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Eggs quality sold at different establishments in the Imperatriz city, Maranhão State, Brazil

Qualidade de ovos comercializados em diferentes estabelecimentos na Cidade de Imperatriz, Estado do Maranhão, Brasil

Calidad de los huevos vendidos en diferentes establecimientos de la ciudad de Imperatriz, Estado de Maranhão, Brasil

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Abstract

This study aimed to evaluate the egg quality sold in several establishments in Imperatriz city Maranhão. It was used white shell eggs from commercial hen laying obtained according to the following treatments: open street markets, grocery stores, and supermarkets. For each

treatment were obtained at three different local sales of eggs, which were chosen to cover different areas of the city. The variables studied were: egg weight, Haugh Units, yolk color, yolk, albumen and shell percentages, and yolk and albumen pH. The establishments type of egg sale did not influence the Haugh units, yolk color, and yolk pH. However, there was an influence on the egg weight, yolk, albumen, and shell percentage, as well as on albumen pH. Thus, eggs sold in open street markets had a higher weight (60.48 g) and the lowest shell percentage (9.23%). The eggs sold in supermarkets had a lower yolk percentage and higher albumen percentage when compared to egg grocery stores, and both had similar albumen percentage to the eggs sold in open street markets. For albumen pH, the eggs sold in supermarkets had the lowest value (9.18). In general, the eggs sold in open street markets, grocery stores, and supermarkets of the Imperatriz city had inferior quality due to low values of Haugh units obtained. However, taking into account the lowest albumen pH obtained for eggs of supermarkets, this establishment had better egg quality when compared to eggs sold in open street markets and grocery stores.

Keywords: Haugh units; Yolk color; Open street markets; Grocery stores; Supermarkets.

Resumo

O objetivo deste trabalho foi avaliar a qualidade de ovos comercializados em vários tipos de estabelecimentos da cidade de Imperatriz – Maranhão. Foram utilizados ovos brancos de poedeiras comerciais obtidos de acordo com os seguintes tratamentos: de feiras livres, de mercearias e supermercados. Para cada tratamento foram obtidos ovos de três diferentes locais de vendas, que foram selecionados de forma a cobrir diferentes áreas da cidade. As variáveis estudadas foram: peso do ovo, Unidades Haugh, cor da gema, percentuais de gema, albumen e casca, e pH da gema e do albumén. Os tipos de estabelecimentos não influenciaram as Unidades Haugh, a cor e pH da gema. No entanto, houve influência no peso do ovo, nos percentuais de gema e albumen, como também, no pH do albumen. Assim, os ovos comercializados em feiras livres tiveram o maior peso (60,48 g) e os menores percentuais de casca (9,23%). Os ovos vendidos em supermercados tiveram menor percentual de gema e maior percentual de albumen quando comparados aos ovos comercializados em mercearias e ambos não diferiram para percentual de albumen quando comparados aos ovos comercializados em feiras livres. Para o pH do albumen, os ovos vendidos em supermercados tiveram o menor valor (9,18). Em geral, os ovos vendidos em feiras livres, mercearias e supermercados da cidade de Imperatriz tiveram qualidade inferior devido aos baixos valores de Unidades Haugh obtidos. Contudo, levando em consideração o menor valor de pH do

albumén obtido para os ovos dos supermercados, este estabelecimento teve melhor qualidade quando comparado àqueles vendidos em feiras livres e mercearias.

Palavras-chave: Unidades haugh; Cor da gema; Feiras livres; Mercearias; Supermercados.

Resumen

El objetivo de este estúdio fue evaluar la calidad de los huevos vendidos en varios tipos de establecimientos en la ciudad de Imperatriz - Maranhão. Se utilizaron huevos blancos de gallinas ponedoras comerciales obtenidos según los siguientes tratamientos: de mercados abiertos, tiendas de abarrotes y supermercados. Para cada tratamiento, los huevos se obtuvieron de tres puntos de venta diferentes, que fueron seleccionados para cubrir diferentes áreas de la ciudad. Las variables estudiadas fueron: peso del huevo, Unidades Haugh, color de la yema, porcentaje de yema, albúmina y cáscara, y pH de la yema y albúmina. Los tipos de establecimiento no influyeron en las Unidades Haugh, el color y el pH de la gema. Sin embargo, hubo influencia en el peso del huevo, los porcentajes de yema y albúmina, así como en el pH de la albúmina. Así, los huevos vendidos en mercados abiertos tuvieron el mayor peso (60,48 g) y el menor porcentaje de cáscara (9,23%). Los huevos vendidos en los supermercados tenían un menor porcentaje de yema y un mayor porcentaje de albúmina en comparación con los huevos vendidos en las tiendas de abarrotes, y ambos no difirieron en el porcentaje de albúmina en comparación con los huevos vendidos en los mercados abiertos. Para el pH de la albúmina, los huevos vendidos en los supermercados tuvieron el valor más bajo (9.18). En general, los huevos vendidos en mercados callejeros, tiendas de abarrotes y supermercados de la ciudad de Imperatriz fueron de calidad inferior debido a los bajos valores de las Unidades Haugh obtenidas. Sin embargo, teniendo en cuenta el menor valor de pH de la albúmina obtenida para los huevos de los supermercados, este establecimiento tuvo mejor calidad en comparación con los que se venden en mercados abiertos y tiendas de abarrotes.

Palabras clave: Unidades haugh; Color de la gema; Ferias gratuitas; Tiendas de comestibles; Supermercados.

1. Introduction

The eggs provide the nutrient balance necessary for human consumption. It is a source of protein of high biological value and low cost, enabling their inclusion in the population diet. Moreover, the eggs have important technological properties for the preparation of many foods. The retention of air capacity through the egg protein leads to foam formation, which is

essential to provide good texture in some food preparations (Nimalaratne, Schieber, & Wu, 2016; Lima et al., 2020).

For better utilization of the nutritional and technological potential of eggs, this must be adequately maintained. The eggs are highly perishable, and their internal quality starts to deteriorate immediately after they have been laid and can be increased by several factors (Giampietro-Ganeco et al., 2015). To preserve the high quality of the eggs, Figueiredo et al. (2011) reported that time and temperature are important factors that must be controlled during the storage period. Santos et al. (2009) reported that egg quality changes depending on the interaction temperature x time storage period, especially for weight loss, yolk and albumen percentages, specific gravity, and Haugh Units (HU) parameters.

The egg quality reduction is due to the loss of moisture and carbon dioxide through the pores on the shell surface during the storage. This reduction is proportional to the increase in room temperature because occur the increase of the reactions that change egg quality (Figueiredo et al., 2011; Santos et al., 2009). According to Pereira, Vidal, Abreu, Zapata e Freitas (2011), refrigeration during the marketing can extend the egg shelf life. However, although Brazil is a tropical country, the use of this system is not required. Thus, most of the eggs are kept at room temperature during the selling period.

The egg quality is determined by several external and internal aspects. The external aspects are related to shell quality when considering their structure and hygiene. The internal aspects consider the albumen and yolk quality. The albumen viscosity and yolk color are the parameters most observed. To ensure the high internal quality, albumen should be bright, translucent, consistent, dense, and high in around the yolk. In turn, the yolk should be shining, consistent, and placed in the middle of the albumen (Figueiredo et al., 2011).

For the internal quality evaluation, are used several parameters such as Haugh unit, albumen, and yolk index, albumen and yolk pH, and yolk color. The HU is the parameter most widely used to evaluate the internal quality of commercial eggs, due to its easy application and high correlation with the internal appearance of the egg when it is broken. It is defined as the height logarithm of the dense albumen corrected by the egg mass and the higher the UH, the better quality (Liu, Chen, Wu, Lee, & Tan, 2016). Brazilian law does not use HU as an evaluation parameter of the internal egg quality. However, in the United States, commercial eggs are grouped in quality classes, according to HU (Yuceer, & Caner, 2014). However, several authors reported that these quality factors are influenced not only by storage conditions, but also by factors such as lineage and birds age (Alsobayel, & Albadry, 2011; Figueiredo et al., 2011).

The consumer trend is relating to their preference, not only the price but also the food quality to be purchased. Therefore, evaluate the characteristics of the commercial egg is important to know the quality of the product offered to the consumer, as well as to provide evidence indicating the need for a legislation update, as to storage conditions and marketing of eggs and their effects on quality. Therefore, the aim of this study was to evaluate the quality of the eggs sold in different types of establishments in the Imperatriz city Maranhão.

2. Materials and Methods

In this study, the quantitative methodology was used as described by Pereira, Shitsuka, Parreira, and Shtsuka (2018). The analyses were used white shell eggs from commercial laying hens. The eggs were collected when the climatic conditions of the region were: average temperature of 30 °C and relative humidity 60-70%. The evaluated eggs were cardboard, half cases and exposed for sale without refrigeration.

The eggs evaluated were purchased before the day of the analysis and according to the following treatments: open street markets, grocery stores, and supermarkets. For each treatment were obtained at three different local sales of eggs (10 eggs in each), totaling 30 eggs per treatment, which were randomly distributed between repetitions. The establishments were chosen to cover different areas of the city. The variables studied were: egg weight, Haugh Units, yolk color, shell, yolk and albumen percentages, and yolk and albumen pH.

For the egg weight (g) determination, all eggs were weighed individually using a semi-analytical balance (SHIMADZU BL-3200H). Eggs were individually weighed and broken out onto a flat surface where yolks were separated from the whites and then weighed. The shells were carefully washed and cleaned of any adhering albumen. The shells were then dried for 48 hours at room temperature (25 °C) and weighed. Albumen weight was calculated by the difference between total egg weight and shell weight plus yolk. Yolk, albumen, and shell percentages were determined about the egg weight.

Haugh units were calculated from the measurements of albumen height, using of a depth micrometer (Ames S-6428), and egg weight using the following formula: HU = 100 x log (H + 7.57 – 1.7 x W0.37), where HU = Haugh Units; H = height of the albumen; and W = egg weight (Yuceer, & Caner, 2014). Yolk color was determined by matching with one of the matching bands of the Roche® color fan (Mota et al., 2017).

The albumen and yolk pH measurement were made directly using a digital pH meter model DPH-2 (ATAGO, Tokyo).

The experimental design was completely randomized with three treatments and five replications of six eggs, totaling ninety eggs. The results were submitted to analysis of variance and means compared by the Student Newman Keuls test (SNK) a 5% probability using ASSISTAT software version 7.7 beta.

3. Results and Discussion

In Table 1 are shown the results of weight and yolk, albumen, and shell percentages of eggs sold in open street markets, grocery stores, and supermarkets in the Imperatriz city Maranhão.

Table 1 - Mean and standard deviation for weight and yolk, albumen, and shell percentages of eggs sold in open street markets, grocery stores, and supermarkets in the Imperatriz city Maranhão.

	Open street markets	Grocery stores	Supermarkets
Egg weight (g)	60.48±0.34 a	57.30 ±1.68 b	55.75± 1.44 b
Yolk percentage (%)	30.18 ±0.97 a	30.05 ±0.82 a	28.47± 0.76 b
Albumen percentage (%)	60.58 ±0.97 ab	59.77 ±1.04 b	61.41± 0.65 a
Shell percentage (%)	9.23 ±0.22 b	10.18 ±0.27 a	10.12±0.29 a

Source: Authors (2020). n = 5. Means values with different small letters within a row are significantly different ($p<0.05$) by SNK.

For the egg weight, there was no significant difference ($p>0.05$) between the eggs of grocery stores and supermarkets. However, the eggs sold in open street markets had higher weight ($p<0.05$) when compared to the other treatments. The yolk percentage of eggs sold in the open street markets did not differ ($p>0.05$) those sold in the grocery stores. The values of the eggs sold in the supermarket were lower than the other establishments evaluated. For the albumen percentage, there was no significant difference ($p>0.05$) between the eggs sold in open street markets and grocery stores and supermarkets. However, eggs sold in supermarkets had higher values for albumen percentage when compared to those sold in grocery stores. For the shell percentage, there was no significant difference ($p>0.05$) between the eggs sold in the

supermarkets and grocery stores. However, the eggs sold in the open street markets had lower shell percentage ($p<0.05$) than the other establishments (Table 1).

These differences on egg weight could be attributed to age and stain of hens (Alsaffar, Attia, Mahmoud, Zewell, & Bovera, 2013), dietary protein/amino acids, energy, and fat/fatty acids, housing density, and housing condition (cages vs. floor), health status, environmental stress and feed intake (Goldberg et al., 2012; Bovera et al., 2014).

According to Brazilian law (Brasil, 2020), the eggs sold in the open street markets can be classified as Type 2 (extra), and the eggs of grocery stores and supermarkets can be classified as type 3 (large).

Leandro et al. (2005), evaluating the internal quality of eggs sold in different establishments of Goiânia, reported similar results. These authors observed egg weight values of 61.00, 61.78 e 58.68 g for eggs sold in open street markets, grocery stores, and supermarkets, respectively.

However, the egg weight sold in open street markets and supermarkets observed in this study was much higher than reported by Pascoal et al. (2008), evaluating the egg quality sold in the Imperatriz city Maranhão. These authors obtained an egg weight of 42.06 g for open street markets and 42.53 g for supermarkets. Pereira, Santos, and Coelho (2014) observed egg weight values ranging between 48.98 and 58.02 g for eggs sold in supermarkets, open street markets, and distributors of the Palmas city the Tocantins.

For the yolk percentage, similar results were reported by Quadros et al. (2011) that observed lower yolk percentage for eggs sold in the supermarkets when compared to those sold in the open street markets in the Barreiras city Bahia. However, Pascoal et al. (2008) and Leandro et al. (2005) did not observe a difference in the yolk percentage sold in these two types of establishments.

The yolk percentage can be influenced by time and temperature of storage and the age birds. Jin, Lee, Lee, and Han (2011), evaluating the effects of storage temperature on the quality eggs, reported a higher yolk percentage with storage for ten days. According to Alsaffar et al. (2013), during the storage, about 2% of water migrates from albumen to yolk, and this stays heavier. Santos et al. (2009) also reported higher yolk percentage in eggs stored for 21 days when compared to those stored with 7 and 14 days. These authors also observed that at room temperature, regardless of the storage period, the eggs had a higher yolk percentage compared to those stored in refrigerated temperature.

For the albumen percentage, similar results were obtained by Pascoal et al. (2008), that did not observe differences in the albumen percentage of eggs sold in open street markets and

supermarkets. In turn, Leandro et al. (2005) did not observe a difference in the albumen percentage in any of the establishments evaluated. The values obtained by these authors for supermarkets, popular markets, farms, and open street markets ranged between 46.28 and 50.04%, being below those found in this study. The albumen percentages reported by Quadros et al. (2011) to eggs sold in supermarkets, popular markets, and open street markets ranged from 56.70 to 60.70% and are very close to those obtained in different establishments in this study. However, different from the present study, these authors observed a difference in the albumen percentage of eggs sold in the open street markets compared with those sold in supermarkets, with this latter having a higher percentage.

Just as for the yolk percentage, albumen percentage may be influenced by time and temperature of storage and the age birds. Jin et al. (2011) reported a reduction of albumen percentage with the increase of storage time (ten days) and temperature (29 °C). For the temperature storage, Figueiredo et al. (2011) had the lowest albumen percentage in eggs stored at room temperature when compared to refrigerated eggs. The same result was reported by Santos et al. (2009), who studied the effect of temperature and time storage in commercial eggs. Thus, the highest albumen percentage observed for eggs sold in supermarkets when compared to those sold in the grocery stores may be indicative of more fresh eggs, so, with less storage time or eggs from younger layers.

For the shell percentage, Pascoal et al. (2008) did not observe differences in the shell percentage of the eggs sold in supermarkets and open street markets. The values obtained by these authors were 12.21 and 11.99%, respectively, and were above those observed in the present study.

The shell percentage is related to the age of the birds. With the increase of the age birds, there is a decrease of shell quality, reducing their thickness, which affects their resistance to breakage. This reduction occurs because the egg weight increases with aging the bird, and the shell weight can not keep up this increase (Bovera et al., 2014). Figueiredo et al. (2011) observed a reduction in the shell percentage of eggs when compare birds 33 and 60 weeks of age. Attia, Al Harthi, and Shiboob (2014), evaluating the internal quality of eggs sold in Jeddah city, Saudi Arabia, reported that lower shell quality could be attributed to older hens' age. These authors observed that the group with lower shell quality was of hens with a production of 18 months when compared to other groups with 6-10 months in production.

In Table 2 are shown the results of Haugh Unit, yolk color, and yolk and albumen of eggs sold in open street markets, grocery stores, and supermarkets in the Imperatriz city Maranhão.

Table 2 – Mean and standard deviation for Haugh unit, yolk color, and yolk and albumen of eggs sold in open street markets, grocery stores, and supermarkets in the Imperatriz city Maranhão.

	Open street markets	Grocery stores	Supermarkets
Haugh Unit	51.01 ±1.85 a	47.89 ±8.89 a	51.32± 5.85 a
Yolk color	4.83 ±0.20 a	4.86 ±0.40 a	4.53± 0.22 a
Yolk pH	6.06 ±0.19 a	6.26 ±0.27 a	6.22± 0.18 a
Albumen pH	9.38± 0.04 a	9.34± 0.09 a	9.18± 0.04 b

Source: Authors (2020). n = 5. Means values with different small letters within a row are significantly different ($p<0.05$) by SNK.

The Haugh units (HU), yolk color, and yolk pH did not differ ($p>0.05$) between the establishments evaluated. The albumen pH values were lower ($p<0.05$) in the eggs sold in supermarkets compared to those sold in open street markets and grocery stores (Table 2).

HU is one of the ways used to evaluate the internal quality of eggs, and the higher its value, the higher the egg quality (Yuceer, & Caner, 2014). A similar result to the present study was reported by Pereira et al. (2014), who evaluated the egg quality sold in supermarkets, open street markets, and distributors. These authors also did not observe a difference in HU values. However, HU values obtained by these authors were higher than those found in this study and ranged between 52.79 and 67.16.

The HU values obtained herein for eggs sold in open street markets, grocery stores, and supermarkets were lower than those found by Quadros et al. (2011). Leandro et al. (2005) reported HU values lower for eggs sold in open street markets (44.91) when compared to those in the present study. However, the HU values of eggs sold in supermarkets (64.04) and grocery stores (53.42) found by these authors were higher than those from the present study. Alsobayel and Albadry (2011) also observed higher HU values (84.72) for eggs sold in supermarkets in the Riyadh region, Saudi Arabia.

The HU values obtained in this study are considered low, indicating a lower freshness of eggs sold in the stablishments of Imperatriz city. Brazilian law does not use Haugh units as an egg internal quality parameter. However, according to the United States Department of Agriculture (USDA, 2000), considered excellent eggs quality HU values greater than 72; High-quality eggs, HU from 60 to 72, and inferior eggs, HU values lower than 60. Thus, by United State law, the eggs obtained in the present study in the establishments evaluated would

be considered inferior. This suggests the importance of quality control during the marketing and the potential of improving these traits by storage conditions.

The yolk color values varied from 4.53 to 4.86 (Table 2). This parameter depends on the diet birds. When the diet is rich in yellow-orange pigments, known as xanthophylls, these are deposited in the yolks, accounting for its color (Krawczyk Przywitowski, & Mikulski, 2015). The yolk color values observed in this study were far below the ranges cited by Lesson and Summers (1997). According to these authors, the requirement for the yolk color is between 7-8 in the colorimetric Fan Roche® (RCF) for eggs better classified.

For the yolk pH, the values obtained herein were similar to those obtained by Leandro et al. (2005) and Pascoal et al. (2008). These authors also did not observe differences in the yolk pH of eggs sold in open street markets, grocery stores, and supermarkets. The pH values are also in accordance with the reported by Caner and Yuceer (2015). According to these authors, the yolk pH in freshly laid eggs is generally about 6.0, but during the storage of eggs, the pH gradually increases to 6.5.

For the albumen pH, the values obtained in this study are in accordance with the values reported by other authors for the same establishment types (Leandro et al., 2005; Pascoal et al., 2008; Figueiredo et al., 2011).

Freshly laid eggs have an albumen pH value of 7.5 to 8.5. Within a short time, the albumen pH increases to 9, owing to the release of CO_2 from the breakdown of carbonic acid in the albumen, resulting in changes to the bicarbonate buffer system. The albumen pH increase is proportional to storage time, reaching a value of 9.5 (Yuceer, & Caner, 2014).

Xavier et al. (2008) observed an increase in albumen pH. This increase was higher in the first five days of storage. The authors obtained pH values of 9.45 for eggs stored for 15 days at room temperature (25 °C). The values reported by these authors are similar to those obtained in this study, indicating that the eggs evaluated in the present study were displayed for sale for several days and thus had a lower freshness.

This increase in albumen pH is the resulting loss of CO_2 to the environment and leads to a reduction of viscosity to destabilize the complex between lysozyme and ovomucin. As a result, there is a decrease in HU, albumen lose the ability to sustain the yolk, and this tends to fluctuate. Thus, the yolk absorbs water lose their spherical shape, and the vitelline membrane becomes more fragile and may rupture when the egg is broken (Mota et al., 2013).

Caner and Yuceer (2015) reported that albumen pH is the most appropriate measure for fresh eggs evaluating because there is less influence of lineage and age of the laying on pH.

4. Conclusion

The establishments type of egg sale (open street markets, grocery stores, and supermarkets) did not influence the Haugh units, yolk color, and yolk pH. However, there was an influence on the egg weight, on the yolk, on the albumen and shell percentage, as well as on albumen pH. Thus, eggs sold in open street markets had higher weight and the lowest shell percentage. The eggs sold in supermarkets had a lower yolk percentage and higher albumen percentage when compared to egg grocery stores, and both had similar albumen percentage to the eggs sold in open street markets. For albumen pH, the eggs sold in supermarkets had the lowest value.

In general, the eggs sold in open street markets, grocery stores, and supermarkets of the Imperatriz city had inferior quality due to low values of Haugh units obtained. However, taking into account the lowest albumen pH obtained for eggs of supermarkets, this establishment had better egg quality when compared to eggs sold in open street markets and grocery stores.

For future research, it is recommended to evaluate the useful life of eggs using different storage conditions that can preserve the eggs for a more extended time.

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