EVALUATION OF BABASSU *(Orbignya ssp)* MESOCARP AS SUPPLEMENT IN BROILER DIET

AVALIAÇÃO DO MESOCARPO DE BABAÇU (Orbignya ssp) NA ALIMENTAÇÃO DE FRANGOS DE CORTE

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SUMMARY

This study evaluates nutritional value and use of babassu mesocarp supplementation in the feeding of broilers. Initially, the chemical composition was determined in order to characterize the ingredient. Then two tests were conducted: the first, to determine the energy values and the second, the optimal supplementation level in the diet. The metabolism trial was conducted using 20 Leghorn cockerels divided into two treatments with five replicates of two birds each. The experiment lasted ten days, five adaptation days and five days for stool collection. Subsequently, 500 one-day-old broiler chicks were used in the growth trial. The design was completely randomized, with four treatments and five replications. Treatments consisted of four levels of babassu mesocarp supplementation: 0, 3, 6 and 9%. The growth trial lasted 21 days and the responses to feed intake, weight gain and feed conversion were evaluated. Based on natural matter, the babassu mesocarp has 87.5%, 3.29%, 1.1%, 2.7%, 75.1% and 3,618 kcal/kg for the variables dry matter, crude protein, ash, crude fiber, starch and gross energy, respectively. The corrected apparent metabolizable energy determined was 2,671 kcal/kg, based on the natural matter. The babassu mesocarp due to its low crude protein content and high starch level can be classified as an energy ingredient. The babassu mesocarp supplemented in the feed of broilers adversely affected the performance of broilers during the initial stages of growth.

KEY-WORDS: Nutritional value. Alternative food. Resistant starch. Babassu palm.

RESUMO

Esta pesquisa objetivou avaliar o valor nutricional e a utilização do mesocarpo de babaçu na alimentação de frangos de corte. Inicialmente, a composição química foi analisada para caracterizar o ingrediente. Em seguida dois ensaios foram conduzidos: o primeiro para determinar os valores energéticos e o segundo o nível ideal de inclusão na ração. O ensaio de metabolismo foi realizado utilizando 20 galos Legorne, distribuídos em dois tratamentos com cinco repetições de duas aves cada. O período experimental foi de dez dias, cinco dias de adaptação e cinco dias de coleta de excretas. Em seguida, 500 pintos de corte com um dia de idade foram utilizados em ensaio de crescimento, delineamento inteiramente ao acaso, com quatro tratamentos e cinco repetições. Os tratamentos consistiram de quatro níveis de inclusão do mesocarpo de babaçu: 0, 3, 6 e 9%. O ensaio de crescimento teve duração de 21 dias e foram avaliadas as respostas para consumo de ração, ganho de peso e conversão alimentar. Com base na matéria natural, o mesocarpo de babaçu apresentou 87,5%; 3,29%; 1,1%; 2,7%; 75,1% e 3.618 kcal/kg de matéria seca, proteína bruta, matéria mineral, fibra bruta, amido e energia bruta, respectivamente. A energia metabolizável aparente corrigida foi determinada em 2.671 kcal/kg, na matéria natural. O mesocarpo de babaçu, pela sua composição com baixo teor de proteína bruta e elevado teor de amido, pode ser classificado como ingrediente energético. A inclusão do mesocarpo na alimentação de frangos de corte afetou negativamente o desempenho das aves na fase inicial de criação.

PALAVRAS-CHAVE: Valor nutricional. Alimento alternativo. Amido resistente. Palmeira do babaçu.

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INTRODUCTION

Poultry production in Northeastern Brazil, especially in Maranhão, is insufficient to meet the population's demand for meat and eggs. The low availability of conventional ingredients such as corn and soybeans leads to increasing production costs for local producers (CARNEIRO, 2011). But on the other hand, the region has alternative foods, especially those obtained from the babassu palm *(Orbignya* ssp*).* An important feature of babassu byproducts is the availability during the conventional grains off-season, thus making it an important alternative to the regional producers (CARVALHO, 2007).

However, there are few studies on the use of babassu mesocarp as a supplementation to poultry feed. According to Rostagno et al. (2011), the babassu mesocarp has 1.9% crude protein; 9.7% crude fiber; 0.3% ether extract; 2.5% ash; 71.9% non-nitrogenous extractive; 3,687 kcal/kg gross energy and 1,731 kcal/kg metabolizable energy.

The composition presented by Rostagno et al. (2011) suggests that less than half of the energy contained in the mesocarp is used by the birds. This feature could possibly limit the inclusion of this ingredient in poultry feed and for minimum cost feed formulations, it is essential to know the supplementation limit of the ingredient in the feed, as well as its effect on the performance parameters. Therefore, this research aims to determine the nutritional value and the ideal inclusion levels of babassu mesocarp in feed for broilers.

MATERIAL AND METHODS

***Processing steps for obtaining* babassu mesocarp**

The babassu mesocarp was obtained from a babassu coconut processing industry located in Itapecuru Mirim - MA. The processing steps of the babassu kernel consist of continuous solvent extraction, where the kernel is thinly sliced, followed by successive immersions in hexane to extract the oil. The continuous recovery of the solvent by evaporation and distillation yields the crude oil and babassu meal pellets. The processing for obtaining mesocarp uses a technology known as PSB (peeling, separation and breakage), in which the mesocarp is separated from the epicarp. Subsequently, the mesocarp is processed into powder and separated from the epicarp by vacuum.

Chemical and energetic characterization

To determine the chemical and energetic composition of the food, the following parameters were analyzed: dry matter (DM), crude protein (CP), ash, crude fiber (CF) and neutral (NDF) and acid detergent fiber (ADF). All analyzes were performed in the Laboratory of Animal Nutrition of the FCAV/UNESP, Jaboticabal, according to methods described by Silva & Queiroz (2002). Starch was determined according to the enzymatic methodology recommended by Poore et al. (1989), modified for glucose reading by colorimetry (Kit), according to Pereira & Rossi (1995). Gross energy was determined by adiabatic bomb calorimeter (1281, *PARR Instrument,* USA). The amino acid composition was determined by HPLC at the CEAN Laboratory (ADISSEO, RS).

Metabolism trial

A metabolism trial with Leghorn roosters was performed at the Laboratory of Avian Sciences, in the Department of Animal Science, FCAV/UNESP, Jaboticabal. Total fecal collection methodology was used, according to the experimental protocol described by Sakomura & Rostagno (2007) to determine the Apparent Metabolizable Energy (AME) and Apparent Metabolizable Energy corrected for nitrogen (AMEn). The 20 Leghorn roosters were housed individually in metabolism cages. The birds were randomly distributed in two diets, with five replicates of two birds each. The diets consisted of a reference feed formulated to meet the nutritional requirements (ROSTAGNO et al., 2005) with 3,050 kcal of ME and 14.80% CP. The ration-test comprised 75% of the reference feed and 25% of babassu mesocarp (BM), based on natural matter.

The experiment lasted ten days, of which five adaptation days and five feces collection days. Aluminum trays, previously coated with plastic, were installed under the cages to collect all the feces. The 1% ferric oxide marker was added to the diets, on the first and last day of collection to identify the start and end of the excreta collection. Thus, the unmarked excreta, in the first collection, and that marked of the last sampling, were discarded. Stool collection was performed twice a day, early morning and late afternoon. The collected material was packaged in plastic bags, identified and frozen. At the end of the experimental period, both feed intake and total excreta produced were determined.

After thawing at room temperature, the feces were weighed and the amounts produced in each repetition determined. Then, they were homogenized, frozen and lyophilized. After drying, the samples were ground in a micro mill and sent to the laboratory, along with samples of test and reference diets for determining dry matter (DM) and nitrogen (N), according to methods described by Silva & Queiroz (2002). Gross energy was determined by adiabatic bomb calorimeter (1281, PARR Instrument, USA). The dry matter and starch apparent digestibility coefficients, as well as apparent metabolizable energy (AME) and corrected AMEn values were calculated using the equations proposed by Matterson et al. (1965).

Broiler performance trial

This trial was conducted at the Experimental Poultry Unit "José dos Reis Ataide" of the Center of Agricultural Sciences, Universidade Estadual do Maranhão, in São Luís, Maranhão. One-day-old, 500 Ross® broiler chicks, 50% males and 50% females, were used. The birds were distributed among treatments based on body weight, following the procedure described by Sakomura & Rostagno (2007). The experimental design was completely randomized with four treatments and five repetitions. The treatments consisted of a reference diet supplemented with babassu mesocarp at 0, 3, 6 and 9% levels.

Table 1 shows the composition of the experimental diets fed during the initial phase (1-21 days). The nutritionally equivalent diets were formulated based on the nutritional requirements and food composition (corn, soybean meal, soybean oil, dicalcium phosphate and limestone) proposed by Rostagno et al. (2005), as well as the nutritional composition of the babassu mesocarp determined in this study. Despite the low contribution of the babassu mesocarp, the diets were formulated based on meeting the digestible amino acids requirements.

The parameters weight gain (kg/bird), feed intake (kg/bird) and feed conversion (kg/kg) were evaluated. Weight gain was determined by weighing the chicks at the beginning when they were 1 day old and at 21 days old. Average feed intake was determined by recording the amount offered to chicks in each plot and the respective leftovers at the end of each phase. Feed conversion was corrected by considering the date of mortality according to the procedure described by Sakomura & Rostagno (2007).

Table 1 - Composition of the experimental diets for broilers from 1 to 21 days old.

Ingredients (%)	Babassu mesocarp level in the diet (%)			
	0	3.0	6.0	9.0
Corn	56.12	52.47	48.59	44.76
Soybean meal	36.76	37.27	37.87	38.75
Mesocarp	0.00	3.00	6.00	9.00
Soybean oil	2.82	3.03	3.36	3.71
Limestone	0.92	0.90	0.89	0.88
Dicalcium phosphate	1.86	1.88	1.89	1.90
Mineral mixture [1]	0.05	0.05	0.05	0.05
Vitamin Mixture [2]	0.10	0.10	0.10	0.10
L - lysine HCl 78%	0.23	0.29	0.23	0.22
DL - methionine 99%	0.43	0.29	0.30	0.31
L-Threonine	0.06	0.06	0.06	0.06
Choline Chloride	0.07	0.07	0.07	0.07
Avilamycin	0.01	0.01	0.01	0.01
Coccistac	0.05	0.05	0.05	0.05
BHT	0.01	0.01	0.01	0.01
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Calculated composition				
AMEn (determined) kcal/kg	2,975	2,975	2,975	2,975
Crude protein (%)	21.80	21.80	21.80	21.80
Crude fiber (%)	2.96	3.00	3.05	3.09
Lysine (%)	1.24	1.29	1.25	1.24
Digestible Methionine (%)	0.73	0.59	0.60	0.60
Met + digestible cystine (%)	1.02	0.88	0.88	0.88
Digestible threonine (%)	0.78	0.78	0.78	0.78
Digestible Tryptophan (%)	0.24	0.24	0.24	0.24
Calcium (%)	0.91	0.91	0.91	0.91
Available phosphorus (%)	0.46	0.46	0.46	0.48
Sodium (%)	0.22	0.22	0.22	0.22
Chlorine (%)	0.35	0.35	0.36	0.36
Potassium (%)	0.83	0.83	0.83	0.83

[1]Inorganic-Mineral Mix (quantity/kg product) - Mn – 150,000 mg; Zn – 100,000 mg; Fe -100,000 mg; Cu - 16,000 mg; I - 1,500 mg.
[2] Vitamin Mix - (quantity/kg of product) - Vit. A – 2,666,000 IU/ Vit. B1 - 600 mg; Vit. B2 - 2,000 mg; Vit. B6 - 933.10 mg; Vit. B12 - 4,000 mcg; Vit. D3 - 666.50 mg; Vit. E - 5,000 IU; Vit. K - 600 mg; folic acid - 333.25 mg; Pantothenic Acid - 5.000 mg; Biotin - 20 mg; Choline – 133,330 mg; Niacin – 13,333 mg; Selenium - 100 mg; Vehicle QSP - 1000g.

The average high and low temperatures were 35.5 and 22.5°C, respectively. The average high and low relative humidity of the air was 92.0 and 68.0%, respectively. The error normality and homoscedasticity assumptions were evaluated by the Cramer-von-Mises and Levene's tests, respectively. Statistical analysis was performed by the SAS statistical software. The treatments were evaluated in polynomial contrasts (linear and quadratic effect).

RESULTS AND DISCUSSION

The error normality and homoscedasticity assumptions were tested and met.

Chemical and energy characterization

Based on natural matter, babassu mesocarp had 87.5%, 3.29%, 1.1%, 2.6%, 8.0%, 5.0%, 75.1% and 3,618 kcal/kg of the following parameters: dry matter, crude protein, ash, crude fiber, neutral and acid detergent fiber, starch and gross energy, respectively (Table 2). The duplicate analysis of fat detected no residual fat, despite the fact that babassu mesocarp had whitish pigments (Table 2).

The babassu mesocarp composition showed large amounts of desirable nutrients such as organic matter and starch, but, on the other hand, low contents of crude fiber, neutral and acid detergent fiber were determined. The composition determined by Rostagno et al. (2011) indicates significant amount of crude fiber, neutral and acid detergent fiber, about 70, 78 and 80% higher than the values determined in this work.

The babassu mesocarp starch level was approximately 16% greater than that reported in the literature for corn kernels (62.66%) (ROSTAGNO et al., 2011). No values for babassu mesocarp starch levels were found in the literature review. Rostagno et al. (2011) reported 71.88% for the non-nitrogen extractive value of starchy babassu flour, another name used to identify the babassu mesocarp. However, differences in the fiber and starch ratios in the composition of the mesocarp are not reflected in the gross energy content, which was similar to that reported by Rostagno et al. (2011). These differences can be attributed to the processing for obtaining the mesocarp; it is well-known that the applied technology influences the quality of the products.

The crude protein content was 42% higher than that reported by Rostagno et al. (2011); however, this protein recovery was not reflected in the amino acid profile. Total essential and non-essential amino acid corresponds to 19% of the total crude protein; therefore, it is suggested that approximately 81% of crude protein is comprised of non-protein nitrogen, indicating the low biological value of this ingredient protein.

The main mineral elements of babassu mesocarp are potassium (25%), chlorine (17%), and magnesium (3.6%), which together account for approximately 46.4% of the analyzed mineral matter.

Values of apparent metabolizable energy (AME) and nitrogen corrected AMEn

The energy values (AME and AMEn), as well as dry matter and starch apparent metabolism coefficients are shown in Table 3.

The AME and AMEn were 2,669 and 2,671 kcal/kg, respectively. The comparison between the energy values shows that the difference was less than 0.1%. The AME corrected for nitrogen aims at eliminating the physiological state of the birds on the food energy estimate. Growing birds retain nitrogen in the body while adult birds do not; in this situation body nitrogen is catabolized to uric acid, causing a negative balance in adult birds (SIBBALD & PRICE, 1978; SILVA et al, 2009.).

When the nitrogen balance is negative, AMEn value is greater than AME, as shown in other studies in the literature (RODRIGUES et al. 2002). The magnitude of the difference between the AME and AMEn is consistent with feed intake and composition of the ingredient (ALBINO, 1991 and SILVA et al., 2009). This justifies the similar values observed for AME and AMEn in this study since only 18% of crude protein is composed of amino acids.

According to the metabolizable coefficient determined, about 490 g starch/kg babassu mesocarp is available for the bird, i.e., 260 g starch/kg mesocarp is not digestible by the enzymatic digestion processes. Furthermore, corn has 627 g starch/kg, and 579 g starch/kg is available for birds (RODRIGUES et al., 2003; ROSTAGNO et al., 2011). Based on resistant starch (RS) classification, of the four types three can be related to the babassu mesocarp and can be minimized by thermal processing (NUGENT, 2005).

No studies evaluating the metabolizable starch coefficients of babassu were found in the literature while the metabolizable energy values were reported by Rostagno et al. (2011). It is known that alternative ingredients have variable chemical composition (SILVA et al., 2010; LIRA et al., 2011) and nutrients quality, which are reflected in the energy content. As mentioned above, the composition of the babassu mesocarp has high amounts of desirable nutrients such as organic matter and starch, but, on the other hand, low crude fiber, and neutral and acid detergent fiber, a combination that affected the content of metabolizable energy, which was about 34% greater than that reported by Rostagno et al. (2011) determined for broilers.

Performance of broilers fed babassu mesocarp in the diet

Inclusion levels of babassu mesocarp (X) in the diets significantly affected the variables (Y) feed intake, weight gain and feed conversion (Table 4). The quadratic effect was observed on feed intake ($p = 0.0037$) and feed conversion ($p = 0.0085$), represented by the equations: $Y= 1.1275 + 0.00393X + 0.0016X^2$, $R^2=0.66$; and, $Y= 1.3569 + 0.0082X + 0.00136X^2$, $R^2=0.64$, respectively.

Table 2 - Nutritional composition of the babassu mesocarp.

Items	Unit	Mesocarp[1]
Dry matter, MS	%	87.74
Organic matter, OM	%	86.62
Ether extract, EE	%	ND
Crude fiber, CF	%	2.66
Neutral detergent fiber, NDF	%	8.04
Acid detergent fiber, ADF	%	4.97
Starch, S	%	75.15
Gross energy, GE	kcal / kg	3,618
Mineral matter, MM	%	1.12
Calcium, Ca	%	0.001
Phosphorus, P	%	0.020
Potassium, K	%	0.290
Magnesium, Mg	%	0.040
Chlorine, Cl	ppm	0.190
Copper, Cu	ppm	0.003
Iron, Fe	ppm	0.020
Manganese, Mn	ppm	0.040
Crude protein, CP	%	3.29
Lysine, Lys	%	0.02
Methionine, Met	%	0.02
Threonine, Thr	%	0.02
Arginine, Arg	%	0.02
Histidine, His	%	0.02
Isoleucine, Ile	%	0.02
Leucine Leu	%	0.04
Phenylalanine, Phe	%	0.02
Valine Val	%	0.08
Cystine, Cys	%	0.02
Alanine, Ala	%	0.06
Aspartic acid, Asp	%	0.07
Glutamic acid	%	0.09
Glycine, Gly	%	0.05
Serine, Ser	%	0.04
Tyrosine, Tyr	%	0.02
Total essential amino acid, AAE	%	0.26
Total nonessential amino acid, NEAA	%	0.35

[1] Values based on natural matter, [ND] not detected

Table 3 - Means and standard error obtained for the apparent metabolizable energy (AME) and nitrogen corrected (AMEn), apparent metabolizable coefficients of dry matter (DMAMC) and starch (SAMC) for babassu mesocarp.

Item	Dry matter	Natural matter
AME (kcal/kg)	3042 ± 26.07	2669 ± 22.87
AMEn (kcal/kg)	3044 ± 31.72	2671 ± 27.83
DMAMC (%)	89.1 ± 0.64	78.20 ± 0.56
SAMC (%)	74.6 ± 1.69	65.43 ± 1.48

Table 4 - Feed intake, weight gain and feed conversion of broilers from 1 to 21 days old fed diets supplemented with different babassu mesocarp levels.

Levels of babassu mesocarp, (%)	Feed Intake	Weight Gain	Feed Conversion
	kg/bird	kg/bird	kg/kg
0%	1.142	0.836	1.35
3%	1.137	0.799	1.43
6%	1.155	0.811	1.42
9%	1.224	0.791	1.59
Statistics			
Treatment F	*	NS	*
F for linear effect	*	NS	*
F for quadratic effect	*	NS	*
CV (%) [1]	2.03	4.78	2.15

* P <0.05; NS, not significant

Higher values were expected for the determination coefficients (R^2); however, random variation contributed to reduce these values.
From the nutritional standpoint, the random variation can be interpreted as poor fit of the model to the responses of birds fed 6% mesocarp in the diet. A different behavior was observed for birds fed 3 and 9% mesocarp supplemented diets.

Overall, the results indicate increasing feed intake with increasing mesocarp supplementation in the diets. The birds regulate feed intake seeking primarily to meet their energy requirements. Thus, when ingredients containing low available energy are included in the diet, it can lead to increased consumption to meet energy demand.

The diets were formulated to be isocaloric; however, the AMEn value of the babassu mesocarp used was that determined in the digestibility trial with adult roosters, which may have led to an overestimation of the true metabolizable energy for broiler chicks, helping to understand the relationship between increasing feed intake as babassu mesocarp supplementation level also increased. According to Brumano et al. (2006) as the chicks grow and the digestive system matures, the bird capacity to digest and absorb nutrients increase and the energy use becomes more efficient. LIMA et al. (2012) reported that broilers increased by 13 kcal/day the utilization of ileal digestible energy. Therefore, it is possible that the values determined with roosters overestimated the energy content for broiler chicks.

Batal & Parsons (2002) also observed an increase in AMEn of diets based on corn and soybean meal for broilers from 2 weeks old and stated that the greater AMEn value for older birds is due to more efficient use of nutrients.

There are no reports in the literature about babassu mesocarp supplementation in the diets fed to broilers. Moreover, the increased feed intake by birds due to the increased inclusion levels of babassu mesocarp in the diet did not improve the weight gain and worsened feed conversion.

Starch is the main component responsible for the energy content of the mesocarp thus its availability is directly related to bird's performance. The hydrolysis by the pancreatic α-amylase resistant starch may be linked to the increased proportion of amylose in the non-gelatinized starch granule since the amylose fraction is slowly hydrolyzed by pancreatic α-amylase (NUGENT, 2005).

Another aspect to be considered is that the replacement of corn by babassu mesocarp in the diets may have required a higher enzymatic activity of the intestinal lumen at a stage when the production curve of the alpha-amylase enzyme is not yet fully established. Sakomura et al. (2004) observed that the amylase enzyme activity increases with advancing bird age, i.e., between the first and second week of life. Therefore, it is likely that the higher consumption presented by the birds in the first three weeks is a consequence of the reduced availability of energy present in the mesocarp.

CONCLUSION

The babassu mesocarp can be classified as an energy ingredient due to low crude protein and high starch contents. The inclusion of the mesocarp in the feed of broilers adversely affected the performance of broilers in the initial stages of growth.

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