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Original Article

*Available Phosphorus Levels in Diets for Muscovy Ducks in Housing**

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ABSTRACT

The present study aimed to determine ideal levels of available phosphorus 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 with treatments consisting of six nutritional plans that included the initial, growth and termination phases and differed in relation to available phosphorus 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 not observed (p>0.05) in performance. Higher available phosphorus levels presented a positive influence (p<0.05) on carcass. Results presented differences (p<0.05) among sexes for carcass development and commercial cuts, with better feed efficiency of males than females in same period. For mineral composition, differences (p<0.05) were observed to calcium (%), phosphorus (%) and Ca:Pratio. The present study indicates that nutritional plan 2 (initial = 0.60%; growth = 0.55% and termination = 0.50%) presented ideal nutritional requirement of available phosphorus for muscovy ducks in housing, with better carcass development and mineral deposition on bones.

INTRODUCTION

Muscovy ducks have the peculiar feature to provide for poultry industry a range of products as meat, eggs, feathers for ornamental purposes, fatty livers and many other products (Rufino *et al.*, 2017). These represent a great market opportunity, but little explored in Latin America (Industrial Poultry, 2005).

There are not many companies that produce muscovy ducks in Brazil, especially due the lack of information's about adequate nutritional requirements, facilities and ideal management (Santos *et al.*, 2012). Brazilian south region concentrates all national production of ducks, muscovy ducks and their derivatives. Only a little piece of this production is destined for internal consumption (ABPA, 2018).

Santa Catarina State is the largest Brazilian producer and exporter of Muscovy duck meat. This meat is especially consumed by the United States, Japan, Angola, Liberia and countries with Arabic ethnicity (Wawro *et al.*, 2004; ABPA, 2018).

According to Mariante *et al.* (2011) and Gois *et al.* (2012), the muscovy ducks are waterfowl with great rusticity, presenting exceptionally resistance to diseases and adverse conditions. Physiologically, like other birds, the muscovy ducks require small amounts of minerals, especially phosphorus, that is the second most abundant mineral in its tissue composition, with 80% present in the bones, presenting vital functions to the organism (Pinheiro *et al.*, 2011).

Dunbar *et al.* (2005) affirms that calcium and phosphorus are independent minerals, and the lack or excess of one can damage the absorption or use of the other, damaging the better performance of birds. And according to Pinheiro *et al.* (2011), studies that report ideal requirements of available phosphorus for muscovy ducks in literature are very scarce, being used requirements of broilers for its.

Considering the above, the present study aimed to determine ideal levels of available phosphorus 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 017/2016) of Federal University of Amazonas.

Two hundred and forty 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 treatments consisting of six nutritional plans that included the initial, growth and termination phases and differed in relation to available phosphorus levels (Table 1), and four replicates of 10 muscovy ducks each.

Table 1 – Experimental levels of available phosphorus.

Treatments	Levels of Available Phosphorus (%)		
	Initial (1 – 35 days)	Growth (36 – 70 days)	Termination (71 – 90 days)
Nut. Plan 1	0.65	0.60	0.55
Nut. Plan 2	0.60	0.55	0.50
Nut. Plan 3	0.55	0.50	0.45
Nut. Plan 4	0.50	0.45	0.40
Nut. Plan 5	0.45	0.40	0.35
Nut. Plan 6	0.40	0.35	0.30

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

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 a 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 jugular vein. The carcasses were immersed into hot water (60ºC for 62s), plucked and eviscerated according 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 Gomide *et al.* (2012) and measured by weighing in analytical balance 0.01 g.

Four tibia samples of males per treatment were collected for bone resistance analysis. These were evaluated in Materials Engineering Laboratory of the State University of Amazonas. The bones were cleaned and analysed in a Universal Machine of Electronic Mechanics (Instron Model 5984, with load capacity of 150 KN) and the data registered for a computer software with results expressed in kgf/mm and N. The load applied was 2000 Newton in the central region of bones and the descent rate of the load was 5 mm/s, with the force applied at the moment before the bone rupture was recorded.

After, the bone's mineral composition (ashes (%), calcium (%) and phosphorus (%)) was evaluated in the EMBRAPA Western Amazon according the methodology proposed by AOAC (1999).

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

Results of performance are present in Table 3. Differences were not observed (p>0.05) in all variables analyzed. Most higher levels of available phosphorus in diets presented better results of feed intake and feed conversion.

Table 2 – Ingredients and nutritional composition of experimental diets.

Diets[4]	Nutritional plans with different levels of available phosphorus for muscovy ducks																	
	------- Plan 1 -------			------- Plan 2 -------			------- Plan 3 ------			------- Plan 4 ------			------- Plan 5 ------			------- Plan 6 ------		
Ingredients	Ini.	Gro.	Term.	Ini.	Gro.	Term.	Ini.	Gro.	Term.	Ini.	Gro.	Term.	Ini.	Gro.	Term.	Ini.	Gro.	Term.
Corn 7.88%	56.86	65.62	68.75	57.06	65.81	68.93	57.25	65.97	69.14	57.44	66.20	69.33	57.65	66.40	69.53	57.83	66.59	69.73
Soybean meal 46%	36.44	28.20	24.34	36.40	28.17	24.31	36.37	28.17	24.28	36.34	28.10	24.24	36.30	28.07	24.21	36.27	28.03	24.17
Limestone	1.15	0.93	0.97	1.33	1.11	1.15	1.50	1.28	1.32	1.68	1.46	1.50	1.85	1.63	1.67	2.03	1.81	1.85
Dicalcium phosphate	2.89	2.69	2.46	2.62	2.42	2.19	2,35	2.15	1.91	2.08	1.88	1.64	1.81	1.61	1.37	1.54	1.34	1.10
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
DL-Methionine 99%	0.07	0.12	0.12	0.07	0.12	0.12	0.07	0.12	0.12	0.07	0.12	0.12	0.07	0.12	0.12	0.07	0.12	0.12
Vit./Mineral Supplement	0.50[1]	0.50[2]	0.50[3]	0.50[1]	0.50[2]	0.50[3]	0.50[1]	0.50[2]	0.50[3]	0.50[1]	0.50[2]	0.50[3]	0.50[1]	0.50[2]	0.50[3]	0.50[1]	0.50[2]	0.50[3]
Soybean oil	1.74	1.59	2.51	1.67	1.52	2.45	1.61	1.46	2.38	1,54	1.39	2.32	1.47	1,32	2.25	1.41	1.26	2.18
Total	56.86	65.62	68.75	57.06	65.81	68.93	57.25	65.97	69.14	57.44	66.20	69.33	57.65	66.40	69.53	57.83	66.59	69.73
Nutritional Levels[5]																		
Met. energy, kcal.kg^{-1}	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	2,900	3,000	3,100
Crude Protein, %	21.00	18.00	16.50	21.00	18.00	16.50	21.00	18.00	16.50	21.00	18.00	16.50	21.00	18.00	16.50	21.00	18.00	16.50
Calcium, %	1.25	1.15	1.05	1.25	1.15	1.05	1.25	1.15	1.05	1.25	1.15	1.05	1.25	1.15	1.05	1.25	1.15	1.05
Available phosphorus, %	0.65	0.60	0.55	0.60	0.55	0.50	0.55	0.50	0.45	0.50	0.45	0.40	0.45	0.40	0.35	0.40	0.35	0.30
Methionine + Cystine, %	0.72	0.70	0.66	0.72	0.70	0.66	0.72	0.70	0.66	0.72	0.70	0.66	0.72	0.70	0.66	0.72	0.70	0.66
Methionine, %	0.49	0.40	0.38	0.49	0.40	0.38	0.49	0.40	0.38	0.49	0.40	0.38	0.49	0.40	0.38	0.49	0.40	0.38
Sodium, %	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

[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

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

Nutritional Plans	Variables		
	Feed intake (g)	Weight gain (g)	Feed conversion (kg/kg)
Nut. Plan 1	8,596.50	2,357.49	3.64
Nut. Plan 2	8,043.93	2,309.49	3.48
Nut. Plan 3	8,396.25	2,340.63	3.58
Nut. Plan 4	8,538.25	2,409.96	3.55
Nut. Plan 5	9,110.91	2,529.52	3.61
Nut. Plan 6	8,891.83	2,447.87	3.63
p-value	0.58^{ns}	0.72^{ns}	0.86^{ns}
CV (%)	9.95	8.93	9.04

CV = Coefficient of variation; ns = non-significant.

Results of carcass traits are present in table 4. Differences ($p<0.05$) were observed for slaughter weight, foot and gizzard among nutritional plans, and for all variables among sexes.

Birds fed nutritional plans 1 and 3 presented better carcass results. Birds fed nutritional plans with lower levels of available phosphorus presented worse development of carcass. Male muscovy ducks presented better development of carcass, with great difference in the development of carcass among sexes. There was not interaction ($p>0.05$) between factors.

Results of commercial cuts are present in table 5. Differences ($p<0.05$) were observed for the % of thigh among nutritional plans, and for all variables among sexes.

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}	70.28	11.59	2.58^{a}	0.93	43.37	20.62	66.25^{ab}	9.87
Nut. Plan 2	2.42^{ab}	69.30	9.02	2.42^{ab}	1.11	40.00	17.37	72.12^{a}	10.50
Nut. Plan 3	2.52^{a}	70.75	10.53	2.52^{a}	0.97	39.25	19.25	58.87^{ab}	13.50
Nut. Plan 4	2.36^{ab}	65.52	26.88	2.00^{b}	0.88	39.50	17.00	58.12^{ab}	8.75
Nut. Plan 5	2.31^{ab}	71.84	9.33	2.36^{ab}	0.72	39.00	21.00	53.62^{bc}	11.25
Nut. Plan 6	2.00^{b}	75.25	20.10	2.31^{ab}	0.83	34.50	16.87	48.25^{c}	10.75
Sexes									
Male	3.07^{a}	71.90^{a}	17.61^{a}	3.03^{a}	0.77^{b}	47.25^{a}	22.83^{a}	68.66^{a}	12.41^{a}
Female	1.67^{b}	69.07^{b}	11.54^{b}	1.68^{b}	1.05^{a}	31.29^{b}	14.54^{b}	50.41^{b}	9.12^{b}
Effect	*p* Value								
Nut. Plans	0.02^{*}	0.80^{ns}	0.58^{ns}	0.01^{**}	0.47^{ns}	0.79^{ns}	0.40^{ns}	0.01^{**}	0.12^{ns}
Sexes	0.01^{**}	0.05^{*}	0.05^{*}	0.01^{**}	0.02^{*}	0.01^{**}	0.01^{**}	0.01^{**}	0.01^{**}
Interation	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 (%)	12.53	18.76	16.27	12.53	4.32	19.71	17.53	17.93	13.80

CV = Coefficient of variation; *Means followed by lowercase letters in column differ in 5% by Tukey test ($p<0.05$); **Means followed by lowercase letters in column differ in 1% by Tukey test ($p<0.01$); ns = non-significant.

Even though the level of available phosphorus in the diets influencing the development of carcass, this did not represent influence on the % of distribution of commercial cuts in carcass. However, birds fed nutritional plans 3 presented better results of % of thigh.

Male muscovy ducks presented more of 50% of carcass constituted by breast and back. Even males presented higher carcass, females presented better distribution of commercial cuts than males, with great distribution of cuts in its carcass. There was not interaction ($p>0.05$) between factors.

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 pH of leg. Differences ($p<0.05$) were observed among sexes for length, width and height of breast and leg.

Birds fed nutritional plan 3 presented better breast and leg development. Nutritional plans with lower levels of available phosphorus presented worse development and lower pH values. There was not interaction ($p>0.05$) between factors.

Male muscovy ducks presented more size of breast and leg, with great difference in the development of carcass among sexes. There was not interaction ($p>0.05$) between factors.

Results of mineral composition and resistance of bones are present in table 7. Differences ($p<0.05$) were observed in all variables of mineral composition. Birds

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	10.61	26.48	17.57	9.95[b]	11.11	24.68
Nut. Plan 2	10.62	25.55	17.56	11.21[ab]	10.92	24.14
Nut. Plan 3	10.59	25.19	17.10	12.32[a]	9.28	25.52
Nut. Plan 4	10.62	25.98	17.42	12.99[a]	9.26	23.73
Nut. Plan 5	10.04	26.04	17.87	12.09[ab]	9.50	24.06
Nut. Plan 6	10.26	24.94	16.68	12.19[ab]	9.56	26.37
Sexes						
Male	10.88[b]	26.60[a]	16.27[b]	10.65[b]	8.86[b]	26.74[a]
Female	11.13[a]	24.39[b]	17.46[a]	12.74[a]	10.12[a]	24.16[b]
Effect	*p* Value					
Nut. Plans	0.91[ns]	0.71[ns]	0.72[ns]	0.01**	0.11[ns]	0.47[ns]
Sexes	0.05*	0.02*	0.05*	0.04*	0.01**	0.01**
Interation	0.25[ns]	0.26[ns]	0.59[ns]	0.65[ns]	0.35[ns]	0.46[ns]
CV (%)	20.35	11.55	8.99	13.90	16.53	15.13

CV = Coefficient of variation; * Means followed by lowercase letters in column differ in 5% by Tukey test ($p<0.05$); ** Means followed by lowercase letters in column differ in 1% by Tukey test ($p<0.01$); ns = non-significant.

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	22.12[a]	14.78[a]	5.50[a]	6.38	17.00	9.62	2.78	6.35[a]
Nut. Plan 2	21.81[ab]	14.75[a]	5.06[ab]	6.12	17.31	9.93	3.06	6.37[a]
Nut. Plan 3	21.75[ab]	14.68[a]	4.68[ab]	6.12	17.12	10.00	2.62	6.29[ab]
Nut. Plan 4	21.50[ab]	11.81[ab]	4.93[ab]	6.28	17.18	9.31	2.62	6.27[ab]
Nut. Plan 5	19.62[ab]	11.16[b]	4.06[ab]	6.21	15.68	9.00	3.06	6.10[b]
Nut. Plan 6	19.00[b]	11.05[b]	3.87[b]	6.16	15.37	8.75	2.68	6.08[b]
Sexes								
Male	23.39[a]	14.35[a]	5.02[a]	6.23	18.29[a]	10.25[a]	3.09[a]	6.25
Female	18.54[b]	11.70[b]	4.35[b]	6.19	14.93[b]	8.62[b]	2.52[b]	6.24
Effect	*p* Value							
Nut. Plans	0.01**	0.01**	0.02*	0.06[ns]	0.02[ns]	0.72[ns]	0.50[ns]	0.01**
Sexes	0.01**	0.01**	0.02*	0.52[ns]	0.01**	0.01**	0.01**	0.74[ns]
Interation	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 (%)	9.39	15.87	21.76	2.88	10.49	20.19	22.05	2.80

CV = Coefficient of variation; * Means followed by lowercase letters in column differ in 5% by Tukey test ($p<0.05$); ** Means followed by lowercase letters in column differ in 1% by Tukey test ($p<0.01$); ns = non-significant.

Table 7 – Mineral composition (ashes, calcium and phosphorus) and resistance of bones of muscovy ducks in housing fed nutritional plans with different levels of available phosphorus.

Nutritional plans	Variables				
	Ashes (%)	Ca (%)	*p* (%)	Ca:P	Break resistance (N)
Nut. Plan 1	51.95	15.60[ab]	9.30[ab]	1.68[ab]	430.55
Nut. Plan 2	53.21	15.70[a]	8.60[b]	1.83[a]	413.81
Nut. Plan 3	51.36	14.47[b]	8.58[b]	1.69[ab]	444.69
Nut. Plan 4	49.74	14.36[b]	9.65[a]	1.49[bc]	387.77
Nut. Plan 5	51.85	11.31[c]	8.34[b]	1.36[c]	423.10
Nut. Plan 6	50.01	14.18[b]	9.18[ab]	1.54[bc]	329.51
p Value	0.72[ns]	0.01*	0.01*	0.01*	0.10[ns]
CV (%)	4.76	1.03	1.10	1.25	8.23

CV = Coefficient of variation; * Means followed by lowercase letters in column differ in 1% by Tukey test ($p<0.01$); ns = non-significant.

fed nutritional plans with higher levels of available phosphorus presented larger mineral deposition on bone, without affecting the break resistance. Nutritional plans with lower levels of available phosphorus presented more fragile bones.

DISCUSSION

In our study, even without differences on performance results, muscovy ducks presented available phosphorus requirements above recommendations for broilers at all phases. According to Feijó *et al.* (2016), higher mineral requirements for muscovy ducks are attributed to its greater carcass conformation and bone structure, larger than broilers.

Pinheiro (2009) observed better feed conversion of slow-growing broilers (both sexes) in free-range system fed diets with available phosphorus levels among 0.25 to 0.36% in the initial phase (1 to 28 days). Runho *et al.* (2001) studying other nutritional plans, observed better feed conversion of broilers in the initial phase (1 to 21 days) fed diets with available phosphorus levels among 0.15 to 0.45%. Our results indicate a requirement near to these recommendations.

According Rostagno *et al.*(2005), Pinheiro (2009) and Rostagno *et al.*(2011), birds for meat production (broilers, ducks or muscovy ducks), present higher requirements of available phosphorus due to its larger and faster body development, with ideal levels according to the phase and profile of nutritional plan used.

These results reflected on carcass traits, where higher levels of available phosphorus presented a positive influence on muscovy ducks carcass development, similar results observed by Feijó *et al.* (2016) studding calcium levels for muscovy ducks, and obeying the 2:1 ratio between Ca and P.

Macari *et al.* (2002) commented that calcium and phosphorus are associated elements. These are almost always combined (2 molecules of calcium for 1 molecule of phosphorus), and the deficiency of one in the diet limits the birds' performance (McDowell, 1992).

Nelson & Peeler (1961), report that levels of phosphorus below or above the requirement difficult the birds' development, especially due to bone mineralization. Thus, Macari *et al.* (2002) and Feijó *et al.* (2016) affirm that the better balance among calcium and phosphorus requirements, and their metabolic relationship, provide better performance and development.

Higher available phosphorus levels were sufficient to meet the nutritional requirements, presented better results of breast and leg and with males presented good development of the main commercial cuts. There was also a greater deposition of minerals in the tibia from higher available phosphorus levels.

Runho *et al.* (2001) observed an increase in bone minerals of broilers (males and females) at 1 to 21 days from available phosphorus levels among 0.15 to 0.45%, below the requirements obtained for muscovy ducks in the same period.

Another important question is the ~~most~~ requirement of available phosphorus in the initial phase for broilers and muscovy ducks, that according to Macari *et al.* (2002) and Sousa *et al.* (2015), is due to the faster growth of bone tissue than other tissues, with Ca and P deposition more necessary at this stage than others. However, there was no influence of available phosphorus levels on mineral composition and bone resistance of muscovy ducks.

Our results also presented a great difference between male and female carcass. Males presented larger carcass than females. According Gois *et al.* (2012), this could be attributed to better feed efficiency of males than females in the same period, presenting a significant difference in weight gain, slaughter weight, % of feathers, % of 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 precocity growth, reaching the adult weight faster, better distribution of commercial cuts and faster ideal carcass fat deposition (Vieira,1999), even though having a lower final weight.

Stringhini *et al.* (2003) affirms that females have great carcass fat deposition due its present adipocytes with larger size than the males, which indirectly cause a lower feed efficiency (Mignon-Grasteau *et al.*, 2000).

The sex is one of the factors that most affects the breast yield of birds (Rosa *et al.*, 2006). Studies with broilers presented that males have higher breast than females, mainly due the reduction of meat deposition in breast at 42 days, when it has reached the maturity, which does not occur in females (Mendes *et al.*, 2003). Our results presented that muscovy ducks males had a higher breast yield (26.60%) than females (24.39%), as well other carcass traits.

All these informations are important to elaborate strategies for Muscovy ducks 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 2 (initial = 0.60%; growth = 0.55% and termination = 0.50%) presented ideal nutritional requirements of available phosphorus for muscovy ducks in housing, with better carcass development and mineral deposition on bones.

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