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Nutritional and Microbiological Evaluation of Meat and Bone Meal Produced in the State of Minas Gerais

Author(s)

Sartorelli SA[1]
Bertechini AG[2]
Fassani EJ[3]
Kato RK[3]
Fialho ET[2]

1-Master of Science (Animal Production)

2-Profº - Depto. de Zootecnia - UFLA, Lavras - MG - Brasil

3-Ph.D student - Depto. de Zootecnia – UFLA/ CAPES, Lavras - MG - Brasil

Mail Address

Antonio Gilberto Bertechini

Depto. de Zootecnia - Universidade Federal de Lavras
Caixa Postal 37
37200-000 - Lavras - MG - Brasil

E-mail: bertechi@ufla.br

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ABSTRACT

The present study investigated the chemical composition and metabolizable energy levels of ten meat and bone meals (MBM) produced in Minas Gerais state (Experiment I) and evaluated the growth performance of broilers fed with diets containing those MBM (Experiment II). In the first experiment, energy values (apparent metabolizable energy [AME] and corrected apparent metabolizable energy [AMEn]) of ten different MBM were determined using the traditional method with total collection of excreta. Four hundred forty 21 day-old Hubbard broilers were used. A reference corn and soybean meal-based diet was replaced in 20% by the feed containing MBM to be tested. A completely randomized experimental design was used with eleven treatments (one reference diet and ten MBM), four repetitions per treatment and 10 birds per repetition (5 males and 5 females). In the second experiment, five MBMs from the ten analyzed in Experiment 1 were used as phosphorus source and compared to a diet containing bicalcium phosphate. The growth performance of the broilers fed with these diets was analyzed, considering two ages of the onset of MBM inclusion in the diet (1 or 7 days of age). One-day-old Hubbard broilers (1,320 birds) were housed in 44 plots with 30 birds per experimental unit. The experiment consisted of 11 treatments in a 5x2 factorial arrangement, with five sources of MBM, two ages for the onset of inclusion, and a reference treatment without addition of MBM. The results obtained showed a great variation in the chemical composition and apparent metabolizable energy of the evaluated meals. No significant differences were found on the performance of broilers fed diets with different MBM or the diet with bicalcium phosphate as phosphorus source. The performance of broilers was not significantly influenced by the onset of MBM inclusion in the diets.

INTRODUCTION

During the last years, beef cattle production in Brazil has increased, which resulted in an higher production of slaughter by-products that can be used in animal feeding. The meat and bone meal (MBM) can be considered the main slaughter by-product, because of the greatest proportion of materials and residues that cannot be used in human nutrition and are thus used to produce MBM. Minas Gerais State has contributed for the increase in the production of this ingredient because it has one of the most important bovine herds of Brazil.

Nowadays, poultry industry consumes most of the MBM produced in that state. MBM is considered to be a good source of amino acids, as well as a source of minerals and vitamins. For a long time, MBM has been used mainly as a source of high quality protein, an essential raw material to elaborate diets for animals in need of protein with high biological value. Besides, it also contains phosphorus, an important mineral in animal metabolism. The increase in soybean meal utilization resulted in a decrease in the use of MBM as the main protein source. Thus, it became the first choice as a phosphorus source, due to the high cost of the inorganic sources for that mineral. In spite of the great use of MBM in chicken diets, the nutritional composition of the many MBMs that can be found in Minas Gerais is not yet known. Several farms and food industries produce diets based on nutrient requirement tables compiled abroad, such as NRC (1994). Nevertheless, due to different production and processing processes, the chemical composition and energy values presented by these tables are different from the values reported by brazilian authors, such as nutrient requirements from the Centro Nacional de Pesquisa em Suínos e Aves (Embrapa, 1991) and Rostagno *et al.* (2000).

This research was undertaken to study the chemical and energetic compositions, presence of microorganisms and foreign bodies, as well as to evaluate the performance of birds fed diets containing MBMs produced in Minas Gerais State.

MATERIAL AND METHODS

Two experiments using broiler chickens were conducted. Experiment 1 determined the chemical composition and metabolizable energy (ME), and the presence of microorganisms and foreign bodies in MBMs produced in Minas Gerais State using an assay with one-day-old broilers.

Experiment 2 was conducted to evaluate the performance of broilers fed with 5 different MBMs that had been analyzed in Experiment 1, at 2 different ages of inclusion onset (1 and 7 days). The MBMs chosen were according to the standard classification of the Divisão de Fiscalização de Alimentos para Animais (Difisa, 1989). MBM percentage in the diets was adjusted so that equal phosphorus levels were supplemented to all treatments .

Experiment 1 used 440 Hubbard broilers aging 21 days and housed randomly in 44 cages in batteries. The birds were given 11 experimental diets: one reference diet (Table 1) and 10 experimental diets in which 20% of the experimental diet was substituted by the diets containing the MBMs. A completely randomized experimental design was used, with 4 repetitions per treatment, and 10 birds per repetition (5 of each sex). Mean body weight was 690 g when they were housed. After 3 days of pre-experimental period, feces were collected for 5 days, using the total collection method. The average minimum and maximum temperatures registered during the trial were 20.0 and 31.5°C, respectively.

Table 1 – Composition of the basal diet – Experiment 1.

Ingredients	%
Corn	68.627
Soybean meal	27.800
Vegetal oil	0.300
Limestone	1.000
Dicalcium phosphate	1.600
Iodized salt	0.385
DL-methionine	0.113
Mineral premix[1]	0.050
Vitamin premix[2]	0.100
Zinc bacitracin	0.025
Total	100.000
Calculated composition[3]	
Dry matter (%)	89.16
Protein (%)	18.51
Calcium (%)	0.867
Available phosphorus (%)[4]	0.400
Gross energy (kcal/kg)	4,434

1 - Mineral premix, levels/kg: Fe, 100g; Cu, 12g; Mn, 160g; Zn, 120g; I, 2.5g; Co, 0.8g; Se, 0.3g.
2 - Vitamin premix, levels/kg: Vitamin A, 12,800,000 IU; Vitamin D3, 3,000,000 IU; Vitamin E, 10g; Vitamin K3, 3g; Thiamin, 2,2g; Riboflavin, 7g; Pyridoxine, 3g; Vitamin $B_{12,}$ 16mg; Niacin, 45g; Calcium pantothenate, 15g; Folacin, 1.3g; Biotin, 70mg; Antioxidant, 30g.
3 - Analysis done at Laboratório de Pesquisa Animal from the Departamento de Zootecnia - UFLA.
4 - Calculated as 1/3 total phosphorus.

Dry matter, crude protein, ash, ether extract, calcium and MBM were evaluated according AOAC (1990), and gross energy were determined in calorimeter "Parr" 1271 model.

Apparent metabolizable energy (AME) and corrected apparent metabolizable energy (AMEn) of the MBMs were determined according to Matterson *et al.* (1965). The chemical composition of the reference and experimental diets is shown in Table 2.

Microbiological analysis were performed according to the methods described by the American Public Health Association (Speck, 1984), and microscopic evaluations

Table 2 – Composition[1,2] of experimental diets – Experiment 1.

Treatment	Dry matter (%)	Protein (%)	Calcium(%)	Total phosphorus (%)	Gross energy (kcal/kg)
T1	89.52	21.80	4.06	2.31	4,149
T2	88.76	22.11	4.04	2.19	4,107
T3	88.28	22.79	3.36	1.78	4,380
T4	88.32	23.02	3.54	1.75	4,317
T5	90.27	23.17	3.50	1.70	4,266
T6	89.82	23.48	3.27	1.93	4,261
T7	89.81	24.32	2.84	1.36	4,464
T8	90.14	25.15	3.09	1.56	4,313
T9	90.01	25.69	3.36	1.57	4,364
T10	90.15	26.07	2.42	1.71	4,413
T11	89.16	18.51	0.86	0.40	4,434

1 - As-fed basis.
2 - Analysis done at Laboratório de Pesquisa Animal from the Departamento de Zootecnia - UFLA.

Table 3 – Treatments used in the Experiment 2 according the MBM sources and inclusion onset.

Treatment	MBM sources	Inclusion onset (days of age)
T1	A[1]	1
T2	A	7
T3	B	1
T4	B	7
T5	C	1
T5	C	7
T7	D	1
T8	D	7
T9	E	1
T10	E	7
T11	-	-

1 - MBM 03 (39.94% CP and 7.31% P).
B= MBM 05 (41.84% CP and 6.91%P).
C= MBM 06 (43.36% CP and 8.09% P).
D= MBM 08 (51.73% CP and 6.24% P).
E= MBM 09 (54.40% CP and 6.25% P).

were made according to the method approved by the American Association of Feed Microscopists (AAFM, 1992).

In Experiment 2, 1320 one-day-old Hubbard broiler chicks were used. The birds were weighed (mean=41.5 g), allocated in 44 cages (4 per treatment) with 30 birds per experimental unity. Average minimum and maximum temperatures were 18.0 and 28.4ºC, respectively. During the experimental phase, birds were given water and feed *ad libitum*. A randomized experimental design was used, with 11 treatments in a 5 x 2 factorial scheme (five MBMs as phosphorus

Table 4 – Composition of starter basal diets (1 to 21 days) – Experiment 2.

Ingredients (%)	Treatments					
	1 and 2	3 and 4	5 and 6	7 and 8	9 and 10	11
Corn	60.394	61.126	61.141	62.797	61.923	61.090
Soybean meal	28.215	27.507	28.177	25.034	24.796	33.349
Vegetal oil	1.500	1.500	1.500	1.500	1.500	1.500
Limestone	0.747	0.509	1.015	0.661	0.415	0.587
Dicalcium phosphate	-	-	-	-	-	2.500
Iodized salt	0.390	0.386	0.396	0.379	0.380	0.450
DL-methionine	0.253	0.255	0.245	0.256	0.254	0.226
L-lysine	0.067	0.074	0.053	0.080	0.079	0.023
Mineral premix[1]	0.100	0.100	0.100	0.100	0.100	0.100
Vitamin premix[2]	0.100	0.100	0.100	0.100	0.100	0.100
Coccidiostat	0.050	0.050	0.050	0.050	0.050	0.050
Zinc bacitracin	0.025	0.025	0.025	0.025	0.025	0.025
Inert	2.148	2.008	1.769	1.967	3.339	-
MBM	6.010	6.360	5.430	7.050	7.040	-
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Composition						
ME (kcal/kg)	2,980	2,980	2,980	2,980	2,980	2,980
Crude Protein (%)	20.40	20.40	20.40	20.40	20.40	20.40
Methionine + Cystine (%)	0.882	0.882	0.882	0.882	0.882	0.882
Lysine (%)	1.120	1.120	1.120	1.120	1.120	1.120
Calcium (%)	1.200	1.200	1.200	1.200	1.200	0.905
Available phosphorus (%)	0.544	0.544	0.545	0.541	0.540	0.540
Sodium(%)	0.180	0.180	0.180	0.180	0.180	0.180

1- Mineral premix, levels/kg: Fe, 100g; Cu, 12g; Mn, 160g; Zn, 120g; I, 2.5g; Co, 0.8g; Se, 0.3g.
2- Vitamin premix, levels/kg: Vitamin A, 12,800,000 IU; Vitamin D3, 3,000,000 IU; Vitamin E, 10g; Vitamin K3, 3g; Thiamin, 2.2g; Riboflavin, 7g; Pyridoxine, 3g; Vitamin B_{12}, 16mg; Niacin, 45g; Calcium pantothenate, 15g; Folacin, 1.3g; Biotin, 70mg; Antioxidant, 30g.

source and 2 ages for the onset of MBM inclusion in the diet, 1 or 7 days) and an extra treatment with dicalcium phosphate as phosphorus source (Table 3). Inclusion level of MBM in the diets was calculated so that all treatments had the same amount of phosphorus provided. The composition of the experimental starter diets (1 to 21 days) is shown in Table 4 and the composition of the grower diets (21 to 42 days) is shown in Table 5. Diets were formulated using the ingredient composition tables of Rostagno *et al.* (2000), except the metabolizable energy values of MBMs, which were determined in Experiment 1.

Weight gain (g), feed intake (g) and feed conversion (g/g) were evaluated and data were statistically analyzed using the software SANEST (Statistical Analysis System) as described by Sarries *et al.* (1992). Performance means were compared using Tukey's test (Experiment 2).

Table 5 – Composition of grower basal diets (21 to 42 days) – Experiment 2.

Ingredients (%)	Treatments					
	1 and 2	3 and 4	5 and 6	7 and 8	9 and 10	11
Corn	65.487	66.219	66.234	67.890	67.015	66.183
Soybean meal	22.003	21.295	21.964	18.821	18.583	27.137
Vegetal oil	2.500	2.500	2.500	2.500	2.500	2.500
Limestone	0.804	0.565	1.072	0.718	0.471	0.679
Dicalcium phosphate	-	-	-	-	-	2.539
Salt iodized	0.390	0.386	0.396	0.379	0.380	0.450
DL-methionine	0.235	0.237	0.227	0.239	0.236	0.208
L-lysine	0.124	0.131	0.110	0.137	0.136	0.080
Mineral premix[1]	0.100	0.100	0.100	0.100	0.100	0.100
Vitamin premix[2]	0.100	0.100	0.100	0.100	0.100	0.100
Zinc bacitracin	0.025	0.025	0.025	0.025	0.025	0.025
Inert	2.223	2.083	1.842	2.041	3.413	-
MBM	6.010	6.360	5.430	7.050	7.040	-
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Composition						
ME (kcal/kg)	3,100	3,100	3,100	3,100	3,100	3,100
Crude Protein (%)	18.00	18.00	18.00	18.00	18.00	18.00
Methionine + Cystine (%)	0.799	0.799	0.799	0.799	0.799	0.799
Lysine (%)	1.010	1.010	1.010	1.010	1.010	1.010
Calcium (%)	1.200	1.200	1.200	1.200	1.200	0.927
Available phosphorus (%)	0.538	0.537	0.538	0.535	0.534	0.540
Sodium (%)	0.180	0.180	0.180	0.180	0.180	0.180

1- Mineral premix, levels/kg: Fe, 100g; Cu, 12g; Mn, 160g; Zn, 120g; I, 2.5g; Co, 0.8g; Se, 0.3g.
2 - Vitamin premix, levels/kg: Vitamin A, 12,800,000 IU; Vitamin D3, 3,000,000 IU; Vitamin E, 10g; Vitamin K3, 3g; Thiamin, 2.2g; Riboflavin, 7g; Pyridoxine, 3g; Vitamin $B_{12,}$ 16mg; Niacin, 45g; Calcium pantothenate, 15g; Folacin, 1.3g; Biotin, 70mg; Antioxidant, 30g.

RESULTS AND DISCUSSION

Experiment 1

Chemical composition (Table 6) and the presence of contaminants (Table 7) were different among the MBMs analysed in Minas Gerais state. Considering the contamination by Mesophilus, molds and yeasts, all samples were classified as of good quality according to the criteria established by Andriguetto *et al.* (1990). Coliforms were found in two MBM samples (Table 7). According to the considered criteria (Andriguetto *et al.*, 1990), 80% of the MBMs were within the acceptable range for that characteristic. *Salmonella* contamination was detected in 90% of the MBMs, an undesirable feature considering that the presence of that microorganism might occur by cross contamination during slaughter due to the contact of the carcass with the feathers or the intestinal content. It was also observed the presence of hair (20%), skull/horn (40%) and leather/collagen (60%) in the MBMs. Routine analysis does not usually detect these foreign bodies that are considered protein sources of low biological value. Even small quantities of contaminants such as plastic, vegetable crude fiber, blood and innards indicates failures during processing.

Table 6 – Chemical composition[1,2] and gross energy values of the MBM - Experiment 1.

Parameters	Meat and Bone Meal									
	1	2	3	4	5	6	7	8	9	10
Crude protein (%)	34.99	36.52	39.94	41.08	41.84	43.36	47.55	51.73	54.40	56.30
Moisture (%)	7.03	8.24	7.47	8.66	6.18	8.94	9.05	4.15	3.27	5.40
Ether extract (%)	12.4	9.25	17.58	13.49	14.93	11.09	15.98	11.88	10.28	11.96
Ash (%)	43.65	44.15	34.49	36.19	36.57	34.98	26.14	30.50	29.35	23.93
Calcium (%)	16.88	16.76	13.35	14.24	14.08	12.90	10.77	12.00	13.36	8.68
Phosphorus (%)	9.96	9.37	7.31	7.18	6.91	8.09	5.24	6.24	6.25	4.47
Gross energy (kcal/kg)	2,626	2,715	3,496	3,264	3,492	3,350	4,011	3,813	3,899	4,226
Ca : P ratio	1.69	1.78	1.82	1.98	2.03	1.59	2.05	1.92	2.13	1.94

1- As-fed basis.
2 - Analysis done at Laboratório de Pesquisa Animal from the Departamento de Zootecnia - UFLA.

Table 7 – Microbiological[1] and microscopic[2] analysis of the MBMs – Experiment 1.

MBM	Mesophillus counts	Molt and yeast counts	Coliform (MPN)	*Salmonella*	Hair	Leather and collagen	Other
01	G	G	<3	Present	++	+++	Plastic (+)
02	G	G	0.9	Present	++	+	Absent
03	G	G	<3	Present	++	+	Blood
04	G	G	<3	Present	+++	+++	Vegetal Fiber
05	G	G	>140	Present	+	++	Vegetal Fiber
06	G	G	<3	Absent	+	++	Blood (+)
07	G	G	<3	Present	++		Vegetal Fiber
08	G	G	<3	Present	+		Vegetal Fiber Plastic (+)
09	G	G	<3	Present	+		Innards (+)
10	G	G	<3	Present	+++		Vegetal Fiber Feather (+) Blood (+)

G: good < 10^6
A: Acceptable = 10^7
UA: Unacceptable > 10^7
(+): scarce.
(++): moderate.
(+++): abundant.
(++++): full up area.
MPN:Most probable number.
1 - Analysis done at Laboratório de Microbiologia dos Alimentos – Departamento de Ciências do Alimento - UFLA.
2 - Analysis done at Laboratório Nacional de Referência Animal (LANARA), Pedro Leopoldo, MG, Brazil.

All samples were classified as meat and bone meal according to the requirements of Divisão de Fiscalização de Alimentos para Animais (Difisa, 1989), with phosphorus levels above 3.8%, independent of the protein content. The maximum allowed calcium:phosphorus ratio is 2.2: 1 (Difisa, 1989) and all samples fulfilled that requirement. Similar results were found by Coelho (1983) and Azevedo (1997).

The protein content of the analyzed samples should be 40 to 55%, according to Difisa (1989) and Rostagno *et al.* (2000). Thus, the samples were graded as: MBM type 40: samples 03, 04, 05 and 06; MBM type 45: sample 07; MBM type 50: samples 08 and 09; MBM type 55: sample 10. Samples 01 and 02 did not fit any standard. Crude protein (CP) results lower than 40% were also observed by Azevedo (1997) in three samples out of nine analyzed samples (30.47; 37.14 and 39.06%). Samples within the same protein class showed variations in the chemical composition. The variation might result from the fact that neither the equipment nor the raw material used to produce MBM have been standardized. The maximum water content allowed by the Department of Agriculture is 8.0% (Difisa, 1989). Therefore, MBM samples 02, 04, 06 and 07 have higher levels than the standard (8.24; 8.66; 8,94 and 9.04%, respectively).

The minimum ether extract value allowed by Difisa (1989) is 8.0%, and all analyzed samples showed values similar to the standard. According to Difisa (1989), the maximum ash values for MBM types 40, 45, 50 and 55 are 43; 36; 32 and 28%, respectively.

Samples 01 and 02 showed higher values, 43.65 and 44.15%, respectively. However, crude protein levels of these samples were lower than the standard value (40). MBM samples 01 and 02 had crude protein values of 34.99 and 36.52% respectively.

Gross energy values (GE) varied greatly among samples. This was expected due to the discrepant ash values. Sample 10 had a high GE content (4,226 kcal/kg) as a result of the high crude protein content (56.30%) and low mineral matter content (23.93%); followed by sample 07 (4,011 kcal/kg), which did not show a high protein content, but showed a high content of ether extract (15.98%) and a low mineral matter level (30.50%). A low GE content was observed in MBM 01 (2,626 kcal/kg), probably because of the smaller protein content (34.99%) found in the same sample together with one of the largest ash levels (43.65%). Azevedo (1997) also found variable GE values (2,986 to 4,320 kcal/kg) giving strong evidence in the relation between GE and mineral matter.

Table 8 – AME and AMEn values of the MBMs[1] (kcal/kg DM±SEM[2]) – Experiment 1.

MBM	AME	AMEn
01	1,151 ± 181	1,218 ± 217
02	1,024 ± 329	980 ± 291
03	2,379 ± 83	2,344 ± 121
04	2,032 ± 100	2,080 ± 108
05	2,132 ± 287	2,076 ± 235
06	2,165 ± 449	2,075 ± 413
07	2,671 ± 125	2,604 ± 88
08	2,025 ± 536	1,987 ± 527
09	2,438 ± 35	2,437 ± 89
10	2,241 ± 292	2,092 ± 240
Mean	2,025 ± 533	1,989 ± 511

1 - Mean of 4 observations.
2 - SEM = standard error of the mean.

The values of AME found for the different MBM samples varied from 1,024 to 2,671 kcal/kg DM (Table 8). These AME values were higher than the values reported in the ingredient composition table from Rostagno *et al.* (2000) for the same protein standard level. Analyzed samples graded as protein standard 40 showed AME values from 2,032 to 2,379 kcal/kg DM whereas the table shows 1,945 kcal/kg DM. For the standard 45, 2,671 kcal/kg DM of the analyzed sample against 2,004 kcal/kg DM of the table. For the standard 50 values from 2,025 to 2,438 kcal/kg DM against 2,227 kcal/kg DM of the table and for the standard 55 the value of 2,241 kcal/kg DM against 2,286 kcal/kg DM. The latter was the only result lower than the values reported by Rostagno *et al.* (2000).

AMEn values decreased after they were corrected for nitrogen balance (NB), except for MBM 01 and 04, which increased from 1,151 to 1,218 kcal/kg DM and 2,032 to 2,080 kcal/kg DM, respectively. The average AMEn values obtained in our study was 98.22% of the EMU values. Coelho (1983), Azevedo (1997) and Albino *et al.* (1992) also observed AMEn values lower than AME.

Experiment 2

The performance of the birds using the evaluated MBMs was inside the normal values (Tables 9, 10 and 11), and no significant differences (p>0.05) was seen

Table 9 – Effects of MBM sample and age of inclusion onset on body weight – Experiment 2.

Treatments	Body weight[1] (g)							
	MBM	Day	7 days	14 days	21 days	28 days	35 days	42 days
1	A	1	158	402	734	1,204	1,667	2,173
2	A	7	169	433	801	1,196	1,705	2,221
3	B	1	156	401	734	1,167	1,609	2,222
4	B	7	156	395	746	1,188	1,621	2,213
5	C	1	159	404	747	1,197	1,659	2,192
6	C	7	163	408	736	1,174	1,626	2,145
7	D	1	159	402	737	1,161	1,640	2,178
8	D	7	158	396	718	1,141	1,645	2,141
9	E	1	151	390	728	1,173	1,602	2,113
10	E	7	162	407	746	1,185	1,639	2,148
11	-	-	156	402	746	1,186	1,662	2,184
Mean	-	-	159	403	743	1,179	1,643	2,175
C.V. (%)	-	-	5.09	4.58	3.90	3.62	4.75	6.01

1 - NS (p>0.05).

Table 10 – Effects of MBM sample and age of inclusion onset on feed conversion – Experiment 2.

Treatements	Feed conversion[1]							
	MBM	Day	7 days	14 days	21 days	28 days	35 days	42 days
1	A	1	1.172	1.398	1.595	1.739	1.874	1.955
2	A	7	1.097	1.348	1.493	1.767	1.866	1.972
3	B	1	1.092	1.379	1.562	1.727	1.886	1.917
4	B	7	1.235	1.452	1.572	1.748	1.912	1.918
5	C	1	1.175	1.415	1.570	1.734	1.898	1.987
6	C	7	1.137	1.379	1.591	1.719	1.897	1.993
7	D	1	1.157	1.392	1.552	1.732	1.856	1.942
8	D	7	1.190	1.444	1.617	1.778	1.820	1.974
9	E	1	1.202	1.418	1.572	1.671	1.883	1.968
10	E	7	1.120	1.409	1.586	1.713	1.871	2.004
11	-	-	1.122	1.381	1.577	1.564	1.869	1.988
Mean	-	-	1.154	1.401	1.571	1.717	1.876	1.965
C.V. (%)	-	-	7.494	4.272	3.550	7.847	3.019	4.080

1 - NS (p>0.05).

Table 11 – Effects of MBM sample and age of inclusion onset on feed intake – Experiment 2.

Treataments			Feed intake[1] (g)					
	MBM	Day	7 days	14 days	21 days	28 days	35 days	42 days
1	A	1	137	505	1,099	2,022	3,050	4,172
2	A	7	142	529	1,134	2,042	3,170	4,302
3	B	1	126	497	1,083	1,951	2,960	4,165
4	B	7	142	513	1,108	2,004	3,022	4,157
5	C	1	139	512	1,108	2,005	3,070	4,271
6	C	7	137	504	1,106	1,994	3,010	4,195
7	D	1	136	501	1,079	1,938	2,962	4,152
8	D	7	140	511	1,093	1,952	2,915	4,135
9	E	1	132	494	1,079	1,935	2,940	4,080
10	E	7	135	516	1,118	2,007	2,990	4,222
11	-	-	128	497	1,111	1,994	3,024	4,258
Mean	-	-	136	507	1,102	1,986	3,005	4,192
C.V. (%)	-	-	8.970	4.664	4.294	4.305	5.019	5.238

1 - NS (p>0.05).

among them at 7, 14, 21, 28, 35 and 42 days of age. These results indicate that a good nutrient supply was provided by the meals. Furthermore, when the specific energetic content of each MBM was corrected, the performance of the birds was similar. Regarding the day of MBM inclusion onset in the diet in the initial phase (1 or 7 days), the final body weight of the birds was not significantly different (p>0.05) between ages (Table 9).

Age had no effect (p>0.05) on weight gain, feed conversion and feed intake at 7, 14, 21, 28, 35 and 42 days of age (Tables 9, 10 and 11, respectively). Thus, changes in the levels of inclusion (with different protein) did not influence the final energy content, even with differences in the metabolizable energy value for the several MBMs.

CONCLUSIONS

The analyzed MBMs showed variation in chemical composition with high Salmonella contamination, and the AME and AMEn values of the MBMs was different with average values of 2,025 and 1,989 kcal/kg, respectively.

Performance of broilers fed MBMs was similar when the nutrition levels of the diet were balanced, and the MBMs used in the initial phase had no detrimental effect on the studied parameters. The source of phosphorus, MBM or dicalcium phosphate, did not affect performance.

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