

## ORIGINAL ARTICLE

# Açaí seed bran in the feed of slow-growth broilers

Janaína de Cássia Braga ARRUDA<sup>1\*</sup>, Lívia Anália Bentes da FONSECA<sup>1</sup>, Leonardo César Portal PINTO<sup>1</sup>, Higor César de Oliveira PINHEIRO<sup>1</sup>, Brenda Thamara Oliveira MONTEIRO<sup>1</sup>, Maria Cristina MANNO<sup>1</sup>, Kedson Raul de Souza LIMA<sup>1</sup>, Ana Rita de LIMA<sup>2</sup>

<sup>1</sup> Universidade Federal Rural da Amazônia, Instituto da Saúde e Produção Animal - Curso de Zootecnia, Campus Belém, Avenida Presidente Tancredo Neves, 2502, Bairro Terra Firme, CEP 66077-830 Belém- Pará, Brasil.

<sup>2</sup> Universidade Federal Rural da Amazônia, Instituto da Saúde e Produção Animal - Curso de Medicina Veterinária, Campus Belém, Avenida Presidente Tancredo Neves, 2502, Bairro Terra Firme, CEP 66077-830 Belém- Pará, Brasil.

\* Corresponding author: [jcb.arruda@gmail.com](mailto:jcb.arruda@gmail.com)

## ABSTRACT

The aim of this study was to analyze the potential use of açai seeds as an alternative ingredient in the feed of slow-growth broilers until 28 days of age. We carried out a bromatological analysis of fractions of the açai fruit. The açai seed without mesocarp was the best choice for formulation of the açai seed bran (ASB), which was evaluated in terms of bird performance and economic viability of the supplemented feed. A total of 416 male chicks of the French Red-Naked Neck lineage were used in a completely randomized design with four treatments (0, 2, 6 and 10% inclusion of ASB in the feed) with eight replicates each. The results indicated that ASB can be included in proportions of up to 10% in the diet of slow growth broilers at early development stage without impairing performance. The 10% inclusion level also was economically equal to the control treatment, representing a viable alternative for broiler production, with potential for reduction of the negative impacts generated by açai residue in the environment.

**KEYWORDS:** alternative feed, chicken, agroindustrial residue, sustainability, *Euterpe oleraceae*

## Farelo de caroço de açai em ração para frangos de crescimento lento

### RESUMO

Objetivou-se analisar o potencial da utilização do caroço de açai como ingrediente alternativo na alimentação de frangos de corte de crescimento lento, até 28 dias de idade. Primeiramente foi feita a análise bromatológica de frações do fruto do açai, que resultou no caroço de açai sem mesocarpo como sendo a melhor opção para a formulação do farelo de caroço de açai (FCA). O farelo foi usado na composição de rações em um experimento de desempenho das aves. Ao final foi realizada uma análise da viabilidade econômica do uso de FCA em ração para frangos. Utilizamos 416 pintos machos, da linhagem Francês Pesçoço Pelado Vermelho, em um delineamento inteiramente casualizado com quatro tratamentos (0, 2, 6 e 10% de inclusão de FCA) de oito repetições cada. Concluímos que o FCA pode ser incluído em até 10% na dieta para frango de corte de crescimento lento em fase inicial, sem ocasionar prejuízo em seu desempenho. O nível de 10% de inclusão mostrou-se economicamente equivalente ao tratamento controle, sendo uma alternativa viável de insumo na produção de frangos, que pode contribuir para a redução do impacto negativo gerado pelo resíduo do açai no meio ambiente.

**PALAVRAS-CHAVE:** alimento alternativo, nutrição de frangos, resíduo agroindustrial, sustentabilidade, *Euterpe oleraceae*

## INTRODUCTION

Poultry production has been the fastest growing agricultural sector in recent years, and, due to improvements in production processes (Moreira *et al.* 2012), it has been adapting to meet the demand of a new consumer market concerned with ecologically sustainable production coupled with food security and differential meat flavor (Braga and Roque 2008; Guéguen and Pascal 2010). This has resulted in the production of slow growth broilers, commonly known in Brazil as *frango caipira*

(free range chicken) or *frango colonial* (colonial chicken), which have lower potential for growth, zootechnical performance, and yield of the noble parts when compared to fast-growing industrial chickens, or “white chickens”. However, the better taste, firmer texture and more pronounced color of slow-growth broiler meat make it a promising niche-market product (Nahashon *et al.* 2010; Morais *et al.* 2015). The late slaughter age of slow-growth broilers results in higher production costs, which makes it desirable to seek alternative ingredients for feed that reduce costs without compromising poultry performance

**CITE AS:** Arruda, J. de C.B.; Fonseca, L.A.B. da; Pinto, L.C.P.; Pinheiro, H.C. de O.; Monteiro, B.T.O.; Manno, M.C.; Lima, K.R. de S.; Lima, A.R. de. 2018. Açai seed bran in the feed of slow-growth broilers. *Acta Amazonica* 48: 298-303.

(Camelo *et al.* 2015; Tavares *et al.* 2015). Several studies have tested the efficacy of agroindustrial byproducts for this purpose (Sousa *et al.* 2012; Delgado *et al.* 2013). Another goal is to successfully replace soybean meal and maize in chicken feed, because the price of these products oscillates strongly, and their supply varies seasonally in many regions (Arruda *et al.* 2008; Camelo *et al.* 2015).

Açai (*Euterpe oleracea* Mart.) is the main fruit culture of economic value in the state of Pará, in the eastern Amazon region (Santana *et al.* 2014). The edible portion of the palm tree fruit is the pulp, which constitutes about 32% of the total fruit mass in relation to the 68% occupied by the seed (Yuyama *et al.* 2011). Brazil produced 216,071 tons of açai in 2015, and the northern region of the country alone was responsible for 201,207 tons of the total production, representing 93% of extracted açai. The state of Pará produces 62% of the açai from the northern region (IBGE 2015), and 90% of this volume corresponds to residues generated after the agroindustrial processing of the fruit for pulp production. These residues are basically composed of the seed and attached fibers, which have potential as renewable lignocellulosic material (Teixeira *et al.* 2002). The residue represents a serious environmental problem. In the city of Belém alone, approximately 255,000 tons of residual organic açai waste are produced each year from fruit processing, which is equivalent to about 700 tons per day (Oliveira *et al.* 2007). Several methods have been investigated for the use of açai agroindustrial residue, including energy generation and fertilizer production (Teixeira *et al.* 2002). The use of açai seed has aroused the interest of animal producers, and, in some cases, it has been empirically tested in animal feed (Gomes *et al.* 2012).

We determined the bromatological characteristics of two different parts of the açai fruit, and then used the component that showed the best bromatological performance to prepare a bran for use in three different concentrations in test feeds for slow-growth broilers in the initial growth phase from 1 to 28 days. We evaluated broiler performance and the economic viability of the proposed diets in order to assess the potential use of açai residue as an alternative ingredient in broiler feed

## MATERIAL AND METHODS

### Bromatological analyses

Post-processing residues of açai fruit pulp were obtained from the local trade of açai juice producers at three commercial establishments in the city of Belém (Pará state). The residue was collected preferably immediately after removal of the pulp, then transferred to 50 kg raffia bags, transported to the preparation room, and washed for removal of the residual pulp sludge and any other attached material. The resulting product was then stored as açai seed with mesocarp (AcM). Part of the material had the fibers (monostels) adhered to the mesocarp removed. After washing, the material was placed in 50-L

buckets and covered with water for 20 days to separate the mesocarp fibers through spontaneous anaerobic fermentation of the vegetable matter, aiding the release of fibrous bundles. The material was then re-washed and underwent a manual scarification process to complete the defibration technique according to Castilhos (2012). The end result was analyzed as açai seed without mesocarp (AsM). The two end products (AcM or AsM) were transformed into açai seed bran for use in broiler feed.

Samples of 500 g of AcM and AsM were weighed and placed in a forced ventilation oven at 55°C for 72 h to obtain ADS (air-dried samples). The ADS were then milled in a 16-mm “knife-like” mill with 16 *mash* and 1 mm sieves, and stored separately in identified containers. Five composite samples of 300 g of AcM and five of AsM were formed using 100 g ADS from each establishment of origin, and were analyzed in triplicate for dry matter (DM), neutral detergent fiber (NDF) and acid detergent fiber (ADF) using the Kjeldahl method, and ether extract (EE) using the ANKOM method. The gross energy (GE) was determined using a calorimetric pump and crude fiber (CF) following the procedures described by Detmann *et al.* (2012). The amount of energy used by the broilers was estimated through the raw energy components, and their value was obtained through bomb calorimetry. The analyses were performed at the Animal Nutrition Laboratory (LABNUTAN) of the Health and Animal Production Institute (ISPA) of the Universidade Federal Rural da Amazônia, Belém campus.

### Broiler performance

The experiment was carried out at the Experimental Performance Shed of the Poultry Sector of ISPA/UFRA – Belém campus. We used 416 one-day-old male chicks (38.25 g ± 0.40 g) of the French Red-Naked Neck lineage obtained from the hatchery and already vaccinated against Marek's disease, Gumboro, Newcastle and bronchitis. The chicks were distributed among four treatments: T0: control diet without the açai seed bran; T1: diet with inclusion of 2% açai seed bran; T2: diet with inclusion of 6% açai seed bran; T3: diet with inclusion of 10% açai seed bran (Table 1). A completely randomized design was used, with eight replicates per treatments, and 13 birds per replicate, distributed in a total of 32 experimental boxes measuring 2.5 m<sup>2</sup> each and a final density of 5.2 birds m<sup>-2</sup> (13 birds per box). The experiment was finished when the birds reached 28 days of age.

Environmental conditions were standardized according to the breeding stage following methods adapted from Cassuce *et al.* (2013). We adopted a program of continuous light (12 hours natural + 12 hours artificial light) with the initial heating provided by incandescent lamps (250 w), using one unit per box. During the reception of the birds, they were individually weighed and distributed in such a way that the initial weight of the boxes was approximately the same. The birds received *ad libitum* water and food. The isoprotein, isovitamin and

**Table 1.** Centesimal composition (%) of rations fed to slow-growth broilers in the initial growth phase (1 to 28 days) submitted to different treatments of inclusion of açai seed bran in their diet. T0: control diet without açai seed bran; T1: diet with 2% açai seed bran; T2: diet with 6% açai seed bran; T3: diet with 10% açai seed bran.

Ingredients (%)	Treatments			
	T0	T1	T2	T3
Corn (7.88% CP*)	61.12	57.87	51.36	44.84
Soybean meal (45% CP*)	33.50	33.91	34.70	35.51
Bicalcium phosphate (23% Ca/18% P*)	1.42	1.42	1.43	1.44
Limestone (38% Ca*)	1.00	0.99	0.99	0.98
Soybean oil (EM 8.790 kcal/kg*)	1.78	2.63	4.34	6.05
Salt	0.48	0.48	0.48	0.48
BHT	0.10	0.10	0.10	0.10
Açai seed bran	-	2.00	6.00	10.00
Premix <sup>1</sup>	0.60	0.60	0.60	0.60
TOTAL	100.00	100.00	100.00	100.00
Nutrients				
Metabolizable energy (Mcal/kg)	2.980.00	2.980.00	2.980.00	2.980.00
Crude protein (%)	20.00	20.00	20.00	20.00
Calcium (%)	0.86	0.86	0.86	0.86
Available P (%)	0.38	0.38	0.38	0.38
Sodium (%)	0.21	0.21	0.21	0.21
Ether extract (%)	4.56	5.29	6.76	8.22

\*CP = crude protein; Ca = Calcium; P = Phosphorus; ME = metabolizable energy.  
<sup>1</sup> Guarantee levels per kilogram of product: Vitamin A 1.333.333.00 IU; Vitamin B1 166.00 mg; Vitamin B12 1.666.00 µg; Vitamin B2 666.00 mg; Vitamin B6 166.00 mg; Vitamin D3 300.000.00 IU; Vitamin E 2.000.00 IU; Vitamin K3 333.00 mg; Biotin 6.00 mg; Cholin 36.0 g; Niacin 4.666.00 mg; Folic acid 67.00 mg; Pantothenic acid 1.717.00 mg; Cobalt 16.00 mg; Copper 1.000.00 mg; Iron 8.333.00 mg; Iodine 166.00 mg; Manganese 10.83 g; Selenium 33.00 mg; Zinc 7.500.00 mg; Methionine 233.33 g; Bacillus subtilis 50.000.000.000.00 UFC; Halquinol 5.000.00 mg; Salinomycin 10.99.00 g.

isomineral diets were formulated to meet the nutritional requirements of the initial phase, and these methods were adapted from Rostagno *et al.* (2011) for regular broilers considering a single phase of 28 days by adjusting the values presented in the phase from 22-33 days, either with or without exceeding the nutritional values (Table 1). Each box contained a pendulum water dispenser and a semi-automatic tubular feeder. The data on poultry weight, feed intake and mortality was recorded weekly for each box and used to evaluate broiler performance through total weight gain (WG), daily weight gain (DWG), viability index (VI), feed intake (FI) and feed conversion rate (FC) at 7, 14, 21 and 28 days.

All procedures in this study involving animals were in accordance with and duly approved by the Ethics Committee on Animal Use (CEUA/UFRA, protocol no. 027/2014).

### Economic viability

Using data on broiler performance, and the cost of feed and chick acquisition, several indices were computed according to Espíndola (2011). The effective operational cost (EOC) is the cost effectively disbursed by the producer to produce a given quantity of a product. The operational expenses (OE) and expenses contracted (EC) are included in the

EOC, and the costs of meals and chicks (I) are used for the calculation as follows:  $EOC = OE + EC + I$  (all values in Brazilian real, R\$). Gross earnings (GEa) represent the monetary value obtained from the sale of production and are calculated according to the production of chickens (in kg of live weight) and the selling price of the product (R\$/kg) as follows:  $GE = \text{price per kg} \times \text{quantity (kg)}$ . The gross margin in relation to the effective operating cost (GMEOC) represents the percentage of resources remaining after the producer pays the effective operating cost (EOC) and considering the unit selling price of the product and its production as follows:  $GMEOC (\%) = (GEa - EOC) / EOC \times 100$ . The leveling point (LP) is a cost indicator for a given level of production cost where the minimum output must cover this cost given the unit selling price of the product and is calculated as:  $LP (\text{unit}) = EOC / \text{live weight (R\$/kg)}$ . The effective operational profit (EOP) is the profitability of an activity in the short term including the economic and operational conditions, thus:  $EOP = GEa - EOC$ . The profitability index (PI) is an indicator of the available rate of revenue of the activity after payment of operating costs, calculated as:  $PI (\%) = EOP / GEa \times 100$ .

### Data analysis

The data on broiler performance and economic viability parameters were submitted to the Shapiro-Wilk normality test. Normally distributed variables were compared among treatments using analysis of variance (ANOVA), followed by the Tukey *ad hoc* pairwise comparison of means. Probability level was set at 5%. All analyses were performed with SAS University Edition (2016).

## RESULTS

The bromatological analysis (Table 2) indicated AsM is the best choice to compose the test rations for the chicken performance evaluation due to the higher level of crude protein, lower levels of NDF, ADF, and crude fiber. Since the açai seed had relatively low protein content and energy density, it was necessary to increase the amount of soybean oil and soybean meal in the treatment feed formulations (Table 1), in order to maintain appropriate isoprotein and isoenergetic levels.

There was no significant difference among treatments for broiler weight gain and viability, but feed intake and feed conversion rate were significantly higher in T2 than in T3 (Table 3). T2 had the highest value for food intake and the highest feed conversion rate, while T3 had the lowest value for feed conversion rate among all treatments.

Regarding economic viability parameters, T3 had the highest cost per kilogram of feed, and the highest cost per kilogram of chicken produced, while T0 had the best economic parameters (Table 4). There was no significant

difference among treatments for GEa, GMEOC, EOP and PI, however EOC and LP were significantly higher for T2 in comparison with T0, and EOC and LP did not differ statistically between T3 and T0 (Table 5).

**Table 2.** Bromatological composition of different components of the açai fruit. AcM= açai seed with mesocarp; AsM= açai seed without mesocarp, expressed on dry basis. Values are mean ± SD of five samples.

Parameter	AcM	AsM
Gross energy (cal/g)	4417 ± 0.02	4304 ± 0.01
Moisture %	43.01 ± 0.07	31.14 ± 0.05
Dry matter %	56.99 ± 0.27	68.86 ± 0.42
Ether extract %	0.78 ± 0.21	1.42 ± 0.19
Crude protein %	2.86 ± 0.03	3.78 ± 0.10
Mineral matter %	1.27 ± 0.04	1.29 ± 0.01
Crude fiber %	80.52 ± 0.56	77.20 ± 0.78
NDF %	87.02 ± 0.32	82.95 ± 0.13
ADF %	72.25 ± 0.19	46.53 ± 0.50

**Table 3.** Means of performance parameters (N = 8 replicates per treatment) of slow-growing broilers in the initial phase (1 to 28 days) submitted to different treatments of inclusion of açai seed bran in their diet. T0: control diet without açai seed bran; T1: diet with 2% açai seed bran; T2: diet with 6% açai seed bran; T3: diet with 10% açai seed bran. CV = coefficient of variance.

Parameters	Treatments				CV(%)
	T0	T1	T2	T3	
Initial weight (g)	38.02	38.34	38.15	38.43	4.95
Weight gain (g)	689.5	685.0	682.7	685.0	4.87
Feed intake (g)	1.194 <sup>ab</sup>	1.206 <sup>ab</sup>	1.241 <sup>a</sup>	1.150 <sup>b</sup>	4.11*
Feed conversion rate	1.735 <sup>ab</sup>	1.766 <sup>ab</sup>	1.821 <sup>a</sup>	1.681 <sup>b</sup>	5.57*
Viability (%)	99.03	99.03	95.19	98.07	3.96

\* indicates that coefficients varied significantly in ANOVA (p < 0.05). Letters group treatment means that do not differ significantly according to the Tukey test (p < 0.05).

**Table 4.** Production performance and production cost of slow-growth broilers in the initial growth phase (1 to 28 days) fed with diets containing different proportions of açai seed bran. T0: control diet without açai seed bran; T1: diet with 2% açai seed bran; T2: diet with 6% açai seed bran; T3: diet with 10% açai seed bran. Values for intake and average weight are the mean of eight replicates per treatments. Production cost values are from March 2016. All monetary values are in Brazilian real (R\$).

Production parameters	Treatments			
	T0	T1	T2	T3
Initial ration (R\$/kg)	1.468	1.484	1.515	1.546
Intake (kg)	1.195	1.207	1.242	1.151
Cost/phase (R\$/chicken)	1.754	1.791	1.881	1.779
Number of chickens/treatment	103	103	99	102
Average weight (kg)	0.728	0.717	0.706	0.724
Cost per kg of chicken (R\$/kg)	2.409	2.497	2.664	2.457

**Table 5.** Economic viability parameters estimated for slow-growth broilers at initial phase (1 to 28 days) submitted to different treatments of inclusion of açai seed bran in their diet. T0: control diet without açai seed bran; T1: diet with 2% açai seed bran; T2: diet with 6% açai seed bran; T3: diet with 10% açai seed bran. EOC = effective operational cost; GEa = gross earning; GMEOC = gross margin in relation to effective operational cost; LP = leveling point; EOP = effective operational profit; PI = profitability index in the production of an experimental unit (13 chickens per unit). All monetary values are in Brazilian real (R\$).

Parameters	Treatments				CV%
	T0	T1	T2	T3	
EOC <sup>1</sup> (R\$/13 chickens)	65.67 <sup>b</sup>	66.15 <sup>ab</sup>	67.32 <sup>a</sup>	65.99 <sup>b</sup>	1.45*
GEa <sup>2</sup> (R\$)	93.68	92.37	84.46	92.27	7.03
GMEOC <sup>3</sup> (%)	42.68	39.63	30.06	39.88	26.79
LP <sup>4</sup> (kg)	6.57 <sup>b</sup>	6.61 <sup>ab</sup>	6.73 <sup>a</sup>	6.60 <sup>b</sup>	1.45*
EOP <sup>5</sup> (R\$)	28.02	26.23	20.14	26.27	26.70
PI <sup>6</sup> (%)	29.76	27.87	22.32	28.33	23.19

<sup>1</sup> Sum of costs with feed + fixed cost + chick acquisition cost (R\$ 2.50/individual) x 13 chickens.

<sup>2</sup> Average weight x number of poultry sold x R\$ 10.00 per kg of live chicken.

<sup>3</sup> (GEa-EOC)/EOCx100.

<sup>4</sup> EOC/selling price.

<sup>5</sup> EOP = GEa-EOC

<sup>6</sup> PI = EOP/GEa

\* indicates that coefficients varied significantly in ANOVA (p < 0.05).

Letters group treatment means that do not differ significantly according to the Tukey test (p < 0.05).

## DISCUSSION

We were not able to find reference values in the literature for GE of any of the açai components analyzed in here, which probably owes to that the açai pulp, which is the economically relevant fruit component, is usually the focus of nutritional research (Pessoa *et al.* 2010; Sangronis and Sanabria 2011; Yuyama *et al.* 2011). Our results differed from those of the pioneering work of Altman (1956), who found values of 13.60% moisture, 3.01% ether extract, and 4.34% crude protein for açai seeds, although it is not clear which fraction of the seed was used, for the author referred only to “crushed açai seed”. Values for açai seeds without mesocarp by Filho *et al.* (1987) were of 19.93% dry matter (well below our result), 2.45% crude protein, 0.98% ether extract, 78.25% NDF and 59.87% ADF (all similar to our values). Townsend *et al.* (2001) also report similar values for açai seeds without mesocarp, with 62% dry matter, 4% crude protein, 1.82% ether extract, 2.34% mineral matter, 93.9% NDF and 64.9% ADF. Bromatological parameters of the seeds may vary due to the influence of numerous factors, such as genetic diversity of the berries, harvest period, soil type and fertilization, location and climatic condition of planting, and differences in pulp extraction methods such as the quantity of water used and the length of time and temperature used during maceration (Cunha *et al.* 2012).

Both fractions of açai residue evaluated in here showed medium levels of gross energy, low levels of crude protein, and high levels of fiber, when compared to the levels recommended by Rostagno *et al.* (2011) for broiler chicken. Thus, except for the percentage of fiber, which is a limiting factor for non-



ruminants, the açai seed can be considered an alternative ingredient with potential for use in slow-growing broiler diet.

The higher FC and lower FI in the 10% ASB treatment was due to the higher proportion of soybean oil and meal in the formulation (see Table 1), which provided energy, and initially stimulated but then reduced the FI. The addition of lipids in the diet promotes an increase in caloric density, the extra-caloric effect, which consists of the increase in nutrient availability of the feed ingredients, and the extra-metabolic effect of the fat that results in improvement of the energy efficiency through the increase in feed net energy (Sakomura *et al.* 2004; Santos *et al.* 2014).

We found no published studies that tested alternative ingredients for feed of slow-growth broilers in the initial phase up to 28 days, in which the birds remain confined without access to the picket. The vast majority of studies evaluate birds in the later growth phase, when breeding takes place semi-extensively with free access to the picket for a large portion of the day until slaughter (Santos *et al.* 2014; Veloso *et al.* 2014; Tavares *et al.* 2015). From a productivity point of view, ASB inclusion did not significantly affect weight gain and viability of the broilers in relation to the control, and the feed with 10% ASB inclusion resulted in significantly lower feed intake and lower feed conversion rate in relation to feed with 6% ASB. We may thus conclude that up to 10% ASB can be included in the diet for slow growth broiler chickens up to 28 days of age without compromising performance.

From the environmental point of view, the use of ASB in broiler feed, specially in higher proportions, as in the 10% ASB treatment, would contribute to the efficiency and sustainability in the açai production chain in the northern region of Brazil, while also reducing the environmental impact generated by the accumulation of açai waste deposits in nature.

Diets with highest levels of ASB had higher cost compared to the standard diet (3.20 and 5.31%, respectively, for 6% and 10% ASB inclusion). Since the proportion of soybean oil and meal had to be increased in the treatment feeds for nutritional reasons, the price of soybean oil (R\$ 3.20/kg) was an important factor in the cost of feed when increasing ASB inclusion. However, the higher feed cost reflected the cost per kilo of chicken produced with the ASB diet of 10%, even with lower broiler feed intake in this treatment. The cost per kilogram in the diet with 10% ASB was 1.99% more than the value for the control treatment. An additional advantage is that the açai seed bran can be prepared *in loco* by producers at low cost, since only manual work with the use of simple equipment is necessary for processing the *in natura* seed residues.

The increase in EOC was associated mainly to the increase in feed cost. However, even with a higher proportion of soybean oil and meal, the 10% ASB feed had EOC and LP values statistically equal to those of the control treatment. In periods of off-season, where supply is scarce and prices are

higher, ASB can be considered as an alternative to substitute corn for up to 10% in slow-growing chicken broiler rations, with the choice being at the producer's discretion, since economically there is no difference between it and the control ration. Future studies should evaluate other diet compositions using ASB, including alternatives that are more financially feasible for small poultry producers.

## CONCLUSIONS

Açai seed bran can be included at proportions of up to 10% in diets for slow-growing broilers in the initial phase (from 1 to 28 days) without impairing performance. The 10% inclusion level was shown to be economically equal to the control treatment. The use of diets containing 10% of açai seed bran for slow growth broiler chickens is thus a viable alternative for production and the reduction of negative impacts generated by residues in the environment.

## ACKNOWLEDGMENTS

This research is part of the doctoral thesis of the first author and was supported by the Fundação Amazônica Paraense de Amparo a Estudos e Pesquisas - Fapespa.

## REFERENCES

- Altman, R.F.A. 1956. Estudo químico de plantas amazônicas. *Boletim Técnico do Instituto Agrônomo do Norte*, Pará, 10p.
- Arruda, J.C.B.; Martins, T.D.D.; Silva, J.H.V.; Silva, L.P.G.; Oliveira, E.R.A. 2008. Desempenho de leitões submetidos a diferentes níveis de substituição da proteína do farelo de soja pela proteína do ovo desidratado. *Acta Scientiarum Animal Sciences*, 30: 401–405.
- Braga, R.M.; Roque, M.S. 2008. *Comercialização de Galinha Viva do Tipo "Caipira" em Boa Vista, Roraima*. Centro de Pesquisa Agroflorestal de Roraima, Boa Vista, Roraima, 24p.
- Camelo, L.C.L.; Lana, G.R.Q.; Santos, M.J.B.; Camelo, Y.A.R.P.; Marinho, A.L.; Rabello, C.B.V. 2015. Inclusão de farelo de goiaba na dieta de codornas européias. *Ciencia Animal Brasileira*, 16: 343–349.
- Cassuce, D.C.; Tinôco, I.F.F.; Baêta, F.C.; Zolnier, S.; Cecon, P.R.; Vieira, M.F.A. 2013. Atualização das temperaturas de conforto térmico para frangos de corte de até 21 dias de idade. *Engenharia Agrícola*, 33: 28–36.
- Castilhos, L.F.F. 2012. *Aproveitamento da fibra de coco*. Instituto de Tecnologia do Paraná, Paraná, 29p.
- Cunha, O.F.R.; Neiva, J.N.M.; Maciel, R.P.; Miotto, F.R.C.; Neiva, A.C.G.R.; Restle, J. 2012. Avaliação bioeconômica do uso da torta de dendê na alimentação de vacas leiteiras. *Ciencia Animal Brasileira*, 13: 315–322.
- Delgado, E.; Orozco, Y.; Uribe, P. 2013. Comportamiento productivo de pollos alimentados a base de harina de plátano considerando la relación beneficio costo. *Zootecnia Tropical*, 31: 279–290.

- Detmann, E.; Souza, M.A.; Valadares Filho, S.C. 2012. *Métodos para Análise de Alimentos*. INCT – Ciência Animal, Ed Visconde do Rio Branco, Suprema, 242p.
- Espíndola, G.B. 2011. *Revisão dos parâmetros não zootécnicos aplicados em nutrição de monogástricos*. Expressão Gráfica e Editora, Fortaleza, 168p.
- Filho, J.A.R.; Batista, H.A.M.; Camarão, A.P.; Silva, E.D. 1987. *Composição química e digestibilidade “in vitro” da matéria seca de resíduos agroindustriais no estado do Pará*. EMBRAPA-CPATU, Pará, 6p.
- Gomes, D.I.; Veras, R.M.L.; Alves, K.S.; Detmann, E.; Oliveira, L.R.S.; Mezzomo, R.; Santos R.B.; Barcelos, S.S. 2012. Performance and digestibility of growing sheep fed with açai seed meal-based diets. *Tropical Animal Health And Production*, 44: 1751–1757.
- Guéguen, L. and Pascal, G. 2010. Le point sur la valeur nutritionnelle et sanitaire des aliments issus de l’agriculture biologique. *Cahiers de Nutrition et de Diétiqque*, 45: 130–143.
- IBGE. 2015. Instituto Brasileiro de Geografia e Estatística. SIDRA. (<http://www.sidra.ibge.gov.br/>). Accessed on 13 July 2017.
- Menezes, E.M.S.; Torres, A.T. and Srur, A.U.S. 2008. Valor nutricional da polpa de açai (*Euterpe oleracea* Mart) liofilizad. *Acta Amazonica*, 38: 311–316.
- Morais, J.; Ferreira, P.B.; Jacome, I.M.T.D.; Mello, R.; Breda, F.C.; Rorato, P.R.N. 2015. Curva de crescimento de diferentes linhagens de frango de corte caipira. *Ciência Rural*, 45: 1872–1878.
- Moreira, A.S.; Santos, M.S.V.; Vieira, S.S.; Tavares, F.B.; Manno, M.C. 2012. Performance of broiler chickens fed diets containing different levels of metabolizable energy. *Arquivo Brasileiro de Medicina Veterinaria e Zootecnia*, 64: 1009–1016.
- Nahashon, S.N.; Aggrey, S.E.; Adefope, N.A.; Amenyenu, A.; Wright, D. 2010. Gompertz-Laird model prediction of optimum utilization of crude protein and metabolizable energy by French guinea fowl broilers. *Poultry Science*, 89: 52–57.
- Oliveira, M.S.P.; Neto, J.T.F. and Pena, R.S. 2007. *Açai : técnicas de cultivo e processamento*. Editora do Instituto de Desenvolvimento da Fruticultura e Agroindústria - FRUTAL, Belém, Pará, 105p.
- Pessoa, J.D.C.; Arduim, M.; Martins, M.A.; Carvalho, J.E.U. 2010. Characterization of Açai (*E. oleracea*) fruits and its processing residues. *Brazilian Archives of Biology and Technology*, 53:1451-1460.
- Rostagno, H.S.; Albino, L.F.T.; Donzele, J.L.; Gomes, P.C.; Oliveira, R.F.; Lopes, D.C.; Ferreira, A.S.; Barreto, S.L.T.; Euclides, R.F. 2011. *Tabelas Brasileiras para Aves e Suínos*. Ed. Universidade Federal de Viçosa, Viçosa, Minas Gerais, 252p.
- Sangronis, E. and Sanabria, N. 2011. Impact of solar dehydration on composition and antioxidant properties of açai (*Euterpe oleracea* Mart.). *Archivos Latinoamericanos de Nutricion*, 61: 74-80.
- Santana, A.C.; Santana, A.L.; Santana, A.L.; Santos, M.A.S.; Pliveira, C.M. 2014. Análise discriminante múltipla do mercado varejista de açai em belém do Pará. *Revista Brasileira de Fruticultura*, 36: 532–54.
- Santos, F.R.; Stringhini, J.H.; Minafra, C.S.; Almeida, R.R.; Oliveira, P.R.; Duarte, E.F.; Silva, R.B.; Café, M. B. 2014. Formulação de ração para frangos de corte de crescimento lento utilizando valores de energia metabolizável dos ingredientes determinada com linhagens de crescimento lento e rápido. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, 66: 1839-1846.
- SAS Institute Inc. 2016. SAS® University Edition: *Installation Guide for Windows*. SAS Institute Inc., Cary, NC.
- Sakomura, N.K.; Longo, F.A.; Rabelo, C.B.; Watanabe, K.; Pelicia, K.; Freitas, E. R. 2004. Efeito dos níveis de energia metabolizável da dieta no desempenho e metabolismo energético de frangos de corte. *Revista Brasileira de Zootecnia*, 33: 1758-1767.
- Sousa, J.P.L.; Rodrigues, K.F.; Albino, L.F.; Santos Neta, E. R.; Vaz, R.G.M.V.; Parente, I.B.; Silva, G.F.; Amorim, A.F. 2012. Bagaço de mandioca em dietas de frangos de corte. *Revista Brasileira de Saúde Produção Animal*, 13: 1044-1053.
- Tavares, F.B.; Santos, M.S.V.; Araújo, C.V.; Costa, H.S.; Loureiro, J.P.B.; Lima, E.M.; Lima, K.R.S. Performance, growth and carcass characteristics of alternatives lineages of broiler chickens created with access to paddock. 2015. *Revista Brasileira de Saúde e Produção Animal*, 16: 420-429.
- Teixeira, L.B.; Germano, V.L.C.; Oliveira, R.F.; Junior, J.F. 2002. *Processo de Compostagem a Partir de Lixo Orgânico Urbano e Carvão de Açai*. Ed. EMBRAPA Amazônia Oriental, CT/29, Pará, 8p.
- Townsend, C.R.; Costa, N.L.; Pereira, R.G.A.; Senger, C.D.C. 2001. *Características químico-bromatológica do carvão de açai*. Ed. EMBRAPA-CPAF, CT/193 Rondônia, 6p.
- Veloso, R.C.; Pires, A.V.; Torres Filho, R.A.; Pinheiro, S.R.F.; Winkelstroter, L.K.; Alcântara, D.C.; Cruz, C.C.D.C.S. Parâmetros de desempenho e carcaça de genótipos de frangos tipo caipira. 2014. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, 66: 1251-1259.
- Yuyama, L.K.O.; Aguiar, J.P.L.; Filho, D.F.S.; Yuyama, K.; Varejão, M.J.; Fávaro, D.I.T.; Vasconcelos, M.B.A.; Pimentel, S.A.; Caruso, M.S.F. 2011. Caracterização físico-química do suco de açai de *Euterpe precatoria* Mart. oriundo de diferentes ecossistemas amazônicos. *Acta Amazonica*, 41: 545–552.

RECEIVED: 13/11/2017

ACCEPTED: 12/07/2018

ASSOCIATE EDITOR: Rodrigo do Valle



This is an Open Access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.