

NUTRITIONAL EVALUATION OF ALMOND CASHEW NUT BY-PRODUCTS IN DIETS FOR SLOW-GROWING BROILER CHICKENS¹

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ABSTRACT: The aim of this study was to determine the apparent digestibility and energy value of almond cashew nut by-products for slow-growing broiler chickens. Seventy-six chickens (males and females) were allocated in a completely randomized design to four treatments: a control diet and the same diet in which the conventional ingredients were replaced with 30% (kg/kg) almond cashew nut film, almond cashew nut meal or almond cashew nut mass. The animals were housed in individual cages adapted for excreta collection. The apparent digestibility coefficients of film, full meal and almond mass were, respectively, 81.3, 87.3 and 86.2% for dry matter; 32.1, 71.2 and 56.7% for crude protein (CP); 82.7, 92.6 and 92.8% for ether extract; 10.9, 29.9 and 34.7% for neutral detergent fiber; 7.7, 17.9 and 19.6% for acid detergent fiber; 41.9, 57.2 and 66.7% for coefficient of gross energy metabolism (CGEM); 1,189, 2,648 and 3,719 kcal/kg for apparent metabolizable energy (AME); 8.1, 19.9 and 12.9% for digestible protein, and 3.9, 15.2 and 6.3% for mineral matter (MM). The CP and MM apparent digestibility coefficients of full meal were higher than those of film and almond cashew nut mass, while the latter exhibited higher apparent digestibility of fiber, CGEM and AME compared to the other by-products. The inclusion of almond cashew nut by-products in diets for slow-growing broiler chickens results in lower nutrient digestibility, except for ether extract, neutral detergent fiber and AME, in diets containing 30% almond cashew nut mass.

Keywords: *Anacardium occidentale*, digestibility, Label Rouge poultry, metabolizable energy.

AVALIAÇÃO NUTRICIONAL DOS SUBPRODUTOS DA AMÊNDOA DA CASTANHA DE CAJU EM DIETAS PARA FRANGOS DE CRESCIMENTO LENTO

RESUMO: Objetivou-se determinar a digestibilidade aparente e o valor energético dos subprodutos da amêndoa da castanha de caju para aves de crescimento lento. Setenta e seis aves (machos e fêmeas) foram distribuídas em delineamento inteiramente casualizado com 4 tratamentos: uma dieta controle a partir da qual houve a inclusão de 30% (kg/kg) da película, farelo integral ou massa da amêndoa da castanha de caju. As aves foram alojadas em gaiolas individuais adaptadas para coleta total de excreta. O coeficiente de digestibilidade aparente da película, farelo integral e massa da amêndoa foram 81,3, 87,3 e 86,2% para matéria seca; 32,1, 71,2 e 56,7% para proteína bruta (PB); 82,7, 92,6 e 92,8% para extrato etéreo; 10,9, 29,9 e 34,7% para fibra em detergente neutro; 7,7, 17,9 e 19,6% para fibra em detergente ácido; 41,9, 57,2 e 66,7% para o coeficiente de metabolização de energia bruta (CMEB); 1189, 2648 e 3719 kcal/kg para energia metabolizável aparente (EMA); 8,1; 19,9 e 12,9% para proteína digestível e disponibilidade de 3,9; 15,2 e 6,3% para matéria mineral (MM). Os coeficientes de digestibilidade aparente de PB e MM do farelo integral foram maiores do que a película e massa da amêndoa da castanha de caju. A massa foi superior para a digestibilidade aparente da fração fibrosa, CMEB e EMA em relação aos outros subprodutos da amêndoa da castanha de caju. A inclusão dos subprodutos da castanha de caju em dietas para frangos de crescimento lento propicia baixa digestibilidade dos nutrientes, com exceção do extrato etéreo, fibra em detergente neutro e energia metabolizável aparente para a dieta com 30% da massa da castanha de caju.

Palavras-chave: *Anacardium occidentale*, digestibilidade, aves Label Rouge, energia metabolizável.

INTRODUCTION

Poultry farming is one of the most developed and technified sectors in global agriculture. Advances in genetics and the development of nutrition, health and management techniques have led to the current highly efficient and organized poultry farming that permits the production of animal protein of high biological value for human consumption at low cost (BAILONE and ROÇA, 2016).

Corn and soybeans are the main cereal grains and oilseeds, respectively, in poultry diets and the recovery of international prices of these commodities has increased the costs of poultry production, reducing marketing margins (ANTUNES, 2011). Thus, researchers are looking for economically viable feed alternatives in an attempt to minimize these costs and to maintain production rates. Within this context, some by-products generated by agribusinesses, such as almond cashew nut bran, film and mass, have potential for use in poultry feeding because of their nutritional composition, providing high energy and protein, and because they can partially replace corn and soybean meal in diets (OJEWOLA *et al.*, 2004). However, the data available in the literature are still inconsistent and inconclusive because of the scarcity of information about the use of cashew nut by-products in industrial and semi-intensive poultry farming, highlighting the need to develop food evaluation surveys applicable to these animal production systems.

Therefore, the aim of this study was to determine the apparent digestibility of nutrients, digestible protein and metabolizable energy values of by-products of almond cashew nuts for slow-growing broiler chickens.

MATERIAL AND METHODS

The experiments were approved by the Ethics Committee on Animal Use of the Universidade Federal Rural do Semi-Árido (CEUA-UFERSA, No. 65/2012, Approval No. 23091.001795/2012-49).

One-day-old chicks were procured, vaccinated (for Marek's, Newcastle and Fowlpox viruses), and housed in sheds. During the initial phase, a conventional commercial diet (2,950 kcal/kg metabolizable energy, 22.0% crude protein (CP), 0.48% available phosphorus, 0.93% total calcium, 0.22% total sodium, 1.33% digestible lysine, and 0.51% digestible methionine) was used.

The experiment was conducted in Mossoró, RN, Brazil (5° 11' south latitude, 37° 22' west longitude,

16 m altitude). Seventy-six metal cages measuring 40 x 40 x 22 cm that were adapted for the digestibility experiments were used. The cages were arranged in battery systems and equipped with semi-automatic nipple drinkers, trough-type feeders and trays adapted for the collection of excreta. These cages were installed in sheds with French tile roofs, concrete floors and masonry side guardrails. The cages had a wire mesh to the base height of the roof and were fitted with side curtains. Seventy-six broiler chickens of the naked neck Label Rouge line (males and females), 12 weeks old, selected based on average body weight (2.800g), were randomly and individually housed in cages modified for the digestibility experiments.

The treatments consisted of four experimental diets: a control diet (COD) formulated with conventional ingredients (corn, soybean meal, and wheat bran) according to the nutritional requirements suggested by Rostagno *et al.* (2011) for brown lines, and diets in which these ingredients (except for vitamin mixture and salinomycin) were replaced with 30% (kg/kg) almond cashew nut film (ACF), almond cashew nut meal (ACME) or mass (ACMA) (Table 1).

During the adaptation period (7 days), the experimental diets were weighed (250 g/bird/day), and water was provided *ad libitum* to broilers. For the next 7 days, all excreta were collected twice daily (8:00 and 16:00 h), transferred to plastic bags, identified, and frozen (-10°C). At the end of the excreta collection period, the samples were thawed at room temperature, homogenized, and used for chemical analysis following the techniques described by SILVA and QUEIROZ (2002). After these analyses, the coefficients of digestibility and the metabolism of energy and CP of the diets and by-products were determined using the conventional food evaluation technique (Matterson) described by SAKOMURA and ROSTAGNO (2007):

$$ADC = \frac{\text{Nutrient intake} - \text{Fecal nutrient}}{\text{Nutrient intake}} \times 100$$

$$AME = \frac{\text{Gross energy intake} - \text{Gross energy excreted}}{\text{Dry matter intake}}$$

$$CGEM = \frac{\text{Metabolizable energy}}{\text{Gross energy}} \times 100$$

$$AMEb = AME(COD) + \frac{[AME(COD) - AME(BD)]}{BI/BDI}$$

Table 1. Ingredients and chemical composition of the control diet (COD) and the diets containing almond cashew nut film (ACF), meal (ACME) or mass (ACMA) for slow-growing broiler chickens

Ingredient (kg)	Diet			
	COD	ACF	ACME	ACMA
Soybean meal	29.6	23.6	23.6	23.6
Almond cashew nut film	-	30.0	-	-
Almond cashew nut meal	-	-	30.0	-
Almond cashew nut mass	-	-	-	30.0
Corn meal	59.3	41.3	41.3	41.3
Wheat meal	5.0	3.5	3.5	3.5
Limestone	0.95	0.68	0.68	0.68
Dicalcium phosphate	1.2	0.85	0.85	0.85
Soybean oil	2.2	1.4	1.4	1.4
Salt	0.45	0.33	0.33	0.33
Vitamin mixture ¹	0.45	0.45	0.45	0.45
Mineral mixture ²	0.48	0.45	0.45	0.45
Salinomycin	0.03	0.03	0.03	0.03
L-lysine Hd	0.19	0.13	0.13	0.13
DL-methionine	0.16	0.11	0.11	0.11
Chemical composition				
Dry matter (%)	88.1	89.5	89.7	87.2
Mineral matter (% DM)	6.06	5.41	5.25	5.16
Ether extract (% DM)	4.82	13.0	14.0	15.2
Neutral detergent fiber (% DM)	12.9	14.8	12.9	10.8
Acid detergent fiber (% DM)	4.9	7.25	6.57	5.5
Crude protein (% DM)	19.7	21.3	22.1	20.6
Gross energy (kcal/kg)	3,862	3,538	4,074	4,355

¹Vitamin mixture (kg of product): vitamin A: 10,000,000 IU; vitamin D3: 2,000,000 IU; vitamin E: 30,000 IU; vitamin B1: 2.0 g; vitamin B2: 6.0 g; vitamin B6: 4.0 g; vitamin B12: 0.015 g; pantothenic acid: 12.0 g; biotin: 0.1 g; vitamin K3: 3.0 g; folic acid: 1.0 g; nicotinic acid: 50.0 g; selenium: 250.0 mg. ²Mineral mixture (kg of product): iron: 80 g; copper: 10 g; cobalt: 2 g; manganese: 80 g; zinc: 50 g; iodine: 1 g.

where ADC: apparent digestibility coefficient; AME: apparent metabolizable energy; CGEM: coefficient of gross energy metabolism (%); AMEb: apparent metabolizable energy of by-product (kcal/kg); AME(COD): apparent metabolizable energy of control diet (kcal/kg); AME(BD): apparent metabolizable energy of diet with by-product (kcal/kg); BI: by-product intake (kg), and BDI: intake of diet with by-product (kg).

The data were assessed for normality and homoscedasticity. The digestibility data were subjected to analysis of variance and means were compared by the Student-Newman-Keuls test, adopting a level of significance of 5%.

RESULTS AND DISCUSSION

The nutritional composition of the almond cashew nut full meal tested (Table 2) differs from that reported by SILVA *et al.* (2008), 94.7%, 22.4%, 47.0%, 28.8%, 21.5%, 3.36% and 6,412 kcal/kg for dry matter (DM), CP, ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF), mineral matter (MM) and gross energy (GE), respectively. PIMENTEL *et al.* (2011) reported a DM, CP and EE content of cashew meal of 83.1%, 24.9% and 44.1%, respectively, values similar to those obtained for almond cashew nut mass.

These variations may be related to the fact that the nutritional composition of plant foods is influenced by factors such as soil, climate and genetic

Table 2. Chemical composition of the almond cashew nut by-products

	Almond cashew nut by-product		
	Film	Meal	Mass
Dry matter (%)	92.7	93.2	84.9
Crude protein (% DM)	25.1	27.9	22.7
Ether extract (% DM)	37.2	42.8	45.6
Neutral detergent fiber (% DM)	19.4	12.9	5.9
Acid detergent fiber (% DM)	9.4	7.2	3.6
Mineral matter (% DM)	3.4	2.9	2.6
Gross energy (kcal/kg)	2,843	4,632	5,567

variability, as well as by the type of processing and unsuitable storage conditions of food (FREITAS *et al.*, 2005; BRUMANO *et al.*, 2006; GOMES *et al.*, 2007; NERY *et al.*, 2007). Particularly by-products may differ in their regional classification and in the proportion of their components.

Average feed intake differed significantly ($P < 0.05$) (Table 3), with the highest intake being observed for the control diet (COD) and the lowest intake for feed containing almond cashew nut film (ACF). The presence of lipids in the ACME and ACMA diets exerts an effect on cholecystokinin release and increases pancreatic secretion, acting on the satiety center and inhibiting feed intake (BERTECHINI, 2013). On the other hand, tannins found in ACF affect the taste buds and proteolytic enzymes, which can trigger a negative feedback on digestive physiology and the animal's satiety center, interrupting feed intake to prevent further damage to the body (KAMATH and RAJINI, 2007).

The ADC of nutrients differed among diets ($P < 0.05$) (Table 3). The highest digestibility coefficients were obtained for ADF, CP and MM of COD ($P < 0.05$). These differences are possibly due to the interactive effects of nutrition, particularly the antinutritional effect of the fiber fraction on intestinal motility and viscosity (ARRUDA *et al.*, 2012), the effect of phytates on the availability of mineral elements, and the negative effect of condensed tannins (which are physiologically responsible for the inhibition of certain enzymes present in the digestive system) on protein and amino acid digestibility (SILVA *et al.*, 2008).

Diets ACME and ACMA were superior in terms of EE digestibility compared to the other experimental diets ($P < 0.05$) (Table 3). This finding might be explained by the high content of polyunsaturated fatty acids in the meal and mass of these feed constituents (PIMENTEL *et al.*, 2011), while the lower digestibility observed for ACF could be

associated with the higher proportion of tannins and the fibrous fraction in the almond film (ARRUDA *et al.*, 2012).

Regarding the CGEM of the diets, superiority was observed for the COD ($P < 0.05$), followed by ACMA. The AME was higher for ACMA ($P < 0.05$) (Table 3) when compared to the other diets, demonstrating that the higher gross energy found in the ACMA diet was sufficient to compensate for the CGEM observed in the COD. On the other hand, the lower CGEM and AME found in FAC can be attributed to the antinutritional factors present in almond film that reduce energy metabolism (ELKIN *et al.*, 1996).

The nutrient ADC, CGEM, AME, and digestible protein differed between the by-products tested ($P < 0.05$) (Table 4). Almond cashew nut meal was superior in terms of the ADC of CP, digestible protein and MM availability when compared to the mass and film ($P < 0.05$). The same trend was observed for the experimental diets containing 30% of these by-products. However, almond cashew nut mass was superior in terms of fiber ADC (NDF and ADF), CGEM and AME compared to the other by-products. Since chickens are monogastric with only one functional cecum, the lower fiber utilization from the cashew nut meal and, especially from the film, may be related to the high fiber content of these foods. According to PACIULLO (2002), the low digestibility of some fiber components is mainly due to the dense arrangement of their cells, thick cell walls and the presence of lignin, reducing the utilization of energy from foods containing these components.

The differences in the nutrient digestibility coefficients among by-products can be attributed to the peculiarities of each product. In this respect, the almond cashew nut meal is composed of whole almonds and parts that are not suitable for human consumption (PIMENTEL *et al.*, 2011), while the almond

Table 3. Intake and apparent digestibility coefficients (ADC) of the control diet (COD) and the diets containing almond cashew nut film (ACF), almond cashew nut meal (ACME) or almond cashew nut mass (ACMA) for slow-growing broiler chickens

	Diet				SEM	P value
	COD	ACF	ACME	ACMA		
Intake (g/bird/day)	209 a	187 c	195 b	195b	2.43	0.0123
ADC (%)						
Dry matter	84.3 a	80.1 c	83.9 a	82.4 b	3.36	0.0123
Ether extract	90.7 b	88.3 c	91.3 a	92.2 a	2.70	0.0003
Neutral detergent fiber	33.9 a	27.0 c	32.7 b	34.1 a	6.70	0.0028
Acid detergent fiber	22.3 a	17.6 c	21.0 b	20.7 b	6.30	0.0145
Mineral matter	20.9 a	15.9 c	19.2 b	16.6 c	8.60	0.0367
Crude protein	84.3 a	68.6 d	80.4 b	76.0 c	2.80	0.0003
¹ CGEM (%)	81.4 a	72.3 c	74.4 c	76.0 b	9.60	0.0001
² AME (kcal/kg)	3,143 b	2,557 c	3,033 b	3,311 a	10.40	0.0001

¹Coefficient of gross energy metabolism. ²Apparent metabolizable energy.

Means in the same row followed by the same lowercase letter do not differ by the Student-Newman-Keuls test (P>0.05).

Table 4. Apparent digestibility coefficients (ADC) of almond cashew nut by-products for slow-growing chickens

	Almond cashew nut by-product			SEM	P value
	Film	Meal	Mass		
ADC (%)					
Dry matter	81.3 c	87.3 a	86.2 a	2.60	0.0001
Ether extract	82.7 b	92.6 a	92.8 a	9.70	0.0001
Neutral detergent fiber	10.9 c	29.9 b	34.7 a	10.50	0.0234
Acid detergent fiber	7.7 b	17.9 b	19.6 a	11.90	0.0196
Mineral matter	3.9 c	15.2 a	6.3 b	9.20	0.0004
Crude protein	32.1 c	71.2 a	56.7 b	6.40	0.0007
Digestible protein	8.1 b	19.9 a	12.9 b	2.90	0.0128
¹ CGEM (%)	41.9 c	57.2 b	66.7 a	4.10	0.0001
² AME (Kcal/kg)	1,189 c	2,648 b	3,719 a	2.90	0.0004

¹Coefficient of gross energy metabolism. ²Apparent metabolizable energy.

Means in the same row followed by the same lowercase letter do not differ by the Student-Newman-Keuls test (P>0.05).

cashew nut film originates from the skimming and processing of this kernel for human consumption and the mass is derived from the production of biofuel through mechanical extraction (FERNANDES, 2015).

CONCLUSION

The inclusion of almond cashew nut by-products in diets for slow-growing broiler chickens results in lower nutrient digestibility, except for ether extract,

neutral detergent fiber and apparent metabolizable energy, in diets containing 30% almond cashew nut mass.

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