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Effect of Creatine Addition in Feeds Containing Animal Meals on the Performance and Carcass Yield of Broilers

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ABSTRACT

The objective of this study was to evaluate the performance and carcass characteristics of broilers fed exclusively vegetable diets and diets containing animal meal with the addition of creatine or not after day 8. In the experiment, 1080 one-day-old male chicks were distributed according to a completely randomized experimental design into six treatments with six replicates each. A control diet based on corn and soybean meal was formulated, to which animal meals and creatine were included or not. Diets were formulated to contain equal mineral (calcium, phosphorus and sodium) and amino acid (available methionine + cystine, lysine and threonine) levels. The following treatments were applied: A. control (diet based on corn and soybean meal); B. control + creatine (600g/ton); C. inclusion of 5% meat and bone meal (MBM), D. inclusion of 5% MBM + creatine (600g/ton), E. inclusion of 5% blood meal (BM), F. inclusion 5% BM + creatine (600g/ton). Weight gain, feed intake, feed conversion, carcass yield and viability were evaluated. At 42 days of age, BM dietary inclusion impaired weight gain and feed conversion ratio. The inclusion of MBM affected only feed conversion ratio. The addition of creatine ito the diet with BM improved weight gain when compared with the BM diet with no creatine. The addition of creatine to the diet containing 5% BM improved weight gain when compared with the same diet without the use of the additive.

INTRODUCTION

Animal products are frequently included in broiler diets to reduce feed cost. The quality of the protein in meat and bone meal and blood meal is good and these ingredients may partially replace soybean meal in feed formulation. In addition of being a protein source, meat and bone meal is a significant source of minerals, such as calcium (Ca) and phosphorus (P), which are considered totally available, whereas in plant feedstuffs, only 33% of the phosphorus is available to the animals due to the presence of phytate.

Sartorelli (1998) included meat and bone meal from five different sources in broiler diets and compared them with a diet containing dicalcium phosphate, but did not find any performance differences. Junqueira *et al*. (2000), using meat and bone meal containing 37.51% or 41.58% crude protein (CP) at two inclusion levels (3 or 6%) in the diet of one- to 49-d-old broilers, also did not find any differences in weight gain, feed intake, feed conversion ratio, or livability.

In the study of Donkoh *et al*. (1999), the inclusion of 5% or 7.5% blood meal promoted higher weight gain and better feed conversion ratio compared with the inclusion of 0% or 2.5% in the diet of 14- to 49-d-old broilers.

The use of feed additives is becoming increasingly frequent in broiler diets to improve performance. Creatine, a compound based on amino acids (arginine, glycine, and methionine), may participate in this market because it is an essential precursor in the production of muscle energy, in addition of favoring muscle growth.

Studies with broilers performed by Halle *et al*. (2006) showed the creatine supplementation (1, 2, 5, and 10g/kg) to a corn- and soybean meal-based diet improved weight gain compared with a control group in 35-d-old broilers.

The objective of the present study was to evaluate the live performance and carcass traits of broilers fed diets including only plant feedstuffs and diets containing animal products with the inclusion or not of creatine.

MATERIALS AND METHODS

The experiment was carried out at the Glória poultry experimental farm of the School of Veterinary Medicine of the Federal University of Uberlândia, state of Minas Gerais, Brasil. In this experiment, 1080 one-d-old male Avian 48 chicks, with 43g average initial weight, were distributed in a completely randomized experimental design with six treatments of six replicates of 30 birds each. The house was divided in 36 pens, with 30 birds each, at a density of 12 birds/m^2. Feed and water were offered *ad libitum*. A continuous lighting program was used, with 24 hours of light. The average minimal and maximal house temperatures daily recorded from day 10 to market were 25.34 ºC and 25.86 ºC, respectively.

Diets were formulated and manufactured to supply the birds' nutritional requirements according to the recommendations of Rostagno *et al*. (2005). Before feed formulation, corn, soybean meal, and animal meals were chemically analyzed (Table 1). Diets contained different combinations of corn, soybean meal, meat and bone meal (MBM), blood meal (BM), soybean oil, dicalcium phosphate, limestone, vitamin and mineral premix, synthetic amino acids (Dl-methionine, L-lysine, and threonine), and creatine (600 g/ton of feed). Diets were supplied according to a four-phase feeding program: pre-starter, starter, grower, and finisher. Animal products and creatine (creAmino^{tm}) were included in the diets after day 8. Tables 2, 3, 4, and 5 show the ingredient and nutritional composition of the experimental feeds.

Table 1 – Chemical composition of the animal meals, corn, and soybean meal used in the experimental diets.

Nutrients	MBM (%)	BM (%)	Corn (%)	SBM
Crude protein	42.02	84.74	8.05	46.84
Ether extract	14.11	0.38	2.18	1.63
Ashes	38.02	3.44	1.93	6.42
Calcium	13.80	0.20	0.03	0.24
Phosphorus	6.81	0.21	0.24	0.53
Dry matter	92.06	93.50	88.00	89.52
Dig. Arginine	3.11	2.73	0.36	3.15
Dig. Lysine	2.03	5.80	0.20	2.53
Dig. methionine	0.53	0.83	0.15	0.60
Dig. Met+cys	0.81	1.31	0.32	1.12
Dig. threonine	1.25	3.32	0.27	1.57
Dig. tryptophan	0.21	1.13	0.05	0.59

Table 2 – Composition of the pre-starter experimental diets (1-7 days).

Ingredients	Quantity (%)
Corn grain	59.16
Soybean meal	35.02
Soybean oil	1.35
Dicalcium phosphate	1.98
Limestone	0.85
Salt	0.44
DL-Methionine	0.38
L-lysine	0.42
Starter premix[1]	0.20
L-Threonine	0.17
R$/kg feed	0.643
Calculated nutritional levels	
ME (Mcal/kg)	2.960
Crude protein (%)	22.11
Calcium (%)	0.95
Available phosphorus (%)	0.47
Sodium (%)	0.22
Dig. methionine (%)	0.67
Dig. Met+cys (%)	0.96
Dig. Lysine (%)	1.36
Dig. threonine (%)	0.88
Dig. Arginine (%)	1.36
Dig. tryptophan (%)	0.23

[1] MC-Mix Frango Inicial SAA 2kg (®M-Cassab Comércio e Indústria Ltda) – composition/kg feed – Vit-A 11,000IU; D3 2,000IU; E 16mg; folic acid 400mcg; calcium pantothenate 10mg; biotin 60mcg; niacin 35mg; pyridoxin 2mg; riboflavin 4.5mg; thiamin 1.2mg; B12 16mcg; K 1.5mg; Se 250mcg; choline 249mg; Cu 9mg; Zn 60mg; I 1mg; Fe 30mg; Mn 60mg; growth promoter 384mg; coccidicide 375mg; antioxidant 120mg.

Table 3 – Composition of the starter experimental diets (7-21 days).

Ingredients (%)	A and B	C and D	E and F
Corn grain	60.51	65.24	61.78
Soybean meal	33.31	27.57	26.84
Soybean oil	2.23	0.55	2.71
Dicalcium phosphate	1.87	0.02	1.87
Limestone	0.80	0.24	0.82
Salt	0.45	0.40	0.41
DL-Methionine	0.27	0.29	0.27
L-lysine	0.25	0.32	0.06
Starter premix[1]	0.20	0.20	0.20
L-Threonine	0.08	0.11	0.0006
Blood meal	-	-	5.00
Meat & bone meal	-	5.00	-
Creatine	(B)0.06	(D)0.06	(F)0.06
R$/kg feed	0.611	0.547	0.601
Calculated nutritional levels			
ME (Mcal/kg)	3.050	3.050	3.050
CP (%)	21.14	21.14	22.24
Calcium (%)	0.90	0.90	0.90
Available P (%)	0.45	0.45	0.45
Sodium (%)	0.22	0.23	0.22
Dig. met+cys (%)	0.56	0.57	0.57
Dig. Met+cys (%)	0.85	0.85	0.85
Dig. Lysine (%)	1.18	1.18	1.18
Dig. threonine (%)	0.78	0.78	0.78
Dig. Arginine (%)	1.31	1.26	1.24
Dig. Tryptophan (%)	0.22	0.20	0.24

ME - metabolizable energy, CP - crude protein, P – phosphorus, M+C – methionine + cystine.

[1]MC-Mix Frango Inicial SAA 2kg (®M-Cassab Comércio e Indústria Ltda) – composition/kg feed – Vit-A 11,000IU; D3 2,000IU; E 16mg; folic acid 400mcg; calcium pantothenate 10mg; biotin 60mcg; niacin 35mg; pyridoxine 2mg; riboflavin 4.5mg; thiamin 1.2mg; B12 16mcg; K 1.5mg; Se 250mcg; choline 249mg; Cu 9mg; Zn 60mg; I 1mg; Fe 30mg; Mn 60mg; growth promoter 384mg; coccidicide 375mg; antioxidant 120mg.

Table 4 – Composition of the grower experimental diets (21-35 days).

Ingredients (%)	A and B	C and D	E and F
Corn grain	63.20	66.82	67.70
Soybean meal	29.85	25.00	20.91
Soybean oil	3.24	1.79	2.81
Dicalcium phosphate	1.73	-	1.74
Limestone	0.76	0.13	0.79
Salt	0.43	0.40	0.40
DL-Methionine	0.09	0.26	0.26
L-lysine	0.24	0.29	0.13
Grower premix[1]	0.20	0.20	0.20
L-Threonine	0.06	0.08	0.01
Blood meal	-	-	5.00
Meat & bone meal	-	5.00	-
Creatine	(B)0.06	(D)0.06	(F)0.06
R$/kg feed	0.613	0.553	0.593
Calculated nutritional levels			
ME (Mcal/kg)	3.150	3.150	3.150
CP (%)	19.73	20.00	20.06
Calcium (%)	0.84	0.84	0.84
Available P (%)	0.42	0.44	0.42
Sodium (%)	0.21	0.23	0.21
Dig. met (%)	0.52	0.53	0.53
Dig. M+C (%)	0.79	0.79	0.79
Dig. Lysine (%)	1.10	1.10	1.10
Dig. threonine (%)	0.71	0.71	0.71
Dig. Arginine (%)	1.20	1.18	1.07
Dig. Tryptophan (%)	0.20	0.18	0.21

ME - metabolizable energy, CP - crude protein, P – phosphorus, M+C – methionine + cystine.

[1]MC-Mix Frango engorda SAA 2kg (®M-Cassab Comércio e Indústria Ltda) - composition/kg feed – Vit-A 9,000IU; D3 1,600IU; E 14mg; folic acid 300mcg; calcium pantothenate 9mg; biotin 50mcg; niacin 30mg; pyridoxine 1.8mg; riboflavin 4mg; thiamin 1mg; B12 12mcg; K 1.5mg; Se 250mcg; choline 219mg; Cu 9mg; Zn 60mg; I 1mg; Fe 30mg; Mn 60mg; growth promoter 385mg; coccidicide 550mg; antioxidant 120mg.

Table 5 – Composition of the finisher experimental diets (35-42 days).

Ingredients (%)	A and B	C and D	E and F
Corn grain	59.36	61.20	66.88
Soybean meal	32.33	29.34	20.72
Soybean oil	5.07	4.04	4.13
Dicalcium phosphate	1.56	-	1.58
Limestone	0.75	0.23	0.79
Salt	0.40	0.33	0.36
DL-Methionine	0.08	0.08	0.12
L-lysine	0.11	0.11	0.09
Finisher premix[1]	0.30	0.30	0.30
L-Threonine	-	-	-
Blood meal	-	-	5.00
Meat & bone meal	-	5.00	-
Creatine	(B)0.06	(D)0.06	(F)0.06
R$/kg feed	0.578	0.528	0.572
Calculated nutritional levels			
ME (Mcal/kg)	3.200	3.200	3.200
CP (%)	20.28	20.92	19.76
Calcium (%)	0.80	0.80	0.80
Available P (%)	0.39	0.40	0.39
Sodium (%)	0.20	0.20	0.20
Dig. methionine (%)	0.48	0.48	0.50
Dig. M+C (%)	0.75	0.75	0.75
Dig. Lysine (%)	1.05	1.05	1.05
Dig. threonine (%)	0.68	0.68	0.69
Dig. Arginine (%)	1.26	1.28	1.05
Dig. Tryptophan (%)	0.21	0.20	0.21

ME - metabolizable energy, CP - crude protein, P – phosphorus, M+C – methionine + cystine.

[1] MC-Mix Frango Abate 3kg (®M-Cassab Comércio e Indústria Ltda) – composition/kg feed – Vit-A 2,700IU; D3 450IU; E 4.5mg;calcium pantothenate 3.6mg; biotin 13.5mcg; niacin 4.5mg; pyridoxine 360mcg; riboflavin 900mcg; thiamin 270mcg; B12 2.7mcg; K3 450mcg; Se 180mcg; choline 130mg; methionine906 mg; Cu 9mg; Zn 60mg; I 1mg; Fe 30mg; Mn 60mg; antioxidant 120mg.

Birds, feed offer, and feed residues were weighed on days 7, 14, 21, 35, and 42 to determine feed intake (FI), body weight gain (WG), and feed conversion ratio (FCR). The number of dead birds was daily recorded to calculate livability (L). Actual feed conversion ratio (aFCR) was expressed as the ratio between feed intake and weight gain per period added to dead bird weight minus initial chick weight.

On day 42, four birds per pen, which body weight was representative of the average body weight of their experimental unit, were selected to evaluate carcass yield. Broilers were feed-fasted for eight hours, and then sacrificed, plucked, and eviscerated. Carcass, bone-in breast, deboned breast, and leg (drumstick+thighs) yields were determined. Carcass yield was expressed relative to live weight [CY% = (carcass weight without feed, neck, and head x 100)/ live weight]. Leg, bone-in breast, and deboned breast yields were expressed relative to carcass weight [Part yield% = (part weight x 100)/carcass weight].

The obtained results were submitted to analysis of variance and to the F test at 5% significance level. Means were compared by the test of Scott-Knott, using the SISVAR statistical package (Ferreira, 2000).

RESULTS AND DISCUSSION

Broiler performance results on day 14 are shown in Table 6. There was no influence of the treatments (p>0.05) on feed intake, weight gain, feed conversion ratio, or livability. This shows that the animal meals did not affect broiler performance when compared with the control feed. The use of creatine in the control diet and in the diet with 5% BM promoted numerically better actual feed conversion ratio and weight gain compared with the diets with no creatine; however, differences were not statistically significant (p>0.05). Sartorelli (1998) and Junqueira *et al*. (2000) did not find any effect of the dietary inclusion of MBM on the performance of broilers during the same period. On the other hand, Khawaja *et al*. (2007), evaluating different BM levels (0, 3, 4, 5, or 6%), observed better weight gain, lower feed intake, and better feed conversion ratio in broilers fed 3% BM during the period of 0 to 28 days of age.

Table 6 – Performance of 14-d-old broilers fed diets containing or not animal meals and creatine.

Treatments	Feed intake (kg)	Body weight (kg)	Actual FCR	FCR
A	0.683[a]	0.507[a]	1.446[a]	1.347[a]
B	0.672[a]	0.527[a]	1.385[a]	1.275[a]
C	0.705[a]	0.513[a]	1.501[a]	1.374[a]
D	0.700[a]	0.513[a]	1.472[a]	1.364[a]
E	0.674[a]	0.501[a]	1.458[a]	1.3453[a]
F	0.694[a]	0.529[a]	1.405[a]	1.311[a]
CV	8.56	3.67	6.09	5.07

A-control feed; B-Control+Creatine; C-Inclusion of 5% MBM; D-Inclusion of 5% MBM+Creatine; E-Inclusion of 5% BM; F-Inclusion of 5% BM+Cretine.

Means followed by different letters in the same column are different by the test of Scott-Knott (p<0.05).

Broiler performance results on day 21 are shown in Table 7. There was no influence of the treatments (p>0.05) on feed intake, weight gain, feed conversion ratio, or livability. These results show that the dietary inclusion of animal meals promoted the same performance as the corn- and soybean meal-based diet. Sartorelli (1998), Junqueira *et al*. (2000), and Faria

Filho *et al*. (2002) did not find any effect of the dietary inclusion of MBM on the performance of broilers during the same period. Also, Bellaver *et al*. (2005), comparing the inclusion of 4% meat and bone meal, 3% poultry offal meal, and vegetable diets, did not find any difference among diets relative to the performance of 21-d-old broilers.

Table 7 – Performance of 21-d-old broilers fed diets containing or not animal meals and creatine.

Treatments	Feed intake (kg)	Body weight (kg)	Actual FCR	FCR
A	1.341[a]	1.003[a]	1.379[a]	1.329[a]
B	1.327[a]	1.033[a]	1.321[a]	1.284[a]
C	1.386[a]	1.028[a]	1.398[a]	1.348[a]
D	1.358[a]	1.024[a]	1.363[a]	1.326[a]
E	1.319[a]	0.986[a]	1.396[a]	1.340[a]
F	1.385[a]	1.042[a]	1.364[a]	1.328[a]
CV	8.90	3.86	8.94	8.91

A-control feed; B-Control+Creatine; C-Inclusion of 5% MBM; D-Inclusion of 5% MBM+Creatine; E-Inclusion of 5% BM; F-Inclusion of 5% BM+Cretine.
Means followed by different letters in the same column are different by the test of Scott-Knott ($p<0.05$).

When broilers were 35 days old (Table 8), it was observed that the studied parameters were not influenced by the treatments ($p>0.05$). Broilers fed animal meals had the same performance as those fed the control diet. Weight gain was numerically higher when creatine was included in the control diet and that containing 5% BM compared to the same treatment with no additive; however, these differences were not statistically significant ($p>0.05$). These results are consistent with those obtained by Sartorelli (1998) and Junqueira *et al*. (2000), who did not find any significant differences in broiler performance when MBM was added to the diets during the same period. On the other hand, Faria Filho *et al*. (2002) found that the dietary inclusion of 6% MBM resulted in lower feed intake and weight gain of broilers evaluated during the same period. According to those authors, performance was impaired because the diets were formulated on total amino acid basis and not on digestible amino acids.

On the other hand, Halle *et al*. (2006) showed the creatine supplementation (1, 2, 5, and 10g/kg) to a corn- and soybean meal-based diet improved weight gain compared with a control group during the same period, differently from the findings of the present study. However, those authors also found that creatine supplementation did not affect feed intake.

Table 8 – Performance of 35-d-old broilers fed diets containing or not animal meals and creatine.

Treatments	Feed intake (kg)	Body weight (kg)	Actual FCR	FCR
A	3.655[a]	2.392[a]	1.505[a]	1.527[a]
B	3.917[a]	2.444[a]	1.504[a]	1.606[a]
C	3.696[a]	2.376[a]	1.461[a]	1.555[a]
D	3.575[a]	2.342[a]	1.503[a]	1.528[a]
E	3.723[a]	2.335[a]	1.528[a]	1.596[a]
F	3.799[a]	2.397[a]	1.478[a]	1.585[a]
CV	8.23	3.29	7.65	8.73

A-control feed; B-Control+Creatine; C-Inclusion of 5% MBM; D-Inclusion of 5% MBM+Creatine; E-Inclusion of 5% BM; F-Inclusion of 5% BM+Cretine.
Means followed by different letters in the same column are different by the test of Scott-Knott ($p<0.05$).

Table 9 shows the performance of broilers at 42 days of age. Feed intake ranged between 5.397 and 5.999 kg, but there were no significant differences ($p>0.05$). On the other hand, the live weight of birds fed diet E, which included 5% BM, was significantly lower than that obtained in the other treatments. However, when creatine was added (diet F: 5% BM+creatine) to this diet, live weight improved. The worst feed conversion ratio was obtained with diet E (5% BM), followed by diet C (5% MBM) and diet F (5% BM+C). These results do not agree with those of Sartorelli (1998) and Junqueira *et al*. (2000), who did not find any effect of the dietary inclusion of MBM on the performance of broilers during the same period. On the other hand, Faria Filho *et al.* (2002) found that the dietary inclusion of 6% MBM resulted in lower feed intake and weight gain of broilers evaluated during the same period. Donkoh *et al*. (1999) concluded that the inclusion of 5 and 7.5% BM resulted in better weight gain and feed conversion ratio when compared with the inclusion of 0.0 and 2.5% BM.

The impaired performance of the broilers fed the diets including 5% BM may be related with the antagonism between the amino acids leucine and isoleucine, as well as with the high crude protein levels in the starter diet (22.24%), because the inclusion of animal meals in the diets was pre-determined. According to Leclercq (1996), the metabolic cost of incorporating an amino acid in the protein chain is estimated in 4 mol ATP, whereas the estimated cost of excreting an amino acid ranges between 6 and 18 mol ATP. Therefore, the excretion of the amino acids supplied in excess has high energy cost, which could explain the worse performance of the broilers fed high CP in the present experiment, as the energy that could be used for meat production was diverted to nitrogen excretion.

There are two theories to explain the positive effect of the diets with creatine inclusion. Firstly, it is assumed that creatine supplementation promotes water retention, and secondly, that it actually promotes protein synthesis. Therefore, further studies are required to determine the contribution of each of these processes (Williams, 1998) to the observed effect.

According to Wyss & Kaddurah-Daouk (2000), even when creatine is correctly used, the expected effects may not be detected. This may be explained by the individual variability in creatine absorption, transport, and intramuscular storage.

Table 9 – Performance of 42-d-old broilers fed diets containing or not animal meals and creatine.

Treatments	Feed intake (kg)	Body weight (kg)	Actual FCR	FCR
A	5.397a	2.994a	1.756a	1.806a
B	5.738a	3.048a	1.738a	1.881a
C	5.999a	2.945a	1.841a	2.035b
D	5.411a	2.915a	1.798a	1.856a
E	5.677a	2.745b	1.886a	2.070b
F	5.867a	3.004a	1.796a	1.953b
CV	7.22	3.85	5.20	7.20

A-control feed; B-Control+Creatine; C-Inclusion of 5% MBM; D-Inclusion of 5% MBM+Creatine; E-Inclusion of 5% BM; F-Inclusion of 5% BM+Cretine.
Means followed by different letters in the same column are different by the test of Scott-Knott ($p<0.05$).

Table 10 presents carcass, bone-in breast, deboned breast, and leg yield results. These parameters were not ($p>0.05$) influenced by the evaluated treatments. These results are consistent with the findings of Halle *et al*. (2006), who showed that creatine supplementation (1g, 2g, 5g, or 10g/kg) to a corn- and soybean meal-based diet did not affect carcass yield during the same period. Junqueira *et al*. (2000) and Faria Filho *et al*. (2002) did not find any effect of the dietary inclusion of MBM on the carcass yield of broilers during the same period. The obtained results show that the dietary inclusion of animal meals did not affect carcass yield; however, feed cost may be reduced in 7%, in average (Tables 2, 3, and 4).

Table 10 – Carcass yield of 42-d-old broilers fed diets containing or not animal meals and creatine.

Treatments	CY (%)	Bone-in breast	Deboned breast	Leg
A	65.00a	36.44a	29.31a	28.96a
B	64.98a	36.61a	28.85a	29.38a
C	65.17a	35.88a	28.96a	29.38a
D	64.96a	36.18a	29.45a	28.90a
E	63.81a	36.43a	29.47a	28.02a
F	64.06a	36.29a	28.82a	28.22a
CV	3.03	6.15	9.06	4.14

A-control feed; B-Control+Creatine; C-Inclusion of 5% MBM; D-Inclusion of 5% MBM+Creatine; E-Inclusion of 5% BM; F-Inclusion of 5% BM+Cretine.
Means followed by different letters in the same column are different by the test of Scott-Knott ($p<0.05$).

CONCLUSION

Creatine supplementation did not influence the performance or carcass yield of broilers fed diets containing meat and bone meal. However, when broilers were 42 days of age, the addition of creatine in the feed with blood meal inclusion improved weight gain compared with the same feed with no creatine.

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