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Physical traits of eggs from free-range domestic hens of the Sura variety in Northeast Brazil

Características físicas de ovos de galinhas domésticas caipiras da variedade Sura no Nordeste

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ABSTRACT This study aimed to analyze the physical characteristics of eggs from free-range hens of the Sura variety. One hundred eggs underwent assessment of various physical parameters, namely, whole egg weight, equatorial diameter, egg height, shell color, presence of cracks via candling, air chamber height, yolk color, presence of flesh and blood spots, albumen width and length, yolk diameter, yolk weight, and shell weight. Additional analyses included determining the albumen weight (calculated by subtracting the weights of the shell and yolk from the total egg weight), percentages of egg components, shape index, and shell index. Statistical analyses were conducted using GLM SAS software (SAS Institute). The results revealed distinct physical traits; eggs from the Sura variety, regardless of size class (large or small), typically have a more rounded shape, light brown shells, and more orange yolks. These findings confirm that Sura variety eggs possess unique characteristics that could appeal to specific market niches, potentially promoting the production of these birds, supporting biodiversity, and aiding in the prevention of their extinction.

Keywords free-range poultry farming, Sura hens, egg quality, eggs

RESUMO *Este estudo teve como objetivo analisar as características físicas dos ovos de galinhas caipiras var. Suras. Foram analisados um total de 100 ovos, onde diversos parâmetros físicos, tais como pesagem do ovo inteiro, medição do diâmetro equatorial e altura do ovo, classificação da cor da casca, miragem para verificação da presença de fendas na casca, determinação da altura da câmara de ar, classificação da cor da gema, verificação da presença de manchas de carne e manchas de sangue, medição da largura e comprimento do albúmen, medição do diâmetro da gema, pesagem da gema, e pesagem da casca. Foram posteriormente determinados o peso do albúmen por diferença entre o peso do ovo e pesos da casca e gema, determinação percentual dos diferentes constituintes do ovo, shape index (índice de forma) e shell index (índice de casca). A análise estatística foi realizada pelo GLM programa SAS (SAS Institute). O resultado comparando as médias de cada parâmetro estudado demonstrou que os ovos da variedade Sura em ambas as classes comerciais (Grande e Pequenos), possuem formato mais arredondado, com casca marrom clara e gema mais alaranjada. Portanto, os parâmetros avaliados confirmam que os ovos provenientes de galinhas var. Suras possuem características que podem favorecer nichos de mercado e assim incentivar a produção destas aves, mantendo a biodiversidade e contrariando a extinção das mesmas.*

Palavras-chave *avicultura caipira, galinhas Suras, qualidade do ovo, ovos*

1. Introduction

Brazil ranks as the sixth largest egg producer globally, with an estimated production rate of around 1,743 eggs per second. In 2021, the average Brazilian consumed approximately 257 eggs, as reported by the latest sectoral survey (ABPA, 2022).

Humans have consumed eggs since the beginning of time, including those from "wild" birds even before the advent of agriculture. Today, chicken eggs are integral to various food industry sectors including bakery, pastry, pasta production, and others. Additionally, eggs are used in animal feed, therapeutic applications, and culture media (Cook and Briggs, 1986). Nutritionally, eggs are among the most complete foods, providing proteins, vitamins, and beneficial fats, and are vital for proper bodily functions (Barbosa et al., 2008; Tarricone et al., 2013).

Currently, egg sales in Brazil are exclusively carried out through industrial systems. However, the free-range and backyard egg production models are gaining traction as consumers increasingly prioritize health, food safety, and even sustainability (Carioca Junior et al., 2015; Reichert et al., 2011).

Floor-raised chickens, which thrive in low-input systems, are well-suited for free-range or backyard settings (Mengesha and Tsega, 2011). This method of raising birds is an ancient and profitable practice, deeply embedded in the culture of family farms (Carvalho et al., 2018). It also contributes to the diversification of the poultry sector, tailored to local conditions (Yakubu et al., 2008; Alders and Pym, 2010; Alderson, 2018). Although floor-raised chickens were once prevalent in Brazilian poultry farming before the current industrial and competitive scenario, they are now facing imminent disappearance or exist only in small, underutilized groups within household farms (Almeida et al., 2019).

Given this background, it is important to explore the production and productivity of these birds so as to implement strategies aimed at the characterization and conservation of these genetic resources (Moula et al., 2010; Machado, 2018). The Sura, a group of floor-raised chickens, exemplifies such under-documented varieties found in small numbers. The objective of this study was to examine the physical characteristics of eggs from free-range hens of the Sura variety in the northeast region of Brazil.

2. Material and methods

2.1. Sampling and collection

The eggs were from a collective community chicken farm of the Sura variety in the municipality of Inhuma - PI, Brazil, with birds aged between 8 to 24 months. The sample comprised 100 eggs, reflecting the total weekly production capacity if the farm excluding consumption and scheduled sales. The eggs were sanitized and tagged for subsequent analysis. Physical characteristics of the eggs were assessed at the Animal Health and Reproduction Laboratory, located at the Technical School of Teresina (CTT−UFPI).

2.2. Laboratory analysis

Upon arrival at the laboratory, each egg was marked with a number at both poles. This number also labeled a beaker and two Petri dishes designated for the albumen, yolk, and shell, respectively. Each egg was individually analyzed.

To analyze the physical characteristics of the eggs, the following tests were conducted in sequence: weighing the entire egg; measuring its equatorial diameter and height; classifying the shell color; candling to check for the presence of cracks in the shell; determining the height of the air chamber; classifying the yolk color; checking for the presence of flesh and blood spots; measuring the width and length of the albumen; measuring the diameter of the yolk; weighing the yolk; and weighing the shell. After collecting the results from the afore mentioned tests, the weight of the albumen was calculated by subtracting the combined weights of the shell and yolk from the total weight of the egg. Additionally, the percentages of the different egg components were calculated, along with the shape index and shell index.

2.3. Determination of egg weight and components: yolk, albumen, shell

Eggs were weighed using an analytical balance. Each egg was then broken, and the length and width of the albumen and the diameter of the yolk were recorded. The albumen was carefully pipetted to ensure complete separation from the yolk and transferred into a pre-labeled vial. The yolk was placed in a Petri dish for weighing.

The eggshell was transferred to a separate Petri dish and placed in an oven to dry at 60 °C for 12 h. Following this, the shells were allowed to rest at room temperature for several hours before being weighed. The weight of the albumen was calculated as the difference between the total weight of the egg and the combined weights of the dried yolk and shell. Based on these weights, the percentages of the whole egg, shell, yolk, and albumen relative to the total egg weight were determined.

2.4. Determination of equatorial index, egg height, shape index, and shell index

After weighing the entire egg, its equatorial diameter and height were measured using a digital caliper. The shape index was then calculated using the formula:

$$shape\ index = \left(\frac{w}{l}\right) \times 100$$

where w: equatorial diameter of the egg, in mm; and l: egg height, in mm.

The shell index (g/cm^2) was determined using the following formula:

$$shell\ index = \left(\frac{SW}{w\ \times 1}\right) \times 100$$

where SW: shell weight, in g; W: egg diameter, in cm; and l: egg height, in cm.

2.4. Eggshell color classification

The color of the shell was classified using a scale developed by Fernandes (2014), with 1 representing the lightest color and 6 the darkest (Figure 1). A seventh category was added for blue or greenish eggs. Color classification was conducted under a spotlight to ensure accurate comparison with the scale.

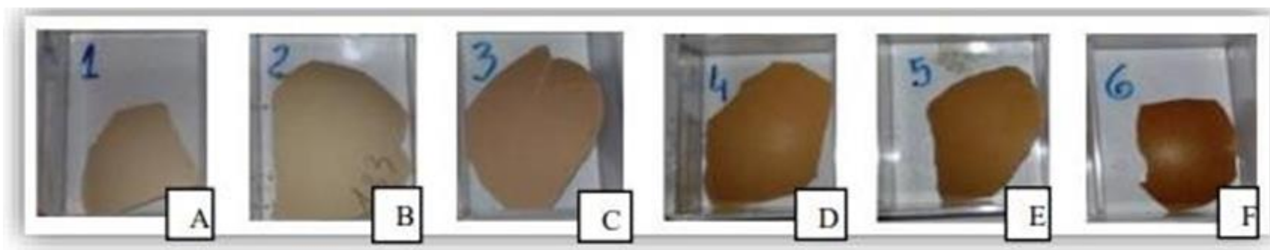

Figure 1 – Shell color classification scale (Source: Fernandes, 2014). Grade: 1: lightest shell color; 6: darkest shell color. Green is assigned a grade of 7.

2.5. Candling and determination of air chamber height

Candling was performed to detect any cracks in the shell. This process was carried out in a darkened laboratory with the lights turned off to ensure as much darkness as possible, allowing for a more accurate analysis. The procedure was performed with an 'ovoscope', a flashlight-shaped device, allowing for internal observation of the egg. Subsequently, the egg was cracked over a smooth, flat, gray tray so that the albumen could spread freely. After the albumen had stabilized, additional analyses were performed. The height of the air chamber was measured with a digital caliper.

2.6. Yolk color classification

To determine the color of the yolk, the Roche Colorimetric Fan was utilized. This tool includes 15 graduations (1−15), with 1 representing light yellow—the lightest color—and 15 indicating reddish orange—the darkest. Yolk color classification was conducted under white light, with the yolk positioned beneath the fan for accurate comparison to the gradations.

2.7. Presence of defects

The presence and the number of defects were carefully inspected. The main type are blood and meat spots.

2.8. Statistical analysis

Statistical analyses were performed using SAS software (SAS Institute). An analysis of variance (ANOVA) was conducted to compare the means of each parameter using Student's t-test as part of the General Linear Models procedures. Differences between means were deemed significant at p<0.05.

3. Results and Discussion

It is noteworthy that Ordinance SDA 747, issued on February 6, 2023, introduced changes to the classification of free-range eggs. Effective from March 1, 2023, the classifications of super small and medium eggs within the “A” category were eliminated. The new classifications defined, as follows: Jumbo − minimum weight of 68 g per unit; Extra − weight between 58 g and 67.99 g per unit; Large − weight between 48 g and 57.99 g per unit; Small − weight less than 47.99 g per unit (Basil, 2022).

Table 1 presents the descriptive results of the physical qualities of eggs from Sura hens categorized by weight. Although egg weight is not an indicator of quality, it is widely used to standardize marketing. In this study, the 100 eggs were classified as small (S; 68 eggs) and large (L; 32 eggs), with average weights of 41.82 g and 52.30 g, respectively. Oliveira and Oliveira (2013) note that the weight of the egg reflects increases in the yolk, albumen, and shell components, constituting approximately 65%, 25%, and 10% of the egg's weight, respectively.

According to Rocha et al. (2008), egg weight significantly influences the incubation process and the weight of chicks at birth, making it a crucial trait in egg production. The occurrence of blood and flesh spots (internal defects) and external defects (candling) was low, indicating good quality. Fernandes (2014) explains that blood spots in the yolk typically arise during ovulation due to minor ruptures in blood vessels. Flesh spots consist of small tissue fragments from the oviduct that adhere to the albumen or yolk. External defects (candling) were detected in only 0.21 to 0.26% of the eggs, whereas internal defects (blood or flesh spots) occurred exclusively in the small class of eggs, at rates of 0.02% and 0.05%, respectively.

The analysis of quantitative traits in common and Sura chickens revealed that most of the variables studied exhibited a coefficient of variation below 25%, except for shell color, whose coefficient of variation was higher for both groups.

In Table 1, significant differences (p<0.05) were observed between weight classes and egg sizes for most traits, except shell color. The egg weights in classes L and S differed, indicating that the largest sizes correspond to the highest weights, and similarly for the smaller sizes. Egg weight and size are primary selection criteria during purchase, with larger eggs being consumer favorites, as stated by Barbosa et al. (2008).

Table 1 – Mean traits of Sura hen eggs divided by class (large and small; according to Ordinance SDA747, Feb. 2023).

Variables	Size class	
	Large (> 48 g)	Small (< 47.9 g)
Egg weight (g)	52.38[a]	41.92[b]
Shell weight (g)	4.81[a]	4.04[b]
Egg diameter (mm)	40.13[a]	38.55[b]
Egg height (mm)	53.49[a]	49.42[b]
Air chamber height (mm)	17.31[a]	15.51[b]
Yok color (1 – 15)	11.28[a]	10.67[b]
Albumen width (mm)	70.91[a]	61.58[b]
Albumen height (mm)	85.12[a]	77.06[b]
Albumen weight (g)	24.18[a]	19.44[b]
Yolk diameter (mm)	42.29[a]	39.89[b]
Yolk weight (g)	18.79[a]	15.44[b]
Shape index	75.00[b]	78.24[a]
Shell index (g/cm²)	0.23[a]	0.21[a]

Means followed by different letters in the row differ from each other according to Student's t-test ($p<0.05$).

According to Jeffrey and Graham (2007), the main concern of producers is shell quality, due to the financial losses it can cause if it is not in adequate condition. In this study, the eggshell weight was higher in L eggs. Chickens can only deposit a limited amount of calcium during egg formation, and therefore, if the egg increases in size and weight, the shell weight does not proportionally increase, leading to a reduction in shell weight. This finding contrasts with Sinha et al. (2017), who observed that smaller egg weights corresponded to greater shell weights.

Egg colors can vary from white to dark brown, and in some cases, they can be greenish or blue. Mendes et al. (2016) explains that shell color is a genetic factor in laying hens, controlled by multiple genes that regulate the deposition of these pigments, contrary to the belief held by some that it stems from nutritional factors.

One of the major issues related to shell quality involves the presence of cracks and dirt, which can lead to egg contamination by pathogenic microorganisms, posing a risk to consumer health (Mertens et al., 2006). Internal defects occurring in the albumen and yolk indicate reproductive issues in birds. Unlike external defects, the presence of blood or flesh spots on chicken eggs, although negatively impacting the appearance of the product, does not affect the nutritional quality of the egg (Fernandes, 2014).

Another variable evaluated for the internal quality of the egg is the yolk color, which is influenced by the birds' genetics as well as their diet (Santos-Bocanegra et al., 2004). Generally, consumers prefer a more orange hue. The yolk color of class Large exhibited a more darkish color, averaging 11 on the Roche Color Fan, aligning with the preferences of most consumers. Similar findings were reported by Sekeroglu and Altuntas (2008), who noted that heavier eggs tended to have darker yolks.

Regarding the height of the air chamber, a significant difference was observed between the two egg classes (Table 1). The air chamber acts as a reserve oxygen pocket for the embryos during the final stage of incubation and can also be used to assess egg freshness (Xavier et al., 2008). The smaller the air chamber, the fresher the egg (Freitas et al., 2011). Eggs begin to lose quality from the moment they are laid; as they age, the air chamber, albumen, and yolk deteriorate due to various chemical reactions that take place within the egg (Lana et al., 2017).

Differences across all egg components—albumen width, albumen height, albumen weight, yolk width, and yolk weight—being consistently higher in class of larger L eggs.

Egg fragility can be assessed by the shell index, which correlates the shell weight with the height and diameter of the egg (Hidalgo et al., 2008). A lower shell index value indicates greater fragility (Clerici et al., 2006). However, egg fragility was found to be low in both size classes (p>0.05). The shape of the egg (shape index) can be evaluated by the ratio between the diameter and height of the egg (Hidalgo et al., 2008). It was observed that the eggs maintained a rounded shape, regardless of size class. This rounded shape, although acceptable, may be a genetic trait of these birds.

4. Conclusions

This study concludes that there are distinct classes (large and small) of eggs from Sura chickens with physical characteristics reflecting egg quality. It was also found that Sura chickens produce eggs that are more rounded in shape, with a light brown shell and a more orange yolk in both classes. Therefore, the parameters evaluated in this study suggest that eggs from Sura chickens possess qualities suitable for niche markets, which could promote the production of these birds, thereby preserving biodiversity and preventing their extinction.

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Declaration of Conflict of Interest

The authors declared no conflicts of interest.

References

ABPA. (2022). Associação Brasileira de Proteína Animal: Relatório anual. Retrieved from: https://abpa-br.org/wp-content/uploads/2022/05/Relatorio-Anual-ABPA-2022-1.pdf. Accessed November 15, 2022.

Alders, R. G. & Pym, R. A. E. (2010). Village poultry: still important to millions, eight thousand years after domestication. *World's Poultry Science Journal, 65*(2), 181−190. https://doi.org/10.1017/S0043933909000117.

Alderson, G. L. H. (2018). Conservation of breeds and maintenance of biodiversity: justification and methodology for the conservation of Animal Genetic Resources. *Archivos de Zootecnia*, *67*(258), 300−309. https://doi.org/10.21071/az.v67i258.3668.

Almeida, E. C. J., Carneiro, P. L. S., Nunes, I. A., Pereira, A. H. R., Farias Filho, R. V., Malhado, C. H. M., & Bittencourt, T. C. B. S. C. (2019). Características físicas de ovos de galinhas nativas comparadas a linhagem de postura. *Archivos de Zootecnia, 68*(261), 82−87. https://doi.org/10.21071/az.v68i261.3943.

Barbosa, N. A. A., Sakomura, N. K., Mendonça, M. O., Freitas, E. R., & Fernandes J. B. K. (2008). Qualidade de ovos comerciais provenientes de poedeiras comerciais armazenados sob diferentes tempos e condições de ambientes. *Ars Veterinaria, 24*(2), 127−133. https://doi.org/10.15361/2175-0106.2008v24n2p127-133.

Brasil. (2022). Agência Nacional de Vigilância Sanitária. Instrução Normativa n. 161 de 01 de julho de 2022. Diário Oficial da União. Retrieved from: https://antigo.anvisa.gov.br/documents/10181/2718376/IN_161_2022_.pdf/b08d70cb-add6-47e3-a5d3-fa317c2d54b2. Accessed October 14, 2023.

Carioca Júnior, H. R., Freitas, H. J., Cordeiro, M. B., & Gomes, F. A. (2015). Efeito da granulometria do milho sobre o desempenho zootécnico e rendimento de carcaça de frangos de corte de linhagem caipira. *Enciclopedia Biosfera, 11*(21), 851−860.

Carvalho, D. A.; Bonafé, C. M.; Rodriguez-Rodriguez, M. D. P.; Almeida, M. J. O. Sarmento J. L. R.; Britto. F. B.; Silva M. A. Genetic variability of twelve microsatellite loci in native Canela-Preta chickens. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia,* v. 70, n. 4, p. 1275-1281, 2018. https://doi.org/10.1590/1678-4162-9675

Clerici, F., Casiraghi, E., Hidalgo, A., & Rossi, M. (2006). Evaluation of eggshell quality characteristics in relation to the housing system of laying hens. XII European Poultry Conference. 10–14 September 2006. Verona, Italy.

Cook, F.; & Briggs, G. M. (1986). The nutritive value of eggs. In W. J. Stadelman, & O. J. Cotterill (Eds.), *Egg Science and Technology* (3rd ed.) (pp. 141−163). AVI Publishing Co.

Fernandes, E. A. (2014). *Características físicas e químicas de ovos provenientes de diferentes sistemas de produção.* Dissertação (Mestrado em Engenharia Zootécnica/Produção Animal) – Faculdade de Medicina Veterinária, Universidade de Lisboa, Lisboa, Portugal, 2014.

Freitas, L. W., Paz, I. C. L. A., Garcia, R. G., Caldara, F. R., Seno, L. O., Felix, G. A., Lima, N. D. S., Ferreira, V. M. O. S., & Cavichiolo, F. (2011). Aspectos qualitativos de ovos comerciais submetidos a diferentes condições de armazenamento. *Agrarian, 4*(11), 66−72.

Hidalgo, A., Rossi, M., Clerici, F., & Ratti, S. (2008). A market study on the quality characteristics of eggs from different housing systems. *Food Chemistry, 106*(3), 1031−1038. https://doi.org/10.1016/j.foodchem.2007.07.019.

Jeffrey, A. C., & Graham, C. W. (2007). Optimum Egg Quality: A Practical Approach. 5M Publishing. 63p.

Lana, S. R. V., Lana, G. R. Q., Salvador, E. L., Lana, A. M. Q., Cunha, F. S. A., & Marinho, A. L. (2017). Qualidade de ovos de poedeiras comerciais armazenados em diferentes temperaturas e períodos de estocagem. *Revista Brasileira de Saúde e Produção Animal*, *18*(1), 140−151. https://doi.org/10.1590/S1519-99402017000100013.

Machado, L. P. M. (2018). *Curva de crescimento e características de carcaças de galinhas canela-preta em diferentes sistemas de criação*. Dissertação (Mestrado em Zootecnia) - Universidade Federal do Piauí, Bom Jesus, PI, Brasil.

Mendes, L. J., Moura, M. M. A., Maciel, M. P., Reis, S. T., Silva, V. G., Silva, B. D., de Moura, V. H. S., Meneses, I. M. A., & Said, J. L. S. (2016). Perfil do consumidor de ovos e carne de frango do município de Janaúba-MG. *Ars Veterinaria, 32*(1), 81−87.

Mengesha, M., & Tsega, W. (2011). Phenotypic and genotypic characteristics of indigenous chickens in Ethiopia: A review. *African Journal of Agricultural Research, 6*(*24)*, 5398−5404.

Mertens, K., Bamelis, F., Kemps, B., Kamers, B., Verhoelst, E., De Ketelaere, B., Bain, M., Decuypere, E., De Baerdemaeker J. (2006). Monitoring of eggshell breakage and eggshell strength in different production chains of consumption eggs. *Poultry Science, 85*(9), 1670–1677. https://doi.org/10.1093/ps/85.9.1670.

Moula, N. A. N., Antoine-Moussiaux, N., Decuypere, E., Farnir, F., Mertens, K., De Baerdemaeker, J., & Leroy, P. (2010). Comparative study of egg quality traits in two Belgian local breeds and two commercial lines of chickens. *Archiv fur Geflugelkunde, 74*(3), 164−171.

Oliveira, B. L., & Oliveira, D. D. (2013). Qualidade e tecnologia de ovos. Editora UFLA. 224p.

Reichert, L. J., Gomes, M. C., & Schwengber, J. E. (2011). Avaliação técnica e econômica de um agroecossistema familiar de base ecológica na região Sul do Rio Grande do Sul. *Revista Brasileira de Agrociência, 17*(1), 123−132.

Rocha, J. S. R., Lara, L. J. C., Baião, N. C., Cançado, S. V., Baião, L. E. C. & Silva, T. R. (2008). Efeito da classificação dos ovos sobre o rendimento de incubação e os pesos do pinto e do saco vitelino. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, *60*(4), 979−986. https://doi.org/10.1590/S0102-09352008000400029.

Santos-Bocanegra, E., Ospina-Osorio, X., & Oviedo-Rondon, E. O. (2004). Evaluation of xanthophylls extracted from *Tagetes erectus* (Marigold Flower) and *Capsicum Sp.* (Red Pepper Paprika) as a pigment for egg-yolks compare with synthetic pigments. *International Journal of Poultry Science, 11(3)*, 685−689. https://doi.org/10.3923/ijps.2004.685.689.

Sekeroglu, A., & Altuntas, E (2008). Effects of egg weight on egg quality characteristics. *Journal of the Science of Food and Agriculture, 89*(3), 379−383. https://doi.org/10.1002/jsfa.3454.

Sinha, B., Mandal, K. G., & Kumari, R. (2017). Effect of egg weight on egg quality traits of laying hens. *International Journal of Pure and Applied Bioscience, 5*(3), 293−300.

Tarricone, G. P. S., Zacarias, L. D., Souza, A. H. P., Rodrigues, A. C., Stroher, G. R., Gohara, A. K., Matsushita, M., Visentainer, J. V., Neves, G. Y. S., Souza, N. E., Stroher, G. L. (2013). Avaliação de Proteína Bruta em Diferentes Tipos de Ovos Comercializados. 53º Congresso Brasileiro de Química: Ampliando Fronteiras. Rio de Janeiro, Brasil.

Xavier, I. M. C., Cançado, S. V., Figueiredo, T. C., Lara, L. J. C., Lana, A. M. Q., Souza, M. R., & Baião, N. C. (2008). Qualidade de ovos de consumo submetidos a diferentes condições de armazenamento. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 60*(4), 953−959. https://doi.org/10.1590/S0102-09352008000400026.

Yakubu, A, Ogah, D. M., & Barde, E. (2008). Productivity and egg quality of free range naked neck and normal feathered Nigerian indigenous chicken. *International Journal Poultry Science, 7*(6), 579−585.