ISSN 1682-8356
ansinet.org/ijps

INTERNATIONAL JOURNAL OF POULTRY SCIENCE

ANSI*net*
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 14 (1): 44-48, 2015
ISSN 1682-8356

Quality and Sensory Evaluation of Meat of Ducks (*Cairina moschata*) in Confinement under Different Nutritional Plans and Housing Densities

João Paulo Ferreira Rufino, Frank George Guimarães Cruz, Lucas Duque Melo, Verena Makarem Soares, Uriel de Almeida Curcio, Jessica Lima Damasceno and Ana Paula Guimarães Cruz Costa
Federal University of Amazonas, College of Agrarian Sciences,
Sector of Poultry, Manaus, Amazonas, Brazil

Abstract: The objective of this study was to evaluate the quality of meat ducks are raised in confinement under different phasic nutritional plans in different housing densities. Were used 240 ducks (Cairina Moschara) creoles of mixed batches housed in experimental shed with water and food *ad libitum*. The experimental design was completely randomized in a factorial arrangement 3 x 2, with three feeding plans and two housing densities. The plans were: P1 with 3 phases (1-35, 36-70 and 71-90 days), P2 with 4 phases (1-28, 29-49, 50-72 and 73-90 days) and P3 with 5 phases (1-14, 14-28, 29-63, 64-76 and 77-90 days) and housing densities (2 and 3 birds/m^2) with 4 repetitions totaling 24 experimental units. Were slaughtered at 90 days of age 2 birds from each plot for measuring the quality of post-slaughter meat and sensory analysis. Significant differences were found for weight wing ($p<0.05$) between nutritional plans and for weight thigh ($p>0.05$) among population densities, with the nutritional plan with three phases and the density of 2 birds/m^2 showing better results. Wasn't found any significant differences for physical measurements of chest and leg and sensory analysis of meat ($p>0.05$). Significant differences for pH chest and leg were found, with better results for extended nutritional plans and density of 2 birds/m^2. Nutritional plans with reduced phases and lower housing densities have better results for development and meat quality of commercial cuts of creole ducks. Future studies are necessary to determine the influence of other nutritional requirements in meat ducks are raised in confinement.

Key words: Duck meat, pH, chest, quality, nutritional plans, housing densities

INTRODUCTION

The quality of poultry meat has become increasingly important, since sensory attributes such as appearance and tenderness of the meat, are required by the consumer (Beraquet, 1999). According to Valle (2003), the meat must meet the quality attributes such as texture, palatability and appearance, as must also provide safety for unwanted chemical residues.

The sensory characteristics of meat can be affected by factors intrinsic to animals, such as age at slaughter, sex, race, strains, muscle type or production systems, food and pre-slaughter management and post harvest (Berri, 2000; Qiao *et al.*, 2001). According to Miller (2003), to acquiring a meat product, the first feature observed by the consumer is the appearance and after are considered other features such as tenderness, juiciness and useful life, adding value to the product. Kennedy *et al.* (2005) demonstrated the importance of flesh color as preference factor for the acquisition of chicken. Fletcher (2002) says that the texture is, individually, the most important sensory characteristic to influence the overall quality of chicken meat. Accordingly, information on the physico-chemical and functional properties, as well as those properties determine the quality of the final product, is essential to obtain quality products. One of the biggest problems regarding this meat is the loss of softness (Komiyama, 2010).

In Brazil, the consumption of duck meat still restricted to 13 grams per person per year. In China, for example, this consumption is 1.5 kg/year and in Europe remains at 1 kg/inhabitant/year. Duck meat is also widely consumed in the United States and the countries of Arab ethnicity, such as Egypt and Saudi Arabia (Industrial Poultry, 2005).

The easily and accurately in the literature data which have recommendations for raising ducks in confinement wasn't found yet, neither the combined with the proposed nutritional plans, that can influence the quality of duck meat and, however necessary the use of parameters used for broilers, but without strict precision about the actual quality of the product that reaches the consumer.

The management, directly responsible for the quality of the confined animal meat, according to the studies of Cruz (2013) already demonstrated that is a major factor in raising ducks in confinement, where housing density significantly influenced the duck carcass yield. Thus, the

Corresponding Author: Frank George Guimarães Cruz, Federal University of Amazonas, College of Agrarian Sciences, Sector of Poultry, Manaus, Amazonas, Brazil

aim of this study was to evaluate the quality of meat ducks are raised in confinement under different phasic nutritional plans (3, 4 and 5 phases) in different housing densities (2 and 3 birds/m^2).

MATERIALS AND METHODS

The experiment was conducted in the Poultry Sector of the College of Agrarian Sciences, located in the southern sector of the university campus in the Federal University of Amazonas-UFAM, Manaus-AM, Brazil, in an experimental aviary measuring 25 m long, 8 m wide and 3.20 m ceilings, with lanternin, subdivided into 24 boxes of 4 m^2 each. 240 ducks (Cairina Moschara) creoles were used distributed in the boxes as the treatments proposed with water and food at libitum. The birds have had initiated the experimental period of 1 day old and evaluated at 90 days. After the end of this period, the ducks were subjected to a 12 h fasting period until the time of slaughter.

The experimental design was completely randomized in a factorial arrangement 3 x 2, with three feeding plans and two housing densities. The plans were: P1 with 3 phases (1-35, 36-70 and 71-90 days), P2 with 4 phases (1-28, 29-49, 50-72 and 73-90 days) and P3 with 5 phases (1-14, 14-28, 29-63, 64-76 and 77-90 days) and housing densities (2 and 3 birds/m^2) with 4 repetitions, totaling 24 experimental units.

The experimental diets were formulated according to the stages of production of the birds and the pre-established nutritional plans (Table 1), according to the nutritional requirements and reference values provided for broilers (Rostagno *et al*., 2011) adapted to creole cutting ducks.

After the experiment, 4 animals of each treatment were slaughtered by cervical dislocation for the evaluation of post-slaughter carcass. After slaughter, the ducks were submitted to the bleeding process, plucking and carcass cleaning and separated into commercial cuts (neck, wing, thigh, drumstick and breast) as the methodology proposed by Gomide (2012) and weighed. After separation of the cuts, the chest and legs samples were collected from all the killing, which were identified in plastic bags and frozen below. Were analyzed for pH, physical measurements (length, height and width) of chest and leg (thigh and drumstick) and sensory analysis of the bird breast fillets.

The determination of pH was made with a pH meter (SENTRON, Model 1001) coupled to a probe (SENTRON LanceFET type, model 1074-001) fine tip penetration directly to the breast and thigh samples.

Physical breast evaluations were made in the *pectoralis major* muscles (right and left). The length and width were measured with the aid of an ordinary ruler and the height was measured with a caliper, considering the final value of each sample obtained in the two middle portions of the breast (right and left).

Table 1: Ingredients and nutritional composition of the experimental diets

	Nutritional plans											
	Nutritional plan 1			Nutritional plan 2				Nutritional plan 3				
Phases[4] ingredients	Init.	Gro.	Term.	Init.	Gro. I	Gro. II	Term.	P-init.	Init.	Gro. I	Gro. II	Term.
Corn	62.040	72.791	75.790	59.614	68.952	71.479	74.589	59.614	62.295	67.750	71.600	77.006
Soybean meal (46%)	34.150	23.443	20.761	34.600	26.386	23.770	20.983	34.600	31.916	26.608	23.602	18.304
Calcitic limestone	0.910	1.139	0.795	0.876	1.120	0.756	0.792	0.876	1.084	1.116	0.757	0.973
Dicalcium phosphate	1.798	1.580	1.321	1.806	1.570	1.772	1.325	1.806	1.549	1.574	1.773	1.069
Salt	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350
DL-Methionine 99%	0.252	0.197	0.142	0.254	0.171	0.133	0.143	0.254	0.247	0.172	0.246	0.171
Vit./Min supplement	0.500[1]	0.500[2]	0.500[3]	0.500[1]	0.500[2]	0.500[2]	0.500[3]	0.500[1]	0.500[1]	0.500[2]	0.500[2]	0.500[3]
Soybean oil	-	-	0.340	2.000	0.952	1.240	1.318	2.000	2.060	1.930	1.172	1.628
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nutritional levels												
Met. energy (kcal/kg)	2.913	3.032	3.100	3.015	3.050	3.100	3.150	3.015	3.050	3.100	3.150	3.200
Crude protein (%)	21.000	17.000	16.000	21.000	18.000	17.000	16.000	21.000	20.000	18.000	17.000	15.000
Calcium (%)	0.890	0.900	0.700	0.890	0.900	0.800	0.700	0.990	0.900	0.900	0.800	0.700
Madonna+Cystine (%)	0.924	0.764	0.684	0.924	0.764	0.700	0.684	0.924	0.890	0.764	0.702	0.684
Methionine (%)	0.577	0.471	0.404	0.578	0.458	0.408	0.405	0.578	0.558	0.458	0.410	0.419
Phosp. Available (%)	0.450	0.400	0.350	0.450	0.400	0.435	0.350	0.450	0.400	0.400	0.350	0.300
Sodium (%)	0.183	0.176	0.174	0.183	0.178	0.176	0.174	0.183	0.181	0.178	0.176	0.172

[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 1.600.000UI, 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]P-Init. = Pre-Initial; Init. = Initial; Gro. = Growth; Term. = Termination

Table 2: Weight of commercial cuts of confined creole ducks under different nutritional plans and housing densities

	Variables				
Factors	Neck (g)	Chest (g)	Wing (g)	Thigh (g)	Over thigh (g)
Nutritional plans					
3 phases	155.00	402.50	326.50^{a}	248.75	186.25
4 phases	146.25	400.00	297.50^{ab}	238.75	178.75
5 phases	116.25	372.50	262.50^{b}	215.00	152.50
Densities					
2 birds/m^2	147.50	419.16	315.83	260.00^{a}	183.33
3 birds/m^2	130.83	364.16	275.00	208.33^{b}	161.66
Effect	p-valor				
Nutritional plans	0.06^{ns}	0.81^{ns}	0.05*	0.47^{ns}	0.36^{ns}
Densities	0.20^{ns}	0.20^{ns}	0.06^{ns}	0.03*	0.29^{ns}
Interaction	0.06^{ns}	0.21^{ns}	0.07^{ns}	0.25^{ns}	0.32^{ns}
CV (%)	22.33	26.42	16.11	23.88	25.34

CV: Coefficient of variation, *Means followed by lowercase letters in the column differ by 5% of Tukey test (p<0.05); ns: not significant

Table 3: Physical measurements of chest and leg of creole ducks confined under different nutritional plans and housing densities

	Variables					
Factors	Height chest (cm)	Width chest (cm)	Length chest (cm)	Height leg (cm)	Width leg (cm)	Length leg (cm)
Nutritional plans						
3 phases	3.47	12.35	20.61	2.87	9.96	16.93
4 phases	3.37	12.62	20.50	2.95	9.68	16.56
5 phases	2.93	12.25	19.68	2.62	8.31	16.56
Densities						
2 birds/m^2	3.29	12.70	19.54	2.80	9.62	16.70
3 birds/m^2	3.23	12.10	20.99	2.83	9.01	16.66
Effect	p-valor					
Nutritional plans	0.40^{ns}	0.90^{ns}	0.05^{ns}	0.66^{ns}	0.14^{ns}	0.92^{ns}
Densities	0.86^{ns}	0.39^{ns}	0.06^{ns}	0.91^{ns}	0.39^{ns}	0.96^{ns}
Interaction	0.67^{ns}	0.82^{ns}	0.08^{ns}	0.74^{ns}	0.23^{ns}	0.89^{ns}
CV (%)	25.47	13.73	16.11	26.48	18.24	13.10

CV: Coefficient of variation; ns: not significant

To perform sensory of analysis, the breast meat samples were subjected to a brine solution (10%) for 20 min and kept at 5°C temperature. Subsequently, the samples were conditioned in aluminum foil and subjected to heating at a temperature of 200°C, in one electric double-strength steel sheet for 6 min and after 3 min, the samples was turned, with the final internal temperature of 85°C. Then the samples were placed in Petri

plates and heated in microwave for 25 sec, until it reaches 45 or 50, soon to be served immediately to the tasters. The aroma sensory evaluations, flavor, tenderness, juiciness, chewiness, color and general appearance, were performed as described by Roca *et al.* (1988) and selected with 8 trained tasters (Roca and Bonassi, 1985).

The data collected were submitted to analysis of variance and means compared by 5% Tukey test, using the GLM procedure of statistical program SAS (SAS Instit. Inc., Cary, NC, USA, 2008).

RESULTS AND DISCUSSION

The results of the variables related to the weight of retail cuts of Creole ducks are shown in Table 2. Significant differences were found for weight wing (p<0.05) between nutritional plans and for thigh (p>0.05) among population densities. The results for weight wing corroborate with Silva *et al.* (2003) and Santos (2012) that working with energy and protein levels in Cobb and slow growth broilers, respectively, also found significant results for weight wing. In ducks, the size of the wing naturally has a greater proportion because of this body in relation to simple commercial broiler chickens, which makes management much closer ducks used to so-called slow-growing broilers. In addition, nutritional plans with reduced phases with lower offshoot of energy-protein relationship showed higher wing.

Table 4: Breast ph measures and leg of creole ducks confined under different nutritional plans and housing densities

	Ph	
Factors	Chest	Leg
Nutritional plans		
3 phases	5.91^{ab}	6.01^{ab}
4 phases	5.78^{b}	5.85^{b}
5 phases	6.19^{a}	6.28^{a}
Densities		
2 birds/m^2	5.72^{b}	5.83^{b}
3 birds/m^2	6.20^{a}	6.26^{a}
Effect	p-valor	
Nutritional plans	0.01*	0.01*
Densities	0.01*	0.01*
Interaction	0.07^{ns}	0.07^{ns}
CV (%)	3.80	3.88

CV: Coefficient of variation; *Means followed by lowercase letters in the column differ by 5% of Tukey test (p<0.05); ns: not significant

To thigh, the results corroborate with Garcia (2002) and Cruz (2013) who found that housing density has a

Table 5: Sensory analysis of confined creole ducks meat submitted to different nutritional plans and housing densities

	Variables						
Factors	Aroma intensity[1]	Strange aroma[2]	Flavor[3]	Strange flavor[4]	Softness[5]	Succulence[6]	Chewiness[7]
Nutritional plans							
3 phases	6.14	6.00	3.35	6.92	5.00	6.07	4.35
4 phases	6.07	6.07	3.07	6.71	4.64	6.14	4.57
5 phases	6.35	6.14	3.28	6.85	4.85	6.00	3.92
Densities							
2 aves/m²	6.04	5.71	3.33	6.71	4.57	6.38	4.38
3 aves/m²	6.33	6.42	3.14	6.95	5.09	5.76	4.19
Effect	p-valor						
Nutritional plans	0.96[ns]	0.99[ns]	0.92[ns]	0.94[ns]	0.91[ns]	0.94[ns]	0.76[ns]
Densities	0.74[ns]	0.42[ns]	0.76[ns]	0.65[ns]	0.44[ns]	0.09[ns]	0.79[ns]
Interaction	0.82[ns]	0.78[ns]	0.89[ns]	0.79[ns]	0.87[ns]	0.59[ns]	0.74[ns]
CV (%)	25.91	26.9	23.10	24.77	25.28	19.01	25.27

[1]Scale ranging from no odor to very intense and characteristic

[2]1-nothing, 2-extremely weak, 3-very weak, 4-poor, 5-moderately weak, 6-moderately strong, 7-strong, 8-very strong, 9-extremely strong

[3]Scale ranging from very bad to very good

[4]1-very soft (catupiri), 2-very soft, 3-moderately soft, 4-soft, 5-or soft or stiff (olive), 6-slightly stiff, 7-moderately stiff, 8-very stiff, 9-extremely stiff (soft bullet)

[5]1-extremely dry, 2-very dry, 3-moderately dry, 4-lightly dry, 5-or dry or juicy, 6-slightly juicy, 7-moderately juicy, 8-very juicy, 9-extremely juicy

[6]Scale ranging from elastic, rubbery, hard to swallow, easily disintegrates in the mouth, easy to swallow

[7]Scale ranging from not characteristic feature

CV: Coefficient of variation; ns: not significant

significant influence on the carcass yield of birds, where birds with more physical space tend to develop larger carcasses, but with less total meat production within the same space because of the small number of animals. Therefore, It should always be search the best balance between productivity in physical space, better carcass yield and cuts with better quality. In contrast, no significant differences were found ($p>0.05$) for the weight of the other cuts between nutritional plans, among densities and interaction among the factors.

The results of the variables related to physical measures of chest and thigh of creole ducks are shown in Table 3. There were no significant differences in height, width and length chest ($p>0.05$) and height, width and length of the leg ($p>0.05$), disagreeing with the results of Takahashi *et al.* (2012), that working with commercial and colonial chickens of different ages, sex and strains, found significant differences for physical measurements of chest and leg.

The Table 4 shows the results for pH measurements of chest and leg of assessed Creole ducks. Significant differences were found for pH of the chest ($p<0.05$) and pH of the leg ($p<0.05$) between nutritional plans and between stocking densities, but no differences in the interaction between the factors ($p>0.05$). These results corroborate those found by Castellini *et al.* (2002), demonstrating the influence of nutritional management on the pH of broiler meat. For ducks, nutritional plans with phases more synthetic and lower densities presented results from more acidic pH, which may be related to extension of diets with energy levels and protein resulting in a greater accumulation of lactic acid in the muscles during the development of animals and the resulting stress of confinement of birds, as ducks managed in confinement still needs further studies.

The results of the variables related to sensory analysis of creole meat ducks are shown in Table 5. There were no significant differences for the sensory analysis variables between nutritional plans ($p>0.05$) between densities ($p>0.05$) and the interaction between factors ($p>0.05$). It was found, however, that the meat ducks have distinct peculiarities in relation to the results already found in conventional chickens (Varoli, 1999; Zanusso *et al.*, 2002; Culioli, 1990), as extreme intensity of aroma and flavor, which can characterize as a duck meat and meat atypical differentiated properties.

Conclusion: Nutritional plans with reduced phases and lower housing densities have better results for development, meat quality commercial cuts Creole ducks, mainly chest and leg (thigh and over thing) and sensory acceptability, however, tend to have meat with more acidic pH. Future studies are necessary to determine the influence of other nutritional requirements in meat ducks raised in confinement.

Declaration of conflicting interests: The authors declared no potential conflicts of interest with respect to the research, authorship and publication of this article.

REFERENCES

Beraquet, N.J., 1999. Influencia de fatores ante e post-mortem na qualidade da carne de aves. Revista Brasileira de Ciencia Avicola, 3: 155-166.

Berri, C.N., 2000. Variability of sensory and processing quality of poultry meat. World's Poult. Sci. J., 56: 209-244.

Castellini, C., C. Mugnai and A. Dal Bosco, 2002. Effect of organic production system on broiler carcass and meat quality. Meat Sci., 60: 219-225.

Cruz, F.G.G., L.C. Maquiné, E.O. Chagas, J.B.S. Melo and F.A.L. Chaves, 2013. Desempenho de patos (Cairina moschata) em confinamento submetidos a diferentes densidades de alojamento. Revista Acadêmica de Ciências Agrárias e Ambientais, 11: 313-319.

Culioli, J., C. Touraille, P. Bordes and J.P. Girard, 1990. Caractéristiques des carcasses et de la viande du poulet label fermier. Archiv für Geflügelkunde, 53: 237-245.

Fletcher, D.L., 2002. Poultry meat quality. World's Poult. Sci. J., 8: 131-145.

Garcia, R.G., A.A. Mendes, E.A. Garcia, I.A. Nääs, J. Moreira, I.C.L. Almeida and T.S. Takita, 2002. Efeito da densidade de criação e do sexo sobre o empenamento, incidência de lesões na carcaça e qualidade da carne de peito de frangos de corte. Braz. J. Poult. Sci., 4: 1-9.

Gomide, L.A.M., N. Alencar and I.A. Macedo, 2012. Processamento de frango (corte, recorte e desossa). 2 ed. Brasilia/DF: LK Editora, 88 p.

Industrial Poultry, 2005. Industrializacao de patos e marrecos. Disponivel em: <http://www.aviculturaindustrial.com.br/noticia/industrializacao-de-patos-e-marrecos/20051206112105_16545>. Acesso em: 25 dez 2014.

Kennedy, O.B., B.J. Stewart-Knox, P.C. Mitchell and D.I. Thurnham, 2005. Flesh colour dominates consumer preference for chicken. Appetite, 4: 181-186.

Komiyama, C.M., A.A. Mendes, C. Sanfelice, M.C. Cañizares, R.O. Roça, S.E. Takahashi, L. Rodrigues, G.I.L. Cañizares, I.C.L.A. Paz and K.F.G. Cardoso, 2010. Qualidade físico-química e sensorial da carne de peito de matrizes pesadas de descarte. Ciência Rural, 40: 1623-1629.

Miller, R., 2003. Assessing consumer preferences and atitudes toward meat and meat products. Brazilian J. Food Technol. Special Issue, pp: 67-80.

Qiao, M., D.L. Fletcher, D.P. Smith and J.K. Northcutt, 2001. The effect of broiler breast meat color on pH, moisture, waterholding capacity and emulsification capacity. Poult. Sci., 80: 676-680.

Roca, R.O. and I.A. Bonassi, 1985. Selecao de provadores para produtos carneos. In: Congresso Brasileiro D.E., Ciencia E., Tecnologia D.E., Alimentos. 7, Itabuna/Ilheus, Anais., Itabuna/Ilheus, SBCTA, pp: 83.

Roca, R.O., A.M. Serrano and I.A. Bonassi, 1988. Utilizacao de toucinho na elaboracao de fiambres com carne de frango. Ciencia e Tecnologia de Alimentos, 8: 67-76.

Rostagno, H.S., L.F.T. Albino, J.L. Donzele, P.C. Gomes, R.F. Oliveira, D.C. Lopes, A.S. Ferreira, S.L.T. Barreto and R.F. Euclides, 2011. Brazilian Tables for Poultry and Swine: Composition of Feedstuffs and Nutritional Requirements, 3rd. Federal University of Vicosa, Vicosa, Minas Gerais, Brazil, pp: 252.

Santos, M.S.V., S.S. Vieira, F.B. Tavares, P.A. Andrade, M.C. Manno, H.S. Costa and A.S. Moreira, 2012. Desempenho, carcaça e cortes de frangos caipira francês barré (Gris Barré Cou Plumé). Archivos de Zootecnia, 61: 287-295.

Statistical Analysis System (SAS), 2008. SAS/STAT Software Version 9.2. Cary: SAS Institute Inc., 2008.

Silva, A.S., G.O. Domingues, L.M. Americo, M.A. Costa and C.V. Alves, 2003. Desempenho e caracteristicas de carcaça de frangos de corte alimentados com dietas contendo diferentes niveis de proteina e energia. Revista Brasileira de Agrociencia, 12: 201-211.

Takahashi, S.E., A.A. Mendes, C. Mori, C.C. Pizzolante, R.G. Garcia, I.C.A. Paz, K. Pelícia, E.S.P.B. Saldanha and J.R.O. Roça, 2012. Qualidade da carne de frangos de corte tipo colonial e industrial. Revista Eletrônica de Medicina Veterinária, ano 9, n. 18.

Valle, J.C.V., 2003. O mercado de frango organico. Agroecologia Hoje, 3: 25.

Varoli, Jr. J.C., 1999. Desempenho e qualidade de carcaça de frangos com gene Na. Botucatu, SP. Dissertacao (Mestrado). Faculdade de Medicina Veterinaria e Zootecnia, UNESP.

Zanusso, J.T., H. Rémignon, A. Auvergne and R. Babilé, 2002. Características zootécnicas e qualidades da carne de frango de corte/ criado em sistema semi-confinado: comparações entre machos inteiros, castrados e fêmeas. In: REUNIÃO ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, 39 ed. Anais... CD-ROM.