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Original Article

Sodium Requirement for Muscovy Ducks in Housing[1]

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ABSTRACT

The present study aimed to determine the ideal sodium levels for muscovy ducks in housing. Two hundred and forty muscovy ducks of creole lineage were used, distributed in boxes with water and food *ad libitum*. The experimental design was completely randomized, where treatments were constituted by six nutritional plans (initial, growth and termination) with different sodium levels, and four replicates of 10 muscovy ducks each. The birds had weekly performance evaluations, and after 90 days, eight birds (four males and four females) in each treatment were slaughtered for evaluation of carcass traits. Data collected were subjected to Tukey test at 5% of significance. Differences were observed ($p<0.05$) in performance (feed intake and feed conversion), where average levels of sodium presented better results. In carcass yields, average levels presented a positive influence ($p<0.05$) on muscovy duck growth. Male muscovy ducks presented better feed efficiency than females in the same period. The present study indicates that nutritional plan 3 (initial = 0.25%; growth = 0.30% and termination = 0.35%) showed better nutritional requirements of sodium for muscovy ducks in housing, obtaining better performance and carcass development.

INTRODUCTION

Muscovy ducks provide several products for the poultry industry as meat, eggs, feathers for ornamental purposes, fatty livers and many others. There is a great market for all these products, but little explored in Latin America (Industrial Poultry, 2005; Rufino *et al.*, 2015).

In Brazil, there aren't many companies that develop the Muscovy duck production. Only in the Brazilian southern region there are some companies that work in the production of ducks, muscovy ducks and their derivatives (Minas State Journal, 2015).The production in industrial scale is an unexplored area, especially due to the lack of technical information about appropriate nutritional requirements, facilities, and other factors that contribute for an ideal productive management (Feijó *et al.*, 2016; Rufino *et al.*, 2017).

Physiologically, like other birds, the muscovy ducks require small amounts of minerals to develop its vital functions in the organism (Pinheiro *et al.*, 2011; Feijó *et al.*, 2016; Costa, 2018). According to Borges (2001) and Borges *et al.* (2002), sodium, together with chlorine and potassium, present high metabolic activity in the acid-base balance and maintain the cellular osmotic pressure and metabolism of water in the tissues. These elements must be in constant balance so as not to compromise the good functioning of the enzymes responsible for several metabolic reactions in the animals.

Sodium and chlorine are also sources of nutrients and improve the feed palatability, especially through NaCl supplementation (Borges *et al.*, 1998). Sodium levels in diets significantly change the absorption of amino acids and simple carbohydrates by the gastrointestinal tract, changing indexes as weight gain and feed conversion (Guyton, 1985).

Considering the above, the present study aimed to determine ideal sodium levels for muscovy ducks in housing.

MATERIAL AND METHODS

This study was conducted in the facilities of the Poultry Sector, Department of Animal and Vegetable Production (DPAV), College of Agrarian Sciences (FCA), Federal University of Amazonas (UFAM), south sector of the University Campus, Manaus/AM, Brazil. The experimental procedures were approved by the Committee for Ethical Animal Use (CEUA - protocol number 027/2017) of the Federal University of Amazonas.

Two hundred muscovy ducks (*Cairinamoschata domesticus*) of creole lineage were used distributed in boxes with water and food *ad libitum*. The experimental design was completely randomized with the treatments constituted by five nutritional plans (initial, growth and termination)of sodium levels (Table 1) with four replicates of 10 muscovy ducks each.

Table 1 – Experimental sodium levels.

Treatments	Levels of Available Phosphorus (%)		
	Initial (1 – 35 days)	Growth (36 – 70 days)	Termination (71 – 90 days)
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

Experimental diets (Table 2) were calculated according to reference values provided by Rostagno *et al.* (2011), except energy and protein (Rufino *et al.*, 2015), calcium (Feijó *et al.*, 2016) and available phosphorus (Costa, 2018) that used ideal requirements for muscovy ducks.

Table 2 – Ingredients and nutritional composition of experimental diets.

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

The birds started the experimental period with one day of age and were evaluated at 90 days. For performance, the feed intake (kg/bird), weight gain (kg/bird) and feed conversion (kg/kg) were analysed. Due to extreme difficulty of performing the sexing of muscovy ducks with one day, and the lack of technique for this (Rufino *et al.*, 2017), performance was measured in mixed lots (birds with both sex in the same box).

At 90 days of age, already with an evident sexual dimorphism, after 12 hours of fasting, eight birds of each treatment (four males and four females) were randomly selected, identified and weighed. Next, these were electrically stunned (40 V; 50 Hz) and slaughtered by cut of the jugular vein. The carcasses were immersed into hot water (60°C for 62s), plucked and eviscerated according to Mendes & Patricio's (2004) recommendations, and the carcass yield was determined. Edible viscera (heart, gizzard, pro-ventricle and liver) were individually weighed.

Breast and leg (thigh + drumstick) samples were collected to measure pH and physical measurements (length, height and width). The commercial cuts (neck, breast, wing, back, thigh and drumstick) were separated according to Gomide *et al.* (2012) and measured by weighing in analytical balance 0.01 g.

Statistical analysis was performed using the software Statistical Analysis System (2008) and estimates of the treatments were subjected to Tukey test at 5% of significance.

RESULTS

The results of performance are present in Table 3. Differences were observed ($p<0.05$) for feed intake and feed conversion. Average levels of sodium in the diets (Nutritional Plan 3) presented better results.

Table 3 – Performance of muscovy ducks in housing fed nutritional plans with different sodium levels.

Nutritional Plans	Variables		
	Feed intake (kg)	Weight gain (kg)	Feed conversion (kg/kg)
Nut. Plan 1	9.84^{b}	2.16	4.58^{b}
Nut. Plan 2	9.41^{ab}	2.12	4.45^{ab}
Nut. Plan 3	8.51^{a}	2.02	4.24^{a}
Nut. Plan 4	9.84^{b}	2.19	4.60^{b}
Nut. Plan 5	9.38^{ab}	2.42	4.89^{c}
p-value	0.05*	0.10^{ns}	0.04*
CV (%)	8.41	12.98	14.03

CV – Coefficient of variation; * Significant effect ($p<0.05$); ns – non significant effect.

The results of carcass traits are present in table 4. Differences ($p<0.05$) were observed for slaughter weight among nutritional plans and sexes, and for foot, abdominal fat, liver, heart, gizzard and pro-ventricle only among sexes.

Birds fed nutritional plans with higher sodium levels showed better carcass results (Nutritional plans 1 at 3). Male muscovy ducks presented better development of carcass, with great difference in the development of carcass among sexes. There was no interaction ($p>0.05$) between factors.

Table 4 – Slaughter weight (SW), carcass yield (CY), feathers (FE), foot (FT), abdominal fat (AF), liver (LV), heart (HT), gizzard (GZ) and pro-ventricle (PV) of muscovy ducks in housing fed nutritional plans with different levels of available phosphorus.

Factors	Variables								
	SW (kg)	CY (%)	FE (%)	FT (%)	AF (%)	LV (g)	HT (g)	GZ (g)	PV (g)
Nut. Plans									
Nut. Plan 1	2.58^{a}	6414	14.79	3.12	0.93	33.12	51.00	11.50	17.75
Nut. Plan 2	2.44^{ab}	65.76	14.72	2.89	0.73	33.37	58.00	9.50	16.25
Nut. Plan 3	2.42^{ab}	65.74	14.87	2.82	0.81	33.62	57.00	10.00	18.00
Nut. Plan 4	2.30^{b}	6730	16.10	2.90	0.64	33.12	50.25	10.62	19.00
Nut. Plan 5	2.33^{b}	67.39	13.98	2.84	0.81	33.62	64.00	11.12	18.75
Sexes									
Male	3.10^{a}	66.14	14.95	3.05^{a}	0.55^{b}	42.55^{a}	66.90^{a}	12.15^{a}	23.05^{a}
Female	1.73^{b}	65.99	14.83	2.78^{b}	1.01^{a}	26.20^{b}	45.20^{b}	8.95^{b}	12.85^{b}
Effect	*p*-value								
Nut. Plans	0.03*	0.43^{ns}	0.84^{ns}	0.53^{ns}	0.52^{ns}	0.79^{ns}	0.21^{ns}	0.62^{ns}	0.28^{ns}
Sexes	0.01**	0.90^{ns}	0.91^{ns}	0.01**	0.01**	0.01**	0.01**	0.01**	0.01**
Interaction	0.23^{ns}	0.25^{ns}	0.30^{ns}	0.33^{ns}	0.35^{ns}	0.45^{ns}	0.28^{ns}	0.32^{ns}	0.34^{ns}
CV (%)	7.15	5.82	14.52	12.79	13.14	19.31	23.09	26.83	14.80

CV – Coefficient of variation; * Significant effect ($P<0.05$); ** Significant effect ($p<0.01$); ns – non-significant effect.

The results of commercial cuts are present in table 5. Differences ($p<0.05$) were observed for %neck, %breast, %wing and %thigh among nutritional plans and sexes, and for %drumstick only among sexes.

The sodium levels directly influenced the development of carcass and its distribution in the commercial cuts. In general, birds fed nutritional plans 3 presented better results. Male muscovy ducks presented large carcass development, except %wing and %back. There was no interaction ($p>0.05$) between factors.

The results of pH and physical measurements are present in table 6. Differences ($p<0.05$) were observed among nutritional plans for length, width and height of breast, and length and pH of the leg. Differences ($p<0.05$) were observed among sexes for length, width and height of breast and leg.

Birds fed diets with higher sodium levels presented better breast and leg development. Nutritional plans with lower levels of sodium presented worse development and lower pH values. Male muscovy ducks presented large size of breast and leg, with great difference in the development of carcass among sexes. There was no interaction ($p>0.05$) between factors.

Table 5 – Commercial cuts of muscovy ducks in housing fed nutritional plans with different levels of available phosphorus.

Factors	Variables					
	Neck (%)	Breast (%)	Wing (%)	Thigh (%)	Drumstick (%)	Back (%)
Nut. Plans						
Nut. Plan 1	11.08^{b}	17.78^{bc}	11.79^{c}	10.10^{a}	26.62	22.63
Nut. Plan 2	10.62^{bc}	18.04^{b}	12.03^{b}	10.01^{a}	25.60	23.70
Nut. Plan 3	12.20^{a}	18.72^{ab}	13.14^{a}	8.85^{c}	23.84	23.25
Nut. Plan 4	11.48^{ab}	18.80^{a}	12.93^{ab}	9.01^{b}	24.96	22.82
Nut. Plan 5	11.47^{ab}	18.07^{b}	12.16^{b}	9.43^{ab}	25.68	23.19
Sexes						
Male	11.77^{a}	18.40^{a}	12.78^{b}	9.93^{a}	26.99^{a}	20.13
Female	10.98^{b}	18.16^{b}	17.44^{a}	9.03^{b}	23.69^{b}	20.70
Effect	*p*-value					
Nut. Plans	0.03*	0.03^{*}	0.05^{*}	0.02^{*}	0.41^{ns}	0.47^{ns}
Sexes	0.05^{*}	0.05*	0.03*	0.04^{*}	0.01^{**}	0.09^{ns}
Interaction	0.25^{ns}	0.26^{ns}	0.59^{ns}	0.65^{ns}	0.35^{ns}	0.46^{ns}
CV (%)	13.58	5.02	9.17	15.45	11.42	15.13

CV – Coefficient of variation; * Significant effect ($P<0.05$); ** Significant effect ($p<0.01$); ns – non-significant effect.

Table 6 – Physical measurements of breast and leg (thigh + drumstick) of muscovy ducks in housing fed nutritional plans with different levels of available phosphorus.

Factors	Variables							
	Breast				Leg (thigh + drumstick)			
	Length (cm)	Width (cm)	Height (cm)	pH	Lenght (cm)	Width (cm)	Height (cm)	pH
Nut. Plans								
Nut. Plan 1	20.18^{a}	13.75^{a}	3.68^{b}	6.61	15.31^{a}	10.37	2.31	6.56^{a}
Nut. Plan 2	19.93^{ab}	12.12^{ab}	3.75^{ab}	6.68	15.00^{ab}	9.06	2.75	6.55^{a}
Nut. Plan 3	18.02^{b}	11.93^{ab}	3.93^{ab}	6.54	15.25^{ab}	9.56	2.93	6.50^{ab}
Nut. Plan 4	18.50^{b}	11.93^{ab}	4.62^{ab}	6.51	14.87^{ab}	9.06	3.06	6.48^{ab}
Nut. Plan 5	18.00^{b}	11.68^{b}	4.87^{a}	6.48	14.06^{b}	9.37	2.87	6.39^{b}
Sexes								
Male	21.02^{a}	13.57^{a}	4.67^{a}	6.59	16.35^{a}	10.52^{a}	3.00^{a}	6.61
Female	16.05^{b}	11.00^{b}	3.67^{b}	6.54	13.45^{b}	8.45^{b}	2.57^{b}	6.58
Effect	*p*-value							
Nut. Plans	0.01^{**}	0.02^{**}	0.01^{*}	0.16^{ns}	0.04^{*}	0.09^{ns}	0.12^{ns}	0.01^{**}
Sexes	0.01^{**}	0.01^{**}	0.01^{*}	0.32^{ns}	0.01^{**}	0.01^{**}	0.02^{**}	0.74^{ns}
Interaction	0.12^{ns}	0.28^{ns}	0.06^{ns}	0.15^{ns}	0.14^{ns}	0.25^{ns}	0.07^{ns}	0.19^{ns}
CV (%)	6.76	10.81	17.88	2.63	5.92	10.90	20.84	1.67

CV – Coefficient of variation; * Significant effect ($P<0.05$); ** Significant effect ($p<0.01$); ns – non-significant effect.

DISCUSSION

In our study, mean levels of sodium (nutritional plan 3) provided regulation of intake and better use of nutrients (feed conversion). However, these nutritional levels were higher than the requirement for broilers (Rostagno *et al.*, 2017). According Feijó *et al.* (2016), higher mineral requirements for muscovy ducks are attributed by its greater carcass conformation and bone structure, larger than broilers.

Pulls (1988) and Guyton & Hall (1997) observed that unbalance in the requirement of sodium in the diets results in the absorption of amino acids and monosaccharides by the gastrointestinal tract, whose transport is highly dependent of sodium and potassium bomb, directly affecting weight gain and feed conversion. According to Dean *et al.* (1973), ducks and muscovy ducks are very sensitive to sodium deficiency, with levels below the minimum recommendation and can cause mortality of more than 60%.

When salt deficiency occurs in diets, sodium is the major limiting mineral, especially due to its lower concentration than chlorine in most of the ingredients (Andriguetto *et al.*, 1990). Rosado (1988) comments that the highest concentration of sodium in the animal body is present in the extracellular fluid, containing on average 0.12%.

According to Pinheiro (2009), Rostagno *et al.* (2011) and Rostagno *et al.* (2017), birds for meat production (broilers, ducks or muscovy ducks), present higher mineral requirement due to its large and fast body development, with ideal levels according to phase and profile of nutritional plan used.

These results reflected on carcass traits, observing that the average sodium presented a positive influence on muscovy ducks growth, with these levels above the recommendation for broilers (Rostagno *et al.*, 2017), similar results were observed by Feijó *et al.* (2016) and Costa (2018), that also observed mineral requirement for muscovy ducks above the recommendation for broilers.

Patience (1990) comments that the acid-base balance may directly influence the growth, appetite, bone development, responses to thermal stress, and the metabolism of nutrients as amino acids, minerals and vitamins. And when this balance or pH of the birds' body fluids has a significant change, an acidosis or an alkalosis can occur, damaging the functionality of enzymes and other several tools of organism.

Our results also presented a great difference between male and female carcass, with males presenting larger carcasses than females. According to Gois *et al.* (2012), males present a better feed efficiency than females in the same period, with better results in weight gain, slaughter weight, %feathers, %feet and edible viscera.

Yakubu (2010), Gois *et al.* (2012) and Almeida (2016) comment that a natural sexual dimorphism for muscovy ducks exists, with mean weight of 3.80 kg for males and 2.22 kg for females. But, Drumond *et al.* (2013) and Almeida (2016) affirm that females present a precocious growth, reaching the adult weight faster, better distribution of commercial cuts and faster ideal carcass fat deposition (Vieira,1999), even having a lower final weight.

The sex is one of the factors that most affects the main cuts of birds, especially the breast and the thigh (Rosa *et al.*, 2006). Studies with broilers affirm that males have higher breast than females, mainly due the reduction of meat deposition in breast at 42 days, when it's reached maturity, which does not occur in females (Mendes *et al.*, 2003). Our results presented that male muscovy ducks had higher yields in almost all major commercial cuts.

All these information's are important to elaborate strategies for muscovy duck production in industrial scale, aiming to meet great consumer markets, such as China, Japan, France, Germany and others countries (Cruz *et al.*, 2013; Minas State Journal, 2015).

CONCLUSIONS

The present study indicates that nutritional plan 3 (initial = 0.25%; growth = 0.30% and termination = 0.35%) showed better nutritional requirements of sodium for muscovy ducks in housing, obtaining better performance and carcass development.

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