METABOLISM AND NUTRITION

Effect of arginine on the development of the pectoralis muscle and the diameter and the protein:deoxyribonucleic acid rate of its skeletal myofibers in broilers

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ABSTRACT This work aimed at evaluating the effects of the supplementation of starter diet with Arg on breast muscle development in broilers and the activation of satellite cells and the aggregation of myofibrillar protein. Male Cobb chicks (n = 990) were randomly assigned to 1 of 5 treatments in a complete random design. Measurements of 33 chicks per treatment were made in 6 repetitions. The treatments consisted of a basal diet with 1.390% digestible Arg (without supplementation) and 4 dietary levels of Arg (1.490, 1.590, 1.690, and 1.790%) with Arg:Lys ratios of 1.103, 1.183, 1.262, 1.341, and 1.421, respectively. Arginine supplementation was used only in the starter phase (1 to 21 d). Dietary supplementation with Arg had a positive effect ($P < 0.05$) on breast and breast fillet weight on d 7 and 21 and on myofiber diameter on d 14 and 21. However, no effect was observed ($P > 0.05$) on the protein:DNA ratio, which demonstrates that Arg does not interfere with the mitotic activity of the satellite cells. Independently from mechanism, Arg affected muscle growth in the starter phase positively. Dietary supplementation with Arg in the starter phase had no effect ($P > 0.05$) on the carcass yield of broilers on d 42. Diet supplementation with Arg at levels above the ones recommended for the starter phase may be necessary for improved muscle development in broilers.

Key words: insulin-like growth factor I, satellite cell, breast fillet weight, protein:deoxyribonucleic acid ratio

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INTRODUCTION

Because the myofibers of chicks are already formed at hatching, posthatching muscle growth depends on muscle hypertrophy (Smith, 1963). Muscle cells are multinuclear and the protein synthesis in myofibers is influenced by the quantity of DNA in the nuclei. Although the nuclei are postmitotic, there is a significant increase in muscle DNA during posthatching growth. The increase in muscle DNA results from the activity of satellite cells, myogenic precursors present in skeletal muscles. They start to develop during the last embryonic phase and are capable of proliferating, differentiating, and joining existing fibers or merging with others to form new fibers (Moss, 1968). Satellite cells are responsible for the generation of nuclei in secondary myofibers (Bischoff, 1975). This process is responsible for about 98% of the final DNA content of myofibers, which maintains the cytoplasm volume and the number of myonuclei, and therefore increases protein synthesis (Halevy et al., 2003; Duclos, 2005). The high number of satellite cells at hatching decreases sharply with the beginning of development. Some remain quiescent and are reactivated only in the case of muscle injury (Hawke and Garry, 2001).

The availability of food to chicks after hatching is a primordial condition for the stimulation of the proliferation of satellite cells, their incorporation into myofibers, and muscle growth (Uni and Ferket, 2004).

The posthatching nutrition of high-yield broiler lines has been the subject of much attention due to the importance of maximizing protein deposition and muscle growth. The nutritional strategy adopted to enhance the early development of chicks must not be restricted only to weight gain. It must also include the improvement of muscle yield.

Arginine is a protein constituent that is involved in the secretion of insulin by pancreas β cells (Bolea et al., 1997) and of growth hormone (**GH**; Merimee et al., 1969). The effects of GH are mediated by insulin-like growth factors (**IGF**; IGF-I and IGF-II; Le Roith et

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al., 2001). Insulin-like growth factor is known to trigger numerous anabolic effects in the metabolism of skeletal muscles such as the proliferation and differentiation of satellite cells (Florini et al., 1996) and the aggregation of myofibrillar protein through its combined effects on the synthesis and degradation of proteins (Duclos et al., 1991; Coleman et al., 1995; Duclos, 2005).

Arginine is considered an essential amino acid in birds, particularly in the starter phase of development after hatching. Birds are incapable of synthesizing Arg because the urea biochemical cycle is not functional. Birds have the highest requirement of Arg among the studied animals (Ball et al., 2007). This is explained by the lack of endogenous synthesis and the high protein deposition rate due to the fast growth of the broiler lines currently raised, in addition to the antagonist metabolic interaction between Lys and Arg (Edmonds and Baker, 1987). High levels of Lys result in high arginase activity in the kidneys and, consequently, the degradation of Arg (Austic and Scott, 1975).

With the constant technological advances and the raising of highly specialized birds with a large genetic growth potential, it is common to supplement diets with Lys. The main role of Lys is to participate in protein synthesis and increased levels seem to be related to carcass yield optimization (Acar et al., 1991).

Physiological and biochemical knowledge of deposition of muscle tissue is invaluable in the manipulation of growth. Despite evidence for the participation of Arg in the secretion of IGF (Hurson et al., 1995; Chevalley et al., 1998), its actual role in muscle growth in birds, mainly in broiler lines with fast growth, has not been elucidated yet.

This work aimed at evaluating the effects of the supplementation of broiler starter diet with Arg on muscle development, the activation of satellite cells, and the aggregation of myofibrillar protein.

MATERIALS AND METHODS

The experiment was conducted in the poultry sector of the Iguatemi Experimental Farm with the approval of the Animal Experimentation Ethics Committee of the State University of Maringa.

Male Cobb 500 chicks (n = 990) produced by 39-wk-old broiler breeders were assigned in a complete random design to dietary supplementation groups of 33 chicks per pen in a total of 30 experimental units submitted to 5 levels of Arg and 6 replicate measurements. The open-sided house had thermostatically controlled heating and ventilation and each pen (0.173 m^2/bird) had rice husk and was equipped with 1 feeder and 1 drinker. Birds had free access to feed and water during the experimental period. Permanent artificial illumination was applied. The average temperature was 25 ± 2°C and relative humidity was 61 ± 10% through experimentation. The nutritional program was divided in 2 phases, a starter phase (d 1 to 21) and a growth phase (d 22 to 42). Corn and soy meal-based diets were formulated in accordance with the chemical composition of the foods and the nutritional recommendations of Rostagno et al. (2000). Increasing levels of supplementary Arg were obtained by adding L-Arg (0, 0.1, 0.2, 0.3, and 0.4% increments) to the starter basal food as a replacement of the inert component. The digestible Arg dietary levels were 1.390, 1.490, 1.590, 1.690, and 1.790% (Table 1) with Arg:Lys ratios of 1.103, 1.183, 1.262, 1.341, and 1.421, respectively. From the age of 22 d on, all birds received conventional growth feed with 19.7% CP, 3,150 ME of kcal/kg, 1.099% Lys, and 1.249% Arg.

The chemical compositions of the experimental diets were calculated in accordance with Silva (1990) and the amino acid contents were determined by HPLC according to Motter (1991).

At the ages of 7, 14, 21, and 42 d, 2 birds per pen were randomly selected and killed (12 birds/treatment) by cervical dislocation and weighed individually. The breasts were removed and weighed. The left breast fillet (pectoralis major) was weighed and its thickness (mm) was measured with a digital caliper. Breast fillet length and width (cm) were measured with a ruler.

After removal of the right pectoralis major, 2 samples (12 samples/treatment) were kept at room temperature for 15 min (Khan, 1977). After cleaning and fragmentation to approximately 1 cm × 0.5 cm, the samples were labeled, frozen, and stored in liquid nitrogen containers until processing. The muscle fragments were transferred to a cryostat chamber with embedding medium for frozen tissue specimens (Sakura Finetek Europe B.V., Zoeterwoude, the Netherlands) for processing. Fiber sample cross sections about 8 μm thick were stained with hematoxylin-eosin for general tissue morphological evaluation and measurement of fiber diameter. In the morphometric study, images were captured using a light microscope (Olympus Bx 40, Artisan Scientific Corporation, Champaign, IL) and a system that analyzes computerized images (Image Proplus 5.2, Media Cybertechnics, São Paulo, Brazil).

Ten muscle tissue images were captured for each evaluated bird with final magnification equivalent to a 10× eyepiece and a 10× objective. Twenty myofibers, totaling 200 myofibers per bird (2,400 fibers/treatment), were measured in each image by the least diameter method, according to Dubowitz (1985).

The quantity of DNA in the breast muscle was evaluated after DNA extraction from the 2 fragment samples of the pectoralis major of every experimental unit (12 samples/treatment).

The DNA was extracted from 50 mg of muscle tissue for genomic isolation with DNeasy Tissue from Qiagen (Hilden, Germany). Next, it was analyzed by spectrophotometry to evaluate extraction yield at A260 and A280. The values were plotted for milligrams of tissue.

The samples were thawed, ground, and dissolved in lyse buffer solution (PBS-T) for the determination of soluble proteins. The solution (1%, g/vol) was centrifuged at 13,000 × *g* for 15 min and the soluble proteins were determined by colorimetric analysis of the super-

Table 1. Composition of experimental diets of broilers in the starter phase (1 to 21 d of age)

	Digestible Arg (%)				
Item	1.390	1.490	1.590	1.690	1.790
Ingredients (%)					
Corn	54.00	54.00	54.00	54.00	54.00
Soybean oil	3.5	3.5	3.5	3.5	3.5
Soybean meal	37.94	37.94	37.94	37.94	37.94
Salt	0.284	0.284	0.284	0.284	0.284
Sodium bicarbonate	0.241	0.241	0.241	0.241	0.241
Calcitic limestone	0.796	0.796	0.796	0.796	0.796
Dicalcium phosphate	1.923	1.923	1.923	1.923	1.923
DL-Met	0.296	0.296	0.296	0.296	0.296
L-Lys	0.246	0.246	0.246	0.246	0.246
L-Thr	0.117	0.117	0.117	0.117	0.117
L-Arg	0	0.101	0.202	0.303	0.404
Inert (kaolin)	0.500	0.399	0.298	0.197	0.096
Butylated hydroxytoluene	0.01	0.01	0.01	0.01	0.01
Mineral and vitamin premix[1,2]	0.150	0.150	0.150	0.150	0.150
Calculated values					
CP (%)	22.4	22.4	22.4	22.4	22.4
ME (kcal/kg)	3,047	3,047	3,047	3,047	3,047
Ca (%)	0.920	0.920	0.920	0.920	0.920
Nonphytate P (%)	0.471	0.471	0.471	0.471	0.471
Digestible TSAA (%)	0.890	0.890	0.890	0.890	0.890
Digestible Lys (%)	1.260	1.260	1.260	1.260	1.260
Digestible Trp (%)	0.252	0.252	0.252	0.252	0.252
Digestible Thr (%)	0.850	0.850	0.850	0.850	0.85
Total Arg (%)	1.479	1.579	1.679	1.779	1.879
Digestible Arg (%)	1.390	1.490	1.590	1.690	1.790
Sodium (%)	0.220	0.220	0.220	0.220	0.220
Chloride (%)	0.200	0.200	0.200	0.200	0.200

[1]Initial vitamin mixture (content per kg of diet): vitamin A, 10,500 IU; vitamin D_3, 3,300 IU; vitamin E, 16.50 mg; vitamin K_3, 2.40 mg; vitamin B_1, 3.00 mg; vitamin B_2, 7.50 mg; vitamin B_{12}, 18.00 mg; niacin, 52.50 mg; pantothenic acid, 19.50 mg; folic acid, 1.20 mg.

[2]Mineral mix (content per kg of diet): iron, 15.00 mg; copper, 24.00 mg; iodine, 3.60 mg; zinc, 150.00 mg; manganese, 210.00 mg; selenium, 0.60 mg.

natant by the Bradford method (Bradford, 1976). Bovine serum albumin was used as a standard protein.

Carcass yield was determined in 2 birds at random per experimental unit (12 birds/treatment). The birds were identified and fasted for 6 h and killed by electric stunning and bleeding.

Carcass yield was calculated as the ratio of hot eviscerated carcass and the BW before euthanasia. Prime cut yield (whole breast, thigh, and legs, all with skin and bones) was calculated in relation to the weight of the eviscerated carcass.

Abdominal fat around the cloaca, in the bursa of Fabricius, gizzards, proventriculus, and adjacent abdominal muscles, was removed as described by Smith (1993). Next, the carcass was weighed and the carcass yield was calculated in relation to the eviscerated carcass.

The data were submitted to regression analysis by polynomial decomposition of the degrees of freedom in relation to the levels of Arg. The data were analyzed with software SAEG (Universidade Federal de Viçosa, 1997) using the statistical model:

$$Y_{ij} = b_0 + b_1A_i + b_2A_i + b_3A_i + e_{ij},$$

where Y_{ij} = observation of the dependent variable in the experimental unit j submitted to level i of Arg, i: 1, 2, 3, 4, 5 (1 = 1.390%; 2 = 1.490%; 3 = 1.590%; 4 = 1.690%; 5 = 1.790%); b_0 = constant; b_1, b_2, and b_3 = linear, quadratic, and cubic regression coefficients of the dependent variable as a function of the levels of Arg; e_{ij} = random error associated with each Y_{ij} observation.

The determination coefficients were calculated as percentages of the sum of the squares of the model in relation to the total sum of squares.

RESULTS AND DISCUSSION

The determined experimental amounts of total Arg in the diets were 10% higher than the calculated values.

Breast muscle growth (breast and breast fillet weight, breast fillet thickness, breast fillet width and length), myofiber diameter, and protein:DNA ratio for different levels of Arg are given in Table 2.

Breast and breast fillet weight and breast fillet thickness at d 7 increased linearly ($P < 0.05$) with the Arg level in diet (Figure 1). Breast fillet width and length were not affected ($P > 0.05$) by the levels of Arg at the studied ages.

No effect ($P > 0.05$) was observed on either breast weight or breast fillet size at d 14. Breast fillet weight varied quadratically ($P < 0.05$) with the Arg level, peaking at 1.560% Arg (Figure 2).

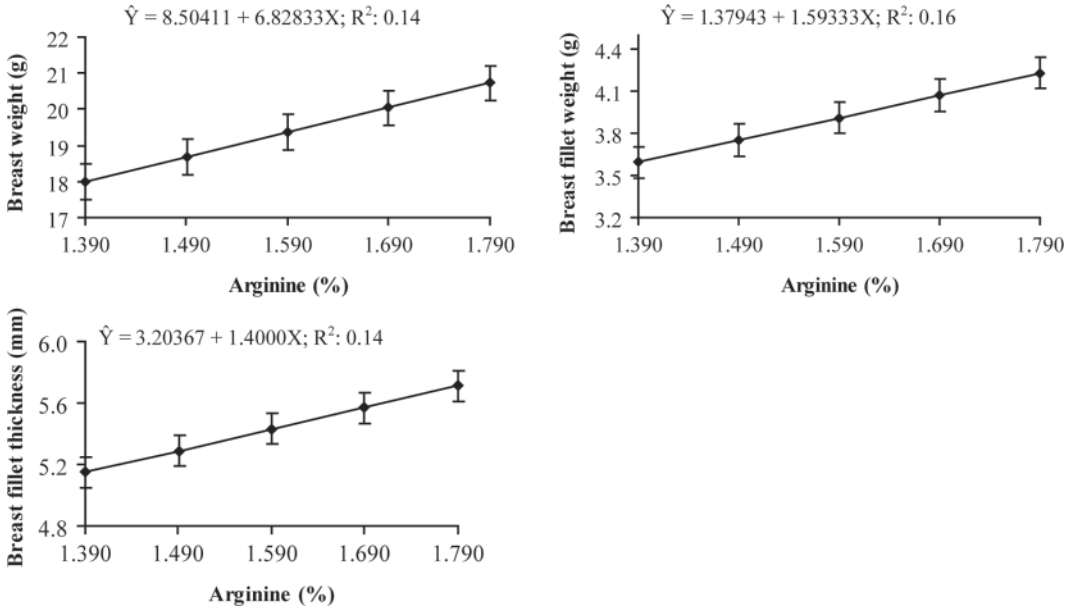

Figure 1. Breast and fillet weight and fillet thickness of 7-d-old broilers fed starter diets with varying levels of Arg.

At d 21, the breast weight value was cubic ($P < 0.05$). Despite this behavior, the linear evolution observed between 1.490 and 1.690% indicates that these levels of Arg supplementation resulted in increased breast weight (Figure 3). Larger amounts of Arg may be required to maximize breast fillet weight and thickness because they increased linearly ($P < 0.05$) with Arg supplementation (Figure 3).

Table 2. Means and estimates of breast muscle growth parameters, skeletal myofiber diameter, and protein:DNA ratio of broilers fed diets with different levels of Arg from 1 to 21 d of age

	Digestible Arg (%)						
Item	1.390	1.490	1.590	1.690	1.790	CV (%)	Effect
7 d							
Breast weight (g)	18.00	18.68	19.36	20.04	20.73	13.78	Linear
Breast fillet weight (g)	3.59	3.75	3.91	4.07	4.23	14.54	Linear
Breast fillet thickness (mm)	5.15	5.29	5.43	5.57	5.71	9.81	Linear
Breast fillet length (cm)	6.14	6.28	6.19	6.14	6.02	6.25	NS[1]
Breast fillet width (cm)	1.88	1.97	1.98	1.95	2.10	8.50	NS
Myofiber diameter (μm)	12.71	12.01	13.20	13.04	13.42	9.28	NS
Protein:DNA ratio	12.09	11.99	12.67	12.36	12.00	24.72	NS
14 d							
Breast weight (g)	66.87	71.18	64.82	66.45	62.05	8.06	NS
Breast fillet weight (g)	13.47	14.18	14.29	13.82	12.77	9.63	Quadratic
Breast fillet thickness (mm)	7.70	8.01	7.48	8.04	7.15	8.13	NS
Breast fillet length (cm)	8.99	8.99	8.84	9.05	8.89	3.60	NS
Breast fillet width (cm)	2.91	3.13	3.00	3.04	3.04	5.43	NS
Myofiber diameter (μm)	17.43	16.93	17.15	18.10	19.77	5.12	Quadratic
Protein:DNA ratio	25.99	23.35	25.20	26.13	25.20	27.06	NS
21 d							
Breast weight (g)	153.04	151.54	161.71	168.49	156.85	7.79	Cubic
Breast fillet weight (g)	32.20	33.20	34.21	35.22	36.22	12.91	Linear
Breast fillet thickness (mm)	10.81	11.14	11.48	11.81	12.14	11.24	Linear
Breast fillet length (cm)	11.78	11.86	11.79	12.30	11.65	3.93	NS
Breast fillet width (cm)	4.11	4.23	4.20	4.33	4.20	5.60	NS
Myofiber diameter (μm)	30.65	32.24	33.12	33.28	32.72	7.00	Quadratic
Protein:DNA ratio	32.08	34.84	31.40	34.90	35.43	22.13	NS
42 d							
Breast weight (g)	608.39	575.58	606.83	616.08	595.48	6.41	NS
Breast fillet weight (g)	141.09	134.57	142.79	143.35	139.51	7.84	NS
Breast fillet thickness (mm)	20.57	21.73	22.34	22.39	21.89	7.46	NS
Breast fillet length (cm)	17.83	17.48	17.53	17.84	17.54	3.30	NS
Breast fillet width (cm)	6.62	6.53	6.57	6.51	6.50	3.59	NS
Myofiber diameter (μm)	44.89	44.93	43.56	46.13	44.29	5.55	NS
Protein:DNA ratio	41.58	43.05	41.89	40.62	37.96	17.41	NS

[1]$P > 0.05$.

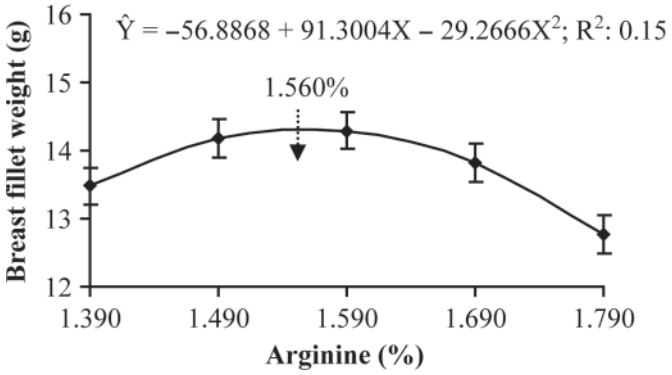

Figure 2. Breast weight of 14-d-old broilers fed starter diets with varying levels of Arg.

At d 42, the Arg levels did not affect ($P > 0.05$) any development measurement. It is important to consider that Arg supplementation was used only in the starter phase (1 to 21 d). During the growth phase, all birds received the diet with 1.290% digestible Arg, a level much lower than the used levels in the initial phase. This lack of response may suggest that an increase in Arg is crucial for improved muscle development in broilers after 21 d, based on the increasing breast fillet weight and the myofiber diameter observed on the 21st day.

The Arg:Lys ratio of the Arg levels for the best breast development in the starter phase is around 1.30, a value much higher than the recommended 1.05 and 1.02 (NRC, 1994; Rostagno et al., 2000).

Myofiber diameter varied only at d 14 and 21. At these ages, the quadratic effect ($P < 0.05$) led to maximum Arg levels of 1.510 and 1.662% Arg, respectively (Figure 4).

The hypertrophy of the myofibers after hatching is initially longitudinal to the fiber due to the increase in the number of sarcomeres and later diametric due to the deposition of myofibrillar proteins (Lawrence and Fowler, 2002). Thus, the contribution of the fiber length at d 7 may have been larger than that of its diameter; the sum of the 2 effects resulted in heavier breast and breast fillet.

The evaluation of the fiber diameter can indicate both muscle hypertrophy and meat quality. The fiber diameter is associated with meat firmness and resistance. Broiler lines with high muscle yield present metabolic postmortem variations, mainly in breast muscle, and higher susceptibility to muscle damage potentially associated with the PSE condition (Velleman, 2007). Possibly, large myofiber diameter limits the energy and oxygen supply by reducing vascularization. Additionally, the elimination of metabolic residues such as CO_2 and lactate in the antemortem period is probably also more difficult.

Thus, the improvement of muscle protein deposition in these broiler lines must be monitored to evaluate meat quality. Attributes such as appearance and consistency determine meat acceptance by consumers.

The number of myofibers may also be associated with commercial broiler line selection programs. Scheuermann et al. (2004) demonstrated that the breast of broiler lines has twice as many fibers as that of laying hens. It could potentially be used to explain yield differences among the commercially available broiler; however, the number of myofibers has not been clearly demonstrated for the breast muscles because of methodological difficulty in estimating the myofiber number in pennate muscles.

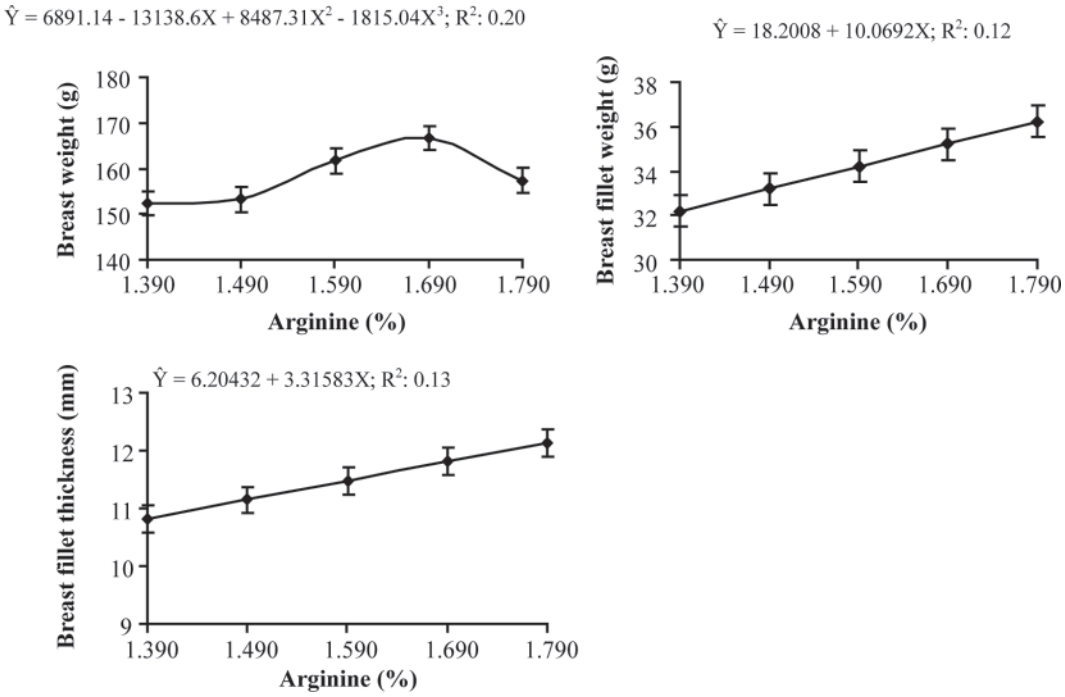

Figure 3. Breast and fillet weight and fillet thickness of 21-d-old broilers fed starter diets with varying levels of Arg.

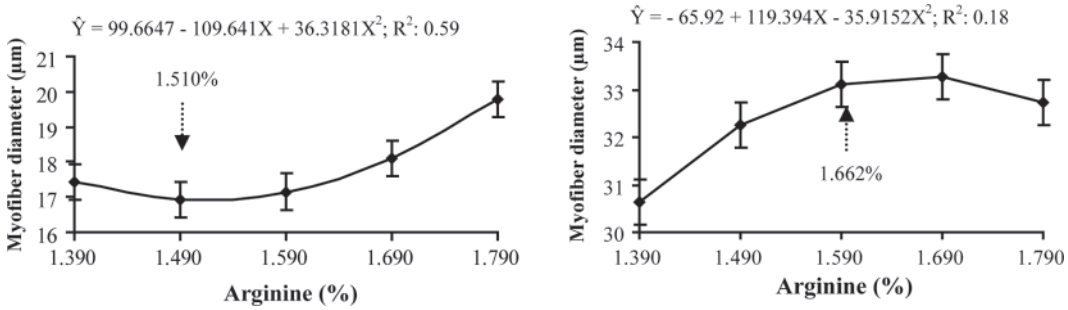

Figure 4. Myofiber diameter of 14- and 21-d-old broilers fed starter diets with varying levels of Arg.

Arginine supplementation had no effect ($P > 0.05$) on the protein:DNA ratio at any age. There was an increase in the protein:DNA ratio with age in the experimental period, which was attributed to the larger mitogenic and proteic activity of young animal cells (Table 2), which is in agreement with literature results (Uni et al., 1998).

Satellite cells are active mainly in the first days after hatching, but their mitotic activity at 7 d of age is reduced to one-third compared with that of the first day of life (Moore et al., 2005). Because the increase in the protein:DNA ratio reflects an increase in tissue mass without an increase in the number of muscle cells, the lack of correlation between the protein:DNA ratio and the Arg level, mainly on d 7, showed that Arg supplementation did not enhance satellite cell mitotic activity by stimulating IGF-I secretion, as suggested by studies on mammals.

The lack of Arg response on the protein:DNA ratio can be attributed to the method used to study the satellite cell activation, due to the complex contributions from DNA or RNA nonmuscle tissues. Other methods to study satellite cells can provide a more comprehensive response, as cell muscle culture and thymidine incorporation into new DNA (Halevy et al., 2003).

Mozdziak et al. (1994) suggest that nutritional manipulations aimed at the satellite cell population may target the embryonic phase of muscle. However, nutritional supplementation during the early phase of growth has failed to stimulate increases in satellite cell mitotic activity while achieving a larger breast muscle size.

In contrast, it is hypothesized that Arg supplementation might stimulate the secretion of IGF-I effectively if carried out during the embryonary period by in ovo application. Kikuchi et al. (1991) detected IGF-I in embryo plasma as early as at the ninth day of hatching, peaking between the 15th and the 17th days, when secondary myofibers are formed (Kocamis and Killefer, 2003). The treatment of embryos also increased the BW of chick at hatching (Girbau et al., 1987). The release of IGF is important for the regulation of muscle hyperplasia because it stimulates the proliferation and differentiation of myoblasts, which increases the number of myofibers.

The effect of Arg supplementation on muscle growth may have been independent of the rise in GH or IGF-I in plasma, as also observed by Kim et al. (2004). They observed increased weight gain in swine in the absence of changes in anabolic hormone concentrations in plasma. Arginine supplementation contributed to the muscle hypertrophy observed in the starter phase, probably by improving the efficiency of nutrient usage. This process is related to the protein turnover efficiency [i.e., the net balance between protein synthesis and degradation, as defined by Tesseraud et al. (1996)].

Sklan and Noy (2004) observed that changing the amino acid ratios and content of the diet alters the catabolism of amino acids much more than their anabolism, which shows the importance of nonessential amino acids. Moran and Stilborn (1996) reported that dietary supplementation with Glu increased the synthesis and decreased the degradation of skeletal muscle in broilers; however, this effect has not been studied for Arg yet.

In high-performance broiler lines, growth and muscle development may be associated with the reduction of protein catabolism. Dransfield and Sosnicki (1999) demonstrated that the enzymes that inhibit muscle proteolysis are more active in broilers than in lines with slow growth, which may also explain the diverse responses to amino acid supplementation of different lines.

The carcass evaluation results of broilers fed varying levels of Arg in diet are given in Table 3. None of the parameters evaluated were affected ($P > 0.05$) by Arg supplementation.

Carcass yield results were obtained after Arg supplementation in the starter phase (1 to 21 d). This explains the lack of response to Arg levels in diet in the growth phase, which may be attributed to the sharp decrease in the Arg levels. A positive effect of Arg levels on breast and breast fillet weight was observed in the starter phase (Table 2).

The observed responses of carcass and cut yield to Arg supplementation are ambiguous in relation to literature results. Mendes et al. (1997) reported improved carcass yield and reduced abdominal fat in broilers in relation to the Arg:Lys ratio.

Costa et al. (2001) reported that carcass yield, breast with skin and bone, and breast fillet were not influenced by supplementation of digestible Arg in 6 levels (from 1.00 to 1.400%) and fixed Lys (1.160%). In contrast, thigh and leg yield and abdominal fat increased linearly with Arg supplementation.

Table 3. Mean carcass yield of broilers fed diets with varying levels of Arg from age 1 to 21 d and measured at the age of 42 d

	Digestible Arg (%)						
Item	1.390	1.490	1.590	1.690	1.790	CV (%)	Effect
Live weight (g)	2,833.33	2,807.08	2,683.75	2,795.00	2,688.33	4.87	NS[1]
Carcass weight[2] (g)	1,875.33	1,868.00	1,793.83	1,863.83	1,785.00	5.61	NS
Carcass yield[3] (%)	66.12	66.56	66.81	66.69	66.36	2.01	NS
Breast yield (%)	35.80	36.82	36.12	36.22	37.09	2.82	NS
Thigh and leg yield (%)	32.26	31.52	32.33	32.17	31.73	2.94	NS
Abdominal fat yield (%)	1.88	2.22	1.66	2.04	1.90	20.51	NS

[1]$P > 0.05$.

[2]Carcasses without neck, giblets, and abdominal fat.

[3]Expressed on a relative basis to the full-fed live weight.

Atencio et al. (2004) found no significant difference in cut weight with the addition of digestible Arg to diet between either d 24 and 38 (1.08 to 1.29%) or 44 and 56 (0.96 to 1.23%), which was attributed to the fact that the Arg levels were as recommended.

High levels of Arg in the first phase did not affect abdominal fat deposition either, which disagrees with that reported by Mendes et al. (1997) and Costa et al. (2001) for Arg supplementation. The absence of effect on abdominal fat also demonstrates that Arg supplementation 30% over the recommended level does not affect the balance of essential and nonessential amino acids in experimental diets. The bird lipid content is significantly affected by nutritional variations, particularly by the amino acid composition.

Arginine supplementation of broiler starter diets over the recommended levels does not interfere with the mitotic activity of satellite cells. In spite of this, high breast and breast fillet weight and the diameter of skeletal myofibers were obtained by Arg supplementation in the starter phase (1 to 21 d). Broiler carcass yield was unaffected by Arg levels in the starter diet. Dietary supplementation with Arg at levels above the ones recommended for the growth phase may be necessary for improved muscle development in lines with fast-growth broilers.

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