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NONRUMINANTS NUTRITION

Relationship between the level and the action period of fiber in diets to laying hens

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ABSTRACT. The aim of the present study was to evaluate the relationship between the level of fiber and its action period in diets to laying hens on performance and egg quality. 180 Hisex white hens (65 weeks-old) were randomly allocated to 3 groups of 60 birds each, comprising 10 replicates of six birds per treatment. The experimental design was factorial scheme considering three levels of fiber (2.50, 4.87 and 7.24%) in birds' diets, and three action periods of this fiber (short - 21 days, medium - 56 days, and long - 105 days) in the feed. The estimates of treatments were firstly subjected to ANOVA and a subsequent Tukey test at 5%. Birds fed diets with moderate levels of fiber (4.87%) presented better ($p < 0.05$) performance. High levels of fiber caused a significant reduction in performance. Birds fed diets with low and moderate levels of fiber produced eggs with better ($p < 0.05$) quality. High levels of fiber caused a significant reduction in egg quality. The exposure of birds to diets with fiber for long-term caused a negative effect ($p < 0.05$) on performance, egg weight and percentage of its main structures, albumen height, yolk height, eggshell thickness, and the specific gravity.

Keywords: dietary fiber; egg weight; gut health; performance; yolk.

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Introduction

The fiber concept was firstly defined for the human medicine by Trowell et al. (1976) as the "the sum of lignin and polysaccharides that are not digested by endogenous secretions of the digestive tract of man". This definition also is commonly used for non-ruminant animal species, considering any polysaccharide reaching the hindgut and so includes resistant starch (RS), and soluble and insoluble non-starch polysaccharides (NSP) (Montagne, Pluske, & Hampson, 2003).

Recent studies pointed that the correct quantification of fiber is beneficial for birds, especially to the gut health, presenting positive effects on performance (Jiménez-Moreno, Frikha, Coca-Sinova, García, & Mateos, 2013; Jiménez-Moreno, Coca-Sinova, González-Alvarado, & Mateos, 2015). Obeying this new concept, has been recommended the inclusion of fiber in poultry diets to maintain a low energetic density and the physiological function of the digestive tract, providing control on intake and absorption of nutrients, and its deposition on the eggs (Braz et al., 2011).

Normally, the agricultural residues present fibers fixed around the seed and located in the mesocarp, near of pulp region (Mateos, Jiménez-Moreno, Serrano, & Lázaro, 2012). In this sense, açaí is the most important agricultural crop to the Amazon. However, its pulp only represents 10% of total mass of fruit (Lima et al., 2008), which represent a considerable amount of wastes annually discarded (Silva, Chaar, & Nascimento, 2014). These residues to present a low concentration of starch and a high content of fiber, especially cellulose (Jiménez-Moreno, González-Alvarado, Coca-Sinova, Lázaro, & Mateos, 2009a; Jiménez-Moreno, González-Alvarado, Lázaro, & Mateos, 2009b).

The fiber content associated with plant feedstuffs can exert considerable influence on small and large intestinal functioning by virtue of its solubility in water and physical characteristics. The structure of fiber and its relationship with water in the lumen greatly influence convective efficiency and microbial dynamics throughout the intestine (Incharoen & Maneechote, 2013; Yokhana, Parkinson, & Frankel, 2015). Many studies have been performed to change gut health and microbial populations by adding types of fibrous fractions into poultry diets (González-Alvarado, Jimenez-Moreno, González-Sanchez, Lazaro, & Mateos, 2010; He, Meng, Li, Zhang, & Ren, 2015).

The variation of fiber level in poultry diets may result in positive or negative effects. Usually, depending on the type and fiber content (soluble and insoluble), birds' age, and nutritional quality of inhaled non-starch polysaccharides, the fiber may act in different forms on birds' metabolism (González-Alvarado et al., 2010; Kalmendal, Elwinger, Holm, & Tauson, 2011). The aim of the present study was to evaluate the relationship between the level of fiber and its action period in diets to laying hens on performance and egg quality.

Material and methods

This study was conducted at the facilities of the Poultry Sector of the Faculty of Agrarian Sciences of the Federal University of Amazonas, Manaus, Amazonas State, Brazil. All experimental procedures were previously evaluated and approved by the Animal Use Ethics Committee of the Federal University of Amazonas (protocol n. 040/2018).

A total of 180 Hisex white hens (65 weeks old) were randomly allocated to 3 groups of 60 birds each, comprising 10 replicates with 6 birds each per treatment. The birds were kept in stainless-steel wire cages 45×45×100 (h×w×l) with a solid floor. Egg collection was performed two times for the day (9 a.m. and 3 p.m.). The temperature and relative humidity also were recorded two times for day (9:00 a.m. and 3:00 p.m.) using a digital term hygrometer positioned above the birds' cage, presenting mean results of 32.06±0.02°C and 62.50%, respectively.

Açaí meal was used as a source of fiber in the diets. The açaí residues (constituted by seed and peel) of *Euterpe precatoria* Mart specie were obtained at one time. The residues were selected, washed, dried in an oven at 60°C for 24 hours and grinding. The composition of açaí meal (Table 1) was determined according to the methodology proposed by Association of Official Analytical Chemists [AOAC] (2016). The three experimental diets (Table 2) were formulated to meet or exceed Rostagno et al. (2017) nutrient requirements for laying hens.

Table 1. Chemical composition of açaí meal.

Chemical composition	Values
Dry matter, %	89.12
Crude protein, %	5.25
Fats, %	4.12
Ashes, %	6.64
Crude fiber, %	25.30
Neutral detergent fiber, %	57.61
Acid detergent fiber, %	44.25
Lignin, %	8.78
Non-fibrous carbohydrates, %	58.69
Gross energy, kcal kg^{-1}	5,389.16
Metabolizable energy, kcal kg^{-1}	2,838.18*

*Determined according to the calculation method proposed by Rostagno et al. (2017).

The experimental design was factorial scheme considering three levels of fiber (2.50, 4.87 and 7.24%) in birds' diets, and three action periods of this fiber (short - 21 days, medium - 56 days, and long - 105 days) in the feed. For animal performance, were evaluated in each period the feed intake (g $bird^{-1}$ day^{-1}), egg production (%), egg weight (g), egg mass (g), feed efficiency (kg of feed per dozen of eggs produced-kg dz^{-1}) and feed conversion (kg of feed per kg of egg produced-kg kg^{-1}).

Feed intake was calculated by the ratio between the feed consumed and the number of birds in each 21 days, considering the amount of feed offered and the leftover at the end of each 21 days period. Egg production was determined by the ratio between the total of eggs produced and the total of possible eggs that would be produced (the production value corresponding to 100%), multiplied by 100 (result in percentage). In the last two days of each period, four eggs from each plot were randomly selected to evaluate the egg weight (g). Egg mass was calculated by the ratio between average egg weight and average egg production at the end of each period divided by 100.

Feed efficiency (kg kg^{-1}) was determined by the ratio of the total feed consumed and the total egg mass produced in each period. Feed efficiency (kg dz^{-1}) was determined by the ratio of the total feed consumed and the total of dozens of eggs produced in each period.

Table 2. Diets composition containing different levels of fiber.

Ingredients	Levels of fiber in the diets (%)		
	2.50	4.87	7.24
Corn (7.88%)	63.9692	50.4634	36.5184
Soybean meal (46%)	23.5066	24.8582	26.3951
Açaí meal	0.0000	10.0000	20.0000
Limestone	9.6009	9.7562	9.7351
Dicalcium phosphate	1.9829	1.7413	1.7706
Vit. min. supplement [1]	0.5000	0.5000	0.5000
Salt	0.3500	0.3500	0.3500
DL-methionine (99%)	0.0904	0.1076	0.1199
Soybean oil	0.0000	2.2233	4.6109
Total	100.000	100.000	100.000
Nutrient			
M.E., kcal kg^{-1}	2,750.500	2,750.500	2,750.500
Crude protein, %	16.000	16.000	16.000
Calcium, %	4.200	4.200	4.200
Available phosphorus, %	0.450	0.450	0.450
Crude fiber, %	2.505	4.873	7.241
Neutral detergent fiber, %	10.49	15.09	19.60
Acid detergent fiber, %	3.80	7.98	12.08
Total methionine, %	0.350	0.350	0.350
Total methionine + Cystine, %	0.600	0.591	0.576
Total lysine, %	0.803	0.812	0.823
Total threonine, %	0.625	0.607	0.590
Total tryptophan, %	0.191	0.193	0.194
Sodium, %	0.156	0.154	0.151

[1]Guaranteed levels per kilogram of the product: Vitamin A 2,000,000 IU, Vitamin D3 400,000 IU, Vitamin E 2,400 mg, Vitamin K3 400 mg, Vitamin B1 100 mg, Vitamin B2 760 mg, Vitamin B6 100 mg, Vitamin B12 2,400 mcg, Niacin 5,000 mg, Calcium Pantothenate 2,000 mg, Folic acid 50 mg, Coccidiostat 12,000 mg, Choline 50,000 mg, Copper 1,200 mg, Iron 6,000 mg, Manganese 14,000 mg, Zinc 10,000 mg, Iodine 100 mg. Selenium 40 mg. Vehicle q.s.p. 1,000 g.

In last two days of each period, four eggs from each plot were random selected to evaluate the egg weight (g), albumen (%), yolk (%), eggshell (%), albumen height (mm), yolk height (mm), yolk diameter (mm), yolk color, specific gravity (g.cm^{-3}), eggshell thickness (μm) and Haugh unit.

The eggs were stored to one hour in room temperature, and weighed using an electronic balance (0.01 g). The eggs were placed in wire baskets and immersed in buckets containing different levels of sodium chloride (NaCl) with density variations from 1.075 to 1.100 g cm^{-3} (interval of 0.005) to evaluate the specific gravity.

Then, the eggs were placed on a flat glass plate to determine albumen and yolk height, and yolk diameter using an electronic caliper. To separate albumen and yolk a manual separator was used. Each one was placed in a plastic cup and weighted in analytical balance.

Eggshells were washed, dried at oven (50ºC) to 48 hours, and weighed. Dry eggshells were used to determine the eggshell thickness using a digital micrometer. Average eggshell thickness was analyzed considering three regions: basal, meridional, and apical. The yolk color was evaluated using a ROCHE© colorimetric fan with a scale of 1 to 15. Haugh unit was calculated using the egg weight and albumen height values in the formula $H_{unit} = 100 \times \log(H + 7.57 - 1.7 \times W^{0.37})$, where H = albumen height (mm), and W = egg weight (g).

Cage was used as the individual experimental unit (six birds per cage) for performance and egg quality responses, considering each factor individually and a possible interaction between the levels of fiber and the action periods of this fiber. All data collected in this study were analyzed using the GLM procedure of Statistical Analysis System (SAS, 2008) and estimates of treatments were firstly subjected to ANOVA and a subsequent Tukey test. Results were considered significant at $p \leq 0.05$.

Results and discussion

All performance results were affected ($p < 0.05$) by fiber and its action period (Table 3). Moderate levels of fiber provide better performance results, while high levels of fiber caused a significant reduction in performance, as well as prolonged exposure of birds to diets with fiber for long-term. There was a significant effect ($p < 0.05$) in interaction of the factors in results of egg production (Table 4) and egg mass (Table 5), where high levels of fiber and a prolonged exposure of birds to diets with high levels of fiber for a long-term caused a significant reduction in egg production and egg mass.

Table 3. Feed intake (FI), egg production (EP), feed conversion (FC, kg kg^{-1} and FC, kg dz^{-1}), and egg mass (EM) of laying hens fed diets with different fiber levels to different action periods.

Factors[1]	Variables				
	FI (g $bird^{-1}$ day^{-1})	EP (%)	FC (kg kg^{-1})	FC (kg dz^{-1})	EM (g)
Fiber (%)					
2.50	103.48^{a}	79.02^{a}	2.19^{c}	1.57^{c}	46.35^{a}
4.87	101.59^{b}	76.24^{b}	2.32^{b}	1.64^{b}	44.79^{b}
7.24	100.85^{b}	70.00^{c}	2.45^{a}	1.74^{a}	41.50^{c}
Action period					
Short	115.71^{a}	79.73^{a}	2.02^{b}	1.44^{b}	47.09^{a}
Medium	104.10^{b}	72.85^{b}	2.46^{a}	1.75^{a}	42.87^{b}
Long	86.11^{c}	72.67^{b}	2.47^{a}	1.75^{a}	42.69^{b}
Effect	p-value				
Fiber (%)	0.05^{**}	0.01^{*}	0.05^{**}	0.05^{**}	0.01^{*}
Action period	0.01^{*}	0.01^{*}	0.01^{*}	0.01^{*}	0.01^{*}
Interaction	0.81^{ns}	0.01^{*}	0.27^{ns}	0.21^{ns}	0.01^{*}
CV (%)[2]	10.45	8.41	12.01	11.12	9.02

[1]Treatments with averages in the column differ or not between the Tukey test at 5%; [2] CV – Coefficient of variation; * Significant effect ($p < 0.01$); ** Significant effect ($p < 0.05$); ns - no significant.

Table 4. Interaction between level of fiber and action period in diets to laying hens on egg production (%)[1].

Factors[1]	Action period		
Fiber (%)	Short	Medium	Long
2.50	84.12^{Aa}	80.31^{Ab}	79.04^{Ac}
4.87	81.20^{Ba}	81.20^{Ab}	74.76^{Ac}
7.24	75.55^{Cb}	75.55^{Bb}	65.55^{Bb}
Effect	p-value		
Period x 2.50	0.02^{**}		
Period x 4.87	0.02^{**}		
Period x 7.24	0.03^{**}		
Fiber x Short	0.02^{**}		
Fiber x Medium	0.04^{**}		
Fiber x Long	0.05^{**}		
CV (%)	10.66		

[1]Treatments with averages in the column (effect between levels of fiber – uppercase letters) and in the line (effect between action periods of fiber – lowercase letters) differ or not between the Tukey test at 5%; [2] CV – Coefficient of variation; * Significant effect ($p < 0.01$); ** Significant effect ($p < 0.05$).

Table 5. Interaction between level of fiber and action period in diets to laying hens on egg mass (g)[1].

Factors[1]	Action period		
Fiber (%)	Short	Medium	Long
2.50	48.88^{Aa}	47.51^{Aa}	44.86^{Ab}
4.87	46.79^{Aba}	47.43^{Aa}	41.95^{ABb}
7.24	44.11^{Ba}	38.70^{Bb}	37.71^{Bb}
Effect	p-value		
Period x 2.50	0.05^{**}		
Period x 4.87	0.03^{**}		
Period x 7.24	0.04^{**}		
Fiber x Short	0.01^{*}		
Fiber x Medium	0.01^{*}		
Fiber x Long	0.01^{*}		
CV (%)	14.84		

[1]Treatments with averages in the column (effect between levels of fiber – uppercase letters) and in the line (effect between action periods of fiber – lowercase letters) differ or not between the Tukey test at 5%;[2]CV – Coefficient of variation; * Significant effect ($p < 0.01$); ** Significant effect ($p < 0.05$).

The use of high levels of fiber in the diets for laying hens caused a significant reduction on performance, being this result clearly reflected in the feed efficiency. It is important to mention that even the açaí meal presenting a good content of non-fibrous carbohydrates and other nutrients, its high levels of fiber for a feedstuff used in poultry diets, especially the fiber digestible in neutral detergent, acts how a barrier that block the absorption of other nutrients, directly affecting the performance and egg quality.

Old studies ever considered fiber as a diet diluent with negative effect on digestibility of birds, negatively affecting the performance (Mateos et al., 2012; Sadeghi, Toghyani, & Gheisari, 2015). Van Soest (1994) affirmed that increasing levels of fiber raises the gut viscosity, interfering in the passage rate and decreasing the enzymes' work and nutrient use.

However, newly studies indicated that moderate levels of fiber in diets to birds are very important components to better results on the physiology of birds and nutrients use, increasing the performance and egg quality (González-Alvarado et al., 2010; Mateos et al., 2012). Agreeing these newly concepts, the results of this study pointed that moderate levels of fiber provided by the inclusion of açaí meal in the diets balanced the feed intake, improving the performance. Moderate levels of fiber may improve the digestibility by continuous stimuli on the gizzard, stimuli on the small and long gut, and positive effect on gut microbiota (Jiménez-Moreno et al., 2009a; Jiménez-Moreno et al., 2009b; Svihus, 2011).

According to Gonzáles-Alvarado et al. (2010), the influence of the fiber on gizzard is associated with the mechanical stimulation of this organ. Generally, larger mechanical stimuli provide a better development of gizzard, and according to Jiménez-Moreno et al. (2015) and Mtei, Abdollahi, Schreurs, Girish, and Ravindran (2019) different sources of fiber cause this positive effect on development of gizzard, especially due to the retention of food in this organ and its constant work stimuli, which increase the contact surface of nutrients, the release of cholecystokinin and pancreatic enzymes secretion, provide a longer time for digestive enzymes to improve the digestibility and nutrients absorption (Mateos et al., 2012).

In the colon, soluble fiber is fermented by the good microbiota, producing short-chain fatty acids (volatile fatty acids, especially acetate, propionate, and butyrate), H_2O and some gases such as CO_2, H_2 and CH_4 (Montagne et al., 2003). Furthermore, the integrity of epithelial cells and the action of digestive enzymes on the lumen of the gut are fundamental for good use of the nutrients (Mateos et al., 2012; Guzmán, Saldaña, Kimiaeitalab, García, & Mateos, 2015; Mtei et al., 2019).

Insoluble fiber is generally innocuous during its journey through the small intestine. If feed formulation leads to an increase in fiber that decreases the plane of nutrition then enhanced motility increases luminal throughput while the villus lengthens. Increases in the levels of soluble fiber have similar effects, but repercussions may be further encountered if increased viscosity of lumen contents also occurs (Amerah, Ravindran, & Lentle, 2009).

Birds fed diets with low and moderate levels of fiber produced eggs with higher ($p < 0.05$) weight and percentage of albumen. The increase in action period of fiber caused a significant reduction ($p < 0.05$) in egg weight and percentage of its main structures (yolk, albumen and eggshell) (Table 6). There was a significant effect ($p < 0.05$) in interaction of the factors on results of %yolk (Table 7), where increase levels of fiber caused a linear reduction in %yolk in all periods evaluated.

Table 6. Egg weight (EW), %albumen (AP), %yolk (YP) and %eggshell (SP) of eggs from laying hens fed diets with different fiber levels to different periods.

Factors[1]	Variables			
	EW (g)	AP (%)	YP (%)	SP (%)
Fiber (%)				
2.50	62.62^{a}	28.55^{a}	58.91	10.00
4.87	58.77^{ab}	27.06^{ab}	57.66	9.77
7.24	59.29^{b}	24.23^{b}	59.97	9.79
Action period				
Short	59.94^{a}	26.91^{a}	59.72^{a}	10.02^{a}
Medium	59.59^{b}	25.75^{b}	59.72^{a}	9.98^{b}
Long	59.50^{c}	25.70^{c}	57.04^{b}	9.83^{b}
Effect	p-value			
Fiber (%)	0.02**	0.01*	0.25^{ns}	0.59^{ns}
Action period	0.05**	0.01*	0.04**	0.04**
Interaction	0.62^{ns}	0.12^{ns}	0.01*	0.69^{ns}
CV (%)[2]	4.08	10.63	8.07	5.88

[1]Treatments with averages in the column differ or not between the Tukey test at 5%; [2]CV – Coefficient of variation; *Significant effect ($p < 0.01$); **Significant effect ($p < 0.05$); ns - no significant.

Table 7. Interaction between level of fiber and action period in diets to laying hens on yolk (%).

Factors[1]	Action period		
Fiber (%)	Short	Medium	Long
2.50	29.15^{Aa}	28.90^{Ab}	25.41^{Ac}
4.87	26.76^{Ba}	26.14^{Ba}	25.41^{Ab}
7.24	26.76^{Ba}	26.14^{Ba}	21.89^{Bb}
Effect	p-value		
Period x 2.50	0.01^{*}		
Period x 4.87	0.02^{**}		
Period x 7.24	0.05^{**}		
Fiber x Short	0.03^{**}		
Fiber x Medium	0.04^{**}		
Fiber x Long	0.02^{**}		
CV (%)	10.77		

[1]Treatments with averages in the column (effect between levels of fiber – uppercase letters) and in the line (effect between action periods of fiber – lowercase letters) differ or not between the Tukey test at 5%; [2]CV – Coefficient of variation; *Significant effect ($p < 0.01$); **Significant effect ($p < 0.05$).

Albumen height, yolk height, yolk diameter and specific gravity presented better results ($p < 0.05$) in eggs from birds fed diets with moderate level of fiber (4.87%). High levels of fiber caused a significant reduction in egg quality. Albumen and yolk height, eggshell thickness and specific gravity presented worst results ($p < 0.05$) when birds fed diets with fiber for long-term (Table 8).

Table 8. Albumen height (AH), yolk height (YH), yolk diameter (YD), eggshell thickness (ST), specific gravity (SG), Haugh unit (HU) and yolk color (YC) of eggs from laying hens fed diets with different fiber levels to different periods.

Factors[1]	Variables						
	AH (mm)	YH (mm)	YD (mm)	ST (μm)	SG (g mL^{-3})	HU	YC
Fiber (%)							
2.50	7.45^{c}	19.60^{c}	41.38^{c}	40.40	$1,083.75^{c}$	82.73	5.15
4.87	8.82^{a}	22.11^{a}	43.08^{a}	39.66	$1,087.86^{a}$	82.58	4.80
7.24	7.81^{b}	21.50^{ab}	42.65^{b}	40.00	$1,085.41^{b}$	83.20	5.01
Action period							
Short	8.32^{a}	21.49^{a}	42.44	45.30^{a}	$1,085.13^{a}$	83.99	4.98
Medium	8.28^{a}	21.42^{a}	42.48	38.33^{b}	$1,085.11^{a}$	83.44	4.96
Long	7.16^{b}	20.25^{b}	42.48	37.66^{b}	$1,166.54^{b}$	83.44	4.96
Effect	p-value						
Fiber (%)	0.01^{*}	0.01^{*}	0.01^{*}	0.08^{ns}	0.03^{**}	0.07^{ns}	0.16^{ns}
Action period	0.01^{*}	0.01^{*}	0.98^{ns}	0.01^{*}	0.03^{**}	0.06^{ns}	0.98^{ns}
Interaction	0.21^{ns}	0.01^{*}	0.64^{ns}	0.61^{ns}	0.41^{ns}	0.21^{ns}	0.09^{ns}
CV (%)[2]	6.76	5.42	2.67	4.70	13.21	2.94	7.10

[1]Treatments with averages in the column differ or not between the Tukey test at 5%; [2]CV – Coefficient of variation; * Significant effect ($p < 0.01$); **Significant effect ($p < 0.05$); ns - no significant.

There was a significant effect ($p < 0.05$) in interaction of the factors on results of yolk height (Table 9). High levels of fiber caused a significant reduction in yolk height, as well as an exposure of the birds for a long-term to diets with high levels of fiber caused a negative effect in yolk height.

Table 9. Relationship between level of fiber and action period in diets to laying hens on yolk height (mm).

Factors[1]	Action period		
Fiber (%)	Short	Medium	Long
2.50	21.80^{a}	21.55^{a}	20.85^{Ab}
4.87	21.75^{a}	21.55^{a}	20.85^{Ab}
7.24	21.75^{a}	21.30^{a}	17.60^{Bb}
Effect	p-value		
Period x 2.50	0.05^{**}		
Period x 4.87	0.04^{**}		
Period x 7.24	0.01^{*}		
Fiber x Short	0.23^{ns}		
Fiber x Medium	0.15^{ns}		
Fiber x Long	0.05^{**}		
CV (%)	6.82		

[1]Treatments with averages in the column (effect between levels of fiber – uppercase letters) and in the line (effect between action periods of fiber – lowercase letters) differ or not between the Tukey test at 5%; [2]CV – Coefficient of variation; * Significant effect ($p < 0.01$); **Significant effect ($p < 0.05$); ns – no significant.

The use of high levels of fiber in the diets to laying hens also caused a significant reduction in egg weight and its principal structures (yolk, albumen and eggshell), affecting internal and external quality of the eggs. Birds fed diets with low and moderate levels of fiber produced eggs with better internal and external quality, regardless the action period evaluated. Some studies pointed that the fiber sources also contain components other than fiber, which in part might have affected the quality of the eggs. The structures and relative proportions of the celluloses, hemicelluloses and lignins of fibrous fractions from different sources can differ considerably and this may explain some of the differences in responses (Longe, 1984; Montagne et al., 2003), how the results of this study where moderate levels of fiber provided by the inclusion of açaí meal provide eggs with better quality.

On the other hand, the results of this study indicated a lower effect of fiber on performance and egg quality in a short-term. However, there is a great reduction in these results when birds fed diets with a high level of fiber for a medium or long-term. Mohiti-Asli et al. (2012) reported that lower rates of egg production and poor quality of the eggs in birds fed on high fiber diets have generally been attributed to low energy intakes or disorders in feed intake. These results also corroborate with newly concepts, where moderate levels of fiber are positive, but cannot be extrapolated (Mateos et al., 2012), because may directly to interfere on the use of nutrients by the birds, reducing the performance.

The fiber acts as a physical barrier, preventing that enzymes have access to vegetable cells content, reducing the digestion, and increasing the size of birds' gastrointestinal tract (Kalmendal et al., 2011; Mateos et al., 2012). However, these effects also depend on the gastrointestinal tract analysed area (Incharoen & Maneechote, 2013). A great increase of the level of fiber or action period of this fiber may raise the viscosity in the gut, decreasing the contact area of enzymes, interfering on passage rate, resulting in low use of the nutrients and worst performance (Van Soest, 1994). An increase in dietary fiber might increase production of saliva, gastric juices and pepsin (Gonzáles-Alvarado et al., 2010).

It is important to mention that the structures and relative proportions of the celluloses, hemicelluloses and lignins of fibrous fractions from different sources can differ considerably and this may explain some of the differences in responses (Longe, 1984). The size of this effect may depend on the fiber source and this may affect the length of time to which the dietary nutrients are exposed to digestive enzymes or microbial fermentation (Kalmendal et al., 2011; Svihus, 2011; Van der Hoeven-Hangoor, Rademaker, Paton, Verstegen, & Hendriks, 2014). In this sense, the action period of fiber in the gastrointestinal tract of the birds, associated with high contents of fiber, may cause a significant disorder in the organism of the birds, especially impairing the nutrients use.

Conclusion

It was concluded that the fiber level of 4.87% (moderate) presented an ideal requirement for laying hens. Birds fed diets with high levels of fiber presented a considerable reduction in performance and egg quality. At short-term, fiber do not negatively affected the performance and egg quality. High levels of fiber to medium and long-term caused a significant reduction in performance and egg quality.

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