REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 23, No. 2 (2022)
http://www.veterinaria.org
Article Received: 28 December 2021; Revised: 20 January 2022; Accepted: 21 January 2022; Publication: 30 March 2022

Carcass Characteristics and Meat Quality of Growing Japanese Quails Fed Diets Containing Calcareous Algae

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ABSTRACT

The objective was to evaluate the replacement of limestone (CC) by calcareous algae (CA I and II) in the diet of Japanese quails, in the growing phase, on carcass yield and meat quality. A total of 300 Japanese quails were used, distributed in a completely randomized design, with three treatments, 10 replicates and 10 birds per experimental unit. The treatments consisted of: basal diet (BD); BD with 0.50% replacement of CC by AC I; BD with 0.50% replacement of CC by AC II. Carcass and viscera yield, and quality variables such as pH and breast luminosity were evaluated. There was no difference between calcium sources in yield and meat quality. The replacement of 0.50% of limestone by any of the calcareou algae can be used in the Japanese quails diet without harming carcass yield and meat quality in the growing phase.

Keywords
Bone quality; *Lithothamnium calcareum*; Organic minerals; Performance; Quail farming; Performance.

Introduction

With the intensification in the production of Japanese quails, they began to get heavier with larger eggs, but there is still no standardization of commercial strains, which leads to variations in performance results. Thus, it is essential to verify the need for minerals for birds, in order to meet their requirements, maximizing animal productivity.

The metabolism of calcium (Ca) and phosphorus (P) is essential for the homeostasis of the animal, birds of the semi-heavy category need a high amount of calcium, which will be important for the formation of the eggshell, for bone and muscle metabolism [1]. The animal's muscular system performs several important functions in the organism, such as movement, organ volume regulation, heat production, among others [2]. The development of living beings is related to the muscle growth of the animal, so meeting their requirements is essential, in order to achieve maximum performance. Deficiency of Ca and/or P, as well as their imbalance in the diet, can reduce the growth of the animal and lead to the occurrence of injuries or disturbances, generating losses in the performance.

Japanese quails, there is still little information in the literature about nutritional requirements [3]. But with the advancement of poultry in the scope of broilers and laying hens, nutritional knowledge and nutritional management can be based and applied with adjustments to quails according to the animal's responses.

The minerals represent 3 to 4% in the live weight of birds, and act in important metabolic pathways for their growth and reproduction, and are also responsible for maintaining the physiological status and production [4]. The use of Ca, directly dependent on the age of the bird

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[2]. The growth period is the one that most demands the proportion of dietary Ca that is directed to the formation of bones, differing from the adult phase where there is a greater demand for this mineral to compose the eggshell [5]. For the formation of the egg, about 30% of the Ca from the bones is used.

The Ca deficiency in laying hens causes growth depression, bone fragility, and a drop in feed intake. During the laying phase, the egg may have a thin shell, reduced production, and decreased bone ash and Ca concentration [6]. The P in turn has an action in the metabolism and absorption of Ca, where 80% of the P is associated with Ca for bone formation to occur, with the remainder in the soft tissues. Among some functions of the P, we can mention hydroxyapatite, which refers to participation in bones, is also found in cell membranes in the form of phospholipids (lectin), phosphate present in DNA and RNA molecules and in the form of potential energy being ATP and ADT [7].

Therefore, the objective of this study is to evaluate the replacement of inorganic calcium sources (limestone) by organic sources (calcareous algae) in the diet of Japanese quails in the growing phase and their influence on carcass yield and meat quality.

Material and Methods

The experiment was conducted at the poultry facilities of the Department of Animal Science at the Federal University of Grande Dourados (UFGD), Dourados, Mato Grosso do Sul, Brazil. All procedures in this study were condecuted according to the protocol with registration number 16/2020 and were approved by the Ethics Committee for Animal Use of the UFGD.

A total of 300 Japanese quails 21 days old with na average weight of 87±5 g. Birds were distributed in a completely randomized design with three treatments, 10 replicates, and 10 birds per experimental unit. Treatments consisted of basal diet (T1) with the replacement of 0.50% of limestone by two calcareous algae (T2 and T3). The experimental period was 21 days (growing phase).

The experimental diets were isonutritive, based on maize, soybean meal, amino acids and vitamin-mineral supplements and formulated according to the nutritional requiriments of the species [8]. The calcareous algae used were purchased from commercial companies. Tables 1 and 2 present the percentage composition of calcium sources, and the percentage and nutritional composition of the diets.

Table 1. Calcareous algae and limestone composition

Composition	Calcareou algae 1	Calcareou algae 2	Limestone
Crude ash (%)	96.00	95.00	97.70
Calcium (%)	34.50	32.39	39.90
Magnesium (%)	3.60	5.00	0.32
Sodium (%)	0.34	0.35	-
Potassium (%)	0.04	0.04	-

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Phosphorus (%)	0.03	0.03	-
Iron (ppm)	77.60	85.00	90.00
Copper (ppm)	7.20	7.25	-
Zinc (ppm)	4.58	5.50	-
Manganese (ppm)	1.47	1.53	-
Molybdenum (ppm)	0.20	0.25	-
Selenium (ppm)	0.50	0.50	-

Adapted: Dias et al. (2000)

Table 2. Formulae and centesimal composition of experimental diets

Ingredients	Limestone	Calcareou algae 1	Calcareou algae 2
Corn	49.23	49.23	49.23
Soybean meal	43.35	43.35	43.35
Soy oil	2.50	2.50	2.50
Inert	2.00	2.00	2.00
Limestone	1.23	0.73	0.73
Calcareou algae 1	-	0.50	-
Calcareou algae 2	-	-	0.50
Dicalcium phosphate	0.89	0.89	0.89
Common salt	0.32	0.32	0.32
DL-Methionine	0.16	0.16	0.16
L-Lysine	0.12	0.12	0.12
Mineral supplement[1]	0.10	0.10	0.10
Vitamin supplement[2]	0.10	0.10	0.10
Calculated composition			
Met. energy (Kcal/kg)	2.900	2.900	2.900
Crude protein (%)	24.36	24.36	24.36
Dig. lysine (%)	1.095	1.095	1.095
Dig. met. + cys. (%)	0.744	0.744	0.744
Dig. trypt. (%)	0.186	0.186	0.186
Dig. thre. (%)	0.733	0.733	0.733
Calcium (%)	1.092	1.092	1.092
Available phosphorus (%)	0.513	0.513	0.513
Sodium (%)	0.205	0.205	0.205

[1]Provided per kg of product: Copper 7.000.0 mg; Iron 50.0 g; Iodine 1.500.0 mg; Manganese 67.5 g; Zinc 45.6 g; Selenium 12.5 g. [2]Provided per kg of product: Folic acid 145.4 mg; Pantothenic acid 5.931.6 mg; Choline 121.8 g; Niacin 12.9 g; Vitamin A 5.000.000.0 UI; Vitamin B12 6.500.0 mcg; Vitamin B2 2.000.0 mg; Vitamin B6 250.0 mg; Vitamin D3 1.850.000.0 UI; Vitamin E 4.500.0 UI; Vitamin K3 918.0 mg.

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All birds were housed in 30 experimental cages made of galvanized wire, measuring 25 x 35 x 20 cm (width x length x height), totaling an area of 175 cm²/bird housed, equipped with nipple-type drinkers, trough-type feeders and excreta trays.

Maximum and minimum temperatures during the experimental period were recorded by using a digital thermo hygrometer. The maximum and minimum values recorded were 32.6º C and 19.1ºC, respectively. The maximum and minimum relative humidity were 84.62% and 33.75%, respectively. The light program used was natural photoperiod so that the birds did not reach sexual maturity prematurely.

Feed and water were provided freely during the experimental period. The internal heating of the shed where the batteries were installed was carried out using incandescent lamps and using curtains when necessary.

On the 42nd day of age, 10 birds were selected per treatment, one bird per replicate, with body weight between -10 and +10% of the average weight of the respective plot. The selected birds were submitted to a six-hour fasting period, euthanized by cervical dislocation and sacrificed by bleeding from the jugular, scalded at 58º C, manually plucked and eviscerated to evaluate the carcass yield. The percentage yield of edible and inedible viscera and abdominal fat were calculated by the ratio between the average weight of the representative cut of each repetition and the carcass weight according to the formula:

$$Carcass\ yield\ (\%) = \frac{Cutting\ weight}{Carcass\ weight}\ x\ 100$$

For meat quality analysis, breast muscle (*Pectoralis major*) was used. The parameters evaluated were: pH 24h, luminosity (L*), red/green content (a*) and yellow/blue content (b*).

The determination of pH 24h was performed using a glass body penetration electrode in four different points of the chest muscle, two in the upper part and two in the lower part [9]. The device used was a potentiometer (Oakton, pH 300, series 35618) with automatic temperature compensation. For the analysis of the luminosity (L*), the red/green content (a*) and the yellow/blue content (b*), a portable colorimeter was used, where the parameters of the CIElab system were read, with a source D65 illuminant, calibrated in standard white porcelain with Y=93.7, x=0.3160 and y=0.3323. The average of three readings obtained at different points of the muscle free of injuries was considered as the final value, in the ventral region, two in the cranial part and two in the central part, with the muscle on an opaque surface [9].

Data Analysis

Data were checked for normality of residuals using the Shapiro-Wilk test and homogeneity of variances using Levene's test. Subsequently, they were submitted to analysis of variance (ANOVA) and compared by Tukey's test, adopting α=0.05. The analyses were carried out using the SAS computational package (SAS 9.3).

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Results and Discussion

Differences (P<0.05) were observed for some carcass yield variables. Birds fed with sources of calcareous algae showed higher absolute and relative weight of the drumstick. For the other variables, no differences were observed (P>0.5) (Table 3).

Table 3. Carcass yield, cuts and meat quality of quails fed different sources of calcium in the diet in the growing phase.

Variables	Treatments			SEM	P value
	Limestone	Calcareou algae 1	Calcareou algae 2		
Live weigth (g)	142.70	144.60	142.90	0.001	0.8363
Carcass (g)	122.60	125.10	124.70	0.001	0.7752
Gutted carcass (g)	100.90	104.50	101.11	1.827	0.6759
Breast (g)	37.08	38.25	35.75	0.724	0.3925
Drumsticks (g)	11.19 b	11.63 ab	12.63 a	0.233	0.0238
Thighs (g)	8.96	9.24	9.14	0.187	0.8326
Wings (g)	7.58	7.87	7.42	0.152	0.5078
Back (g)	23.67	24.31	22.72	0.743	0.7154
Feets (g)	2.74	2.73	2.82	0.030	0.4742
Breast (%)	36.79	36.68	35.32	0.415	0.2936
Drumsticks (%)	11.26 b	11.58 ab	12.71 a	0.226	0.0122
Thighs (%)	8.89	8.87	9.19	0.215	0.8134
Wings (%)	7.51	7.54	7.47	0.135	0.9820
Back (%)	23.42	23.15	22.46	0.418	0.6529
Feets (%)	2.73	2.62	2.85	0.054	0.2634

Means followed by different letters in the line differ by Tukey's test (P<0.05).
SEM = standard error.

The weight and percentage of the drumsticks of the quails that consumed the diets with calcareou algae 2 was higher (P<0.05). The use of calcareous algae meal did not influence the composition of the meat carcass and the deposition of abdominal fat in the broiler carcass [10]. Organic minerals have aroused great interest in recent years because in this form, minerals are

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absorbed by intestinal amino acid and peptide carriers and not by classical intestinal mineral transporters [11].

Several researches that used the *Lithothamnium* calcareou algae, it was observed that it has alkalizing characteristics, which has the maintenance of acid-base balance in parallel, provides minerals with high bioavailability with adsorption in its cell wall with easy assimilation by the organism due to porous structure [12, 13, 14].

It is necessary to verify if the difference in the absolute and relative weight of the drumsticks referring to the weight of the femur of the birds, this can be evaluated through the dissection of this segment. The constitution of the bones shows, on a large scale, the conditions of the skeleton that, in turn, are directly associated with the diet, as well as the state in which the birds are nutritionally.

The high demands of calcium in commercial laying hens necessary for the production of eggs induce the resorption or breakage of the bone matrix and release of the contained mineral, a deleterious consequence of this process is the weakening of these bones, resulting in possible fractures [15].

No differences (P>0.05) were observed between treatments for meat quality variables (Table 4).

Table 4. Meat quality of quails fed different sources of calcium in the diet in the growing phase.

Variables	Treatments			SEM	P value
	Limestone	**Calcareou algae 1**	**Calcareou algae 2**		
L	50,47	46,47	47,25	0,604	0,161
A	10,59	12,85	12,91	0,558	0,150
B	4,47	5,28	5,24	0,420	0,684
pH 0h	5,59	5,72	5,67	0,037	0,355
pH 24h	5,55	5,65	5,56	0,025	0,133

L = luminosity; A = red/green content; B = yellow/blue content.
SEM = standard error.

In the selection of birds for laying over the years, it was concerned with the characteristics of production and egg quality, but little was addressed about the skeletal and muscular structure of the bird, especially with regard to long bones, necessary to support the carcass and as a reserve matrix to supply the demand for egg formation [16].

As a consequence, there were physiological disorders, bone fractures and damage to animal welfare. Diets that promote greater mineral deposition in the bones of birds, as indicated in the present study, are of interest, as they may reduce the adverse effects of high mineral demand.

An efficient nutritional program for quails must pay attention to the nutritional recommendations, giving emphasis and attention to the requirement of calcium and available phosphorus of 0.80 and 0.30% respectively, designed to meet the nutritional demands of Japanese quails for laying due to their body weight is lower than that of quails destined for meat production [17]. The feed, when formulated according to the requirements of the species, is essential for the birds to express their full genetic potential, becoming a priority in any animal exploitation activity, including the creation of quail for meat production, because in the growth, there is an increase of approximately 16 times of the quail in relation to its initial weight [18].

The replacement of an inorganic calcium source (limestone) for organic (calcareous algae) in up to 30% in the diet of Japanese quails provides better shell thickness and does not impair the performance [14]. The *Lithothamnium* has alkalizing characteristics that act to maintain the acid-base balance, it provides minerals with high bioavailability with adsorption on its cell wall with easy assimilation by the organism due to the porous structure [19]. Calcium from this alga does not present ionic antagonism [20].

It is possible to include *Lithothamnium* in the diet of laying hens in up to 45% of limestone replacement, without affecting performance and egg quality [21]. An increase in egg production of 4.16% was observed in relation to the control treatment in the addition of 0.25% of this product, for Japanese quail [22].

The calcareous algae has its constant renewal in the marine environment at the most varied depths, being characterized by a renewable source of macro and microminerals. For animal production, one of the highest costs comes from feeding, representing about 70% of the total cost of production in some creations, where calcium has a significant participation in costs and proportions in commercial formulations, especially in poultry production [12], and at this point, when finding possible substitutes for these mineral sources, benefiting animal nutrition and its cost in production, it becomes a key point in the advancement of animal production.

Thus, it is observed that the sources of calcium directly interfere in the absorption, deposition and use of this mineral in the animal organism, and especially in laying birds that need a greater contribution when compared to other species. In view of the above, it is justified to carry out experiments with different products, calcitic limestone and calcareous algae in the diet of laying quails in the rearing phase.

Conclusion

The replacement of 0.50% of limestone by any of the calcareous algae can be used in the Japanese quails diet without harming carcass yield and meat quality in the growing phase.

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