



Poultry viscera and bone meal in broiler pre-starter and starter diets

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ABSTRACT - The use of viscera and bone meal in poultry pre-starter and starter diets and its effects on performance, digestive organ development and digestibility and nutrient retention were evaluated. In the first assay, 280-day-old Avian Cobb[®] chicks were allotted in four experimental groups with five replicates of 14 birds each, in the pre-starter phase; in the second assay, 280 eight-day-old Avian Cobb 48[®] chicks were allotted in four experimental groups with five replicates of 12 birds each. The experimental diet consisted of increasing levels of viscera and bone meal: 0% (control diet), 3%, 6% and 9% in pre-starter (Assay 1) and starter (Assay 2) diets, to meet nutritional requirements and feed composition proposed by the Brazilian Tables, all of them isonutritive and isoenergetic. A metabolic assay was developed and the total excreta collection was performed from the 4th to the 7th days in Assay 1 and from the 14th to the 17th days in Assay 2. On these days, one chick per experimental unit, representing the mean body weight of the parcel, was euthanized to perform digestive organ morphometry. Mean body weight was 45.4±0.4 on the 1st day in Assay 1 and 179.5±0.8 at 8 days of age in Assay 2. In Assay 1, a negative linear effect was observed for weight gain. Levels of viscera and bone meal influenced quadratically nitrogen digestibility index ($Y = 66.0101 + 0.482425X - 0.0481086X^2$) and linearly the digestibility of dry matter ($Y = 71.7775 - 0.615792X$) and ether extract ($Y = 78.3678 - 0.309136X$). Morphometric measures of digestive organs were not influenced by viscera and bone meal levels. For Assay 2, negative and linear effect was observed for viscera and bone meal levels on weight gain ($Y = 551.667 - 5.08341X$) and feed intake ($Y = 955.961 - 7.48435X$). Quadratic effect was observed for ether extract digestibility ($Y = 82.557 + 1.12021X - 0.150117X^2$) and maximum point was obtained at 3.7% viscera and bone meal inclusion for ether extract retention. Mortality was not affected by treatments in either of the assays. Viscera and bone meal can be used at 3 or 4% inclusion in broiler pre-starter and starter diets.

Key Words: animal origin by-products, diets, digestibility, digestive development, performance

Introduction

Animal-origin byproducts present nutritional and microbiological variations, which result in lack of uniformity of the ingredient and impair broiler performance (Faria Filho et al., 2000). Each animal-origin ingredient must be specifically characterized (Rostagno et al., 2005).

The variation in amino acid content is about 25% for animal-origin byproducts, while in vegetable byproducts it ranges from 10 to 15% (Brugalli, 2002). Including animal-origin byproducts in poultry diets can cause an amino acid imbalance, mainly in the non-essential ones (MacLeod, 2001) if their levels are not analyzed. However, these ingredients can result in low feed cost, especially when the ideal protein concept based on digestible amino acids is used (Vieites et al., 2000; Bellaver et al., 2005; Longo et al., 2005).

Animal protein sources significantly reduce nutrient digestibility in chicks from four to seven days of age, especially lipids, because of its effect on pancreas function (Xavier et al., 2004; Xavier et al., 2011). Diets containing broiler viscera meal based on ideal or crude protein concept resulted in better performance for broilers of 43 to 49 days of age (Cancherini et al., 2004). Apparent metabolizable energy values determined for young broilers can be 100 kcal higher than the ones observed for 40-day-old broilers and cockerels (Mello et al., 2009).

Animal feed industries, in many cases, obtain the nutritional composition of feedstuffs, but this is done only after feed production and animal consumption. Because of that, a systematic control of the quality of ingredients is recommended, in order to make it possible to obtain preliminary results and decide about their inclusion or not in animal diets (Brugalli, 2002).

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The objective of this experiment was to evaluate broiler performance with pre-starter and starter diets formulated with different levels of viscera and bone meal inclusion and the effects on nutrient digestibility and digestive organ measures.

Material and Methods

Two assays were carried out in order to evaluate performance and nutrient digestibility of broilers in two periods. A total of 280 chicks in the pre-starter phase (1 to 7 days of age) and 240 chicks in starter phase (8 to 21 days of age), both from Avian Cobb 48[®] genetic strain, was used. Chicks were standardized according to the starter weight and divided into four groups with five replicates with 14 and 12 chicks each, half of each sex, in the pre-starter and starter phases of the experiment, respectively.

In both assays, broilers received the experimental diets, corresponding to the different inclusion levels of viscera and bone meal. The viscera and bone meal used contained 93.9% dry matter, 10.2% nitrogen and 11.3% ether extract, and was obtained by frying in high temperature (110 to 120°C) in conventional fixed volume digesters; after, the fat was extracted by compression.

Four brood batteries of galvanized steel, with five floors and 0.80 × 0.75 × 0.25 m (length × width × height) pens in a masonry shed were used. The batteries warming was performed by 60 W incandescent lamps exposing broilers to 12 hours of natural light and 12 hours of artificial light per day. The batteries were equipped with linear feeders and drinkers, cleaned and supplied twice a day. Warming was controlled daily and associated to the curtains handling to maintain the temperature in the hall adequate to broilers.

Experimental diets were formulated taking into account the levels of viscera and bone meal inclusion, as follows: 0% (Control diet), 3%, 6% and 9% in pre-starter (Table 1) and starter (Table 2) diets. Diets were formulated to meet the nutritional recommendations and feedstuffs composition proposed by Rostagno et al. (2005); all of them were isonutritive and isoenergetic.

Live weight and feed intake were determined weekly; the number and weight of dead birds were registered and used to calculate the mortality index and corrected feed intake and feed conversion. The following variables were analyzed: weight gain, feed intake, feed conversion and mortality rate (transformed into arcsine (%/100)^{0.5} to statistical analysis).

From the 4th to the 7th day (pre-starter phase experiment) and from the 14th to the 17th days of age (starter phase

experiment), a digestibility assay was conducted. Total excreta collection method was used, and excreta were collected twice a day. At the end, the excreta collected were prepared in a pool of the daily samples, homogenized and maintained in freezer for analysis. Bromatological analyses of diets and excreta were performed in the Laboratório de Nutrição Animal of the Escola de Medicina Veterinária e Zootecnia of the Universidade Federal de Goiás (EVZ/UFG). Dry matter (DM), crude protein (CP) and ether extract (EE) were determined according to the methodology proposed by Silva & Queiroz (2002). Results were used to determine the digestibility coefficient (DC%) of diets, following the formula proposed by Matterson et al. (1965): $DC (\%) = ((\text{Nutrient in diets} \% - \text{Nutrient in excreta} \%) / \text{Nutrient of diet} \%) \times 100$

Table 1 - Calculated composition of the experimental diets (pre-starter phase assay)

Ingredients	Control diet	Viscera and bone meal content		
		3%	6%	9%
Corn grain	55.82	56.96	58.10	59.23
Soybean meal	36.78	32.06	27.34	22.62
Wheat meal	1.00	2.54	4.08	5.62
Dicalcium phosphate	1.85	1.45	1.05	0.65
Limestone	1.02	0.97	0.93	0.88
Soybean oil	2.25	1.66	1.08	0.50
Viscera and bone meal	0.00	3.00	6.00	9.00
Common salt	0.47	0.35	0.23	0.10
Mineral and vitamin supplement*	0.40	0.40	0.40	0.40
Sodium bicarbonate	0.00	0.13	0.27	0.40
DL-methionine	0.24	0.24	0.24	0.24
L-lysine HCl	0.17	0.21	0.25	0.30
L-threonine	0.00	0.01	0.02	0.03
L-tryptophan	0.00	0.01	0.02	0.03
Calculated nutritional composition				
Crude protein, %	22.00	22.00	22.00	22.00
AMEn, kcal/kg	2950	2950	2950	2950
Calcium, %	0.99	0.99	0.99	0.99
Available phosphorus, %	0.46	0.46	0.46	0.46
Potassium, %	0.85	0.80	0.74	0.69
Sodium, %	0.23	0.23	0.23	0.23
Digestible lysine, %	1.18	1.18	1.18	1.18
Digestible met+cys, %	0.83	0.83	0.83	0.83
Threonine, %	0.74	0.74	0.74	0.74
Digestible tryptophan, %	0.25	0.25	0.25	0.25
Chlorine, %	0.36	0.31	0.26	0.21
Mongin, mEq/kg	216	216	216	216

* Micromineral and vitamin supplement for broiler starter phase, minimum levels per kilogram of product: vitamin A - 3,125,000 IU; vitamin D3 - 550,000 IU; vitamin E - 3,750 mg; vitamin K3 - 625 mg; vitamin B1 - 250 mg; vitamin B2 - 1,125 mg; vitamin B6 - 250 mg; vitamin B12 - 3,750 mcg; niacin - 9,500 mg; calcium pathotenate - 3,750 mg; folic acid - 125 mg; DL-methionine - 350,000 mg; 50% choline chloride - 150,000 mg; growth promoter - 12,500 mg; anticoccidial agent - 15,000 mg; selenium - 50 mg; antioxidant - 2,500 mg; vehicle q.s. - 1,000 g. AMEn - apparent metabolizable energy corrected by nitrogen; met+cys - methionine + cystine.

Table 2 - Calculated composition of the experimental diets (starter phase assay)

Ingredients	1 st to 7 th day of age	Control diet	Viscera and bone meal content		
			3%	6%	9%
Corn grain	55.82	58.29	60.56	62.85	64.94
Soybean meal	36.78	33.66	29.00	24.39	20.01
Wheat bran	1.00	1.50	2.05	2.60	3.12
Dicalcium phosphate	1.85	1.76	1.38	0.98	0.58
Limestone	1.02	0.98	0.93	0.87	0.81
Soybean oil	2.25	2.57	1.76	0.92	0.10
Viscera and bone meal	0.00	0.00	3.00	6.00	9.00
Salt	0.47	0.44	0.33	0.22	0.11
Mineral and vitamin supplement ¹	0.40	0.40	0.40	0.40	0.40
Sodium bicarbonate	0.00	0.00	0.12	0.24	0.35
DL-methionine	0.24	0.22	0.22	0.22	0.22
L-lysine HCl	0.17	0.18	0.22	0.26	0.30
L-threonine	0.00	0.00	0.01	0.02	0.02
L-tryptophan	0.00	0.00	0.01	0.02	0.03
Calculated nutritional composition					
Crude protein, %	22.00	20.88	20.88	20.88	20.88
AMEn, kcal/kg	2950	3000	3000	3000	3000
Calcium, %	0.99	0.94	0.94	0.94	0.94
Available phosphorus, %	0.46	0.44	0.44	0.44	0.44
Potassium, %	0.85	0.81	0.77	0.73	0.69
Sodium, %	0.23	0.22	0.22	0.22	0.22
Digestible lysine, %	1.18	1.12	1.12	1.12	1.12
Digestible met+cys, %	0.83	0.79	0.79	0.79	0.79
Digestible threonine, %	0.74	0.69	0.69	0.69	0.69
Digestible tryptophan, %	0.25	0.23	0.23	0.23	0.23
Chlorine, %	0.36	0.35	0.31	0.28	0.24
Mongin, mEq/kg	216	203	203	203	203

¹ Micromineral and vitamin supplement for broiler starter phase, minimum levels per kilogram of product: vitamin A - 3,125,000 IU; vitamin D3 - 550,000 IU; vitamin E - 3,750 mg; vitamin K3 - 625 mg; vitamin B1 - 250 mg; vitamin B2 - 1,125 mg; vitamin B6 - 250 mg; vitamin B12 - 3,750 mcg; niacin - 9,500 mg; calcium pathotenat - 3,750 mg; folic acid - 125 mg; DL-methionine - 350,000 mg; 50% choline chloride - 150,000 mg; growth promoter - 12,500 mg; anticoccidial agent - 15,000 mg; selenium - 50 mg; antioxidant - 2,500 mg; vehicle q.s. - 1,000 g.

AMEn - apparent metabolizable energy corrected by nitrogen; met+cys - methionine + cystine.

Nutrient retention was calculated as a ratio between the nutrient balance and the weight gain registered from the fourth to the seventh day of age (pre-starter phase) and from the 17th to the 21st day of age (starter phase), according to Noy & Sklan (2002).

From the fourth to the seventh days of age (pre-starter phase assay) and from the 14th to the 17th days of age (starter phase assay), one chick per replicate was selected, weighed, transported to the Laboratório de Doenças das Aves of the Departamento de Medicina Veterinária and euthanized by cervical dislocation to determine the biometrical indexes related to the bird weight, as follows: esophagus + crop; proventriculus + gizzard; small intestine; pancreas, liver + gall bladder; and small and large intestines length. The values, except for intestines length, were expressed in percentage of live weight.

The statistical analysis was performed by ANOVA in a completely randomized design, with four treatments and five replicates each, using the software SAEG (Sistema para Análises Estatísticas, version 7.1), by employing the polynomial regression until third degree.

Results and Discussion

The mean values of temperature (minimum 25.1 and maximum 30.8 °C) and air humidity (minimum 41.3 and maximum 56.8%) observed during the experiments were considered normal for the geographic region in which the experiments were carried out and did not interfere with the experimental results. The average bird weight in pre-starter assay was 45.4±0.4 (average weight on the 1st day of age) and of 179.5±0.8 g (average weight on the 8th day of age) in the starter phase assay.

In the pre-starter assay, viscera and bone meal did not affect ($P>0.05$) broiler performance (Table 3). In the total period (1 to 21 days of age), negative linear effect ($P<0.05$) was observed for weight gain ($Y = 691.606 - 4.23968X$). This data indicated that the use of high levels of viscera and bone meal determined a significant reduction in the performance variables at older ages.

Unlike the results observed in this experiment, Bellaver et al. (2001) observed that diets with 5% of viscera and bone meal in substitution of soybean meal resulted in better

broiler performance in the growing phase, but diets with 3% of viscera and bone meal did not affect performance until 21 days of age (Bellaver et al., 2005). Laboissiere (2008) verified that the best performance in the pre-starter phase was achieved with 9.0% of viscera and bone meal obtained from different processing systems (varying cooking temperature and moisture). The inclusion of this ingredient resulted in 7% (Bellaver et al., 2001) to 14% (Giroto et al., 2002) cost reductions compared with soybean meal.

By evaluating the digestibility data from the pre-starter assay (Table 4), one can observe that the levels of viscera and bone meal linearly increased ($P < 0.05$) the digestibility coefficient of dry matter ($Y = 71.816 + 0.487182X$) and ether extract ($Y = 78.3325 - 0.8120488X$). Quadratic effect ($P < 0.05$) was observed for nitrogen digestibility coefficient ($Y = 66.0108 + 0.48242X - 0.048108X^2$), and the maximum point of the quadratic curve was obtained with 5% viscera and bone meal inclusion in the diet. For nutrient retention data obtained from the pre-starter phase assay (Table 4), it is possible to observe that the viscera and bone meal levels reduced retention coefficients of nitrogen ($Y = 32.784 - 0.079964X$) and ether extract ($Y = 49.0154 - 1.2668X$) linearly

($P < 0.05$). This significant reduction in nitrogen and fat retention due to the levels of viscera and bone meal may corroborate the reduction observed in performance variables.

The inclusion of viscera and bone meal in pre-starter diets ($P > 0.05$) had no effect on morphometric measures (Table 5). Bellaver et al. (2005) and Laboissiere (2008) did not find difference in broiler organs with viscera and bone meal in diets either.

In the starter phase assay, performance was affected (Table 6) by viscera and bone meal inclusion and a negative linear effect was observed for weight gain ($Y = 551.667 - 5.08341X$) and feed intake ($Y = 955.961 - 7.48435X$). Therefore, high levels of viscera and bone meal in the broiler starter phase may reduce performance. However, it is important to emphasize that the use of viscera and bone meal depends on their nutritional and sanitary quality and processing system (Nascimento et al., 2002; Penz Júnior et al., 2005; Laboissière, 2008). Nevertheless, Laboissière (2008) verified that pre-starter diets with 9.0% of viscera and bone meal increased broiler performance, but she emphasized that adequate processing reflects the nutritional and sanitary quality of this ingredient.

Table 3 - Performance of broilers fed increasing levels of viscera and bone meal in pre-starter diets

		1 to 7 days of age			8 to 21 days of age			1 to 21 days of age		
		WG, g	FI, g	FC	WG, g	FI, g	FC	WG, g	FI, g	FC
Viscera and bone meal levels	0%	130.6	153.6	1.176	568.4	891.9	1.569	686.4	1021.5	1.488
	3%	133.3	152.8	1.147	562.2	880.4	1.566	683.4	1009.5	1.477
	6%	131.3	153.6	1.171	573.1	901.2	1.572	689.7	1026.5	1.488
	9%	133.2	152.7	1.146	535.1	852.6	1.594	656.1	980.0	1.494
CV, %	3,01	2.87	2.18	4.27	4.97	1.70	3.76	4.42	1.67	
R ²	-	-	-	-	-	-	0.60	-	-	
Effect	ns	ns	ns	ns	ns	ns	L	ns	ns	
Probability	>0.5	>0.5	0.16	0.09	0.36	0.37	0.02	0.38	>0.5	

WG - weight gain; FI - feed intake; FC - feed conversion; ns - non-significant effect ($P > 0.05$); CV - coefficient of variation; L - linear effect for viscera and bone meal inclusion levels.

Table 4 - Data of metabolic assay obtained from 4 to 7 days of age with chicks fed increasing levels of viscera and bone meal in pre-starter diets

		Digestibility coefficient (%)			Retention coefficient (mg/g)		
		EE	N	EE	DM	N	EE
Viscera and bone meal levels	0%	71.6	65.4	81.2	914.4	32.0	49.5
	3%	73.7	68.8	79.9	921.7	34.2	47.5
	6%	73.8	65.4	79.8	926.8	31.2	45.5
	9%	74.6	64.0	78.1	923.2	32.3	48.7
CV, %	0,8	2.7	1.5	2.9	2.8	3.2	
R ²	0,84	0.71	0.93	-	0.82	0.75	
Effect	L	Q	L	ns	L	L	
Probability	0.001	0.029	0.001	>0.500	0.001	0.001	

EE - ether extract; N - nitrogen; DM - dry matter; ns - non-significant effect ($P > 0.05$); L - linear or Q - quadratic effect for viscera and bone meal inclusion levels; CV - coefficient of variation.

Haqui et al. (1991) verified that 9.3% of viscera meal in diets, extruded or not, did not affect broiler performance. Escalona & Pesti (1987) included 0, 5 and 10% of poultry byproducts in broiler diets and observed that 10% inclusion affected performance with reduced weight gain and worsened feed conversion.

The digestibility assay carried out during the starter phase experiment (Table 7), showed that viscera and bone meal inclusion in diets affected ($P < 0.05$) ether extract digestibility coefficient ($Y = 82.557 + 1.12021X - 0.150117X^2$) and ether extract retention coefficient ($Y = 63.6312 + 4.64598X - 0.665865X^2$). The maximum points obtained with these quadratic equations were 3.7% and 3.5% of viscera and bone meal inclusion in diets, respectively, for ether extract digestibility and retention coefficients. Wang & Parsons (1998) verified that temperature and time of processing also reduced amino acid digestibility, which could affect protein digestion and metabolism in broilers, although it did not occur in this experiment.

Morphometric measures of digestive organs were not affected by the levels of viscera and bone meal included in broiler starter diets (Table 8). Contrarily to the results observed in this experiment, Longo et al. (2003) obtained differences in liver weight, small intestine length and weight using protein sources in pre-starter diets (soybean isolated protein, powdered egg, blood plasma, corn gluten 60% and dried yeast). Brito et al. (2004) compared different animal byproduct-based diets with vegetable-based diets and did not observe any difference in digestive organ relative weights.

Analyzing all the results obtained in these two experiments, it can be observed that high levels of viscera and bone meal gradually reduced performance in broilers. Diets based on the ideal protein concept, as proposed by Baker & Han (1994), are more efficient when alternative ingredients to corn and soybean meal are included, and animal byproducts are considered good alternatives. However, it is important to stress that processing methods must guarantee nutritional and sanitary quality (Wang & Parsons, 1998; Laboissière, 2008).

Table 5 - Digestive organ dimensions of broilers fed increasing levels of viscera and bone meal in pre-starter diets

	Viscera and bone meal levels				CV, %	R ²	Effect	Probability
	0%	3%	6%	9%				
4 days of age								
Intestine length (cm)	83.30	82.60	84.50	80.00	6.6	-	ns	>0.5
Relative weight of esophagus and crop (%)	1.58	1.53	1.54	1.58	15.5	-	ns	>0.5
Relative weight of proventriculus and gizzard (%)	9.14	9.20	9.24	9.08	9.1	-	ns	>0.5
Relative weight of liver (%)	4.38	5.09	4.59	4.89	9.1	-	ns	0.085
Relative weight of pancreas (%)	0.455	0.453	0.479	0.497	17.5	-	ns	>0.5
Relative weight of small intestine (%)	7.47	7.15	7.16	6.82	15.4	-	ns	>0.5
7 days of age								
Intestine length (cm)	89.56	97.84	90.36	86.96	6.8	-	ns	0.071
Relative weight of esophagus and crop (%)	1.10	1.09	1.02	1.00	9.6	-	ns	0.319
Relative weight of proventriculus and gizzard (%)	7.19	7.26	7.17	6.75	9.7	-	ns	>0.5
Relative weight of liver (%)	3.86	4.10	3.95	4.12	10.6	-	ns	>0.5
Relative weight of pancreas (%)	0.458	0.408	0.449	0.438	11.9	-	ns	>0.5
Relative weight of small intestine (%)	6.61	5.82	5.74	5.91	11.7	-	ns	>0.5

ns - non-significant effect ($P > 0.05$); CV - coefficient of variation.

Table 6 - Performance of broilers fed increasing levels of viscera and bone meal in starter diets

		Weight gain, g	Feed intake, g	Feed conversion, g
Viscera and bone meal levels	0%	546.1	954.5	1.748
	3%	541.1	929.5	1.718
	6%	548.9	953.4	1.736
	9%	509.6	896.6	1.762
Coefficient of variation, %	4.68	4.42	2.70	
R ²	0.63	0.61	-	
Effect	L	L	ns	
Probability	0.05	0.03	>0.5	

ns - non-significant effect ($P > 0.05$); L - linear effect for viscera and bone meal inclusion levels.

Some aspects may help to explain such reductions. According to Bellaver et al. (2001), the inclusion of 5% viscera meal in broiler diets increased performance when diets were formulated based on the ideal protein concept. The authors suggested that the amount of digestible isoleucine in diets became insufficient when viscera meal in the diet was over 5%. El-Sheikh et al. (1996) indicated that the supplementation of methionine and lysine to broiler diets containing viscera meal increased nitrogen use and performance.

Alleman et al. (2000) offered a plausible explanation for the reduced performance. These authors affirmed that animal protein sources have a complex tertiary structure compared with the vegetable ones. Therefore, the limited enzymatic secretion and the complexity of the protein structure can explain the reduction in nitrogen and fat retention when higher levels of viscera and bone meal were used, hence the reduced performance and digestibility indexes.

The inclusion of animal byproducts in diets resulted in higher dry matter digestibility which, possibly, can be justified by the increased inclusion of corn. The digestibility of carbohydrates is relatively simpler than protein. Likewise, the inclusion of animal byproducts reduced digestion and absorption of fats, which can be justified by the lower inclusion of soybean oil in diets. Besides, on the first post-hatch days, chicks are not completely mature to digest and absorb nutrients, especially fat (Chambers & Gray, 1979; Moran Jr., 1994; Krogdahl & Sell, 1989).

Despite these problems, the use of such animal byproducts can be viable in moderate levels considering their nutritional and sanitary quality. According to Penz Júnior et al. (2005), the most visible loss when animal byproducts and fats are not included in broiler diets is the increase of production costs. In a practical view, animal-origin ingredients and fats can be replaced by vegetable oils, soybean meal and dicalcium phosphate; however, for

Table 7 - Data of metabolic assay obtained from 17 to 21-day-old chicks fed increasing levels of viscera and bone meal in starter diets

		Digestibility coefficient (%)			Retention coefficient (mg/g)		
		DM	N	EE	DM	N	EE
Viscera and bone meal levels	0%	74.2	64.6	82.5	1267.6	42.4	63.8
	3%	76.0	67.6	84.9	1342.5	46.8	71.0
	6%	76.3	65.8	83.6	1414.3	45.1	68.1
	9%	74.3	62.4	80.6	1261.1	39.8	51.3
CV, %	3.9	7.0	3.9	11.8	13.5	10.8	
R ²	-	-	0.98	-	-	0.99	
Effect	ns	ns	Q	ns	ns	Q	
Probability	>0.5	0.36	0.03	0.39	0.29	0.001	

EE - ether extract; N - Nitrogen; DM - dry matter; ns - non-significant effect (P>0.05); L - linear or Q - quadratic effect for viscera and bone meal inclusion levels; CV - coefficient of variation.

Table 8 - Digestive organ dimensions of broilers fed increasing levels of viscera and bone meal in starter diets

	Viscera and bone meal levels				CV, %	R ²	Effect	Probability
	0%	3%	6%	9%				
14 days of age								
Intestine length (cm)	118.2	113.4	112.8	108.6	8.19	-	ns	>0.500
Relative weight of esophagus and crop (%)	0.88	0.92	0.78	0.77	15.23	-	ns	0.33
Relative weight of proventriculus and gizzard (%)	5.01	5.15	5.09	4.79	9.43	-	ns	>0.500
Relative weight of liver (%)	3.29	3.18	2.80	2.81	13.43	-	ns	0.17
Relative weight of pancreas (%)	0.331	0.341	0.318	0.333	14.08	-	ns	>0.500
Relative weight of small intestine (%)	4.69	4.09	4.25	4.22	8.55	-	ns	0.09
17 days of age								
Intestine length (cm)	113.80	115.00	118.00	115.80	7.75	-	ns	>0.500
Relative weight of esophagus and crop (%)	0.87	0.92	0.78	0.77	18.24	-	ns	0.328
Relative weight of proventriculus and gizzard (%)	4.41	4.44	4.12	4.49	8.48	-	ns	0.400
Relative weight of liver (%)	2.89	2.75	2.78	2.66	8.60	-	ns	>0.500
Relative weight of pancreas (%)	0.308	0.288	0.289	0.326	17.05	-	ns	>0.500
Relative weight of small intestine (%)	3.83	3.97	3.93	3.85	8.63	-	ns	>0.500

ns - non-significant effect (P>0.05); CV - coefficient of variation.

the same protein level, higher inclusion levels of synthetic amino acids are required, which increase production costs (Bellaver et al., 2005).

Conclusions

Viscera and bone meal can be recommended at the inclusion level of 3 and 4% in pre-starter and starter diets for broilers, respectively.

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