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NONRUMINANTS NUTRITION

Glycemic response of poultries in different feeding systems

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ABSTRACT. The management of poultry feed is an important welfare promoter and the glycemic index a noninvasive evaluation. The aim was to evaluate the glycemic response of broiler breeders in restricted feeding system, and broilers receiving *ad libitum* feeding. Two experiments were carried out: I) 39-week-oldbroiler breeders, fed with three sources of fiber, in a completely randomized design in factorial scheme (3 fiber diets x 7 collection periods); and II) broilers, 42 days old, housed in different light systems, in a completely randomized design in factorial design (2 sexes x 2 lighting conditions x 13 collection periods). Blood glucose levels were measured at random collecting one blood drop from foot, with three replicates in each condition and treatment. In broiler breeder different fiber sources had no effect on glycemia, but the period affected circulating glucose levels, presenting a minimum of 184.3 mg dL^{-1} before feed and, a maximum of 242.5 mg dL^{-1} four hours after feeding. In broilers, there was a significant effect in glycemia for collection period and for sex, and interaction between lighting conditions and collection period. Further studies are needed to establish reference values to compare blood glucose levels in poultry.

Keywords: broiler breeders; broilers; glycemic; welfare.

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Introduction

Poultry welfare is influenced by the nutrition, as metabolic factors alter blood glucose levels (Blundell & Halford, 1994); therefore an important physiological response. The measurement and control of the normal responses of blood glucose levels of birds, under different conditions, allows to identify aspects of physiological and pathological state of the birds as well as its welfare conditions (Kodaira, Pereira, Soares, & Bueno, 2015). The poultry feed intake is regulated by a complex short and long-terms regulation depending on a negative or positive energy balance that involves the circulating glycemic levels in blood (Richards, 2003). The improvement of the knowledge of poultry glycemic response in different conditions will help to develop smart feeder or tools applicable in precision livestock farming.

Feed management of broiler breeders need be restricted due to the nutritional requirements and diets concentration, reducing the access time to the feeder. These rigid nutritional restrictions on broiler breeders may change the welfare conditions, however, different sources of fiber are able to bring satiety throughout the day. Also, other effects attributed to the use of fiber in the diet are the delay on gastric empty and gradual absorption of carbohydrates in the intestine (Graham, Maskell, Rawlings, Nash, & Markwell, 2002), which can modulate and regulate postprandial blood glucose levels.

Broilers are selected for weight gain and feed intake (Zuidhof, Schneider, Carney, Korver, & Robinson, 2014), so, the feed is *ad libitum*, in opposition to the breeders. In production system, lighting is one of the factors that can alter food intake and have potential capability to changes broilers responses in terms of feed intake and growth (Campos, 2000; Olanrewaju, Purswell, Collier, & Branton, 2012). There are few works on poultry studying glycemia levels, and the existing ones present different results, associated with genetics, type of feed and the production system.Glycemia levels in poultry is 150 to 300% higher than in mammals, considering the same body weight (Braun & Sweazea, 2008), and its maintenance is influenced by insulin and glucagon. Rajman et al. (2006) found glucose values in broiler breeders ranging from 243 mg dL^{-1} to 216 mg dL^{-1}.

Most glycemic studies are focused on monitoring only one individual. Using a flock, the evaluation is less invasive, allowing indicate the most relevant environmental conditions for feed intake (Mumma, Thaxton, Vizzier-Thaxton, & Dodson, 2006; Nicol, Caplen, Edgar, & Browne, 2009; Star, Decuypere, Parmentier, & Kemp, 2008). The objective of this study was to evaluate the glycemic response from flocks of broiler breeders in restricted feeding system, and of broilers fed *ad libitum*.

Material and methods

Two experiments were conducted to evaluate average flock glycemia in breeders and broilers: experiment I - broiler breeder receiving restrict feed with different sources of dietary fiberand; Experiment II - broiler chickens receiving *ad libitum* diet with two lighting program.

Experiment I

A total of 168 broiler breeders Cobb 500 with 39 weeks of age, were housed in a conventional facility with wood shaving litter, pendulum drinker and tubular feeder, lighting program of 14 hours of constant light, combining natural and artificial light. The feed was offered in a single delivery in the first period of the morning (8 hours), providing 160 g day^{-1} bird of feed. The design was completely randomized, in a factorial arrangement 3 x 7 (three diets and seven collection times) with seven replicates of eight birds per experimental unit.

The diets were formulated according to the lineage manual, where treatments consisted of the individual use of three sources of fiber in the diet: wheat bran (WB), soybean hull (SH) or citrus pulp (CP; Table 1). The broiler breeders went through a period to adapting the diets and feed system for 14 days.

Measurements were taken by collecting one drop of blood from foot of one broiler breeder per experimental unit, randomly chosen. The calibration was done using the Accu-Chek® device, determining the glucose levels in mg dL^{-1} of blood, from colorimetric reagent strips. The collection periods started at 8 a.m., just before feeding, and finished at 8 p.m., with intervals of two hours.

The data were submitted to analysis of variance and Tukey test with a significance of 5% and later elaborated the regression of glycemia according to collection periods using the statistical program R (R, 2016).

Experiment II

Broilers were housed in conventional facility with rice husk litter, equipped with pendulum drinker and tubular feeder, and fed with a commercial formulation *ad libitum*. A number of 90 broilers with 42 days of age was used, distributed in a completely randomized design, in factorial arrangement (two lighting systems, two sexes and 13 blood collection periods).

The simulated lighting systems were from conventional facility (CF) with lighting program of eight hours of dark and light intensity greater than 20 lux in the combination of natural and supplied. The other, simulated a Dark House (DH) where the maximum illumination was 4 lux. The adaption period to the systems was seven days for both facility systems.

Table 1. Energy and calculated nutrients levels of broiler breeder's diets.

		Formulation		
Nutrient	Unit	WB[2]	SH[2]	CP[2]
Corn	%	47.89	60.72	50.29
Soybean meal	%	21.21	23.46	24.94
WB	%	16.28	0.00	0.00
SH	%	0.00	3.69	0.00
CP	%	0.00	0.00	10.30
Others[3]	%	14.61	12.13	14.46
		Calculated Levels[1]		
ME	Kcal kg^{-1}	2860	2860	2860
CP	%	15.98	15.98	15.98
CF	%	3.5	3.5	3.5
Calcium	%	2.99	2.99	2.99
Avail. P	%	0.44	0.44	0.44
Lys	%	0.737	0.738	0.713
M+C	%	0.64	0.64	0.64

1 – ME, metabolizable energy; CP, crude protein; CF, crude fibre; Avail. P, poultry available phosphorus; Lis, poultry digestible lysine; M+C, digestible methionine plus cystine.2 – Main source of fiber in diets: WB= wheat bran; SH= soybean hull; e CP= citrus pulp. 3 - Calcitic limestone, dicalcium phosphate, salt and premix mineral and vitamin adjusted to provide isonutritional levels of lysine, methionine, calcium, phosphorus, sodium and other minerals and vitamins.

Blood samples were collected from three broilers of each sex per lighting system, every two hours, starting at 8 a.m. to 8 p.m. Measurements of glycemia levels were identical to Experiment I.

The glucose averages collected were submitted to analysis of variance and 5% of significance by F test by the statistical program R (R, 2016).

Results and discussion

Experiment I

The different sources of fiber used in conventional levels (3.5%) in broiler breeder's diets did not affect the glycemic levels ($p > 0.05$; Table 2). The concentration of fiber is a determinant factor on glycemic responses (Englyst, Englyst, Hudson, Cole, & Cummings, 1999), as it causes a delay in the passage of food through the gastrointestinal tract and gradually releases glucose into the circulation (Silva Júnior et al., 2004).

The glycemia of broiler breeders was on average 184.33 mg dL^{-1} of circulating blood glucose, minimum average value before the first meal of the day. Similar values were observed over 24 hours of fasting, 185 mg dL^{-1}(Belo, Romsos, & Leveille, 1976).

From the feed supply on, the glucose increased until 12 a.m., with 242.52 mg dL^{-1} of blood glucose, the maximum daily average, and then reduced to 209.38 mg dL^{-1} at 6 pm, when it resumed to increase (Figure 1). The presence of feed in feeder, observed during blood collection, possibly stimulated new intake with leftovers at 6 p.m.

Dietary fiber is important in poultry nutrition and a minimum level of dietary fiber has to be included to maintain normal physiological function in the digestive tract (Wenk, 2001). For broiler breeders, dietary fiber, also stimulate gut health, increase the satiety, delays gastric emptying, delays glucose absorption, slows absorption, and affect behavior and improve animal well-being (Dinsa, 2017; Knudsen, Hedemann, & Lærke, 2012).

Experiment II

The lighting conditions did not influence the blood glucose values (Table 3). Broilers are more resistant to fasting hypoglycemia, since blood glucose concentrations are maintained even during long periods of food restriction (Belo et al., 1976; Rajman et al., 2006). In stress conditions, blood glucose levels increase significantly, but there is a lack of reference values for comparison (Yalçinkaya et al., 2012).

Table 2. Glycemia in mg dL^{-1} of blood glucose from broiler breeders.

	Treatments				
Collections	WB[1]	SH[1]	CP[1]	Mean	SEM[2]
8 a.m.	187.5	180.1	185.2	184.3[3]±3.8	0.8
10 a.m.	232.1	245.1	236.0	237.7[3]±6.6	1.3
12 a.m.	244.8	246.0	236.7	242.5[3]±5.0	1.0
2 p.m.	236.1	224.1	225.8	228.7[3]±6.4	1.3
4 p.m.	212.8	214.8	219.1	215.6[3]±3.2	0.6
6 p.m.	203.4	212.5	212.1	209.3[3]±5.1	1.0
8 p.m.	214.5	212.0	205.4	210.6[3]±4.7	0.9
Mean	218.7[3]±20.0	219.2[3]±22.5	217.2[3]±18.2	218.4[3]±19.8	
SEM[2]	2.7	3.0	2.4	2.6	

1 - WB= wheat bran; SH= soybean hull; e CP= citrus pulp; 2-SEM=Standard Error of the Mean;3- Mean of the treatments with no difference by Tukey test ($p > 0.05$).

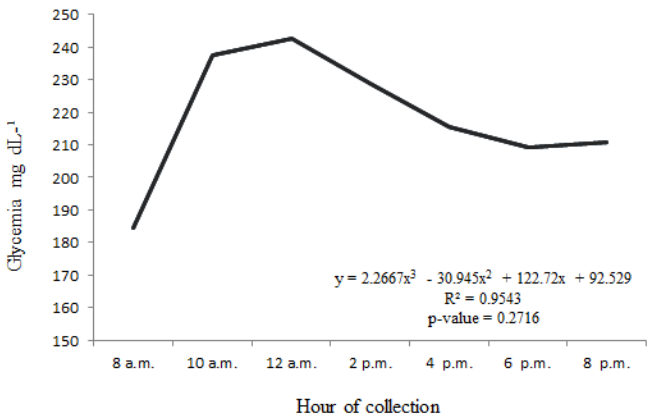

Figure1. Broiler breeders glycemia levels during a day with restricted feeding system.

Table 3. Glycemia in mg dL^{-1} of broilers in different lighting conditions.

	Lighting conditions					
	CF*			DH*		
CP*	Male**	Female**	Mean	Male**	Female**	Mean
6 a.m.	216.7	199.7	208.2±12.0	227.3	234.0	230.6±4.7
8 a.m.	218.3	201.0	209.6±12.2	220.0	211.3	215.6±6.1
10 a.m.	240.7	247.0	243.8±4.4	239.3	232.7	236.0±4.6
12 a.m.	242.7	238.7	240.7±2.8	252.7	244.3	248.5±5.9
2 p.m.	233.3	233.0	233.1±0.2	210.3	222.0	216.1±8.2
4 p.m.	257.3	246.7	252.0±7.4	222.7	220.3	221.5±1.6
6 p.m.	240.7	220.3	230.5±14.4	234.0	227.3	230.6±4.7
8 p.m.	254.3	219.7	237.0±24.4	226.7	240.0	233.5±9.4
10 p.m.	226.3	188.3	207.3±26.8	257.7	233.3	245.5±17.2
12 p.m.	223.0	229.0	226.0±4.2	228.7	194.0	211.3±24.5
2 a.m.	228.7	202.0	215.3±18.8	227.7	224.0	225.8±2.6
4 a.m.	232.7	219.0	225.8±9.6	242.0	223.0	232.5±13.4
6 a.m.	217.3	208.7	213.0±6.0	261.0	239.7	250.3±15.0
Mean	233.2±13.3	219.4±18.8		234.6±15.2	226.6±13.4	
SEM	2.1	3.0		2.4	2.1	

CP- Collection periods; CF-Conventional facility; DH-dark house; SEM=Standard Error of the Mean; *Significant interaction with p-value < 0.05; **Significant interaction with P-value <0.001.

Broilers in different lighting conditions showed different interactions between the analyzed variables ($p < 0.05$). Regarding sex ($p < 0.001$), male broilers had higher levels of circulating glucose when compared to females. These differences happen due to males having a higher growth rate, weight gain and feed intake (Marcato et al., 2010; Martins, Taveira, Hitz, Castilhano, & Santos, 2012; Santos et al., 2005).

The interaction of the collection periods and lighting conditions ($p < 0.05$) is justified by the difference in the synchrony of physical activity of ingestion due to the light and dark exposition. In the two lighting conditions, different values of glycemia were observed throughout the day, obtaining alternate values of glycemia. When blood glucose levels decline, there is a stimulus in the nerve center that controls hunger, instigating food intake (Schwartz, Woods, Porte Junior, Seeley, & Baskin, 2000). These peaks may be related to ingestion timing of the flock, a collective behavior that requires further study. This study presented an initial approach on evaluating glycemia of poultry flocks, which may help to establish better feeding and lighting management methods, and can help to stablish the development of optimal feeders. The condition in which glycemia is different between male and female broilers need to be better studied, to understand if hierarchies between sexes influence the feeder access.

Conclusion

Broiler breeders glycemia was not influenced by different sources of fiber, presenting a peak of 242.52 mg dL^{-1} of blood glucose four hours after feeding. Due to that, the effect of collection period was not significant. In broilers, glucose levels in this experiment were influenced by the interaction between collection period, sex, and lighting conditions.

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