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CARCASS YIELD AND QUALITY OF BREAST MEAT FROM FREE-RANGE CHICKEN FED WITH COTTONSEED CAKE

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ABSTRACT

The food used in the rearing of free-range chicken represent the potential for finding results related to their growth and the quality of their meat. Therefore, the objective of this study was to evaluate the carcass yield and physicochemical parameters of the meat of the free-range chicken breast of the naked neck lineage by replacing the protein of soybean meal for the protein of the cottonseed cake. For this purpose, the experiments were conducted in a completely randomized design, with five treatments (0, 10, 20, 30 and 40% replacement), six replicates and fifteen birds per repetition. Therefore, the relative weight of the carcass, the noble cuts (breast, drumstick leg and thigh), the edible viscera, the small intestine, and the length of the small intestine were evaluated. Results showed that there was no influence of the diet on the evaluated parameters, except for the chemical composition in which there was a linear reduction in the fat content of the free-range chicken breast meat as the level of replacement of soybean meal protein by cottonseed cake protein increased. Thus, the results of the variables of relative weight and the physicochemical composition of breast meat revealed the possibility of replacing up to 40% of soybean meal protein for cottonseed cake protein for the rearing of free-range chicken.

Keywords: alternative food, nacked neck, chicken meat.

RENDIMENTO DE CARCAÇA E QUALIDADE DA CARNE DO PEITO DE FRANGOS CAIPIRA ALIMENTADOS COM TORTA DE ALGODÃO

RESUMO:

Os alimentos utilizados na criação de frangos caipira representam a potencialidade de constatação de resultados relacionados ao seu crescimento e à qualidade de suas carnes. Nesse sentido, o objetivo deste estudo foi o de avaliar o rendimento da carcaça e dos parâmetros físico-químicos da carne do peito de frango caipira da linguagem pescoço pelado mediante a substituição da proteína do farelo de soja pela proteína da torta de algodão. Para tanto, os experimentos foram conduzidos em delineamento inteiramente ao acaso, com cinco tratamentos (0, 10, 20, 30 e 40% de substituição), seis repetições e quinze aves por repetição. Por conseguinte, foi avaliado o peso relativo da carcaça, dos cortes nobres (peito, coxa e sobrecoxa), das vísceras comestíveis, do intestino delgado, e o comprimento do intestino delgado. Os resultados indicaram que não houve influência da dieta nos parâmetros avaliados, com exceção da composição química em que houve redução linear do teor de gordura da carne do peito de frangos caipira à medida que aumentou o nível de substituição da proteína do farelo de soja pela proteína da torta de algodão. Desse modo, e sob o foco de aspectos conclusivos, os resultados das variáveis de peso relativo e da composição físico-química da

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carne do peito revelaram a possibilidade de substituição de até 40% da proteína do farelo de soja pela proteína da torta de algodão para a criação de frangos caipira.

Palavras-chaves: alimento alternativo, pescoço pelado, carne de frango.

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INTRODUCTION

The incessant initiatives of researchers interested in the identification of alternative feeds, whether in full or partial proportions regarding the use of soybean meal as a feed that will meet the requirement of slow growing chickens, as well as the reduction of production costs, has placed highlighted co-products from cotton, such as cottonseed cake, which has a high protein content and reasonable palatability (Carvalho et al., 2010; Diaw et al., 2010).

The cotton agribusiness generates around 37% of fiber destined for the textile industry, and 63% of seed, destined for the extraction of oil. From the cottonseeds, the industry extracts 12.5% of linter, 15.2% of oil, 46.7% of cottonseed cake, 20.7% of shell and 4.9% of processing residues. are extracted. The oil is extracted from the hydraulic pressing of the cottonseed, which can be followed by chemical extractors washing for greater oil extraction, and the residue of this process is called cottonseed cake (Beltrão, 2000).

The percentage of fat determines the classification of cotton in cottonseed cake or cotton bran. For example, the mechanical pressing with a content of 5% residual fat classifies the cotton in cottonseed cake. However, when it comes from solvent extraction and contains less than 2% residual oil, it is classified as lean cake or cottonseed meal bran (Araújo et al., 2003).

Thus, the bottleneck for the use of cottonseed cake in poultry is its high fiber content limiting the digestion of birds. In addition to this, there is the anti-nutritional factor present in the cotton called gossypol, which can be toxic, depending on the level ingested. The gossypol binds to the lysine, decreasing its nutritional availability to the animal (Barbosa and Gattas, 2004).

As reported in the literature, it is possible to verify good performance responses to the use of cotton by-products in the chicken diet (Carvalho et al., 2010; Carvalho et al., 2012; Diaw et al., 2010), but there are few reports on the quality of the meat. Thus, there is a need for studies that evaluate the effect of the co-product not only on the performance of the birds, but also on the final product, the chicken meat.

For Bertechini (2012), the animal's performance is part of a context of the chicken broiler industry, where modern nutrition aims to maximize the yields of prime cuts (breast, thighs, and drumsticks) and to reduce the fat yield in the carcass, as consumers are more demanding with the quality of the meat they consume.

In general, the slow-growing bird has peculiar characteristics, which makes it an attractive product, either due to the way it is reared in a free-range system or due to the organoleptic characteristics of the meat that call the consumer's attention due to the more pigmented colour and more consistent texture. All these characteristics influence in a different flavour from the breeding lines at the industrial system. Therefore, the insertion of an alternative meal to the diet of slow-growing birds must maintain the characteristics of the meat desirable by the consumer.

Due to the influence exerted by the diet on the carcass characteristics, the objective of this study was to evaluate the effect of replacing the soybean bran protein for the cottonseed cake protein in the diet of slow growth broiler chicken and check the carcass yield and physical and chemical parameters of the naked neck lineage.

MATERIAL AND METHODS

The experiment was conducted in the poultry sector, according to the Ethics Committee's standards on the use of animals CEUA-UFT-EMVZ, protocol no. 2301.002965/201599, from January 30, 2017, to April 25, 2017. The daily temperature and humidity data in the experimental period were provided by the weather station, located on the University's campus. Then the study calculated the minimum, maximum, and average temperatures as well as humidity from the data set. The analyses of the nutritional composition of the feed were carried out at the Animal Nutrition Laboratory which followed the physical characteristics analyses performed at the Meat Laboratory, both at the Federal University of Tocantins - UFT, School of Veterinary Medicine and Animal Science - EMVZ, at the campus of Araguaína.

The study used 450 birds (male and female) of the nacked neck lineage. They were one day old, with an average weight of 36.26 grams. The experiment was conducted in a completely randomized design (DIC), with a basal feed and four levels of replacement of crude soybean protein meal by crude protein from cottonseed cake, totaling five treatments (0, 10, 20, 30 and 40 %), six repetitions with fifteen birds per repetition.

Considering the chemical composition of the cottonseed cake purchased from the market (Table 1), the rations were formulated to meet the nutritional requirements of the birds in the initial phase (1 to 30 days), growth (31 to 60 days) and finishing (61 to 85 days) according to the recommendations of Sakomura et al. (2014) for the naked neck lineage. The electrolyte balance of the rations was calculated according to Mongin (1981): (mg.kg-1 of Na + of the ration / 22.990) + (mg.kg-1 of K + of the ration / 39.102) - (mg.kg-1 of Cl- ration / 35.453) (Table 2).

Table 1 - Composition of the cottonseed cake used in the formulation of experimental diets

Chemical composition	**Cottonseed cake[1]**
Dry matter (MS) %	94.20
Crude protein (CP) %	36.21
Mineral matter (MM) %	5.18
Ethereal Extract (EE) %	6.27
Crude fiber (FB) %	15.19
Neutral detergent insoluble fiber (NDF) %	42.00
Acid detergent insoluble fiber (ADF) %	23.49
Gross energy (GE) cal.g^{-1}	4771.17
Gossypol[2] %	0.03

[1]Analyses carried out in the laboratory of animal nutrition at the School of Veterinary Medicine and Animal Science of the Federal University of Tocantins. [2] Gossypol content reported on the packaging label of the cottonseed cake

From 1 to 30 days of age the birds were housed in metallic batteries (1.0 mx 1.0 mx 0.40 m) equipped with experimental cages, equipped with troughs and troughs and lighting system for heating the chicks until the 14th day of life.

At 31 days of age, following the same distribution of treatments, the birds were transferred to the paddocks, with an area of 10 mx 5 m containing a small artisanal wooden shelter for the birds, the tubular feeder and drinking fountain, where they remained until slaughter at 85 days of age.

Before slaughter, the birds were fasted for 12 hours, sampling two birds from each plot, totalling 60 birds, with body weight close to the mean of the plot (± 10%). The birds were individually identified and slaughtered by cervical dislocation, then bled, scalded, plucked and eviscerated for the evaluation of the relative weights (%) of the whole carcasses (with feet, neck and head), of the noble cuts (thigh, drumstick and breast) and the viscera (heart, liver, gizzard, small intestine, and abdominal fat).

Edible viscera (gizzard, heart, and liver) and small intestine and abdominal fat were collected during evisceration, cleaned, dried on paper towels and weighed separately on a precision scale. From the gizzard, all adhered fat, its contents and the coiline membrane were removed. In addition to weight, the length of the intestine from the beginning of the duodenum to the ileocecal junction was measured. The relative weight of plucked and gutted carcass was calculated in relation to the alive fasting weight. The relative weight of the cuts, edible viscera and small intestine were obtained in relation to the plucked and gutted carcass.

Raw breast meat (boneless, skin, ligaments and fat) the color of the meat was evaluated by the CIELAB system (L * = luminosity, a * = red content and b * = yellow content) with colorimeter (Chroma meter), being the reading carried out in three different points of the musculature and the determination of the pH, carried out by means of penetration electrode, directly in the meat.

The breast cuts were crushed separately, pre-dried in an oven at 55 ° C and ground in a Willey mill, in a 2 mm sieve, and then subjected to analysis to determine the levels of crude protein and ether extract according to the methodologies proposed by Silva and Queiroz (2006).

To determine the weight loss by cooking, fillets were removed from the breast (Pectoralis major muscle), which after weighing, an electrode was introduced and vacuum packed and cooked in a water bath until it reached an internal temperature of 82 ° C. Then, the samples were placed on absorbent paper for cooling, for about ten minutes, until reaching an ambient temperature of 25 ° C. Again, these were weighed and determined to lose weight after cooking and kept refrigerated at 4ºC for 24 hours, according to the methodology described by Ramos and Gomide (2017).

To determine the shear force, samples were taken in a cylindrical shape (1.27 cm in diameter), which were placed with the fibers oriented perpendicular to the blades of the Warner-Bratzler device (Ramos and Gomide, 2017).

For the statistical analysis of the data, normality and homoscedasticity were performed, given these assumptions, the data were subjected to analysis of variance according to the statistical model: $Yij = \mu + TAi + eij$. Where: Yij = value of the j-th observation for a dependent variable at the i-th level of substitution of soybean meal with cottonseed cake; μ = general average common to all observations; TAi = effect of the i-th level of substitution of soybean meal with cottonseed cake; eij = experimental error.

The variables were submitted to regression analysis using first and second order polynomial models. The study considered for adjustment of the models the significance level of the F test, the coefficient of determination (R^2 = SQ model / SQ treatments), and the linearity deviation. Thus, when the linearity deviation was not significant ($P>0.05$), the model was accepted. When it was significant ($P< 0.05$), the model was only accepted if the variation coefficient was less than 10%. The model was rejected in the case of significant value ($P<0.05$) and the coefficient of variation above 10% (Gomes, 1990).

The SISVAR program was used for statistical analyses, considering the significance level of 5%.

RESULTS AND DISCUSSION

In the experimental period, the average temperature was 25.5 ° C, the maximum of 30.9 ° C, the minimum of 22.4 ° C and relative humidity of 85%.

Results showed that the levels of replacement of soybean meal protein by cottonseed cake protein did not affect the relative weights of the carcass, noble cuts or viscera evaluated (Table 3). These results corroborate with Carvalho et al. (2012), who verified that the cottonseed meal protein could replace up to 38% of soybean bran protein without affecting the carcass characteristics of the poultries. The authors studied the carcass weight of free-range broilers chicken from the redneck lineage fed with cottonseed meal at four levels of replacement of soybean bran meal protein (25, 50, 75, and 100%). The result showed a quadratic behavior of the variables carcass weight, breast, thigh and thigh, wings, back and abdominal fat with optimal levels, respectively, 38.42; 32.46; 36.50; 35.35; 25.34; and 36.44%.

Mushtaq et al. (2009) study showed that the use of 30% of cottonseed meal decreased the yield of breast eat of poultry. They used levels of 20 and 30% of cottonseed meal supplemented with three levels of synthetic lysine (0.8, 0.9 and 1%) with or without the addition of enzymes (xylanase and glucanase, 0.50 g.kg-1) in diets for broilers from one to 42 days of age.

Table 3 -Live body wight at fasting (LBWF), carcass weight (CW), carcass yield (CY), breast (BY), Drumstick (DY), thigh (TY), heart (HY), gizzard (GY), liver (LY), fat (FY) small intestine (SIY) and small intestine length (SMLY) of slow-growing broilers slaughtered at 86 days of age fed with cottonseed cake (CC) in replacement for crude protein (CP) of soybean meal (SM)

Variables	Replacement of FS PB by TA PB					Average	P			Cv
	0%	10%	20%	30%	40%		El	Eq	Dl	
LBWF (g)	2599.2	2665.8	2551.7	2776.7	2714.2	2661.5	0.31	0.84	0.42	9.7
CW (g)	2030.4	2060.4	1958.3	2176.7	2112.1	2067.5	0.31	0.68	0.31	10.2
CY %	78.15	77.27	76.69	78.36	77.76	77.6	0.87	0.22	0.19	1.9
B%	26.53	26.50	26.88	26.27	26.33	26.5	0.78	0.77	0.88	6.9
DY%	13.33	13.49	13.13	13.55	13.17	13.3	0.74	0.74	0.35	4.4
TY%	15.20	15.05	15.22	15.85	15.34	15.3	0.15	0.76	0.11	3.6
H Y%	0.52	0.55	0.55	0.58	0.59	0.56	0.10	0.80	0.90	13.5
LY%	2.12	2.06	2.30	1.99	2.01	2.09	0.51	0.44	0.32	15.9
GY %	1.81	1.96	2.12	1.89	1.83	1.92	0.94	0.06	0.53	14.3
FY %	4.54	4.09	5.52	4.42	5.84	4.88	0.09	0.54	0.11	26.3
SIY %	2.23	2.45	2.49	2.18	2.14	2.30	0.24	0.05	0.32	12.0
SMLY m	1.61	1.70	1.63	1.69	1.59	1.64	0.77	0.16	0.30	6.3

CV= coefficient of variation; P= probability of type I error by test F; EL= linear effect; EQ= quadratic effect; DL= linearity deviation;

Table 2 - Centesimal composition of experimental diets in the initial phase (1 to 30 days), growth (31 to 60 days) and termination (61 to 85 days) with crude protein (CP) of cottonseed cake (CC) in replacement for crude protein of (CP) of soybean meal (SM).

Ingredients	Levels of replacement of CP of SM by CP of CC (%)														
	---------------1 to 30 days old-------------					--------------31 to 60 days old------------					----------------.. 61 to 85 days old--------------				
	0	**10**	**20**	**30**	**40**	**0**	**10**	**20**	**30**	**40**	**0**	**10**	**20**	**30**	40
Corn	55.42	55.76	55.61	54.00	52.19	62.98	63.08	63.18	62.45	60.49	74.75	73.70	73.00	72.55	72.00
Soybean Meal	37.71	34.08	30.01	26.75	23.70	31.90	28.69	25.48	22.42	19.50	21.42	19.27	17.13	14.99	12.85
Cottonseed cake.	0.00	4.62	9.74	13.88	18.52	0.00	3.98	7.97	11.95	15.94	0.00	2.66	5.33	7.98	10.64
Inert	2.52	1.56	0.34	0.00	0.00	2.51	1.55	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phosp. Bic.	1.85	1.88	1.92	1.90	1.65	0.88	0.91	0.94	0.98	1.01	0.91	0.91	0.91	0.91	0.91
Limestone	0.97	0.98	0.99	0.99	0.81	0.89	0.90	0.90	0.91	0.91	0.92	0.60	0.92	0.92	0.92
Premix[a b]	0.24	0.24	0.24	0.24	0.24	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Salt	0.50	0.50	0.50	0.49	0.49	0.38	0.39	0.39	0.40	0.41	0.42	0.42	0.42	0.42	0.42
DL-metion.	0.63	0.37	0.40	0.43	0.45	0.02	0.06	0.10	0.15	0.19	0.17	0.10	0.15	0.17	0.15
L-lysine	0.08	0.00	0.25	0.38	0.40	0.00	0.00	0.00	0.06	0.17	0.11	0.00	0.18	0.18	0.19
L-threonine	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.05
Soybean oil	0.00	0.00	0.00	0.94	1.55	0.00	0.00	0.00	0.24	0.89	0.86	1.92	1.53	1.44	1.45
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Nutritional Composition															
EM (kcal.kg^{-1})	2750	2750	2750	2750	2750	2850	2850	2850	2850	2850	3100	3100	3100	3100	3100
PB%	21.48	21.48	21.48	21.48	21.48	19.39	19.39	19.39	19.39	19.39	15.48	15.48	15.48	15.48	15.48
FB%	2.95	3.47	4.03	4.46	4.95	2.78	3.21	3.65	4.08	4.50	2.42	2.70	2.98	3.26	3.54
NDF%	11.81	13.29	14.86	15.96	17.27	11.90	13.14	14.38	15.55	16.58	11.82	12.55	13.29	14.07	14.81
ADF%	4.90	5.72	6.58	7.24	8.02	4.69	5.37	6.05	6.71	7.35	4.24	4.66	5.09	5.52	5.95
EE%	2.66	2.90	3.14	4.23	5.01	2.83	3.03	3.23	3.64	4.42	3.93	5.08	4.81	4.82	4.93
EETA%	0.00	0.28	0.61	0.87	1.16	0.00	0.24	0.49	0.74	0.99	0.00	0.16	0.33	0.50	0.66
Calcium	0.97	0.97	0.97	0.97	0.97	0.68	0.68	0.68	0.68	0.68	0.67	0.54	0.65	0.65	0.64
Available Phosphorus	0.45	0.45	0.45	0.45	0.45	0.27	0.27	0.27	0.27	0.27	0.27	0.26	0.26	0.25	0.25

Chlorine	0.35	0.35	0.34	0.34	0.33	0.27	0.27	0.27	0.28	0.28	0.29	0.29	0.29	0.29	0.29
Potassium	0.85	0.82	0.78	0.76	0.73	0.77	0.71	0.65	0.59	0.54	0.61	0.57	0.53	0.49	0.45
Sodium	0.22	0.22	0.22	0.22	0.22	0.19	0.19	0.19	0.19	0.19	0.20	0.20	0.20	0.20	0.20
Lis. Total	1.18	1.16	1.31	1.11	1.14	1.04	0.95	0.86	0.83	0.83	0.87	0.72	0.80	0.74	0.68
Met+Cist. Total	0.68	0.69	0.69	0.70	0.70	0.66	0.66	0.66	0.66	0.66	0.72	0.61	0.63	0.63	0.57
Treo. Total	0.85	0.84	0.83	0.83	0.82	0.77	0.71	0.66	0.60	0.59	0.62	0.58	0.54	0.50	0.51
*BE $mEq.kg^{-1}$	210.99	202.19	191.88	182.71	175.21	189.10	181.01	172.94	165.00	156.92	148.38	142.21	136.35	130.61	124.82

[the] Composition per kilogram of the Premix for early stage birds: vitamin A 2000,000 IU; vitamin D3 600,000 IU; vitamin E 5000 IU; vitamin K3 450 mg; vitamin B1 500 mg; vitamin B2 1500 mg; Acid Pantothenic 3,500 mg; vitamin B6 700 mg; vitamin B12 2,500 mcg; nicotinic acid 9,000 mg; folic acid 250 mg; biotin 15 mg; choline 80 mg; iron 10 mg; covers 2,500 mg; manganese 20 mg; zinc 18 mg; iodine 535.00 mg; selenium 75 mg; [b] Composition per kilogram of the Premix for growing birds: folic acid120 mg; cobalt 179 mg; copper 2,688 mg; choline 108 mg; iron 11 mg; iodine 537 mg; lysine 49 mg; manganese 31 mg; mineral matter 350 mg; methionine 321 mg; niacin 6,000 mg; Pantothenate calcium 1,920 mg; vitamin A 1,500,000 IU; vitamin B1 300 mg; vitamin B12 2,800 mcg; vitamin B2 960 mg; vitamin B6 450 mg; vitamin D3 300,000 IU; vitamin E 3,000 IU; vitamin H mg; vitamin K 400 mg; zinc 22 mg.*BE=electrolyte balance calculated according to Mongin (1981)

The results found by Carvalho et al. (2010) showed no effect on carcass yield. They tested the inclusion of 3, 6, 9, and 12% levels of cottonseed meal in the diet of broilers from 1 to 42 days of age. Pimentel et al. (2007) also evaluated the replacement of corn and soybean meal with sorghum and extruded cottonseed meal, respectively, in poultry diets. They found that the extruded cottonseed meal can replace soybean meal on up to 19.4% of the diet without influencing the carcass yield and noble cuts of broilers

This study observed that the levels of replacement of soybean meal protein by cottonseed cake protein affected variable ethereal extract with decreasing linear effect. For the other variables of the chemical composition of breast meat, there was no significant effect (Table 4).

Table 4 - Analysis of dry matter (DM), moisture (M), crude protein (CP), ether extract (EE), mineral matter (MM) and gross energy (GB) of breast meat of slow-growing broilers fed crude protein (PB) replacement levels of soybean meal (FS) by cotton cake protein (TA)[1]

Variables	Replacement of FS PB by TA PB						P			
	0%	10%	20%	30%	40%	Average	El	Eq	Dl	Cv
DM %	25.61	25.50	25.83	25.19	25.32	25.49	0.12	0.47	0.11	1.7
M %	74.38	74.49	74.16	74.80	74.67	74.50	0.12	0.47	0.11	0.5
CP %	23.68	24.03	23.68	23.86	24.07	23.86	0.47	0.80	0.50	2.6
EE %	0.58	0.59	0.55	0.48	0.45	0.53	0.01	0.52	0.60	26.3
MM %	1.57	1.60	1.59	1.41	1.48	1.53	0.21	0.75	0.49	14.8
GE cal.g^{-1}	5064	5032	5020	5034	5005	5031	0.32	0.81	0.83	1.7

[1]Analyses carried out in the animal nutrition laboratory at the School of Veterinary Medicine and Animal Science of the Federal University of Tocantins. CV= coefficient of variation; P= probability of type I error by test F; EL= linear effect; EQ= quadratic effect; DL= linearity deviation; EL= -0.0066TA+0.7009 ($p=0.01$; $R^2=0.25$)

It is observed that the content of ether extract and fiber in the diet (Table 2) increased with the level of replacement of soybean meal protein by cottonseed cake protein. At the same time, the deposition of EE in the breast muscle decreased. A possible explanation for this may be that the increase in fiber content may have adsorbed much of the vegetable oil included in the diet to promote energy balance, decreasing fat deposition in the muscle (Holanda, 2011).

The proximal composition of the breast meat of naked neck free-range chicken fed with a diet based on corn and soybean meal, slaughtered at 85 days of age, was evaluated by Faria et al. (2009). They observed humidity values (73.55%) and protein (23.25%) close to those found in this work. However, there was a significant difference in the ether extract content (0.72%), evidencing the possible influence of the high fiber content of diets containing cotton seedcake on the reduction of EE in breast meat.

The Brazilian Table of reference for Food Composition (NEPA-UNICAMP, 2011) describes similar moisture content (74.8%), for raw and skinless chicken breast. However, lower protein content (21.5%) , mineral matter (1.0%) and higher lipid content (3.0%).

The study showed that the levels of replacement of soybean meal protein by cottonseed cake protein did not affect the physical composition of breast meat of slow-growing chickens (Table 5).

According to Sterten et al. (2009), the uniformity of meat color and consistency is an essential attribute by which consumers evaluate and select animal origin products. The non-significant variations in color (L*a*b*), weight loss by cooking, shear force probably result from the non-significance in pH variations since there is a dependence between pH and these parameters.

Qiao et al., (2001) point out that pH measures of 6.23 correspond to the darkest color, pH of 5.96 to a standard color and pH 5.81 corresponds to the light color. This study found a pH mean found ranging from 5.74 to 5.81, with an average of 5.77, corresponding to the light color, with the possibility of occurrence of PSE meat. The authors also suggest that luminosity (L*) above 53 indicates that the meat is lighter than normal. They consider "normal" luminosity between 48 and 53. According to Lara et al. (2002), the PSE phenomenon in broilers can be detected by combining the values of pH (below 5.8) and color (L* value above 52.0).

Table 5 - Average values of red (a*), yellow (b*), luminosity (Lumin. L*) weight loss by cooking WLC), shear strength (SS), temperature (Temp.) and pH of the meat, and red value (a*), yellow (b*), luminosity (Lumin. L*) of the breast skin of slow-growing broilers fed with cottonseed cake (CC) in replacement for crude protein (CP) of soybean meal (SM).

Variables	Replacement of FS PB by TA PB						P			
	0%	10%	20%	30%	40%	Average	El	Eq	Dl	Cv
Meat										
Red (a*)	8.80	9.24	8.91	8.95	8.59	8.90	0.45	0.27	0.67	8.0
Yellow (b*)	12.47	10.92	13.12	11.63	12.82	12.19	0.66	0.63	0.26	20.0
Lumin. (L*)	56.49	57.60	57.54	58.57	56.83	57.40	0.52	0.13	0.54	3.4
WLC %	20.02	20.55	20.74	21.10	20.20	20.52	0.61	0.22	0.81	6.8
SS(Kgf)	1.68	1.70	1.80	1.75	1.77	1.74	0.55	0.74	0.91	16.9
Temp. (°C)	25.94	25.78	25.71	24.52	25.50	25.49	0.19	0.54	0.25	4.8
pH	5.75	5.81	5.74	5.79	5.77	5.77	0.90	0.87	0.41	1.6
Skin										
Red (a*)	9.94	7.99	8.27	8.84	8.23	8.65	0.29	0.30	0.38	21.5
Yellow (b*)	19.11	17.10	17.88	18.76	19.76	18.52	0.54	0.29	0.84	20.2
Lumin. (L*)	65.88	65.26	66.48	65.54	64.06	65.44	0.21	0.22	0.49	3.1

[1]Analyses carried out in the meat laboratory at the School of Veterinary Medicine and Animal Science of the Federal University of Tocantins. CV= coefficient of variation; P= probability of type I error by test F; EL= linear effect; EQ= quadratic effect; DL= linearity deviation.

PSE meat *(Pale, Soft, and Exsudative)* present undesirable functional properties, such as pale color and low water retention capacity. These particularities reflect on products of low yield in industrial production and low acceptance by consumers. Factors such as pre-slaughter stress, type of distress, and cooling temperature of the carcass can trigger the PSE condition in poultry (Ramos and Gomide, 2017).

According to some authors, the texture is classified as extremely soft when the Kgf value is below 3.62, slightly soft when it is between 6.62 to 9.60 and slightly hard when it is above 12.60 kgf (Castellini et al., 2002; Ramos and Gomide 2017). The values found in this study ranged from 1.68 to 1.80 kgf, classified as extremely soft.

Santos et al. (2005) found higher shear force value for the Nacked Neck, *Paradise Pedrês (*1.53) than to the cobb industrial lineage (1.06). They reached this outcome by evaluating the quality of the breast meat of the Naked Neck, *Paraíso Pedrês*, and the Cobb lineage, slaughtered at 77 days of age. The study indicated that the meat of the nacked neck free-range chicken has a more rigid texture than that of the cobb lineage.

Oliveira et al. (2015) also observed close values in their study on the effects of the pre-slaughter fasting time (12 hours). They evaluated the quality of free-range chicken breast from the "Pesadão" red lineage slaughtered at 85 days of age. The authors found pH values of 5.71 in breast meat, luminosity of 58.85, the sheer force of 1.71 kgf, and cooking losses of 23.45%.

Cottonseed cake may contain a small amount of gossypol, a yellow polyphenolic pigment produced in the pigment glands of cotton. When present in the diet of laying chicken from 30 ppm, it may cause discoloration of the egg yolk, which assumes a greenish-brown resulting from free gossypol (Lima Junior et al., 2010; Paim et al., 2010; Barbosa and Gattás, 2004). However, in this study, no significant change was observed in the skin pigmentation of broilers fed cottonseed cake.

CONCLUSION

Results based on the variables of relative weight and physicochemical composition of breast meat showed that it is possible to use 40% of cottonseed cake protein in replacement for soybean meal protein for slow-growing chicken.

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