Acta Scientiarum
http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v42i1.46552

ANIMAL PRODUCTION

Quality of brown-shelled eggs marketed in different commercial establishments

Thiago Souza, Claudia da Costa Lopes*, Rita Brito Vieira, Gabriela Coelho Santos, Rodrigo Ferreira Silva, Ediane Santos Calixto and Jaine Alves Azevedo

Instituto de Ciências Sociais, Educação e Zootecnia, Universidade Federal do Amazonas, Estrada Parintins Macurany, 1805, 69152-240, Parintins, Amazonas, Brasil. *Author for correspondence. E-mail: cclway@yahoo.com.br

ABSTRACT. This study aimed at evaluating the internal and external quality of brown-shelled eggs commercialized in the municipality of Parintins-AM. A total of 540 eggs were evaluated and distributed in a completely randomized design, which consisted of three treatments and six replications of 30 eggs each. The treatments were: eggs sold in supermarkets; in grocery stores; and eggs sold directly at the farm. The age of the eggs from supermarkets and grocery stores was unknown, however, the eggs bought at the farm were marketed as being from the day of laying. The collected data were submitted to analysis of variance and Tukey test at 5% probability. There were no differences ($p > 0.05$) of treatments in the percentage of dirty eggs, however, grocery and farm eggs presented higher ($p < 0.05$) crack percentage. The eggs at the farm presented higher incidence ($p < 0.05$) of internal stains of blood. The weight of the egg and albumen presented no differences ($p > 0.05$). However, the albumen percentage of the farm eggs was higher than the other treatments ($p < 0.05$). The percentages for yolk and eggshell weight from the farm eggs were lower than the supermarket and grocery eggs ($p < 0.05$). For the variables albumen height, Haugh unit, albumen index, yolk and albumen pH, the best results were observed for the farm eggs, however, regarding these variables, eggs sold in supermarkets and grocery stores did not differ from each other. The brown shell eggs sold in the city of Parintins/AM have high rates of external defects, and the eggs bought directly from the farm presented better internal quality, when compared to eggs sold in different establishments.

Keywords: albumen index; commercial eggs; egg pH; shell quality; Haugh unit.

Received on February 8, 2019.
Accepted on July 15, 2019.

Introduction

Brazil registered a record in egg production in 2017, with approximately 3.3 million dozen of new eggs produced, which represented a 6.7% increase when compared to 2016. Thus, the country is among the largest egg producers in the world, mainly due to the new technologies incorporated over the years in the areas of genetics, management and nutrition of the animals.

The commercial egg is the product of an efficient biological transformation performed by laying hens during laying. They are capable of transforming foods with low biological value from their diet into a food with high available nutritional value for human consumption. This transformation relies on factors related to the bird's physiology; however, it can be also influenced by the nutritional support, management practices and environmental conditions to which the birds are submitted (Santos, Roberto, Lima, & Oliveira, 2017).

According to Ruxton, Derbyshire, and Gibson (2010) the egg contributes to a healthy diet because it presents an adequate protein content, monounsaturated fat and a good variety of vitamins, minerals and trace elements, which can meet up to 15% of the daily nutritional needs of an adult. Nonetheless, according to Perry, Rasmussen, and Johnson (2009), eggs can be considered as a functional food, because, besides having nutritional characteristics, this food also contain substances such as zeaxanthin and lutein, which are carotenoids that have antioxidant effect, and protect the eyes from light damages. In addition to these positive characteristics, the egg still has a lower price when compared to other sources of animal protein, which makes it accessible to most of the population.

However, to ensure that eggs reaches the consumer's table with excellent quality, beyond the care taken in the farms during production, several factors related to marketing site can also affect the quality of the egg for consumption, such as, improper cooling temperature, marketing period, storage time and humidity at the commercialization site (Guedes et al., 2016). The egg quality is defined by a set of properties that determine the degree of acceptability of the product by consumers, and it is determined by various external and internal aspects (Gole, Chousalkar, & Roberts, 2012). The external aspects are evaluated by the quality of the shell and dirt, while the internal aspects consist of albumen, yolk color, blood spots, and yolk and albumen pH evaluation.

This research was developed to evaluate the internal and external quality of brown-shelled eggs marketed in different commercial establishments located in the city of Parintins, Amazonas state.

Material and methods

The research was conducted at the Animal Nutrition Laboratory of the Institute of Social Sciences, Education and Animal Science, from the Universidade Federal do Amazonas, located in Parintins city, Amazonas state, Brazil.

To perform the research, a total of 540 eggs were randomly collected from an egg farm, and from some supermarkets and grocery stores of different districts of Parintins. The experiment took place from April to May 2018. The eggs collection was performed weekly, for six weeks, where each week represented a repetition and each repetition contained 30 eggs. The experimental design set was completely randomized.

The treatments were: A – eggs marketed by a local farm (fresh); B – eggs marketed in different supermarkets; C – eggs sold in different grocery stores in the city. The eggs obtained from the local farm were fresh eggs, which mean that they were sold on the same day of laying. It should be noted that the age of the eggs purchased in supermarkets and grocery stores were unknown, since the packages in which they were marketed did not contain date of packing. The egg collections occurred at the same time and day of the week, and the eggs were then sent to the Animal Nutrition Laboratory, where they were identified, individually weighed on a precision scale and separated by treatment.

Initially, the eggs were visually analyzed in order to find the presence of external spots or cracks in the shell, and after being broken, their content was visually evaluated to check if they had internal blood spots in the yolk or albumen. To determine the percentage of eggs that have had one of these variables, we considered the amount of eggs that had a defect in relation to the total number of eggs evaluated, which means: % dirty = Total dirty eggs x 100 / total eggs collected. It was also possible that the same egg had more than one of the evaluated defects, that is, an egg could have its shell cracked and dirty at the same time, or another egg could have had a cracked shell and internal blood stain, when it was evaluated internally. Thus, all variables recorded were accounted individually in relation to the total number of collected eggs. Subsequently, specific gravity evaluations were made using saline solutions with known density, ranging from 1.050 to 1.090 g cm^{-3}, with a variation gradient of 0.005, measured by means of a densimeter. The determination of gravity was performed by dipping the eggs in each solution and, in the solution where they floated, the gravity was defined.

The eggs were individually broken on a flat, smooth and white-bottomed surface, in order to determine the largest diameter, smallest diameter and height of the dense albumen, measured with the aid of a digital caliper (0.01 mm scale). With these data, the albumen index was calculated by using the formula: Albumen Index = Albumen height / mean diameter.

Subsequently, the yolk, shell and albumen were separated. The egg yolk was weighed on a precision scale and the albumen weight was determined by the difference between the weight of the whole egg, subtracting the egg yolk and shell weight after drying it at room temperature. Immediately after weighing the yolks, five yolk units and five albumen units were pooled in a glass Becker and homogenized for pH reading, by using a digital pH meter (model: K39-0014PA).

The shell thickness was determined in the equatorial region of the egg by means of a digital caliper, after air drying for a period of 48 hours. This measurement was taken in two distinct regions and, the arithmetic mean was calculated with the found values. After thickness measurement, the shells were also weighed on a precision scale.

The Haugh unit was calculated by the formula: $UH = 100 \log (H + 7.57 - 1.7W^{0.37})$, where H is albumen height (mm) and W is egg weight (g). The percentage of yolk, shell and albumen as a function of egg weight was also calculated.

The results were subjected to analysis of variance, and the means were compared by Tukey test set at 5% significance level, with the aid of the Statistical Analysis System (SAS, 2004) computer program.

Results and discussion

No significant differences were observed in the percentage of dirty eggs purchased at different commercial establishments (Table 1). The eggs were considered dirty when they presented external stains, such as feathers, down, blood or excreta stain. Although there was no difference between treatments, a high incidence of eggs with dirty shell was observed, which is a relevant fact, since such feature can cause rejection by consumers, as well as being a major vehicle of contamination for the eggs. At the farms, eggs must be collected at least 4 times a day, in order to reduce contamination among the eggs. This procedure avoids longer contact time of eggs with dust and other sources of dirt that may accumulate on the eggshell surface.

The highest percentage of cracked eggs was obtained for those sold directly in the local farm, with no statistical difference from the eggs sold in grocery stores. On the other hand, supermarket eggs presented lower cracking rates. These cracked eggs should not be marketed in any establishment, since they do not comply with the legislation, as they pose a risk to public health (Edema & Atayese, 2006; Netto, Silva, & Xavier, 2018). Cracked eggs are suitable for penetration of microorganisms, which can lead to the contamination of those who consume them (Lima et al., 2018).

Table 1. Percentage of eggs that presented undesirable external or internal characteristics, in relation to the total eggs evaluated.

Variables	Egg Farm	Supermarkets	Grocery Stores	CV (%)	P
% Dirty eggs	46.66a	47.77a	39.44a	60.74	0.840
% Cracked eggs	8.33b	5.00a	6.67ab	18.26	0.010
% Internal stains	39.44b	10.55a	22.66ab	49.04	0.020

*Means followed by different letters on the same line differ from each other by the Tukey test ($P < 0.05$). CV (%): Coefficient of variation; P: probability.

Some factors contribute to the occurrence of cracked or broken eggs, such as the maintenance of cages, numbers of housed birds, the time between laying and egg collection, genetic factors of the birds, laying age, and deficiency in meeting the nutritional requirements of the animals. This type of eggshell damage can also be influenced by the type of collection of eggs after posture (manual or automatic collection), in addition to roads conditions, in which the eggs should be taken until the points of sale.

Grocery store eggs and farm eggs showed a higher percentage of internal stains, when compared to the supermarket eggs. This feature may be related to bird disease, blood vessel rupture at the time of laying, or the age of the birds (Fernandes, Mori, Nazareno, Pizzolante, & Moraes, 2015). Eggs that arrive in shops with blood stains are unlikely to have undergone ovoscopy (Honkatukia et al., 2011), which is often a standard procedure for eggs sold directly at the farms. At the ovoscopy room, the presence or absence of internal stains is verified, and the eggs with these characteristics should not be marketed. Although small stains do not interfere in consumption, when they appear in large quantities, it may be a cause for rejection by the consumer. According to Honkatukia et al. (2011), brown-shelled eggs, even after undergoing the process of ovoscopy, may occasionally reach the consumer's table with internal stains, due to the difficulty of detecting them because of the darker shells.

As observed in Table 2, supermarket eggs had the highest weights when compared to grocery store eggs, however, they did not differ statistically from farm eggs. The eggs of all points of sale were classified as medium type according to the established classification, which says that medium eggs must weigh between 50 and 54 grams (Netto et al., 2018).

For albumen weight, there was no significant difference, however, when this feature was evaluated in relation to its percentage, the farm eggs (fresh) presented higher values when compared to the supermarket and grocery eggs. Immediately after laying, eggs begin to undergo processes of quality loss, which can be visually noted by the appearance of dense albumen. Some external factors may accelerate this process, such as high temperatures and long storage time. This process of loss occurs through the presence of albumen enzymes, which begin to hydrolyze amino acid chains, which leads to the destruction of the protein structure, followed by the release of water, which is bounded to large protein molecules, thus provoking viscosity loss of the dense albumen, alkalinization, and ultimately the alteration of the egg’s taste (Vilela, 2012). Lana et al. (2017) observed that the albumen percentage was higher for refrigerated eggs, when compared to eggs kept at room temperature conditions.

Table 2. Absolute and relative composition of egg parts.

Variables	Egg Farm	Supermarkets	Grocery Stores	CV (%)	P
Egg weight (g)	49.39a	51.69 a	50.83a	5.33	0.350
Weight yolk(g)	11.89 a	13.25 b	13.69 b	4.97	0.006
Weight albumen(g)	34.17a	32.98 a	31.68 a	6.69	0.180
Weight eggshell(g)	3.32 a	5.46 b	5.45b	5.65	0.001
Proportions of yolk (%)	24.08a	25.64 ab	27.02 b	4.71	0.028
Proportions of albumen(%)	69.18 b	63.78 a	62.23[a]	2.05	0.000
Proportions of eggshell(%)	6.72 a	10.57 b	10.74b	4.48	0.000

*Means followed by different letters on the same line differ from each other by the Tukey test ($P < 0.05$). CV (%): Coefficient of variation; P: probability.

In contrast, the weight and percentage of yolk showed a significant difference, in which higher weights and percentages of yolk were observed for eggs sold in supermarkets and grocery stores. The increase in weight and percentage of yolk may have occurred due to the time and storage condition of these eggs, as they were sold at room temperature. According to Figueiredo et al. (2011), the water resulting from the chemical reactions that happen in the albumen is incorporated into the yolk, which consequently increases its weight, thus, justifying the higher values for yolk without change in egg weight, when compared to the fresh eggs. As the storage period increases, the yolk begins to acquire water from the albumen through the osmosis process, resulting in a more liquid albumen and a heavier yolk, as the fluid albumen crosses the vitelline membrane by osmosis and is retained in the yolk. This excess of water determines the volume increase, leading to the weakening of the vitelline membrane. In a study by Akter, Kasim, Omar, and Sazili (2014), the authors found a linear increase in the percentage of yolk in eggs stored up to 28 days.

Regarding the eggshell, it was observed that both weight and percentage differed statistically between the treatments, with eggs marketed by supermarkets and grocery stores presenting higher weights and percentage of shell than farm eggs. The results obtained for the commercial establishments are in agreement with the literature, which reports that the percentage of shell corresponds to 8 to 12% of the total egg weight (Kovacs-Nolan, Phillips, & Mine, 2005). The eggs from the farms presented weights and shell percentage below this range. According to Trindade, Nascimento, and Furtado (2007), one of the factors that contribute to the decrease of the shell percentage is the advancing age of the bird, as the eggs become larger and present a lower proportion of shell.

Through the results of specific gravity (Table 3), we observed an average of 1.070 g cm^{-3} for all marketed eggs, with no difference between the treatments. Even fresh eggs had specific gravity values similar to those found by Pissinati et al. (2014), who obtained values of specific gravity of 1.076 g cm^{-3} for eggs stored for up to 14 days, whereas grocery store eggs presented similar values (1.068 g cm^{-3}) to the eggs stored for 21 days.

Table 3. Internal quality characteristics of eggs.

Variables	Egg Farm	Supermarkets	Grocery Stores	CV (%)	P
Specific gravity (g cm^{-3})	1.068 a	1.073 a	1.069a	0.98	0.740
Albumen height (mm)	8.44 b	3.74 a	3.94 a	12.13	0.000
Haugh Unit	94.47 b	59.72 a	62.39 a	7.82	0.000
Albumen index	0.12 b	0.043 a	0.048 a	9.87	0.000
Shell thickness	0.34 a	0.45 b	0.46 b	8.98	0.001
Albumen pH	8.06 a	8.97 b	9.15 b	2.50	0.000
Yolk pH	5.81 a	6.24 b	6.33 b	2.91	0.003

*Means followed by different letters on the same line differ from each other by the Tukey test ($P < 0.05$). CV (%): Coefficient of variation; P: probability.

The albumen height, Haugh Unit (UH) and albumen index of eggs collected in farms presented the best results, when compared to these data obtained from supermarkets and grocery store eggs. This result meets the literature, since the eggs right after laying present higher albumen height, and, consequently, higher Haugh Unit. According to Nepomuceno et al. (2014), to be considered of excellent quality, the eggs must reach the consumer's table presenting high UH values. Table 6 shows that farm eggs presented excellent internal quality for consumers, while eggs from supermarkets and grocery stores presented high quality. The UH value is influenced by time and temperature of storage, due to the effects of these parameters on albumen quality (Brandão et al., 2014).

The albumen index is directly correlated with the height and the diameter of dense albumen. The results obtained show that the means differed between the treatments, since the farm eggs (fresh) showed greater height and smaller average diameter for albumen. Lana et al. (2017) found similar results, where the albumen index was 0.12 in fresh eggs, and 0.05 for old eggs.

The eggs marketed by supermarkets and grocery stores showed the best shell thickness, which provide greater resistance to cracking and breaking during transportation, serving effectively as a barrier against the microorganism entry in the egg's interior. These data confirm the results found for crack percentage observed in farm eggs, and several factors may be related to the eggshell quality, such as age of birds, nutritional deficiency, among others (Tanure et al., 2009).

Regarding the albumen and yolk pH, there was a significant difference for the treatments ($p < 0.05$). The eggs of the farm (fresh) presented the lowest pH value, thus corroborating with the literature, which says that fresh eggs present albumen pH around 7.6, and yolk pH next to 6.5 (Nepomuceno et al., 2014). Eggs from supermarkets and grocery stores had higher pH values in both portions, because they were probably stored for more than a week after laying (Lacerda et al., 2013).

The pH increase occurs because of the carbonic acid dissociation (H_2CO_3), which produces water and carbon dioxide (CO_2). This reaction is accelerated when the storage temperature is high, resulting in a more liquid albumen, which leads to the accumulation of water from the albumen by the yolk, thus resulting in changes in taste and consequently in the palatability of the product (Figueiredo et al., 2011). These factors corroborate with the results obtained by Eke, Olaitan, and Ochefu (2013), who showed that eggs stored for up to one week at room temperature have a more alkaline pH, while fresh eggs have a pH around 7.6.

The observed results indicate that eggs marketed at different commercial establishments presented reduced internal quality when compared to the farm eggs, which can be justified by the different age among those eggs. Due to the lack of proper labeling, the age of the eggs marketed at those locations could not be known. This means that, most of the time, in these establishments the consumer ends up impaired by purchasing older eggs with a consequently lower quality. Considering that not all eggs will be consumed immediately after purchase, until their use, there will be even greater quality losses.

Conclusion

Brown-shelled eggs sold in supermarkets, grocery stores and directly on the farm in Parintins/AM have high rates of external defects, which may lead to rejection by the consumers. In the evaluated city, the eggs up to one day acquired at the farm had better internal quality when compared to eggs sold in supermarkets and grocery stores, since the age of the eggs sold in these two locations was unknown, thus generating losses for the consumer.

References

Akter, Y., Kasim, A., Omar, H., & Sazili, A. Q. (2014). Effect of storage time and temperature on the quality characteristics of chicken eggs. *Journal of Food, Agriculture & Environment, 12*(2), 87-92.

Brandão, M. D. M., Santos, F. F., Machado, L. S., Verinaud, M. S., Oliveira, J. M., Soares, N. M., ... Pereira, V. L. A. (2014). The effect of eggshell apex abnormalities on table egg quality during storage in 2 seasons of the year. *Poultry Science, 93*(10), 2657-2662. doi: 10.3382/ps.2014-03991

Edema, M., & Atayese, A. O. (2006). Bacteriological quality of cracked eggs sold for consumption in Abeokuta, Nigeria. *International Journal of Poultry Science, 5*(8), 772-775.

Eke, M. O., Olaitan, N. I., & Ochefu, J. H. (2013). Effect of storage conditions on the quality attributes of shell (table) eggs. *Nigerian Food Journal, 31*(2), 18-24. doi: 10.1016/S0189-7241(15)30072-2

Fernandes, D. P. B., Mori, C., Nazareno, A. C., Pizzolante, C. C., & Moraes, J. E. (2015). Qualidade interna de diferentes tipos de ovos comercializados durante o inverno e o verão. *Arquivo Brasileiro de Medecina Veterinária e Zootecnia, 67*(4), 1159-1165. doi: 10.1590/1678-4162-7808

Figueiredo, T. C., Cançado, S. V., Viegas, R. P., Rêgo, I. O., Lara, L. J., Souza, M. R., & Baião, N. C. (2011). Qualidade de ovos comerciais submetidos a diferentes condições de armazenamento. *Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 63*(3), 712-720. doi: 10.1590/S0102-09352011000300024

Gole, V. C., Chousalkar, K. K., & Roberts, J. R. (2012). Prevalence of antibodies to *Mycoplasma synoviae* in laying hens and possible effects on egg shell quality. *Preventive Veterinary Medicine, 106*(1), 75-78. doi: 10.1016/j.prevetmed.2012.02.018

Guedes, L. L. M., Souza, C. M. M., Saccomani, A. P. d. O., Faria Filho, D. E. d., Suckeveris, D., & Faria, D. E. (2016). Internal quality of laying hens' commercial eggs according to storage time, temperature and packaging. *Acta Scientiarum. Animal Sciences, 38*(1), 87-90. doi: 10.4025/actascianimsci.v38i1.28922

Honkatukia, M., Tuiskula-Haavisto, M., Ahola, V., Uimari, P., Schmutz, M., Preisinger, R., ... O'Sullivan, N. (2011). Mapping of QTL affecting incidence of blood and meat inclusions in egg layers. *BMC Genetics, 55*(12), 2-10. doi: 10.1186/1471-2156-12-55

Kovacs-Nolan, J., Phillips, M., & Mine, Y. (2005). Advances in the value of eggs and egg components for human health. *Journal of Agricultural and Food Chemistry, 53*(22), 8421-8431. doi: 10.1021/jf050964f

Lacerda, M. J. R., Andrade, M. A., Santos, F. R. M., Mendes, F. R., Leite, P. R. S. C., & Lima, H. J. D. (2013). Qualidade microbiológica de ovos comerciais. *Revista Eletrônica Nutritime, 10*(6), 2925-2961.

Lana, S. R. V., Lana, G. R. Q., Salvador, E. L., Lana, Â. 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 de Produção Animal, 18*(1), 140-151. doi: 10.1590/S1519-99402017000100013

Lima, W. K. S., Barros, L. S. S., Silva, R. M., Deus, T. B., Lima, D. V., & Silva, A. S. (2018). Hygienic and sanitary conditions of eggs commercialized in town fairs and markets. *Food and Nutrition Sciences, 9*(7), 855-867. doi: 10.4236/fns.2018.97064

Nepomuceno, R. C., Watanabe, P. H., Freitas, E. R., Cruz, C. E. B., Peixoto, M. S. M., & Sousa, M. L. (2014). Quality of quail eggs at different times of storage. *Ciência Animal Brasileira, 15*(4), 409-413. doi: 10.590/1089-6891v15i424107

Netto, L. B. C., Silva, L. M., & Xavier, M. M. B. B. S. (2018). Qualidade e rotulagem de ovos comercializados no município de Valença-RJ. *PUBVET, 12*(9), 1-9. doi: 10.31533/pubvet.v12n9a173.1-9

Perry, A., Rasmussen, H., & Johnson, E. J. (2009). Xanthophyll (lutein, zeaxanthin) content in fruits, vegetables and corn and egg products. *Journal of food Composition and Analysis, 22*(1), 9-15. doi: 10.1016/j.jfca.2008.07.006

Pissinati, A., Oba, A., Yamashita, F., Silva, C. A., Pinheiro, J. W., & Roman, J. M. M. (2014). Qualidade interna de ovos submetidos a diferentes tipos de revestimento e armazenados por 35 dias a 25°C. *Semina: Ciências Agrárias, 35*(1), 531-540. doi: 10.5433/1679-0359.2014v35n1p531

Ruxton, C. H. S., Derbyshire, E., & Gibson, S. (2010). The nutritional properties and health benefits of eggs. *Nutrition & Food Science, 40*(3), 263-279. doi: 10.1108/00346651011043961

Santos, F. F., Roberto, R. L., Lima, S. P. C. H., & Oliveira, J. B. (2017). Avaliação da qualidade de ovos comercializados no município de Manaus – AM. *Higiene Alimentar, 31*(264/265), 109-114.

Statistical Analysis Software [SAS]. (2004). *SAS/STAT User guide, Version 9.3*. Cary, NC: SAS Institute Inc.

Tanure, C. B. G., Café, M. B., Leandro, N. S. M., Baião, N. C., Stringhini, J. H., & Gomes, N. A. (2009). Efeitos da idade da matriz leve e do período de armazenamento de ovos incubáveis no rendimento de incubação. *Revista Brasileira de Medicina Veterinária e Zootecnia, 61*(6), 1391-1396. doi: 10.1590/S0102-09352009000600019

Trindade, J. L., Nascimento, J. W. B., & Furtado, D. A. (2007). Qualidade do ovo de galinhas poedeiras criadas em galpões no semi-árido paraibano. *Revista Brasileira de Engenharia Agricola e Ambiental, 11*(6), 652-657. doi: 10.1590/S1415-43662007000600015

Vilela, D. R. (2012). Qualidade interna e externa de ovos de poedeiras comerciais com casca normal e vítrea. *Ciência Animal Brasileira, 17*(4), 509-518. doi: 10.1590/1089-6891v17i421535