).

The climate is classified as Aw (tropical wet and dry climate) according to Köppen classification, with maximum temperatures of 40º C and minimum of 18º C, and annual relative humidity averaging 76%.

EXPERIMENT I: ENERGY AND NUTRITIONAL EVALUATION OF CASSAVA BAGASSE

A total of 120 slow-growing Label Rouge (Naked Neck) broilers with 28 days of age were used. Chicks were reared in metallic cages equipped with trough-type feeders and drinkers, heating system and metal trays below the cages to remove excreta. Animals were housed inside an experimental shed with concrete floor and wire mesh sides, equipped with adjustable side curtains according to temperature and animal behavior.

On the 28th day, birds were weighed and randomly distributed in experimental cages according to the respective dietary treatments. A completely randomized design with two treatments, six replicates and ten birds per experimental unit were used, with the following treatments:

T1: Control diet based on corn and soybean meal formulated to meet the nutritional requirements for this phase, according to Rostagno et al. (2011) (Table 1).

T2: 60% control diet + 40% test diet (cassava bagasse).

The experimental period lasted nine days, comprised of five days of adaptation to experimental diets and the four subsequent days to total excreta collection. For the metabolism assay, the metallic trays were covered with plastic and placed under the cages to allow the total excreta collection according to (SIBBALD; SLINGER, 1963; SIBBALD, 1976; ALBINO et al., 1992). Samples were collected twice a day, at 8 a.m. and 4 p.m., thus avoiding fermentation and possible loss of nutrients from the excreta, according to Rodrigues et al. (2005).

Table 1. Centesimal and calculated composition of control diet (organic matter basis)

Ingredients	(%)
Corn	61.813
Soybean meal (45%)	32.559
Soybean oil	1.787
Dicalcium phosphate	1.697
Limestone	0.853
Salt	0.474
DL-Methionine	0.218
L-Lysine HCl	0.181
Choline chloride (60%)	0.125
Premix[1]	0.250
L-Threonine	0.033
BHT	0.010
Calculated composition	
ME (kcal/kg)	3000
Crude protein (%)	20.17
Calcium (%)	0.840
Available Phosphorus (%)	0.422
Chlorine (%)	0.330
Potassium (%)	0.769
Sodium (%)	0.207
Total Lysine (%)	1.192
Total Methionine (%)	0.529
Total Methionine + Cysteine (%)	0.852
Total Threonine (%)	0.810
Total Tryptophan (%)	0.245

[1]Composition/ton: Folic Acid: 150.00 mg; Cobalt: 178.00 mg; Copper: 2,675.00 mg; Choline: 120.00 g; Iron: 11.00 g; Iodine: 535.00 mg; Manganese: 31.00 g; Mineral matter: 350.00 g; Niacin: 7,200.00 mg; Calcium Pantothenate: 2,400.00 mg; Selenium: 60.00 mg; Vitamin A: 1,920,000.00 IU; Vitamin B1: 300.00 mg; Vitamin B12: 3,600.00 mg; Vitamin B2: 1,200.00 mg; Vitamin B6: 450.00 mg; Vitamin D3: 360,000.00 IU; Vitamin E: 3,600.00 IU; Vitamin H: 18.00 mg; Vitamin K: 480.00 mg; Zinc: 22.00 g.

A liquid red dye was added at 1% to the control diet, and sampling started when the dye was observed in the excreta. At the end of the metabolism assay, the dye was added to the control diet and the collections were performed until the end of its occurrence in excreta. After sampling, excreta were packed in plastic bags, properly identified and then were finally frozen. At the end of the experimental period, the total amount of feed consumed and excreta produced were determined.

For analysis, 400 g of excreta was defrosted at room temperature and homogenized. The samples were oven-dried at 55° C until constant weight to determine the oven-dry sample weight. Subsequently, the samples were processed in a knife-type mill with a 1 mm sieve and transported to the laboratory, along with feed samples to determine the dry matter (DM), ether extract (EE), mineral matter (MM), crude protein (CP) and gross energy (GE), following the procedures described by Silva and Queiroz (2002).

After laboratory analysis of the sampled materials (ingredients, excreta and diets), the apparent metabolizable energy (AME) and apparent metabolizable energy corrected for nitrogen balance (AMEn) were determined according to Matterson et al. (1965), as well as the apparent metabolizable coefficients of dry matter (AMCDM), crude protein (AMCCP) and ether extract (AMCEE) of cassava bagasse.

EXPERIMENT II: EFFECTS OF FEEDING CASSAVA BAGASSE TO SLOW-GROWING BROILERS ON PERFORMANCE

A total of 280 slow-growing chicks were used for 28 days. Until the 7th day old, chicks were fed a corn-soybean meal-based diet formulated to meet nutritional requirements for each phase according to the recommendations of Rostagno et al. (2011). During the starter phase (8 to 28 days old), broilers were distributed in a completely randomized experimental design with four treatments (0, 10, 20 and 30%) and five replicates of 20 birds per experimental unit.

Broilers were housed in experimental cages (1.00x1.00x0.40 m) equipped with trough-type feeders and drinkers and heating system using incandescent lamps (60 W) located inside the cages. The broilers were reared on an experimental shed equipped with adjustable side curtains according to temperature and animal behavior. The bromatological composition of ingredients used to formulate the experimental diets are shown in Table 2.

Table 2. Composition of ingredients used in the experimental diets (organic matter basis).

Nutrient	Corn[1]	Soybean meal[1]	Cassava bagasse[1,2,3]
ME (kcal/kg)	3381	2256	2508[2]
Crude protein (%)	8.26	45.32	1.26[2]
Calcium (%)	0.030	0.240	0.200
Available Phosphorus (%)	0.080	0.180	0.300
Chlorine (%)	0.050	0.050	0.050
Potassium (%)	0.280	1.830	ND[3]
Sodium (%)	0.020	0.020	0.030
Total Lysine (%)	0.240	2.770	0.090
Total Methionine (%)	0.170	0.640	0.030
Total Methionine + Cysteine (%)	0.360	1.370	0.070
Total Threonine (%)	0.320	1.780	0.070
Total Tryptophan (%)	0.070	0.620	0.020

[1]Rostagno et al. (2005); [2] Laboratory of the Federal University of Tocantins;[3] Not determined.

To evaluate the biochemical parameters, the blood was centrifuged at 6,000 rpm for 10 minutes. Serum levels of glucose (mg dL $^{-1}$), triglycerides (mg dL $^{-1}$), cholesterol (mg dL $^{-1}$), uric acid (mg dL $^{-1}$) and total proteins (g dL $^{-1}$) were determined using Labtest commercial kits.

Table 3. Composition of experimental diets for the starter phase (8 to 28 days).

Ingredients	Cassava bagasse inclusion levels (%)			
	0	10	20	30
Corn	59.850	46.011	32.171	19.288
Soybean meal (45%)	33.763	35.858	37.952	39.198
Cassava bagasse	0.000	10.000	20.000	30.000
Soybean oil	2.451	4.336	6.221	7.956
Dicalcium phosphate	1.802	1.660	1.518	1.383
Limestone	0.921	0.958	0.995	1.032
Salt	0.494	0.492	0.490	0.489
DL-Methionine	0.200	0.212	0.224	0.244
L-Lysine HCl	0.109	0.063	0.018	0.0000
Premix[1]	0.4000	0.4000	0.4000	0.4000
BHT	0.0100	0.0100	0.0100	0.0100
Total	100.000	100.000	100.000	100.000
Calculated composition				
ME (kcal/kg)	3000	3000	3000	3000
Crude protein (%)	20.077	20.029	19.965	19.624
Calcium (%)	0.8878	0.8878	0.8878	0.8878
Crude fiber (%)	2.8248	3.8057	4.7865	5.7379
Available Phosphorus (%)	0.4436	0.4436	0.4436	0.4436
Chlorine (%)	0.3470	0.3437	0.3405	0.3373
Potassium (%)	0.7914	0.7897	0.7879	0.7729
Sodium (%)	0.2147	0.2147	0.2147	0.2147
Total Lysine (%)	1.1650	1.1650	1.1650	1.1650
Total Methionine (%)	0.5381	0.5336	0.5292	0.5298
Total Methionine + Cysteine (%)	0.8275	0.8275	0.8275	0.8275
Total Threonine (%)	0.7925	0.7925	0.7925	0.7925
Total Tryptophan (%)	0.2486	0.2536	0.2585	0.2585

[1]Composition/ton: Manganese 18.175 mg, Zinc 17.500 mg, Iron 11.250 mg, Copper 2,000 mg, Iodine 187.50 mg, Selenium 75 mg, Vitamin K3 360 mg, Vitamin B1 436.50 mg, Vitamin B2 4,300 mg, Vitamin B6 624 mg, Vitamin B12 2,400 mg, Folic Acid 200 mg, Pantothenic Acid 3,120 mg, Niacin 8,400 mg, Biotin 10,000 mg, Choline 78,102.01 mg, Antioxidant 25,000 mg.

At 29 days, following the same distribution of treatments, the broilers were transferred to 20 paddocks with a grazing area containing a small handmade shelter of 2 m² equipped with tubular feeder and bell drinkers. Each wood shelter had an inside height of 1.5m, covered with babassu straw and without side walls. The grazing area, fenced out by galvanized mesh screen, had a total area of 50 m², containing predominantly *sp-tifton* grasses.

For each experimental phase (starter: from 07 to 28 days of age; growing: from 29 to 56 days of age; and finishing: from 57 to 84 days of age), diets were formulated to meet the nutritional requirements of broilers according to Rostagno et al. (2005), with 0, 10, 20 and 30% inclusion of cassava bagasse (Tables 3, 4 and 5).

The final weight (g), weight gain (g), feed intake (g) and feed conversion ratio (**g.g** $^{-1}$) were evaluated to assess the performance of animals at each phase.

Table 4. Composition of experimental diets for the growing phase (29 to 56 days).

Ingredients	Cassava bagasse inclusion levels (%)			
	0	10	20	30
Corn	71.282	57.253	43.225	30.139
Soybean meal (45%)	24.468	26.730	28.993	30.419
Cassava bagasse	0.000	10.000	20.000	30.000
Soybean oil	1.006	2.921	4.836	6.603
Dicalcium phosphate	1.394	1.250	1.107	0.970
Limestone	0.768	0.805	0.842	0.879
Salt	0.413	0.412	0.410	0.408
DL-Methionine	0.133	0.143	0.154	0.172
L-Lysine HCl	0.126	0.075	0.024	0.0000
Premix[1]	0.4000	0.4000	0.4000	0.4000
BHT	0.0100	0.0100	0.0100	0.0100
Total	100.000	100.000	100.000	100.000
Calculated composition				
ME (kcal/kg)	3050	3050	3050	3050
Crude protein (%)	16.7890	16.7890	16.7890	16.7890
Calcium (%)	0.7113	0.7113	0.7113	0.7113
Crude fiber (%)	2.5300	3.5164	4.5029	5.4603
Available Phosphorus (%)	0.3545	0.3545	0.3545	0.3545
Chlorine (%)	0.3013	0.2980	0.2947	0.2916
Potassium (%)	0.6545	0.6552	0.6559	0.6437
Sodium (%)	0.1832	0.1832	0.1832	0.1832
Total Lysine (%)	0.9450	0.9450	0.9450	0.9450
Total Methionine (%)	0.4423	0.4370	0.4316	0.4310
Total Methionine + Cysteine (%)	0.6800	0.6800	0.6800	0.6800
Total Threonine (%)	0.6636	0.6660	0.6684	0.6585
Total Tryptophan (%)	0.1969	0.2028	0.2087	0.2097

[1]Composition/ton: Manganese 18.175 mg, Zinc 17.500 mg, Iron 11.250 mg, Copper 2,000 mg, Iodine 187.50 mg, Selenium 75 mg, Vitamin K3 360 mg, Vitamin B1 436.50 mg, Vitamin B2 4,300 mg, Vitamin B6 624 mg, Vitamin B12 2,400 mg, Folic Acid 200 mg, Pantothenic Acid 3,120 mg, Niacin 8,400 mg, Biotin 10,000 mg, Choline 78,102.01 mg, Antioxidant 25,000 mg.

At the end of each phase, two broilers from each plot were fasted for twelve hours to evaluate the carcass traits, totaling 40 broilers per phase. The broilers were individually weighed, identified and slaughtered by cervical dislocation, scalded, plucked, eviscerated and the carcass yield was calculated by the relation between hot carcass weight and live weight after fasting. Using an analytical balance, the individual weights of gizzard, heart, liver and small intestine were taken and the relative weight (%) was calculated by the ratio of organ weight to carcass weight multiplied by 100.

Table 5. Composition of experimental diets for the finishing phase (57 to 84 days).

Ingredients	Cassava bagasse inclusion levels (%)			
	0	10	20	30
Corn	77.407	63.379	49.350	35.511
Soybean meal (45%)	19.593	21.856	24.118	26.212
Cassava bagasse	0.000	10.000	20.000	30.0000
Soybean oil	0.469	2.384	4.229	6.184
Dicalcium phosphate	0.609	0.790	0.647	0.504
Limestone	0.609	0.646	0.683	0.720
Salt	0.331	0.329	0.327	0.326
DL-Methionine	0.100	0.110	0.121	0.133
L-Lysine HCl	0.147	0.096	0.045	0.000
Premix[1]	0.400	0.400	0.400	0.400
BHT	0.010	0.010	0.010	0.010
Total	100.000	100.000	100.000	100.000
Calculated composition				
ME (kcal/kg)	3100	3100	3100	3100
Crude protein (%)	15.0860	15.0860	15.0860	15.0860
Calcium (%)	0.5286	0.5286	0.5286	0.5286
Crude fiber (%)	2.3776	3.3641	4.3505	5.3303
Available Phosphorus (%)	0.2623	0.2623	0.2623	0.2623
Chlorine (%)	0.2534	0.2501	0.2468	0.2435
Potassium (%)	0.5830	0.5838	0.5846	0.5823
Sodium (%)	0.1507	0.1507	0.1507	0.1507
Total Lysine (%)	0.8400	0.8400	0.8400	0.8400
Total Methionine (%)	0.3944	0.3890	0.3836	0.3794
Total Methionine + Cysteine (%)	0.6050	0.6050	0.6050	0.6050
Total Threonine (%)	0.5965	0.5988	0.6012	0.6008
Total Tryptophan (%)	0.1699	0.1757	0.1817	0.1864

[1]Composition/ton: Manganese 18.175 mg, Zinc 17.500 mg, Iron 11.250 mg, Copper 2,000 mg, Iodine 187.50 mg, Selenium 75 mg, Vitamin K3 360 mg, Vitamin B1 436.50 mg, Vitamin B2 4,300 mg, Vitamin B6 624 mg, Vitamin B12 2,400 mg, Folic Acid 200 mg, Pantothenic Acid 3,120 mg, Niacin 8,400 mg, Biotin 10,000 mg, Choline 78,102.01 mg, Antioxidant 25,000 mg.

For the statistical analysis, data were submitted to analysis of variance according to the statistical model: $Y_{ijk} = \mu + CB_i + e_{ij}$, where: Y_{ijk} = the dependent variable value for the j^{th} observation in the i^{th} substitution level with cassava bagasse; μ = overall mean; CB_i

= effect of the ith substitution level with cassava bagasse; e_{ijk} = experimental error for the jth observation in the ith substitution level with cassava bagasse.

Data were submitted to regression analysis using polynomial models, considering the level of significance of the F test for the adjustment of models and the coefficient of determination (R^2). Statistical analyzes were performed using the SAS 9.0 software throughout the General Linear Model (GLM) procedure (STATISTICAL ANALYSIS SYSTEM, 2002).

3 RESULTS AND DISCUSSION

CHEMICAL COMPOSITION, ENERGY VALUES AND METABOLIZABLE COEFFICIENTS OF CASSAVA BAGASSE

The results of chemical composition of cassava bagasse are shown in Table 6. Considering that its crude protein content it is lower than 20% (1.26%), this residue is classified as an energy feed.

Table 6. Bromatological composition of cassava bagasse

Item	Cassava bagasse
Dry matter (%)	88.46
Crude protein (%)	1.26
Ether extract (%)	3.86
Mineral matter (%)	1.06
Gross energy (kcal/kg)	3565

[1]Dry matter basis.

The values found for crude protein and dry matter are similar to the data found in the literature, where the lowest and highest values were 88% to 89% for dry matter and 1.59% to 1.98% for crude protein. On the other hand, the results for ether extract ranged from 0.19% to 2.47% and mineral matter from 1.12% to 2.32% (EMBRAPA, 1991; CEREDA, 1994; PANDEY et al., 2000; ABRAHÃO et al., 2006).

Pandey et al. (2000) stated that the chemical composition varies due to the processing under poorly controlled technological conditions. In contrast, Butolo (2002) mentions that the composition is modified by environmental conditions, cultivar and age of the plant. This variation demonstrates the importance of local analyzes for the bromatological adjustments of alternative feedstuffs.

The values of the apparent metabolizable energy (AME), apparent metabolizable energy corrected for nitrogen balance (AMEn) and apparent metabolizable coefficients of dry matter (AMCDM), crude protein (AMCCP) and ether extract (AMCEE) of cassava bagasse are shown in Table 7.

The values found are similar to those of Embrapa (1991) for the metabolizable energy (ME) on a dry matter basis, of 2450 kcal. Ramos et al. (2008) evaluated the apparent metabolizability of dehydrated and ground cassava root for broilers and determined values of 1921 and 2377.50 kcal kg^{-1} when fed in the starter and growing phases, respectively.

There are few studies that have determined the metabolizable coefficients for a more detailed comparison of the values obtained in the present study. In spite of the low protein content, the energy value of cassava bagasse is lower to that of the whole cassava scrapings (2973 kcal kg^{-1}) and it may substitute corn, the main energy source in feed (3381 kcal kg^{-1}), provided that nutritional adjustments are made and the price of the residue favors its use.

Table 7. Means (± standard error) of apparent metabolizable energy (AME), apparent metabolizable energy corrected for nitrogen balance (AMEn), apparent metabolizable coefficients of dry matter (AMCDM), crude protein (AMCCP) and ether extract (AMCEE) of cassava bagasse

Variable[1]	Energy value
Apparent metabolizable energy (kcal/kg)	2508.74(±0.077)
Apparent metabolizable energy corrected for nitrogen balance (kcal/kg)	2465.30(±0.073)
Apparent metabolizable coefficients (%)	
Dry matter	69.15(±2.03)
Crude protein	53.59(±4.34)
Ether extract	84.55(±2.03)

[1]Dry matter basis.

PERFORMANCE, BIOMETRY OF THE GASTROINTESTINAL TRACT AND BLOOD PARAMETERS OF SLOW-GROWING BROILERS FED INCREASING LEVELS OF CASSAVA BAGASSE

Performance results and relative weights of the organs of slow-growing broilers in the starter phase (8 to 28 days) fed diets containing increasing levels of cassava bagasse (CB) are shown in Table 8.

Table 8. Means of performance, small intestine (SI) size and relative weight of internal organs of slow-growing broilers fed increasing levels of cassava bagasse from 8 to 28 days of age

Variables	CB inclusion levels				CV (%)[1]	P > F[2]
	0%	10%	20%	30%		
Feed intake (g)	870.11	815.36	795.4	784.18	5.21	0.0262
Weight gain (g)	418.53	394.6	386.16	351.86	5.85	0.0025
Feed conversion (g/g)	2.08	2.07	2.06	2.23	4.38	0.0345
Final weight (g)	475	470.9	449.4	418.9	6.02	0.0191
Carcass yield (%)	78.03	78.23	76.78	76.91	2.39	0.5041
SI size (cm)	109.7	111.5	113	111.3	5.25	0.8487
Small intestine (%)	4.38	4.32	5.08	5.45	8.47	0.0009
Gizzard (%)	3.16	3.12	2.92	2.76	10.58	0.1927
Heart (%)	0.28	0.27	0.26	0.25	9.63	0.4117
Liver (%)	3.56	3.17	3.14	3.34	7.24	0.053

[1]Coefficent of variation
[2]ANOVA F-test.

In the starter phase (8 to 28 days), increasing CB levels linearly reduced feed intake and weight gain of broilers, according to the equations: FI = 857.9 - 2.77CB (P<0.05, R^2 = 0.429) and WG = 419.0 - 2.08CB (P<0.05, R^2 = 0.5809), respectively. These results contradict those obtained by Morara and Carrijo (2009) who evaluated cassava residues in backyard chickens, with no significant effect on feed intake and weight gain. In addition, Carrijo et al. (2010) did not find a significant effect on performance when slow-growing broilers were fed increasing levels (0, 15, 30 and 45%) of whole cassava root meal in the starter phase. However, broilers fed 45% cassava meal had the worst results.

Souza et al. (2011) evaluated increasing dietary levels (0, 20, 40 and 60%) of whole cassava root meal to slow-growing broilers in the starter phase and concluded that this residue can be added up to 60% without affecting the performance. In addition, they observed an increase in the final weight and weight gain of broilers.

The decrease in feed intake possibly occurred because diets with higher levels of cassava bagasse had lower density, which contributes to filling the crop with an absolute weight of feed lower than the corn-soybean meal-based diet (control), leading to a physical limitation. Genetically improved strains of poultry seem to have a limitation in feed intake, triggered more by a physical action of filling the gastrointestinal tract and feed palatability than by maintaining weight and body composition (GONZÁLES, 2002).

Another possible cause may be related to the amount of crude fiber in the cell wall of plant-feed ingredients that cannot be digested by broilers due to the nature of its glycosidic bonds (α-1→6 and β1→4 and β1→6), which are resistant to hydrolysis in the digestive tract, and may influence the digestion of other nutrients (BRITO et al., 2008). The difference in feed intake between CB levels is more significant from 0% to 10% (54.75g) than from 10% to 20% (19.96g) and 20% to 30% (11.22g), indicating that, in addition to the low CB density, the fiber content possibly influences nutrient digestibility.

The inclusion of CB decreased the productive performance of slow-growing broilers in the starter phase. There was an improvement in feed conversion, which had a quadratic behavior, according to the equation: $FC = 2.092 - 0.00956CB + 0.00046CB^2$ ($P<0.05$, $R^2 = 0.408$), with the best dietary level at 10.39% CB.

The final weight of broilers was influenced by the CB levels, which reduced linearly according to the equation: $FW = 482.0 - 1.89CB$ ($P<0.05$, $R^2 = 0.4531$). Campelo et al. (2009), studying backyard poultry fed diets with increasing levels of whole cassava meal (0, 18, 36 and 53%) in substitution to corn, observed that the increase in the residue adversely affects the final weight of broilers.

The results are similar to those found by Loan (2004) and Nascimento et al. (2005), who consider cassava residues as nutritionally limited. Sousa (2010) reported that increasing levels of cassava bagasse for broilers affected performance, especially at higher levels. The authors recommend an inclusion of up to 4.84% CB in the starter phase, based on weight gain.

No significant effect ($P>0.05$) of using CB on carcass yield was found. This result corroborates those found by Carrijo et al. (2010), who also did not verify significant differences in the carcass yield of slow-growing broilers in the starter phase, when evaluating different levels (0, 15, 30 and 45%) of cassava root meal. In addition, Souza et al. (2011) concluded that there was no effect on the carcass yield of slow-growing broilers fed increasing levels (0, 20, 40 and 60%) of cassava root meal in the starter phase.

Feeding increasing levels of CB to backyard poultry did not significantly influence the size of the small intestine, relative weights of the gizzard, heart and liver. However, the relative weight of the small intestine was affected, with a positive linear behavior according to the equation: $RWSI = 4.2116 + 0.039760CB$ ($P<0.05$, $R^2 = 0.5482$).

The increase in the relative weight of the small intestine may be due to the high fiber content, which impairs digestibility in addition to promoting an increase in the intestinal membrane absorptive cells to maintain broiler performance. This fact was confirmed by the increase in the relative weight of the small intestine in the present study.

The mean blood parameters of slow-growing broilers fed increasing levels of cassava bagasse from 8 to 28 days are shown in Table 9. Although the inclusion of bagasse affected the productive performance of broilers in the starter phase (P<0.05), the means of the biochemical parameters demonstrate that the broilers had an adequate metabolic balance.

Table 9. Means of biochemical parameters of slow-growing broilers fed increasing levels of cassava bagasse from 8 to 28 days of age

Variables	CB inclusion levels				CV (%)[1]	P > F[2]
	0%	10%	20%	30%		
Glucose (mg/dL)	122.06	117.56	124.98	110.18	19.58	0.7656
Triglycerides (mg/dL)	225.58	239.35	243.24	230.52	11.77	0.7373
Cholesterol (mg/dL)	125.13	92.07	82.27	76.68	43.73	0.3104
Uric acid (mg/dL)	2.53	2.93	4.11	5.37	61.88	0.2452
Total protein (g/dL)*	3.70b	5.23a	4.15b	4.45b	16.64	0.029

[1]Coefficent of variation
[2]ANOVA F-test
*Means followed by same letters did not differ by the SNK test (P>0.05)

According to Schmidt et al. (2007), analyzes of biochemical parameters are a useful tool to evaluate the physiological status of poultry, including those exposed to different environmental conditions related to nutrition and feed supply or intoxication.

Increasing CB levels in the starter phase had no significant effect (P>0.05) on the glucose, triglyceride and cholesterol levels of slow-growing broilers. However, despite the absence of significant differences, there was a reduction of cholesterol as CB levels increased.

Uric acid had no significant effect (P>0.05) and the values were within the reference limits that ranges from 2 to 15 mg/dL. Nevertheless, the values increased as dietary CB levels increased. Campbell (2007) states that the concentration of uric acid in the blood varies according to species, age and diet.

Total protein levels were influenced (P<0.05) by the inclusion of CB, with the highest protein content at 10% CB. Therefore, it can be associated with the best inclusion level for feed conversion, which was 10.39% CB.

There is a lack of data on reference levels for biochemical values in backyard poultry. Hence, it is essential to evaluate the blood profile of broilers under several situations.

Dietary levels of cassava bagasse in the growing phase (29 to 56 days of age) did not affect feed intake (FI) and carcass yield (CY), whereas weight gain (WG), feed conversion (FC) and final weight (FW) linearly worsened according to equations: WG = 0.945 – 0.0080CB (R^2 = 0.601), FC = 2.855 + 0.025CB (R^2 = 0.470) and FW = 1.3798 – 0.00849CB (R^2= 0.517), respectively (Table 10).

Table 10. Means of performance, gastrointestinal tract (GIT) biometry and biochemical parameters of slow-growing broilers fed increasing levels of cassava bagasse from 29 to 56 days.

Variables	CB inclusion levels				CV%[1]	P >F[2]
	0%	10%	20%	30%		
Performance						
Feed intake (g)	2719	2572	2716	2504	6.74	0.1811
Weight gain (g)	967.80	828.80	778.80	714.20	10.16	0.0017
Feed conversion (g/g)	2.82	3.11	3.47	3.55	10.71	0.0149
Final weight (g)	1396	1250	1246	1115	7.72	0.0030
Carcass yield (%)	75.74	74.07	73.82	72.49	3.54	0.3104
GIT Biometry						
SI size (cm)	159	158	159	160	7.14	0.9839
Small intestine (%)	3.91	4.23	4.88	5.39	12.79	0.0064
Gizzard (%)	2.69	3.08	3.05	2.60	7.42	0.0063
Heart (%)	0.54	0.54	0.58	0.61	16.08	0.5060
Liver (%)	3.22	3.36	3.41	3.41	13.92	0.9074
Blood parameters						
Glucose (mg/dL)	131.15	117.32	117.96	131.27	11.23	0.2352
Triglycerides (mg/dL)	96.23	104.15	103.28	93.97	7.11	0.1134
Cholesterol (mg/dL)	211.80	256.11	227.25	248.15	26.23	0.6690
Uric acid (mg/dL)	5.82	5.85	5.83	5.85	20.16	1.0000
Total protein (g/dL)	2.85	4.74	4.16	4.15	23.88	0.0377

[1]Coefficent of variation
[2]ANOVA F-test

The experimental diets were isoenergetic even with the increase of cassava bagasse levels. It was a result of increasing levels of oil, which may have guaranteed the consistency observed in feed intake. However, the higher the inclusion of cassava bagasse, the greater the crude fiber levels of the experimental diets, as verified in the calculated nutritional composition (Table 2).

It is likely that the variation in the fiber and oil dietary contents are the factors with the greatest influence on the results. Warpechowski (2005) stated that dietary fiber had a negative correlation with nutrient and energy digestibility when studying the effect of fiber levels and sources for growing broilers.

Braz et al. (2011) also found that increasing fiber levels did not affect feed intake in growing laying hens. On the other hand, weight gain and feed conversion were worsened in hens fed diets with higher fiber levels. The authors stated that fibers act as physical barriers preventing endogenous enzymes from access the internal contents of plant cells, thereby reducing the digestion and absorption of nutrients.

Classen (1996), when discussing the effects of digesta viscosity on nutrient digestibility, stated that viscous substances affect nutrient diffusion rates, and thus low enzyme-substrate interaction would have a negative impact on nutrient utilization. The author states that lipid digestion is highly susceptible to increased digesta viscosity due to the size of micelles compared to the simpler products of digestion, because the larger the molecule, the greater the impact of increasing digesta viscosity on its diffusion rate. Based on the above-mentioned author's statements and the diet profile analysis regarding the use of oil in the feed, the reduction in the weight gain of broilers was due to an increase in viscosity. This resulted from the increase in cassava bagasse levels, which impaired the digestion and absorption of dietary lipids.

Regarding the results of carcass yield, Carrijo et al. (2010) also did not find significant differences for slow-growing broilers fed different levels (0, 15, 30 and 45%) of cassava root meal.

In the growing phase, the small intestine size (SIS) and relative heart (RHW) and liver (RLW) weights were not influenced by CB inclusion levels ($P > 0.05$) (Table 10). On the other hand, the relative weight of gizzard (RWG) and small intestine (RWSI) were affected ($P<0.05$) by CB inclusion levels.

Increased CB dietary levels in growing poultry linearly increased the RWSI ($RWSI = 3.851 + 0.0504CB$, $R^2 = 0.54$) possibly due to the high fiber content in the diets, which increased according to the CB inclusion levels. The relative weight of the gizzard had a quadratic behavior, according to the equation: $RWG = 2.6923 + 0.0595CB - 0.0020CB^2$ ($P<0.05$, $R^2 = 0.549$), increasing up to 14.875% inclusion and then decreasing with the highest levels of bagasse.

In the finishing phase (57 to 84 days), CB levels did not significantly influence ($P>0.05$) the FI, WG and FC. However, these variables influenced the FW and CY of broilers according to the equations: FW = 2.6212 - 0.0351CB + $0.0007CB^2$ (R^2 = 0.62) and CY = 87.83 - 0.777477CB + $0.02245CB^2$ (R^2 = 0.35), respectively (Table 11).

Table 11. Means of performance, small intestine (SI) size and relative weight of internal organs of slow-growing broilers fed increasing levels of cassava bagasse from 57 to 84 days.

Variables	CB inclusion levels (%)				CV%[1]	P >F[2]
	0%	10%	20%	30%		
Feed intake (g)	3203	3555	3746	3261	10.19	0.4082
Weight gain (g)	1242	1070	0971	1151	14.29	0.1432
Feed conversion (g/g)	2.58	3.32	3.80	2.85	19.03	0.0577
Final weight (g)	2630	2321	2239	2216	5.97	0.0038
Carcass yield (%)	87.52	83.24	80.40	85.10	4.41	0.0479
GIT Biometry						
SI size (cm)	189	175	179	185	4.34	0.0691
Small intestine (%)	2.57	3.00	3.27	3.29	8.78	0.0040
Gizzard (%)	2.10	2.32	2.22	1.99	8.19	0.0658
Heart (%)	0.47	0.51	0.47	0.47	10.84	0.5843
Liver (%)	2.06	2.05	2.16	2.00	8.33	0.5667
Blood parameters						
Glycose (mg/dL)	154.50	135.34	127.26	122.46	13.64	0.0648
Triglycerides (mg/dL)	92.46	92.52	94.04	92.66	3.59	0.8884
Cholesterol (mg/dL)	121.45	92.12	106.73	116.32	35.82	0.6596
Uric acid (mg/dL)	1.95	4.43	6.52	9.68	62.36	0.0204
Total protein (g/dL)	3.97	4.81	4.48	4.41	10.70	0.0814

[1][1]Coefficent of variation;
[2]ANOVA F-test.

The final weight was negatively influenced up to the estimated level of 25.07% CB, whereas the carcass yield was negatively influenced up to the estimated level of 17.25% CB.

Contrasting results were found by Souza et al. (2011) when using increasing levels (0, 20, 40 and 60%) of whole cassava root meal in the diet of backyard broilers. The authors did not observe significant differences between treatments for feed intake, weight gain, final weight and feed conversion in the finishing phase (57 to 84 days of age).

In the finishing phase (57 to 84 days), CB levels did not significantly influence the relative weights of gizzard (RWG), heart (RWH), liver (RWL) and small intestine size (SIS). However, the relative weight of the small intestine (RWSI) was affected ($P<0.05$) by CB inclusion.

Arruda et al. (2008) found similar results when evaluating the performance of slow-growing broilers fed 0, 10, 25, 50 and 100% whole cassava in substitution to corn, in which the productive parameters were not statistically influenced. Complementary, when studying different levels (0, 20, 40 and 60%) of whole cassava root meal to slow-growing broilers, Souza et al. (2011) concluded that there was no effect on the carcass yield at 84 days of age.

There was an increase of the RWSI as it occurred in the growing phase. Probably, an increase in the intestinal membrane absorptive cells could have occurred, helping to maintain the final performance of broilers.

The blood parameters (Table 8) of slow-growing broilers fed increasing levels of CB in the growing and finishing phases did not have significant effects (P>0.05) for blood glucose, triglyceride and cholesterol levels.

Uric acid levels were not affected by the inclusion of cassava bagasse in the growing phase. Values were within the reference range (2 to 15 mg dL^{-1}). However, in the finishing phase, there was a significant increase (P<0.05) as dietary CB levels increased, even though they remained within the reference limits. Campbell (2007) states that the concentration of uric acid in the blood varies according to species, age and diet.

The total protein levels had significant differences (P<0.05) only in the growing phase, with a quadratic behavior (TPRO = $-0.00477CB^2 + 0.17642CB + 2.998$ (P<0.05, $R^2 = 0.304$), with a maximum at 18.49% CB. In the finishing phase, the total protein contents were equivalent between the treatments.

There is a lack of data on reference levels for biochemical values in backyard poultry. Hence, it is essential to evaluate the blood profile of broilers under several situations.

4 CONCLUSION

The determined values of apparent metabolizable energy and apparent metabolizable energy corrected for nitrogen balance of cassava bagasse on the organic matter basis were: 2508.07 kcal/kg and 2465.30 kcal/kg, respectively. The metabolizable coefficients of dry matter, crude protein and ether extract were: 69.15%, 53.59% and 84.55%, respectively.

In the starter phase, it is recommended to include cassava bagasse up to 10.39%, whereas in the growing phase is not recommended due to its negative effects on performance. In the finishing phase, cassava bagasse can be used up to the 30% without affecting the performance of slow-growing broilers.

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