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Supplementation of choline in diets for meat quails *(Coturnix coturnix coturnix)*

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SUMMARY

The nutritional requirements manuals for quails are based on studies with Japanese quails, and there are few publications that investigate the vitamin requirements for European qualis. Aiming to evaluate the effects of choline supplementation on meat quails, two experiments were performed. In the first one, 480 seven-day-old quails of both sexes with an average weight of 43 ± 0.22 g were distributed in a completely randomised design with six treatments and five replicates of 16 birds. In the second experiment, 540 one-day-old quails of both sexes with an average weight of 8 ± 0.33 g were distributed in a completely randomised experimental design with six treatments and five replicates with 18 birds each. In both experiments, the treatments consisted of diets containing 0, 0.025, 0.050, 0.075, 0.100 and 0.125% choline chloride, corresponding to 0, 150, 300, 450, 600 and 750 mg/kg of supplemented choline, respectively. The experimental diets were calculated to be isoenergetic and isonutritive, with the exception of choline levels. At the end of the experimental period (quails of 42 days of age), the following parameters were evaluated: feed intake, weight gain, feed conversion, carcass, breast, drumstick + thigh yields, proportion of abdominal fat, liver fat and liver composition. Data were submitted to regression analysis. In both experiments, there was no significant effect of choline supplementation on performance variables, carcass characteristics and liver composition. However, in the comparison between the sexes there was significant difference in the carcass yield, breast yield in experiment 1, in the relative weight of the liver in both experiments, and amount of fat in the liver only in experiment 1. Thus, it is concluded that when the amount of choline supplied by the feed ingredients is 1,546 mg choline/kg diet, supplementation of this vitamin is not necessary.

Additional keywords

Carcass quality.
Liver.
Nutrition requirement.
Performance.
Vitamins.

Suplementação de colina em dietas para codornas de corte *(Coturnix coturnix coturnix)*

RESUMO

Os manuais de exigência nutricionais para codornas são baseados em estudos com codornas japonesas, e há poucas publicações que pesquisaram a exigência de vitaminas para codornas europeias. Objetivou-se avaliar os efeitos da suplementação de colina na alimentação de codornas de corte em 2 experimentos. No primeiro, foram alojadas 480 codornas machos e fêmeas, com 7 dias de idade e peso médio de 43 ± 0,22 g, distribuídas em delineamento inteiramente casualizado, com 6 tratamentos e 5 repetições de 16 aves. No segundo, foram alojadas 540 codornas machos e fêmeas, com 1 dia de idade peso médio de 8 ± 0,33 g, distribuídas em um delineamento experimental inteiramente casualizado com 6 tratamentos e 5 repetições com 18 aves cada. Em ambos os experimentos, os tratamentos consistiram de rações contendo 0, 0,025, 0,050, 0,075, 0,100 e 0,125% de cloreto de colina, correspondendo a 0, 150, 300, 450, 600 e 750 mg / kg de colina suplementada, respectivamente. As rações foram calculadas para serem isoenergéticas e isonutrientes, com exceção dos níveis de colina. Ao final do período experimental, foram avaliados o consumo de ração, ganho de peso, conversão alimentar, rendimento de carcaça, peito, coxa e sobrecoxa, proporção de gordura abdominal e do fígado e a composição do fígado. Os dados foram submetidos à análise de regressão. Em ambos experimentos, não houve efeito significativo da suplementação de colina sobre o desempenho, características de carcaça e composição do fígado. No entanto, na comparação entre os sexos houve diferença significativa no rendimento de carcaça, rendimento de peito no experimento 1, no peso relativo do fígado em ambos os experimentos e na quantidade de gordura no fígado apenas no experimento 1. Conclui-se que quando a quantidade de colina aportada pelos ingredientes for de 1.546 mg de colina/ kg de ração, a suplementação dessa vitamina não é necessária para codornas de corte.

Palavras chave adicionais

Características de carcaça.
Desempenho.
Exigência Nutricional.
Fígado.
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INTRODUCTION

The growing interest in determining the nutritional requirements of quails has contributed to the development of quail production. Several studies have estimated the requirements for energy, proteins, amino acids, calcium and phosphorus. However, few researches have been carried out with the objective of determining the requirements of vitamins.

Among the vitamins considered essential for adequate growth and development of birds, choline is of special importance. It is a vitamin B complex and biochemically participates in the synthesis of lecithin, sphingomyelin and acetylcholine. Lecithin participates in the absorption and transport of fats in the liver and the subsequent mobilisation and transport of liver fats. Sphingomyelin participates in nervous metabolism, while acetylcholine is a mediator of nervous activity, enabling the transmission of nervous stimuli (Bertechini, 2012).

In birds, the deficiency of this vitamin results in retarded growth, poor feathering, perosis and fatty liver due to the difficulty of mobilising fat into the circulation, caused by decreased formation of low-density lipoproteins (Sakomura et al., 1996). In studies carried out with broilers, Menten et al. (1997) found that the response to weight gain stabilised as a result of supplementation with 200 mg/kg choline chloride (supply of 1,430 mg choline/kg of feed). Pompeu et al. (2011) found that the use of 400 mg of choline chloride/kg of supplemented feed resulted in better feed conversion and a higher carcass yield. In a study with laying quails, Fouladi et al. (2011) found that a level of 1,000 mg choline chloride/kg diet decreased liver size as well as abdominal fat deposition. Similarly, Önel et al. (2017), in research with Japanese quails 1 to 35 days of age, verified that the total lipid content of liver was reduced from quails fed with diet supplements to 3600 mg choline chloride/kg diet, while the choline content of quail meat increased with increasing amount of added choline to feed.

According to the NRC (1994), the choline requirement for growing quails is 2,000 mg/kg feed. However, factors such as the contents of sulphur amino acids and lipids in the diet can influence choline requirements, thereby impacting experiments on choline supplementation (Santana et al., 2014).

On the other hand, there is a need to standardise the quantification of choline in the feed. Many studies consider only choline supplementation in the form of choline chloride, without considering the amount of choline present in the ingredients used. Various foods that make up the diet formulation base for birds have choline in their composition. For example, corn, sorghum and soybean meal have 620, 668 and 2,794 mg of choline/kg (NRC, 1994), with a bioavailability of 60 to 75% (Bertechini, 2012).In this context, it is necessary to update the evaluation of the nutritional requirements of this vitamin for meat quails. The objective of this study was to evaluate the effects of choline supplementation in corn and soybean meal based diets and in sorghum and soybean meal based diets on performance, carcass characteristics and the liver of quails intended for the production of meat.

MATERIAL AND METHODS

Procedures involving animals were carried out in accordance with the Ethical Principles in Animal Experimentation adopted by the Brazilian College of Animal Experimentation.Two experiments were carried out in the Poultry Farming Sector of the Animal Science Department of the Federal University of Ceará. In experimente 1 was to test choline supplementation in corn and soybean meal based diets for quail from 7 to 42 days old, and in experiment 2 was to test choline supplementation in sorghum and soybean meal based diets for quail from 1 to 42 days old. In experiment 1, we used 480 male and female quails (Coturnix coturnix coturnix), distributed in a completely randomizsed design with six treatments and five replicates of 16 birds per experimental unit. For experiment 2, we used 540 male and female quails, distributed in the same design, treatment and repetitions used in experiment 1, with 18 birds per pen.

In the two experiments, the treatments consisted of six diets **(Table I)** containing 0, 0.025, 0.050, 0.075, 0.100 and 0.125% choline chloride, corresponding to 0, 150, 300, 450, 600 and 750 mg/kg of supplemented choline, respectively. The diets were formulated to be isoenergetic and isonutritive, except for choline.

In the diets formulated for experiment 1, the inert was used in replace to the choline to maintain the equivalence of the ingredients among the diets. In experiment 2, the diets were formulated via the dilution method; from the diets containing the extreme levels of choline chloride (T1 = 0% and T6 = 0.125%), we obtained the diets with intermediate levels, ie: 0.025% (80% of the T1 diet + 20% of the T6 diet), 0.050% (60% of the T1 diet + 40% of the T6 diet), 0.075% (40% of the T1 diet + 60% of the T6 diet) and 0.100% (20% of the T1 diet + 80% of the T6 diet).

The calculated choline amount of the diets was obtained considering the amounts of choline present in maize, sorghum, soybean meal and choline chloride, so that the nutritional composition of the diets presented 1,546, 1,696, 1,846, 1,996, 2,146, 2,296 mg choline/kg diet. The experimental diets were formulated according to the nutritional recommendations proposed in the NRC (1994), except that of choline, which varied according to the treatments. The food composition data were based on Rostagno et al. (2011).

In the first week of experiment 1, the quails were housed in protective circles containing a brooder as heat source, pressure cup drinkers, tray type feeders with basal diet, without supplementation of choline. At seven days of age, the birds were weighed and distributed according to the mean weight 43 ± 0.22 g (42,78 and 43,22 g, minimum and maximun weight, respectively) into 30 boxes with the dimensions of 60 x 60 cm. The floor was covered with wood shavings and a pendulum drinker and a tube-type feeder were supplied; the animals remained in the boxes until 42 days of age. In experiment 2, one-day-old birds were weighed and distributed in the pits according to the mean weight 8 ± 0.33 g (7,67 and 8,33 g, minimum and maximun weight, respectively). The conditions were the same as those described for experiment one; the birds stayed in the pits until 42 days of age.

As a heat source, each box had a 100-watt incandescent lamp. In both experiments, the lighting program consisted of 23 hours of light (natural and artificial) per day, being the night illumination, after the removal of the incandescent lamps from the heating, made by 40-watt fluorescent lamps. Food and water were offered ad libitum.

Table I. Composition, nutritional and energetic levels of the diets for meat quails in the different experiments (Composição nutricional e níveis energéticos de dietas para codornas de corte em diferentes experimentos).

Ingredients (kg)	Supplementation of choline (%)							
	Experiment 1						Experiment 2	
	0.000	0.025	0.050	0.075	0.100	0.125	0.000	0.125
Corn	51.02	51.02	51.02	51.02	51.02	51.02	0.00	0.00
Sorghum	0.00	0.00	0.00	0.00	0.00	0.00	50.91	50.65
Soybean meal	43.98	43.98	43.98	43.98	43.98	43.98	42.74	42.8
Soybean oil	2.00	2.00	2.00	2.00	2.00	2.00	3.46	3.54
Calcitic limestone	1.17	1.17	1.17	1.17	1.17	1.17	1.20	1.20
Dicalcium phosphate	0.93	0.93	0.93	0.93	0.93	0.93	0.89	0.89
Vitamin-mineral supplement[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Common salt	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
DL-methionine	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17
Choline chloride 60%	0.00	0.025	0.050	0.075	0.100	0.125	0.00	0.125
Inert (washed sand)	0.125	0.10	0.075	0.05	0.025	0.00	0.00	0.00
Coxistac-anticoccidian	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Butylhydroxytoluene	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL	100	100	100	100	100	100	100	100
Calculated nutritional composition								
Metabolizable energy (kcal/kg)	2,900	2,900	2,900	2,900	2,900	2,900	2,900	2,900
Crude protein (%)	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Calcium (%)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Available phosphorus (%)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Choline (mg/kg)	1.546	1.696	1.846	1.996	2.146	2.296	1.546	2.296
Sodium (%)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Chlorine (%)	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
Total lysine (%)	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
Total methionine + cystine (%)	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Total methionine (%)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total threonine (%)	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Total tryptophan (%)	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Total valine (%)	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16

[1]Guaranteed levels per kg of product: vitamin A 5,500,000 UI, vitamin B1 500 mg, vitamin B12 7,500 mcg, vitamin B2 2,502 mg, vitamin B6 750 mg, vitamin D3 1,000,000 UI, vitamin E 6,500 UI, vitamin K3 1,250 mg, biotin 25 mg, niacin 17.5 g, folic acid 251 mg, pantothenic acid 6,030 mg, cobalt 50 mg, copper 3,000 mg, iron 25 g, iodo 500 mg, manganese 32.5 g, selenium 100.05 mg, zinc 22.49 g.

Performance data (Feed intake, weight gain and feed conversion) were obtained by weighing the diets and birds at the beginning and the end of the experimental period. Throughout the experimental period, mortality was recorded for the correction of feed intake and, consequently, feed conversion (Sakomura and Rostagno, 2016).

At the end of the experimental period (birds at 42 days of age), two quails from each plot, one male and one female, represented by the average weight of the plot after eight hours of fasting, were slaughtered by electronarcosis. Thus, in each experiment, a total of 10 birds per treatment were exsanguinated skinned in a water bath at 60ºC for 3 min, plucked and eviscerated. Head, neck and feet were removed for the determination of carcass yield in relation to the body weight of the quails. Subsequently, the carcasses were sectioned and the parts were weighed to determine the yields of breast and drumstick + thigh and the percentage of abdominal fat, calculated as a function of the hot carcass weight. The relative weight of the liver was calculated as the ratio between absolute liver weight and body weight.

The livers were packed in labelled plastic bags and frozen (-15°C). Prior to analyses, samples were thawed, pre-dried in a forced ventilation oven at 55° C for 72 hours and subjected to analysis of dry matter (DM) and ethereal extract (EE), according to the methodology proposed by AOAC (2000).

Statistical analysis was performed using the software package Statistical Analysis System 9.2 (SAS, 2009). The performance data of each experiment were submitted to analysis of variance according to a completely randomised model, using PROC ANOVA. For the data of carcass characteristics and liver, we adopted a factorial model (6 x 2), added to the model besides the choline level factor, the sex factor and the interaction between them. All data were submitted to regression analysis to determine the best level of choline supplementation at 5% probability.

RESULTS AND DISCUSSION

According to the results in **Table II**, there was no significant effect of choline levels for the variables feed intake, weight gain and feed conversion in the two experiments.

Our results are in agreement with the findings of Sakomura et al. (1996), who stated that choline values contained in the basal diet (1,335 mg/kg) were sufficient to meet the requirements of broiler chickens up to 21 days of age, as well as, by Önel et al. (2017), that concluded that the dietary supplementation of choline chloride up to 3600 mg/kg does not have any effect on performance, body weight gain, feed intake, and feed conversion ratio values of quails compared with the control groups.

Another aspect to be considered is the fact that the diets were formulated to be isoaminoacidic for methionine and therefore, there was a need for synthetic amino acid supplementation. Thus, meeting the requirements of quail for methionine may have influenced the results, so that the birds did not show signs of deficiency with no supplementation or improvement in performance with supplementation.

The absence of deficiency with no supplementation could be attributed to the fact that choline biosynthesis may occur in the liver from the donation of methyl groups from methionine, because in a situation of choline deficiency, methionine is diverted from its normal metabolic processes and starts donating methyl radicals to the choline biosynthesis (McDowell, 2000; Vasconcelos et al., 2013). Thus, depending on the level of methionine in the diet, choline supplementation may be dispensed because choline biosynthesis may support poultry needs for maximum performance, as reported by other researchers (Castro et al., 2011; Reis et al., 2012). According to Reis et al. (2012), the use of methionine in the diet contributed to the lack of effect of choline supplementation (0, 500, 1,000 and 1,500 mg choline/kg diet) on feed intake, feed conversion and egg quality.

In turn, the lack of benefits of supplementation can be associated with the fact that choline was not necessary as a donor of methyl groups for methionine formation, which is the case when there is a deficiency of this amino acid (Lipstein et al., 1997). Santana et al. (2014) reported that the benefits of choline supplementation for broiler chickens were more evident with neglected levels of methionine.

Although information about choline supplementation for meat quails is scarce, the lack of benefits of this practice has been reported for Japanese quails in growth and laying (Fouladi et al., 2011; Ebrahimnezhad et al., 2011; Castro et al., 2011), commercial

Table II. Performance of meat quails according to choline supplementation in the different experiments. (Desempenho de codornas de corte de acordo com a suplementação de colina).

Choline (%)	Experiment 1 (7 to 42 days of age)			Experiment 2 (1 to 42 days of age)		
	Feed intake (g/ave)	Weight gain (g/ave)	Feed conversion	Feed intake (g/ave)	Weight gain (g/ave)	Feed conversion
0.000	742.90	246.96	3.00	693.95	275.42	2.51
0.025	786.45	241.21	3.26	677.91	274.26	2.47
0.050	793.88	244.51	3.24	680.40	273.59	2.48
0.075	782.41	252.65	3.14	650.61	270.84	2.40
0.100	793.42	246.97	3.21	703.02	270.38	2.59
0.125	785.79	243.58	3.22	690.92	277.45	2.49
Mean	780.81	245.98	3.18	682.80	273.66	2.49
ANOVA[1]	p-value					
Choline (%)	0.3812	0.3609	0.0503	0.6313	0.8812	0.5915
Regression	p-value					
Linear	0.1243	0.7627	0.1123	0.8904	0.8901	0.8212
Quadratic	0.1532	0.5554	0.1323	0.3112	0.2909	0.5743
CV[2] (%)	5.01	3.04	3.91	7.04	3.72	6.13

[1]ANOVA = analysis of variance; [2]CV = coefficient of variation.

laying hens (Tsiagbe et al., 1982; Harms and Russell, 2002; Vasconcelos et al., 2013) and broilers (Sakomura et al., 1996; Fouladi et al., 2008). Usually, factors such as the use of methionine supplementation, the presence of choline in ingredients used in bird feeding and the bird's own capability of choline biosynthesis are associated with these results. In a literature review, Santana et al. (2014) reported that the significant interaction between methionine and choline has often been associated with divergence in the results of research investigating choline supplementation in poultry diets. In addition, the levels of folacin and vitamin B12, a combination of different levels and lipid compositions, carbohydrates and proteins in the diet, age, sex, caloric intake and growth rate of the animal may influence the lipotropic action of choline and, consequently, the requirement of this vitamin.

In the evaluation of the parameters of carcass characteristics (**Table III**), it was verified that there was no significant interaction between the factors choline level and sex on any of the variables. It was also observed that the level of choline supplementation did not significantly influence the carcass characteristics evaluated. However, in the comparison between the sexes, carcass yield differed between males and females, with males showing higher carcass yield and females presenting higher breast yield in experiment 1.

The absence of a significant effect of choline supplementation on carcass, breast and drumstick + thigh yield of meat quails is similar to for the results reported for broilers (Fouladi et al., 2008) and Japanese quails (Fouladi et al., 2011) and may be associated with the fact that quails submitted to different levels of supplementation received isoenergetic and isonutritive diets, except for choline, and there were no significant differences between feed intake. This guaranteed the availability of nutrients for similar growth and deposition of body tissue, because according to Freitas et al. (2006), with inadequate nutrient intake and unchanged energy/protein or energy/amino acids ratios of the diet, it is difficult to change carcass characteristics.

However, contrary to our results, a reduction in the proportion of abdominal fat of broilers (Fouladi et al., 2008) and Japanese quails (Fouladi et al., 2011) has been reported with choline supplementation. This effect has been attributed to the contribution of choline to fat metabolism; choline is a precursor of lecithin, which participates in fat metabolism and is considered a lipotropic factor (Fouladi et al., 2011).

The accentuated sexual dimorphism presented by the lines of meat quail, due to the greater precocity of the females in relation to the males (Caron et al., 1990; Oguz et al., 1996; Vasconcelos et al., 2013), is responsible for differences between the carcass yield and carcass parts verified in this research. At 42 days of age, females were larger due to greater body development and greater development of the reproductive system and the liver. Thus, although the females presented

Table III. **Carcass, breast, drumstick + thigh yields and abdominal fat of meat quail according to choline supplementation in the different experiments** (Rendimentos de carcaça, coxa+sobrecoxa, peito e gordura abdominal de codornas de corte de acordo com a suplementação de colina).

Choline (%)	Experiment 1				Experiment 2			
	CY[1]	BY[2]	DTY[3]	AT[4]	CY[1]	BY[2]	DTY[3]	AT[4]
0.000	73.26	38.81	21.27	1.37	72.25	42.96	22.55	1.68
0.025	72.09	39.51	21.85	1.46	70.37	41.55	21.92	1.77
0.050	74.38	39.30	22.67	1.46	70.26	41.19	23.09	1.65
0.075	74.46	40.09	22.20	1.41	70.73	40.82	22.13	1.68
0.100	73.27	38.43	22.57	1.37	72.93	40.25	23.03	1.75
0.125	73.52	38.49	21.46	1.35	70.06	41.58	22.34	1.58
Male	76.38a	37.50b	22.40	1.43	72.91a	40.74	22.61	1.30
Female	70.53b	40.83a	21.53	1.33	69.28b	42.03	22.40	1.37
ANOVA[5]	p-value							
Choline	0.8002	0.7702	0.3901	0.5901	0.1604	0.4103	0.4805	0.3108
Sex	0.0001	0.0001	0.0603	0.0505	0.0001	0.0803	0.6003	0.2605
Choline x Sex	0.7003	0.7603	0.4302	0.1001	0.5003	0.8003	0.2402	0.9204
Regression	p-value							
Linear	0.5802	0.6503	0.6502	0.7302	0.8802	0.1602	0.6102	0.4803
Quadratic	0.4002	0.3907	0.0606	0.1607	0.9008	0.2106	0.4209	0.3605
Mean	73.50	39.11	22.00	1.41	71.10	41.39	22.51	1.69
CV[6] (%)	5.42	7.01	7.81	13.5	4.16	6.92	6.93	18.15

[1]CY - Carcass yields (%); [2]BY - breast yields (%); [3]DTY – drumstick + thigh yields (%); [4]AT – abdominal fat (%); [5]ANOVA – analysis of variance, [6]CV - coefficient of variation; means followed by distinct letters differ from each other by the F test (5%).

Table IV. Relative weight and contents of dry matter and ethereal extract of the liver of meat quails according to choline supplementation in the different experiments (Peso relativo do fígado, teor de matéria seca e extrato etéreo no fígado de codorna de corte de acordo com a suplementação de colina).

Choline (%)	Experiment 1			Experiment 2		
	RW[1]	DM[2]	EE[3]	RW[1]	DM[2]	EE[3]
0.000	1.91	30.26	8.43	1.27	27.67	7.33
0.025	1.71	30.54	8.71	1.31	30.80	7.25
0.050	1.78	32.06	8.42	1.36	29.24	7.16
0.075	1.96	30.13	8.82	1.30	27.16	8.59
0.100	1.83	27.10	7.64	1.33	26.82	7.07
0.125	1.77	28.33	8.31	1.48	27.38	7.67
Male	1.68b	29.09	7.24b	1.53b	28.09	7.35
Female	1.98a	30.68	10.01a	1.83a	28.27	7.66
ANOVA[4]			p-value			
Choline	0.7212	0.6543	0.8665	0.7845	0.2125	0.1143
Sex	0.0054	0.4243	0.0014	0.0004	0.8632	0.3421
Choline x Sex	0.9322	0.5723	0.1123	0.4854	0.1476	0.1686
Regression			p-value			
Linear	0.9734	0.2223	0.7132	0.0623	0.1235	0.4434
Quadratic	0.5534	0.3867	0.9567	0.8145	0.9676	0.5145
Mean	1.84	29.85	8.39	1.34	28.18	7.51
CV[5] (%)	21.32	13.52	14.91	15.82	8.42	10.17

[1]RW - Relative weight (g); [2]DM - dry matter (%); [3]EE - ethereal extract (%); [4]ANOVA – analysis of variance, [5]CV - coefficient of variation; means followed by distinct letters differ from each other by the F test (5%).

higher carcass weights, the carcass yield in relation to the males was lower because the weight of the liver and the reproductive system were discarded in the evaluation of this variable. On the other hand, the greater body development of the female, contributed to the greater proportion of breast in relation to the gutted carcass.

In evaluating the relative weights and dry matter and ethereal extract contents of the liver **(Table IV)**, it was verified that there was no significant interaction between choline level and sex on any of the variables. We also observed that choline supplementation did not significantly influence the evaluated parameters. However, in the comparison between the sexes, we observed that the relative weight of the liver differed between males and females in both experiments, while the amount of fat in the liver differed between the sexes only in experiment 1. According to these results, the females showed a larger liver size and a greater amount of fat in the liver.

Our findings do not agree with the findings of previous studies, stating that choline supplementation can benefit the metabolic activity and the health of this organ, maintaining its size and fat amount. Choline is essential for the lipid metabolism in the liver, preventing abnormal accumulation of fat in this organ through lecithin or increased fatty acid catabolism (Fouladi et al., 2011). The absence of choline makes membrane phospholipids fragile, which prevents the transfer of triglycerides and cholesterol into the bloodstream, accumulating them in the liver.

The fatty liver syndrome is characterised by an increased organ size and an accumulation of fat or triglycerides in the cytoplasm of hepatocytes and fatty changes or hepatic lipidosis and can be observed in birds fed a choline-deficient diet (Pompeu et al., 2011; Bertechini 2012). In this context, it can be stated that the choline level received by birds fed without choline supplementation (1,546 mg choline/kg diet) was adequate to guarantee high performance and hepatic health of the quail.

The greater size of the liver and the higher concentration of ethereal extract in the liver of the female compared to the liver of the male is related to the precocious characteristic of the female for reproduction, as egg laying began before the slaughter age was reached. The beginning of the reproductive activity of poultry for egg production is characterised by the intense synthesis of lipids in the liver for the formation of ovarian follicles and, consequently, an increase in liver size and in the amount of fat of this organ (Lima et al., 2011; Vasconcelos et al., 2013).

CONCLUSIONS

Based on our results, choline supplementation is not necessary when the amount of choline supplied by the ingredients is 1,546 mg choline/kg diet for meat quails.

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