Perfil bioquímicos sérico de patos (*Cairina moschata domesticus*) alimentados com rações contendo diferentes níveis de sódio

Serum biochemical profile of the muscovy ducks (Cairina moschata domesticus) fed diets with different levels of sodium

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RESUMO

Este estudo foi conduzido para estabelecer valores padrões para exames laboratoriais clínicos de patos em confinamento conforme a idade e os níveis de sódio das dietas. O delineamento experimental foi inteiramente casualizado, onde os tratamentos foram constituídos por cinco planos nutricionais (inicial, crescimento e terminação) com diferentes níveis de sódio e quatro repetições de 10 patos cada. No último dia de cada fase foram coletadas amostras de sangue da veia *Subcutanea ulnaris* de 12 patos de cada tratamento selecionados aleatoriamente (seis machos e seis fêmeas) para as análises. Os dados coletados foram submetidos a ANONA com posterior análise de regressão polinomial para determinação do efeito de sódio nas aves. Diferenças significativas foram encontradas quando o coeficiente de probabilidade foi menor que 0,05. Aos 35, 70 e 90 dias, com exceção das proteínas totais, o perfil bioquímico sérico dos patos foi significativamente afetado ($p<0,05$) pelos níveis de sódio nas dietas. Independentemente da fase, níveis de sódio entre 0,25 a 0,30% proporcionaram melhor equilíbrio no perfil bioquímico sérico dos patos. Os patos apresentaram grande sensibilidade ao nível de sódio da dieta, tanto por deficiência quanto por excesso. Os patos apresentam um requerimento de sódio maior que os requerimentos para frangos de corte.

Palavras-chave: bioquímica sérica, *Cairina moschata domesticus*, fisiologia, mineral.

ABSTRACT

This study was conducted to establish accurate baseline values of clinical laboratory data for muscovy ducks in confinement with regard to age-related changes and levels of sodium in the diets. The experimental design was completely randomized, where treatments were constituted by five nutritional plans (initial, growth, and termination) with different sodium levels, and four replicates of 10 muscovy ducks each. At the last day of each management stage blood samples for biochemical analyses were collected from v. *Subcutanea ulnaris* of randomly selected 12 muscovy ducks of each treatment (six males and six females). Data collected were subjected to one-way ANONA with subsequent polynomial regression for sodium effect determination. Significant differences were found when possibility value (p-value) was less than 0.05. At 35, 70, and 90 days, except total proteins, serum biochemistry profile of muscovy ducks were significantly affected ($p<0.05$) by the levels of sodium in the diets. Regardless the stage, levels of sodium between 0.25 to 0.30% provided better equilibrium in serum biochemistry profile of muscovy ducks. Muscovy ducks present a great sensibility to sodium level of the diet, both deficiency and excess. Muscovy ducks present a requirement of sodium larger than the requirement used for broilers.

Keywords: *Cairina moschata domesticus*, mineral, physiology, serum biochemistry.

INTRODUCTION

The muscovy duck (*Cairina mochata domesticus*) belongs to the family Anatidae and the order Anseriformes. This bird can be found in regions of Mexico, Central America and South America, mainly in Amazon. In Brazil, south region concentrates all national production of ducks, muscovy ducks, and their derivatives, where the most amount is exported (RUFINO *et al*., 2017a). However, the production of muscovy ducks in industrial scale is poor explored, especially due to the lack of technical information's about appropriate nutritional requirements, facilities, and other factors that contributed for an ideal management (FEIJÓ *et al*., 2016; RUFINO *et al*., 2017b).

Physiologically, like other birds, the muscovy ducks require small amounts of minerals for developed its vital functions (PINHEIRO *et al*., 2011; FEIJÓ *et al*., 2016). Sodium, together chlorine and potassium, present high metabolic activity in the acid-base balance, maintenance of the cellular osmotic pressure and metabolism of water in the tissues. These elements must be in constant balance so as not compromise the good functioning of enzymes responsible to several metabolic reactions (BORGES *et al*., 2002).

Blood analyses are widely used to monitor general health with physiological processes in birds as part of efforts to increase productive attributes (COOPER *et al*., 1998; NAIDOO *et al*., 2008; HAN *et al*., 2011; TAMUKAI *et al*., 2011). While interpreting data pertaining to blood analyses for animals, it is possible to analyze how the nutrition can affect the organism (HOWLET *et al*., 1998; BAILEY *et al*., 1999). Previous studies have reported hematological and biochemical parameters for ducks (CHEN *et al*., 2014; ORTIZO *et al*., 2014; GERZILOV *et al*., 2015; RATH *et al*., 2019); however, to the best of our knowledge, baseline values to muscovy ducks in housing have not been published to date.

Therefore, this study was conducted to establish accurate baseline values of clinical laboratory data for muscovy ducks in confinement with regard to age-related changes and levels of sodium in the diets. These data will help researchers who work for the production of this species in industrial scale using the confinement system.

MATERIAL AND METHODS

The experimental protocols applied in this study were complied with the Brazilian guidelines for animal welfare and approved by the Animal Care and Use Committee of Federal University of Amazonas (protocol number 027/2017).

200 muscovy ducks of Creole strain were used. One-day-old birds were obtained from an experimental hatchery (Experimental Farm of Federal University of Amazonas, Manaus, Amazonas, Brazil). Management

stages were divided into initial (1 to 35 days), growth (36 to 70 days), and termination (71 to 90 days). A constant intermittent lighting program provided 22L: 2D, and temperature was maintained from 27 to 32 ºC. Birds were housing in pens (2 x 2 m) using 2.5 birds/m^2. Feed and water were provided *ad libitum*. Ducklings were inspected daily for any health problems, and mortality was recorded as it occurred.

Birds were distributed in a completely randomized experimental design, where the treatments were constituted by five nutritional plans containing different levels of sodium (Table 1) with four replicates of 10 muscovy ducks each. Experimental diets (Table 2) were calculated according reference values provided for broilers (ROSTAGNO *et al*., 2017), except energy and protein (RUFINO *et al*., 2017b), calcium (FEIJÓ *et al*., 2016), and available phosphorus (COSTA *et al*., 2019) that used ideal requirements for muscovy ducks.

Table 1. Experimental treatments.

Treatments	Levels of Sodium (%)		
	Initial (1-35 d)	Growth (36-70 d)	Termination (71-90 d)
Nut. Plan 1	0.35	0.40	0.45
Nut. Plan 2	0.30	0.35	0.40
Nut. Plan 3	0.25	0.30	0.35
Nut. Plan 4	0.20	0.25	0.30
Nut. Plan 5	0.15	0.20	0.25

At the last day of each management stage blood samples for biochemical analyses were collected from v. *Subcutanea ulnaris* of randomly selected 12 muscovy ducks of each treatment (six males and six females). The collected blood was placed into heparin-treated tubes and serum separator tubes, and serum was obtained from the clotted blood in the serum separator tube after centrifugation at 1,500 × g for 5 min. The blood serum biochemical parameters total proteins, albumin, urea, uric acid, ammonia, creatine, glucose, triglycerides, total cholesterol, calcium, phosphorus, sodium, potassium, chlorine, and magnesium were determined using an electronic spectrophotometer (ThermoMultiskanGo®).

Data collected were subjected to one-way ANONA in Statistical Analysis System (SAS Inc., Cary, NC). Polynomial regression was utilized for sodium effect determination. The regression procedure of curve estimation was applied in determination of the regression model. A linear or quadratic model was decided, derived from the scatter diagram plot. Significant differences were found when possibility value (p-value) was less than 0.05.

RESULTS AND DISCUSSION

At 35 days (Table 3), except total proteins, serum biochemistry profile of muscovy ducks were significantly affected ($p<0.05$) by the levels of sodium in the diets. Sodium level of 0.25% provided lower concentration of ammonia ($y = 0.0229x^2$ -

Table 2. Experimental diets composition.

Diets[4]	Nutritional plans with different levels of sodium for muscovy ducks														
	------- Plan 1 -------			------- Plan 2 -------			------- Plan 3 ------			------- Plan 4 ------			------- Plan 5 ------		
Ingredients	Ini.	Gro.	Term.	Ini.	Gro.	Term.	Ini.	Gro.	Term.	Ini.	Gro.	Term.	Ini.	Gro.	Term.
Corn 7.88%	56.119	64.529	67.396	56.379	64.789	67.659	56.639	65.048	67.917	56.898	65.307	68.177	57.157	65.567	68.437
Soybean meal 46%	36.567	28.392	24.580	36.522	28.347	24.532	36.477	28.302	24.487	36.432	28.257	24.442	36.387	28.212	24.397
Soybean oil	1.989	1.955	2.968	1.901	1.867	2.880	1.812	1.779	2.792	1.724	1.691	2.704	1.636	1.602	2.615
Dicalcium phosphate	2.896	2.426	2.191	2.896	2.425	2.191	2.896	2.425	2.191	2.895	2.425	2.190	2.895	2.424	2.190
Limestone	1.023	1.109	1.150	1.023	1.109	1.150	1.023	1.109	1.151	1.024	1.109	1.151	1.024	1.110	1.151
Salt	0.834	0.960	1.087	0.708	0.834	0.961	0.582	0.708	0.835	0.456	0.582	0.709	0.330	0.456	0.583
Vit./Mineral Supplement	0.500[1]	0.500[2]	0.500[3]	0.500[1]	0.500[2]	0.500[3]	0.500[1]	0.500[2]	0.500[3]	0.500[1]	0.500[2]	0.500[3]	0.500[1]	0.500[2]	0.500[3]
DL-Methionine 99%	0.072	0.129	0.128	0.071	0.129	0.127	0.071	0.129	0.127	0.071	0.129	0.127	0.071	0.129	0.127
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Nutritional Levels[5]															
Met. energy, kcal/kg	2,900	3,000	3,100	2,900	3,000	3,100	2,900	3,000	3,100	2,900	3,000	3,100	2,900	3,000	3,100
Crude Protein, %	21.000	18.000	16.500	21.000	18.000	16.500	21.000	18.000	16.500	21.000	18.000	16.500	21.000	18.000	16.500
Met. + cystine, %	0.720	0.705	0.664	0.720	0.705	0.664	0.720	0.705	0.664	0.720	0.705	0.664	0.720	0.705	0.664
Methionine, %	0.498	0.402	0.382	0.498	0.402	0.382	0.498	0.402	0.382	0.498	0.402	0.382	0.498	0.402	0.382
Calcium, %	1.250	1.100	1.050	1.250	1.100	1.050	1.250	1.100	1.050	1.250	1.100	1.050	1.250	1.100	1.050
Available phosphorus, %	0.650	0.550	0.500	0.650	0.550	0.500	0.650	0.550	0.500	0.650	0.550	0.500	0.650	0.550	0.500
Sodium, %	0.350	0.400	0.450	0.300	0.350	0.400	0.250	0.300	0.350	0.200	0.250	0.300	0.150	0.200	0.250

[1] Vit./mineral supplement – initial – content in 1 kg = Folic Acid 800 mg, Pantothenic Acid 12,500 mg, Antioxidant 0.5 g, Biotin 40 mg, Niacin 33,600 mg, Selenium 300 mg, Vit. A 6,700,000 UI, Vit. B1 1,750 mg, Vit. B12 9,600 mcg, Vit. B2 4,800 mg, Vit. B6 2,500 mg, Vit. D3 1,600,000 UI, Vit. E 14,000 mg, Vit. K3 1,440 mg. Mineral supplement – content in 0.5 kg = Manganese 150,000 mg, Zinc 100,000 mg, Iron 100,000 mg, Copper 16,000 mg, Iodine 1,500 mg.

[2] Vit./mineral supplement – growth – content in 1 kg = Folic Acid 650 mg, Pantothenic Acid 10,400 mg, Antioxidant 0.5 g, Niacin 28,000 mg, Selenium 300 mg, Vit. A 5,600,000 UI, Vit. B1 0.550 mg, Vit. B12 8,000 mcg, Vit. B2 4,000 mg; Vit. B6 2,080 mg, Vit. D3 1,200,000 UI, Vit. E 10,000 mg, Vit. K3 1,200 mg. Mineral supplement – content in 0.5 kg = Manganese 150,000 mg, Zinc 100,000 mg, Iron 100,000 mg, Copper 16,000 mg, Iodine 1,500 mg.

[3] Vit./mineral supplement – termination – content in 1 kg = Pantothenic Acid 7,070 mg, Antioxidant 0.5 g, Niacin 20,400 mg, Selenium 200 mg, Vit. A 1,960,000 UI, Vit. B12 4,700 mcg, Vit. B2 2,400 mg, Vit. D3 550,000 UI, Vit. E 5,500 mg, Vit. K3 550 mg. Mineral supplement – content in 0.5 kg = Manganese 150,000 mg, Zinc 100,000 mg, Iron 100,000 mg, Copper 16,000 mg, Iodine 1,500 mg.

[4] Ini. = Initial; Gro. = Growth; Term. = Termination

[5] Estimated levels in Dry Matter

0.01231x + 1.334 R^2 = 0.83), and creatine (y = 0.0057x^2 - 0.0029x + 0.06 R^2 = 0.76), and higher concentration of total cholesterol (y = -8.8743x^2 + 4.6016x + 325.26 R^2 = 0.92), chlorine (y = -0.595x^2 + 0.3037x + 66.652 R^2 = 0.61), and magnesium (y = -0.0164x^2 + 0.00846x + 1.2258 R^2 = 0.91). Decrease levels of sodium caused a linear reduction in albumin (y = -0,026x + 2,204 R^2 = 0,97), urea (y = -0,0569x + 2,5709 R^2 = 0,99), uric acid (y = -0,331x + 5,205 R^2 = 0,77), glucose (y = -0,601x + 115,78 R^2 = 0,92), triglycerides (y = -11,373x + 284,4 R^2 = 0,83), calcium (y = -1,16x + 17,72 R^2 = 0,83), phosphorus (y = -0,4294x + 7,073 R^2 = 0,91), sodium (y = -7,208x + 183,64 R^2 = 0,94), and potassium (y = -0,5797x + 7,3925 R^2 = 0,82).

At 70 days (Table 4), serum biochemistry profile of muscovy ducks were significantly affected ($p<0.05$) by the levels of sodium in the diets. Sodium level of 0.30% provided lower concentration of total proteins (y = 0.0093x^2 - 0.0057x + 5.112 R^2 = 0,63), albumin (y = 0.0864x^2 - 0.052x + 1.812 R^2 = 0.92), urea (y = 0.6543x^2 - 0.4014x + 7.7946 R^2 = 0.49), uric acid (y = 0.2629x^2 - 0.1659x + 2.86 R^2 = 0.81), ammonia (y = 0.1007x^2 - 0.0609x + 0.788 R^2 = 0.64), creatine (y = 0.0207x^2 - 0.125x + 0.019 R^2 = 0.95), glucose (y = 2.385x^2 - 1.4579x + 296.42 R^2 = 0.93), triglycerides (y = 11.436x^2 - 7.0862x + 211.66 R^2 = 0.88), and magnesium (y = 0.0064x^2 - 0.0396x + 1.36 R^2 = 0.72). Decrease levels of sodium caused a linear reduction in total cholesterol (y = -8.824x + 147.6 R^2 = 0.95), calcium (y = -1.16x + 17.72 R^2 = 0.83), phosphorus (y = -1.672x + 21.452 R^2 = 0.84), sodium (y = -6.027x + 192.03 R^2 = 0.90), potassium (y = -0.304x + 6.924 R^2 = 0.99), and chlorine (y = -0.718x + 72.86 R^2 = 0.89).

At 90 days (Table 5), serum biochemistry profile of muscovy ducks were significantly affected ($p<0.05$) by the levels of sodium in the diets. Sodium level of 0.30% provided lower concentration of total proteins (y = 0.0379x^2 - 0.02281x + 4.952 R^2 = 0.94), urea (y = 0.6271x^2 - 0.38269x + 5.654 R^2 = 0.90), uric acid (y = 0.1786x^2 - 0.11034x + 3.0696 R^2 = 0.99), creatine (y = 0.0121x^2 - 0.00729x + 0.0164 R^2 = 0.65), glucose (y = 0.9179x^2 - 0.56781x + 296.15 R^2 = 0.72), total cholesterol (y = 2.1271x^2 - 1.3025x + 118.95 R^2 = 0.98), calcium (y = 0.4029x^2 - 0.24771x + 11.692 R^2 = 0.78), phosphorus (y = 1.2379x^2 - 0.74881x + 12.78 R^2 = 0.79), sodium (y = 1.6429x^2 - 1.0107x + 142.85 R^2 = 0.98), potassium (y = 0.0657x^2 - 0.04043x + 4.658 R^2 = 0.80), and magnesium (y = 0.0207x^2 - 0.01253x + 1.352 R^2 = 0.93). Decrease levels of sodium caused a linear reduction in albumin (y = -0.077x + 2.193 R^2 = 0.96), ammonia (y = -0.044x + 1.356 R^2 = 0.85), triglycerides (y = -11.62x + 220.14 R^2 = 0.64), and chlorine (y = -2.101x + 74.123 R^2 = 0.65).

Table 3. Serum biochemical profile of the muscovy ducks at 35 days fed diets with different levels of sodium.

Variables[1]	Levels of sodium, %					p-value	Effect[2]	CV[3], %
	0.35	0.30	0.25	0.20	0.15			
Total protein, $g.dl^{-1}$	4.53	4.58	4.50	4.54	4.48	0.10	ns	4.43
Albumin, $g.dl^{-1}$	2.18	2.15	2.13	2.09	2.08	0.05	LN	5.35
Urea, $mg.dl^{-1}$	2.50	2.46	2.40	2.33	2.28	0.03	LN	4.78
Uric acid, $mg.dl^{-1}$	5.10	4.12	4.26	4.15	3.43	0.05	LN	7.65
Ammonia, $mg.dl^{-1}$	1.54	1.56	1.34	1.50	1.49	0.05	Q	5.84
Creatine, $mg.dl^{-1}$	0.09	0.08	0.06	0.08	0.09	0.03	Q	6.69
Glucose, $mg.dl^{-1}$	115.53	114.26	113.76	113.37	112.97	0.02	LN	7.12
Triglycerides, $mg.dl^{-1}$	278.99	262.57	237.86	237.10	234.86	0.01	LN	7.10
Total cholesterol, $mg.dl^{-1}$	274.97	318.72	333.01	321.50	316.03	0.01	Q	7.15
Calcium, $mg.dl^{-1}$	17.60	14.40	13.70	13.00	12.50	0.01	LN	4.54
Phosphorus, $mg.dl^{-1}$	6.44	6.35	5.86	5.58	4.68	0.02	LN	4.12
Sodium, $mEq.L^{-1}$	177.00	171.33	157.00	156.25	148.50	0.01	LN	5.12
Potassium, $mEq.L^{-1}$	6.57	6.88	5.19	5.01	4.60	0.02	LN	5.25
Chlorine, $mEq.L^{-1}$	63.69	66.66	66.89	64.49	64.20	0.01	Q	4.25
Magnesium, $mg.dl^{-1}$	1.14	1.19	1.22	1.18	1.15	0.02	Q	6.25

[1]All data represent the mean of replicates per treatment. [2]Q = Quadratic. LN = Linear Negative. ns = non significant. [3]CV = Coefficient of variation.

Table 4. Serum biochemical profile of the muscovy ducks at 70 days fed diets with different levels of sodium.

Variables[1]	Levels of sodium, %					p-value	Effect[2]	CV[3], %
	0.40	0.35	0.30	0.25	0.20			
Total protein, $g.dl^{-1}$	5.15	5.13	5.11	5.18	5.18	0.01	Q	3.26
Albumin, $g.dl^{-1}$	2.12	1.98	1.80	2.03	2.29	0.03	Q	4.12
Urea, $mg.dl^{-1}$	11.71	11.48	7.72	11.18	11.92	0.04	Q	5.16
Uric acid, $mg.dl^{-1}$	4.61	3.64	2.83	3.64	3.70	0.02	Q	2.13
Ammonia, $mg.dl^{-1}$	1.27	1.22	0.78	1.23	1.44	0.01	Q	5.25
Creatine, $mg.dl^{-1}$	0.09	0.01	0.01	0.02	0.08	0.03	Q	6.78
Glucose, $mg.dl^{-1}$	302.28	297.79	296.88	297.64	309.01	0.02	Q	9.13
Triglycerides, $mg.dl^{-1}$	298.53	260.29	210.36	235.41	239.73	0.03	Q	8.37
Total cholesterol, $mg.dl^{-1}$	141.26	125.16	122.92	113.14	103.15	0.04	LN	3.42
Calcium, $mg.dl^{-1}$	17.60	14.40	13.70	13.00	12.50	0.03	LN	9.15
Phosphorus, $mg.dl^{-1}$	21.16	16.66	15.57	15.32	13.47	0.05	LN	8.28
Sodium, $mEq.L^{-1}$	185.01	183.25	169.75	170.50	161.25	0.02	LN	5.72
Potassium, $mEq.L^{-1}$	6.67	6.27	5.99	5.69	5.44	0.01	LN	9.47
Chlorine, $mEq.L^{-1}$	72.61	70.92	70.44	70.16	69.40	0.02	LN	3.13
Magnesium, $mg.dl^{-1}$	1.38	1.37	1.35	1.38	1.39	0.05	Q	2.98

[1]All data represent the mean of replicates per treatment. [2]Q = Quadratic. LN = Linear Negative. [3]CV = Coefficient of variation.

Previous studies pointed that unbalance in the requirement of sodium in animal feed directly affect the transport and absorption of several biomolecules, especially due to these processes are highly dependent of sodium and potassium pump (DUHM *et al*., 1983; MERCHANT *et al*., 1985). In this sense, ducks and muscovy ducks present a great sensibility to sodium deficiency, where levels below the minimum requirement causing a high mortality due to decrease in osmotic pressure and consequent disturbance of acid-base balance (DEAN *et al*., 1973; BALOŠ *et al*., 2016). When occurs salt deficiency in the diets, sodium is the major mineral limiting due to its lower concentration than chlorine in most of the ingredients (DAMRON *et al*., 1986).

Birds for meat production (broilers, ducks or muscovy ducks), normally present higher mineral requirement due its large and fast body development, with ideal level being adjusted according to the development stage (PINHEIRO *et al*., 2011). And really, the results of the present study indicated that muscovy ducks present better balance in their serum biochemistry profile fed diets with higher levels of sodium than the requirement usually used for broilers (MURAKAMI *et al*., 1997; MURAKAMI *et al*., 2001). Previous studies suggested that higher mineral requirements for muscovy ducks are attributed by its greater carcass conformation and bone structure, larger than broilers (FEIJÓ *et al*., 2016; RUFINO *et al*., 2017a; RUFINO *et al*., 2017b). However, sodium levels above this ideal requirement may be considered toxic, stimulating increased water intake in poultry, thus causing electrolyte imbalance and negatively affecting heart, kidneys and other essential organs (BALOŠ *et al*., 2016).

The ducks and muscovy ducks present obviously limited salt regulating ability, where its salt gland function changes more in response to saline acclimation than does that of a truly marine species. In some osmoregulatory studies of ducks only male birds were used (HOLMES *et al*., 1968; HOLMES *et al*., 1982), whereas in other studies the sex was not indicated (DEUTSCH *et al*., 1979; HAMMEL *et al*., 1980) or both sexes were used (SIMON-OPPERMANN *et al*., 1980; GERSTBERGER *et al*., 1984). However, all these studies reported a great difficult to perform an efficient identification of this sexual dimorphism before a determined age. And when is possible make this selection, there were differences in the osmoregulatory capacities of male and female ducks. In this sense, the results of the present study indicated that muscovy ducks, regardless of sex, present a great sensibility in their serum biochemistry profile when there were abrupt changes in sodium levels of the diets out of its ideal range (0.25 to 0.30%) in all stages.

Since discovery of NaCl-secreting capacity of avian salt glands (FANGE *et al*., 1958), most experimental work using ducks has been carried out to elucidate physiology and the functional relationship between the sodium and the main organs responsible to it metabolism, especially the kidneys (SIMON, 1982). These works reported that the sodium is the most important ion to acid-base balance in bloodstream makes some 93% of the total cation content in blood plasma (BALOŠ *et al*., 2016), directly influencing the growth, appetite, bone development, responses to thermal stress, and the metabolism of nutrients as amino acids, minerals, and

Table 5. Serum biochemical profile of the muscovy ducks at 90 days fed diets with different levels of sodium.

Variables[1]	Levels of sodium, %					p-value	Effect[2]	CV[3], %
	0.45	0.40	0.35	0.30	0.25			
Total protein, g.dl $^{-1}$	5.32	5.19	5.03	4.94	5.04	0.03	Q	8.13
Albumin, g.dl $^{-1}$	2.14	2.00	1.97	1.89	1.81	0.02	LN	7.25
Urea, mg.dl^{-1}	12.77	9.87	9.74	8.59	10.59	0.04	Q	8.19
Uric acid, mg.dl^{-1}	4.33	3.62	3.09	3.06	3.35	0.02	Q	7.39
Ammonia, mg.dl^{-1}	1.32	1.29	1.18	1.17	1.16	0.03	LN	5.15
Creatine, mg.dl^{-1}	0.09	0.06	0.05	0.01	0.08	0.05	Q	6.74
Glucose, mg.dl^{-1}	298.76	296.13	296.18	294.06	298.94	0.04	Q	5.15
Triglycerides, mg.dl^{-1}	225.38	178.00	177.94	177.62	167.47	0.03	LN	9.19
Total cholesterol, mg.dl^{-1}	135.66	127.10	121.28	118.84	123.48	0.02	Q	6.42
Calcium, mg.dl^{-1}	12.29	12.13	11.81	11.65	14.23	0.01	Q	9.12
Phosphorus, mg.dl^{-1}	22.98	20.63	15.93	12.56	18.21	0.03	Q	8.45
Sodium, mEq.L^{-1}	171.75	161.25	152.00	142.75	143.75	0.05	Q	5.24
Potassium, mEq.L^{-1}	5.79	5.41	5.32	4.65	5.02	0.04	Q	6.67
Chlorine, mEq.L^{-1}	70.11	70.55	69.29	68.54	60.61	0.05	LN	2.14
Magnesium, mg.dl^{-1}	1.54	1.40	1.39	1.35	1.37	0.03	Q	3.32

[1]All data represent the mean of replicates per treatment. [2]Q = Quadratic. LN = Linear Negative. ns = non significant. [3]CV = Coefficient of variation.

vitamins. And when this balance or pH of the birds' body fluids has a significant change, can to occur an acidosis or an alkalosis, damaging the functionality of enzymes and other several tools of organism (PATIENCE, 1990).

Most tables of nutrient requirements for poultry or ingredient analysis now have values for sodium, but no distinction is made concerning inorganic sodium sources. Previous studies associate sodium chloride with discussions concerning sodium. But, at least two other sodium containing mineral compounds, sodium sulfate and sodium bicarbonate, are also currently used in poultry feeds (MURAKAMI *et al.*, 1997; MURAKAMI *et al.*, 2001; BALOŠ *et al.*, 2016). During the early years of poultry research, dietary salt (NaCl) studies were primarily designed to measure the effects of excess or deficient levels aiming to determine the maximum safe use level (DAMRON *et al.*, 1986). On the other hand, the same tables do not present specific requirements for muscovy ducks, only presenting some information's about ducks (*Anas platyrhynchos domesticus*), but without deepness. It is important to mention that the previous studies that provided these requirements considered the effect of sodium in all metabolic processes, especially in transport and absorption of other nutrients.

CONCLUSIONS

The results of the present study indicated that levels of sodium between 0.25 to 0.30% provided better equilibrium in serum biochemistry profile of muscovy ducks in confinement. Muscovy ducks present a great sensibility to sodium level of the diet, both deficiency and excess. Muscovy ducks present a requirement of sodium larger than the requirement used for broilers.

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