Shelf life of brown eggs from laying hens of different ages in organic production system

Vida de prateleira de ovos marrons de poedeiras com diferentes idades de postura em sistema orgânico de produção

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ABSTRACT
The aim of this study was to evaluate the shelf life of brown eggs from laying hens of different ages in an organic production system. A total of 192 brown eggs from laying hens were used, t experimental design was in a factorial scheme, with four laying hens ages (40, 50, 60, 70, weeks) and four storage periods (0, 14, 28 and 42 days) with 12 repetitions each. Chicken age and storage period ($p < 0.05$) interfered with egg weight loss. Eggs from older laying hens showed superior internal quality in the first days of storage, but with high susceptibility to losses when stored for up to 42 days. Young laying hens (up to 40 weeks of age) showed better internal egg quality when compared to chickens with 50 and 60 weeks of age, when stored for up to 42 days. The albumen pH was not affected by the age of the laying hens, but increased significantly with a longer storage period. The shelf life of the eggs was affected by the age of the laying hens and the storage time.

Keywords: albumen height, albumen pH, albumen foam stability, egg weight loss, Haugh unit, specific gravity.

RESUMO
O objetivo deste estudo foi avaliar a vida de prateleira de ovos marrons de galinhas poedeiras com diferentes idades em um sistema de produção orgânica. Foram utilizados 192 ovos marrons, o delineamento experimental foi em esquema fatorial, com quatro idades de galinhas poedeiras (40, 50, 60, 70, semanas) e quatro períodos de armazenamento (0, 14, 28 e 42 dias) com 12 repetições cada. A idade da galinha e o período de armazenamento ($p < 0,05$) interferiram na perda de peso dos ovos. Ovos de galinhas poedeiras mais velhas apresentaram qualidade interna superior nos primeiros dias de armazenamento, mas com alta suscetibilidade a perdas quando armazenados por até 42 dias. As galinhas poedeiras jovens (até 40 semanas de idade) apresentaram melhor qualidade interna dos ovos quando comparadas às galinhas com 50 e 60 semanas de idade, quando armazenadas por até 42 dias. O pH do albúmen não foi afetado pela idade das galinhas poedeiras, mas aumentou

significativamente com um período mais longo de armazenamento. A vida de prateleira dos ovos foi afetado pela idade das galinhas poedeiras e pelo tempo de armazenamento.

Palavras-chave: altura de albúmen, pH do albúmen, estabilidade de espuma do albúmen, perda de peso, unidade Haugh, gravidade específica.

1 INTRODUCTION

Egg consumption in Brazil has increased significantly in the last five decades, a fact that has kept the country among the seven largest egg producers in the world (Lana, 2017). The main system of egg production in Brazil is through intensive production, where the laying hens are kept in cage batteries. However, another aspect of poultry farming has been consolidated: the organic production system. Law 10.831 of December 23, 2003, which provides for organic agriculture, states in its Article 1: "An organic system of agricultural production is any one in which specific techniques are adopted, by optimizing the use of natural and socioeconomic resources available and the respect for the cultural integrity of rural communities; aiming at economic and ecological sustainability, maximizing social benefits, minimizing dependence on non-renewable energy, employing, whenever possible, cultural, biological and mechanical methods, as opposed to the use of synthetic materials, eliminating the use of genetically modified organisms and ionizing radiation at any stage of the production, processing, storage, distribution and marketing process and the protection of the environment ". This system has gained strength and demonstrated a sustained growth over the years, either as a source of income aggregation for the family farmer or as an instrument of food sustainability (Lemos et al., 2015). Organic egg production is another option, with characteristics to be developed in small farms, which can contribute to the establishment of man in the field, by allowing a better standard of living for rural families (Figueiredo, 2012).

The selection criteria to evaluate egg quality implies in considering quality from different perspectives; for producers, the quality is related to the egg mass and shell resistance; for consumers, quality is related to shelf-life and sensory characteristics, such as yolk and shell color; for processors, the quality is also related to the ease of removing the shell and the separation of the yolk from the albumen to the functional properties (Carvalho, 2013). In Brazil, quality aspects are evaluated by the Identity and Quality Standards of Fresh Eggs (Brazil, 1991), mainly on the shell, air cell, albumen and yolk. However, this has been criticized due to the egg weight correction, because when comparing fresh eggs which were laid on different periods, from different laying breeds and egg albumen measurement stored in different periods, this method becomes inadequate.

The shelf-life of food is characterized by a period where it does not suffer any changes in its chemical and organoleptic structure, varying according to the type of food, period of storage and the environment where it will be stored (Garcia et al., 2015). Eggs are foods that are highly susceptible to losses, since they are formed by a high concentration of essential amino acids, vitamins, minerals and polyunsaturated fatty acids, which present a high capacity of oxidation (Caner et al., 2015), making the storage period a relevant factor for obtaining a quality product. Inevitably, after being laid, eggs begin to lose their internal quality due to movements of carbon dioxide and humidity that occur due to internal and environmental factors, through the pores of the eggshell and can be accelerated depending on the room temperature (Carvalho et al., 2013). The age of laying hens can be a direct influence on both internal and external quality of eggs, especially on fresh eggs (Figueiredo et al., 2011; Jin et al., 2011).

The aim of the present study was to evaluate the influence of the age of laying hens and the shelf life of brown eggs, in an organic production system.

2 MATERIALS AND METHODS

The eggs were collected in an egg farm located in the city of Viamão, Brazil (30 ° 06'28.4 "S 51 ° 03'57.0" W), linked to the Agroecological Association of the State of Rio Grande do Sul, and received the Certificate of Compliance Through the Ecovida Agroecology Network in October, 2011.

Within the property there were brown egg laying hens, which were purchased from a certified hatchery. The laying hens were kept in a shed with access to the external area, with natural sunlight and an artificial supply in winter months, following the requirements of the Brazilian legislation for animal farming in an organic production system. The diet provided to them was formulated to meet their nutritional requirements, with ingredients such as corn, soybean meal, calcitic limestone, wheat bran, sunflower, linseed, rock powder and water. All grains are purchased from suppliers certified for organic production. Grazing was also part of the animal dietary routine, as hens had access to the external area.

A total of 192 brown eggs were used during the experimental period. These eggs were collected when laying hens had different ages (40, 50, 60, and 70 weeks). They were washed in water and dried with forced ventilation and after that, they were weighted. Then, the eggs were distributed in different treatments for later evaluation of the storage time. All eggs were stored in a room with relative air humidity (70 ± 4%) and temperature (14 ± 2 ° C) control. The eggs were evaluated in different storage periods (0, 14, 28 and 42 days of storage) with the purpose of determining their total shelf life. The evaluations were carried out at the Universidade Federal do Rio Grande do Sul (UFRGS, Federal University of Rio Grande do Sul).

Eggs were weighed, and thus determining the total weight loss, using a digital, high-precision scale. At the beginning of each collection (day 0), from different ages of laying hens, all eggs were weighed individually, with 12 replicates for each day of storage (14, 28 and 42 days) to determine the egg weight. On the day of their quality evaluation, they were weighted once again, and by calculating the difference between the initial and the final weight, the total weight loss(g) was determined.

Albumen pH was determined using a digital potentiometer. Albumen height was determined using a digital, high precision caliper (mm). The albumen height was measured in the thick layer of albumen, close to the yolk.

Albumen foam stability was determined by adapting the method of McKellar & Stadelman (1995). A total of 10 ml of each albumen sample was pipetted and beaten with a mixer for 2 minutes at constant rotation (1300 RPM). The foam was then transferred to a funnel, which was placed under a volumetric beaker, and rested for 60 minutes, after which time the researchers measured the amount of liquid drained in milliliters (ml). The greater the amount of fluid drained after the foam rested, the lower the stability of the albumen foam.

The Haugh unit (HU) is a unit that correlates the height of the thick albumen layer with the egg weight, whose score is calculated through the equation: UH = 100 log (H + 7.57 - 1.7 x W x 0.37), where H = thick albumen height (mm) and W = egg weight (g) (Haugh, 1937). This is a standard measure of quality used and accepted throughout the egg industry. In general, the higher the UH value, the better the egg quality (Alleoni & Antunes 2001). For that, eggs considered of excellent quality must have HU values above 72; higher quality eggs, between 60 and 72 HU; and lower quality eggs have HU values below 60 (Lana et al., 2017).

The specific gravity of the eggs was determined by immersion in saline solution. Eggs were immersed in the solutions with known densities ranging from 1.064 to 1.100 g/cm 3. They were immersed successively in containers containing salt solutions in increasing order of density. The specific gravity of an egg was considered the solution in which it floated. The measurement of the specific gravity of an egg can be considered one of the most used techniques to determine the quality of the shell because it is a simple, practical and low-cost process. In addition, it is a way for consumers to assess the egg quality in their homes for, when buying eggs in the supermarket, they do not know the age of the laying hen, only the date of laying.

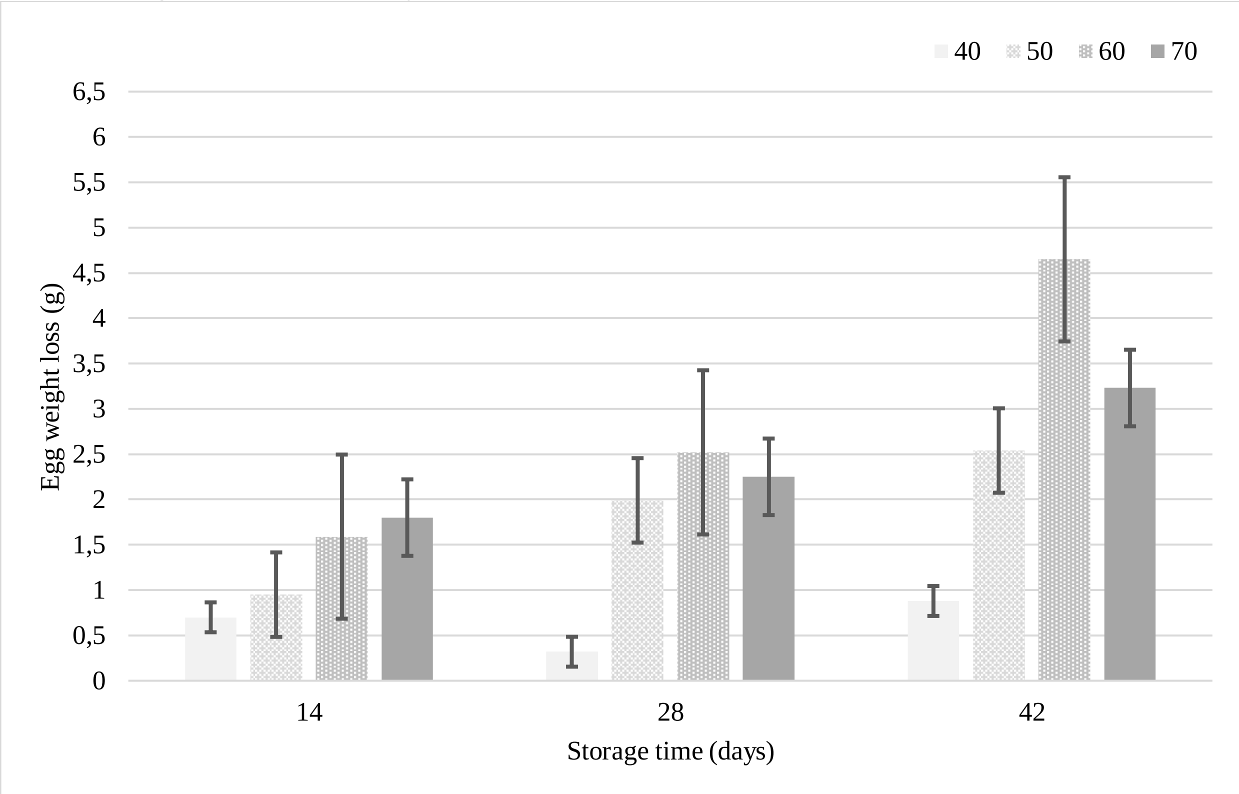
The experimental design was in a factorial arrangement, with four ages of laying hens (40, 50, 60, 70, weeks) and four storage periods (0, 14, 28 and 42 days) with 12 repetitions each. The results were subjected to statistical analysis using the SAS® software. The results were processed statistically via analysis of variance through the GLM Procedure. Mean results were compared using

Tukey's test at 5% significance level ($p < 0.05$) . The FREQ Procedure was performed to analyze specific gravity.

3 RESULTS AND DISCUSSION

There was a significant interaction between the laying hen age and the egg storage period, which was verified in the egg weight loss ($p<0.05$). Egg weight loss increased in 42 days of storage for hens of all ages, as shown in Figure 1.

Figure 1. Egg weight loss (g) from laying hens of different ages (40-, 50-, 60-, and 70-week-old hens) and with different periods of storage (0, 14, 28, and 42 days).

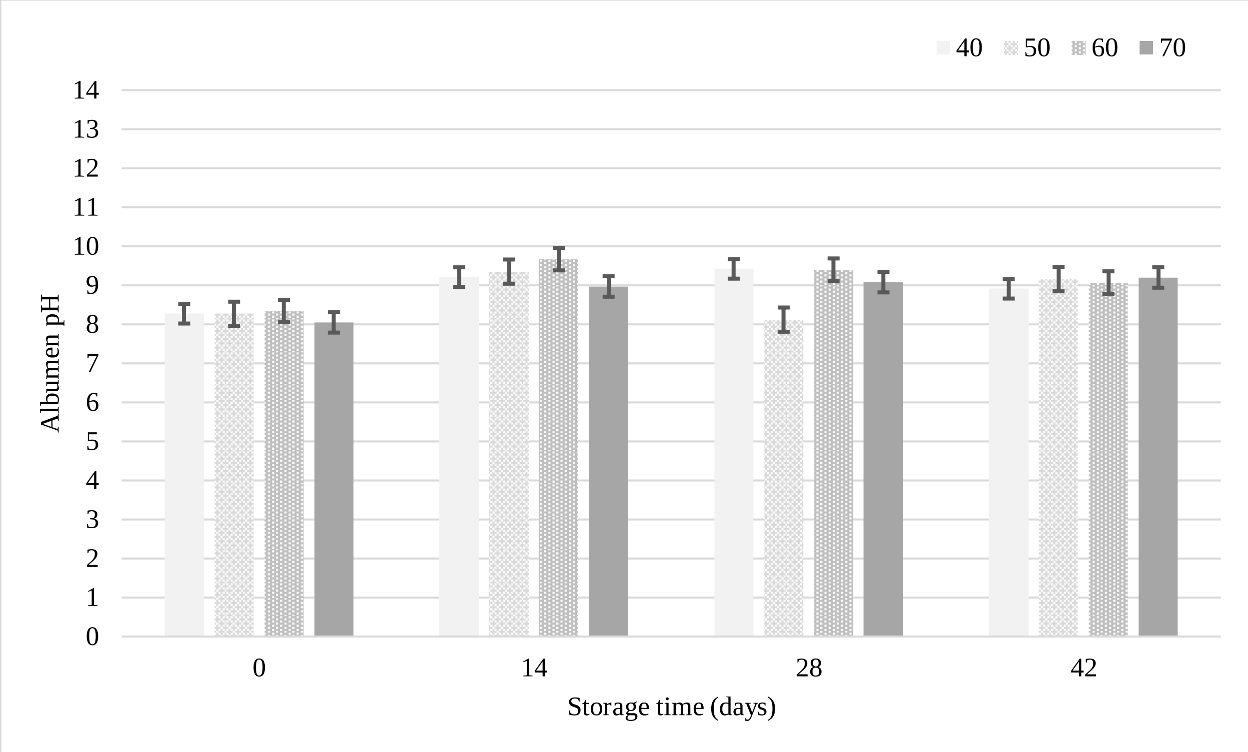


Fonte: O autor.

Eggs of laying hens at 40 weeks of age showed less variability between weight loss and days of storage, however, eggs from 60- and 70-week-old hens showed a greater variability. The values of egg weight loss found were of 0.70g, 0.32g and 0.88g in eggs of 40-week-old laying hens with 14, 28 and 42 days of storage, respectively. Eggs of 50-week-old laying hens presented losses of 0.95g, 1.99g and 2.54g; eggs of 60-week-old laying hens presented losses of 1.59g, 2.52g and 4.65g, and, finally, eggs of 70-week-old laying hens presented losses of 1.18g, 2.25g and 3.23g in 14, 28 and 42 days of storage, respectively.

A significant interaction between the age of the laying hen and the egg storage period was observed in the albumen pH and height (p <0.05). Albumen pH values were more affected by their storage time than by the age of the laying hen. The albumen pH on day zero was similar between laying hens of all ages but differences increased for eggs from hens of all ages after 14 days of storage. (Figure 2).

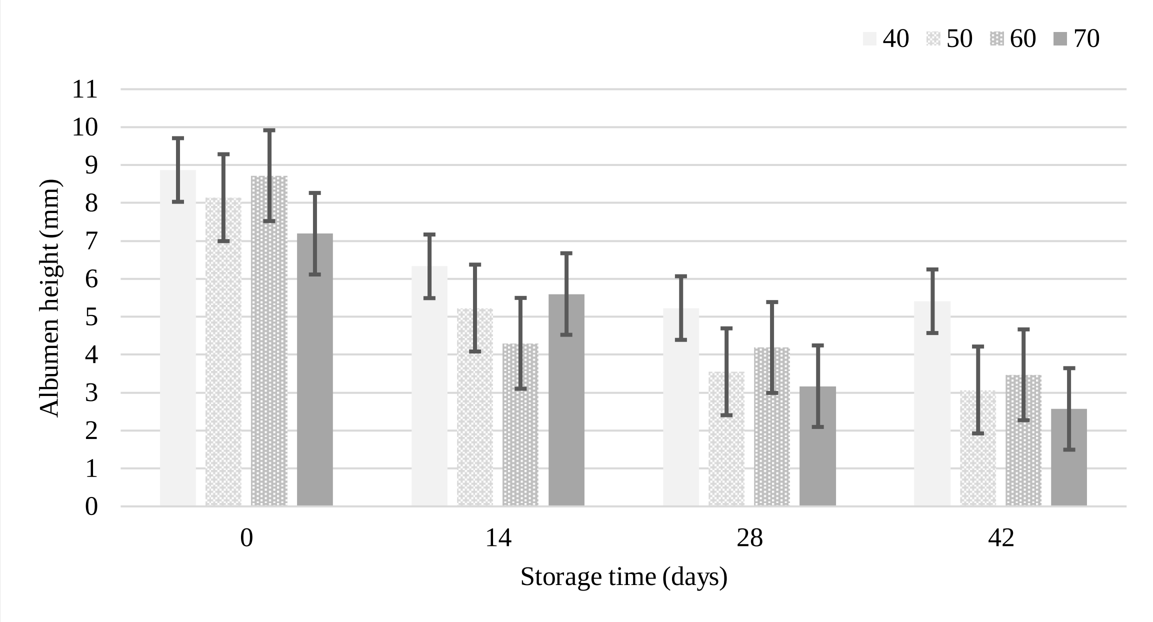
Figure 2. Albumen pH in eggs from laying hens of different ages (40-50-60-70-week-old hens) and with different periods of storage (0-14-28-42 days), (p<0.001).



Fonte: O autor.

The albumen height decreased consistently along the storage time (Figure 3), while a decrease in albumen height is also related to older hens, resulting in lower heights in eggs from 60- and 70-week-old laying hens.

Figure 3. Albumen height (mm) in eggs from laying hens of different ages (40-50-60-70-week-old hens) and with different periods of storage (0-14-28-42 days), (p<0.001).



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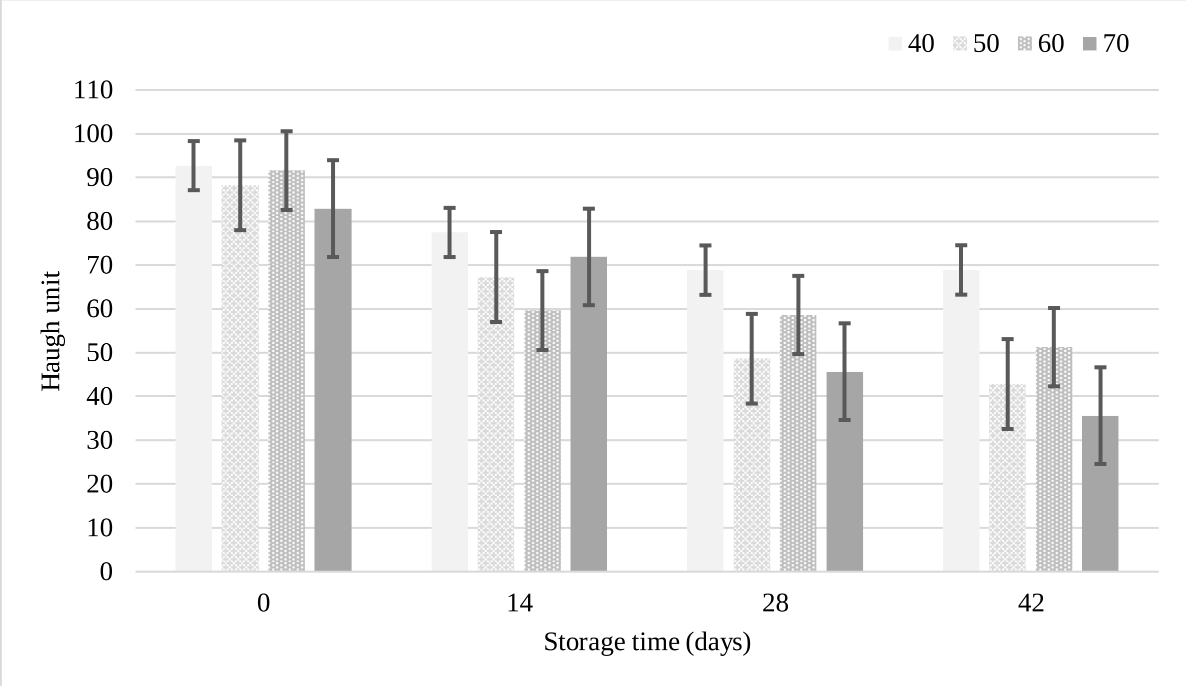
In the foam stability evaluation, there was a significant interaction (p <0.005) between the evaluated factors. Foam stability improved in quality with an increased storage time and at an older laying age of hens (Table 1). Comparing the amount of liquid drained at the end of the 60-minute rest, at 42 days of storage of eggs of 40- to 70-week-old laying hens, it was found that the youngest hens had twice the liquid, i.e., had foam stability results lower than the ones obtained in older eggs.

Table 1. Albumen foam stability in eggs from laying hens of different ages (40-, 50-, 60-, and 70-week-old hens) and with different periods of storage (0, 14, 28, and 42 days).

Storage time (days)	Laying hens age (weeks)			
	40	50	60	70
0	2,066Ab	3,654Bb	2,441Cb	3,236Cb
14	4,975Aa	4,533Ba	4,225Ca	3,258Ca
28	5,500Aa	3,200Ba	3,290Ca	3,790Ca
42	6,300Aa	3,550Ba	3,716Ca	2,412Ca
Probabilities				
Laying hens age	0,01	0,01	0,01	0,01
Storage time	0,01	0,01	0,01	0,01
Laying hens age*Storage time	0,01	0,01	0,01	0,01
Standard error	0,63	0,63	0,63	0,63

There was a significant interaction between the age of the laying hen and the egg storage period, which was measured in Haugh units (p <0.05). Younger laying hens produced eggs with higher Haugh unit scores than older laying hens (Figure 4).

Figure 4. Haugh unit score in eggs from laying hens of different ages (40-50-60-70-week- old hens) and with different periods of storage (0-14-28-42 days), (p<0.001).

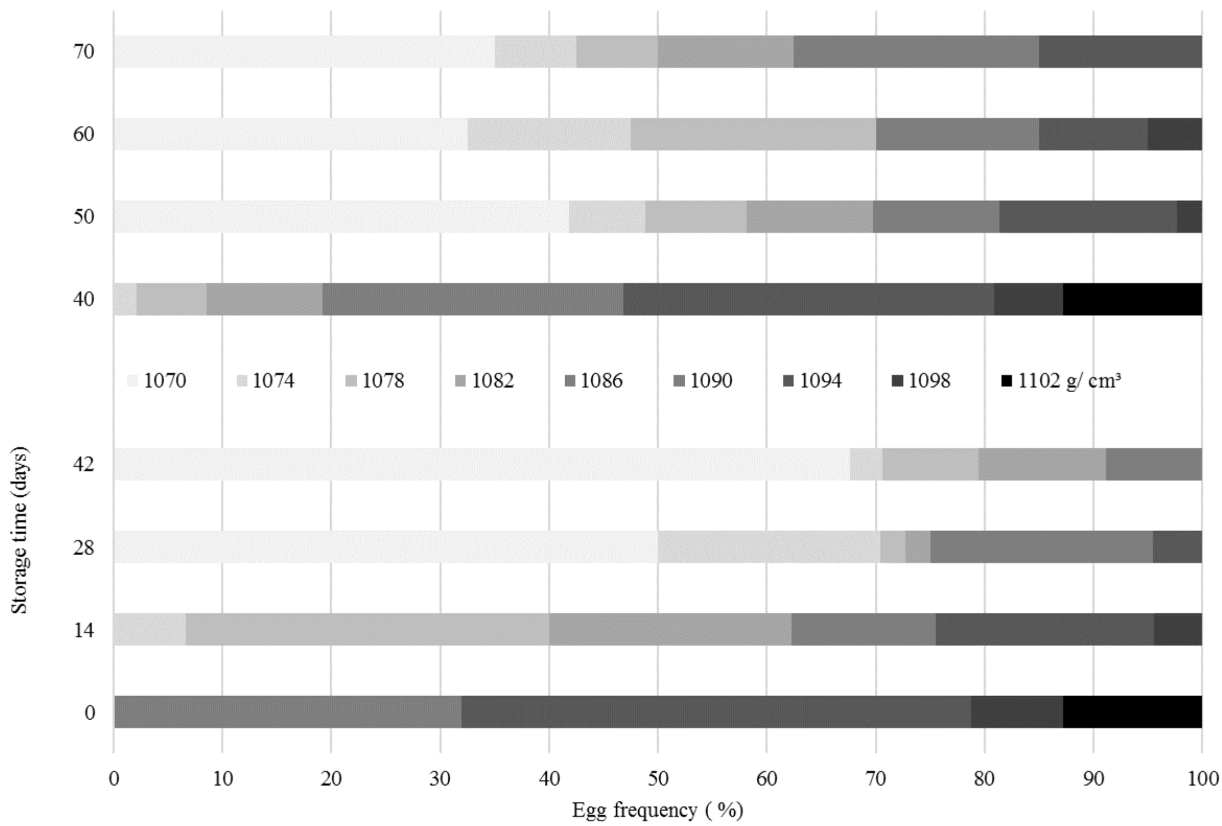


Fonte: O autor.

The Haugh unit score decreased from an initial value of 92.71 to 69.29 after 42 days of storage for eggs of 40-week-old laying hens, and from 80.79 to 37.05 for eggs of 70-week-old laying hens. In fresh eggs (day 0) the Haugh unit score decreased from 92.71 (40-week-old laying hens) to 80.79 (70-week-old laying hens); and after 42 days of storage, from 69.29 to 37.05 for the same laying ages.

There was a significant interaction between the laying age of hens and the egg storage period, which was verified through specific gravity tests ($p < 0.05$). Older laying hens and a longer storage time resulted in the decrease of this variable, ranging from 1.090g / cm3 to 1.078g/cm3 for 40- and 70-week-old laying hens, respectively.

Figure 5. Specific gravity (g/ cm3) in eggs from laying hens of different ages (40, 50, 60, and 70 week-old hens) and with different periods of storage (0, 14, 28, and 42 days), (p<0.001).



Fonte: O autor.

Eggs from younger laying hens presented lower weight loss, regardless of storage time. Greater weight losses were found in longer storage periods of eggs from older hens. A reduction of 9.20% in the egg weight was observed in eggs stored for up to 30 days, when stored in an environment with high temperatures and humidity levels (Lana et al. 2017). The same levels of weight loss were verified when storing eggs at 21 °C, with an increased loss from 0.65g to 1.03g, with five and 10 days of storage, respectively (Figueiredo et al., 2012). The results found in this research support the findings of other authors (Pérez-Bonilla, 2011; Garcia, 2015), and they can be justified by the fact that the amount of calcium supplied by the hens to produce egg shells was the same throughout their lives, but as laying hens got older, they laid bigger eggs and, consequently, the thickness of the shell decreased, generating a greater number of pores in the shell, enabling a greater loss of water from the internal to the external environment (Barbosa, 2012). Eggs of 40-week-old laying hens which had been stored for 42 days presented a lower weight loss when compared to eggs from 60-week-old hens after 14 days of storage.

The increase in pH in the first days and its subsequent reduction was reported by Figueiredo et al. (2011) and Figueiredo et al. (2012) with higher pH values at five and 10 days of storage, respectively. A significant increase in albumen pH was also observed by Jin et al. (2011) when storing eggs at high temperatures, with reports of albumen alkalinity after two days of storage and potentialized in the first five days. Variation in albumen pH is mainly associated with the loss of water and carbon dioxide during the storage period, causing a gas exchange and resulting in an alteration of the albumen pH with a consequent alteration of the proteins and functional properties, besides weight loss (Carvalho, 2013).

During storage, the loss of carbon dioxide through the eggshell pores results in the thinning of the albumen and a pH increase to 9.4–9.5 (Santos, 2016). The increased pH is influenced by chemical changes in albumen, storage time, and temperature. The acid carbon dioxide, one of the components of the albumen buffer system, dissociates to form water and carbon dioxide. Under natural conditions, this gas diffuses through the shell and is lost in the environment. Due to this release, the albumen pH increases, decreasing its acidity and causing chemical dissociation of the protein complex (Aquino, 2016). It was observed in this study that the age of the hens did not influence the pH values of the albumen, thus, the pH of the albumen could be used, under conditions of storage with controlled room temperature of 14°C ± 2, as one of the main parameters for measuring the quality of eggs according to their storage period.

The albumen has a great influence in quality loss, and it can be measured by height, pH and Haugh units (Pissinati, 2014). Silversides & Scott (2001) evaluated the quality of white and brown eggs of 25,31, 45- and 59-week-old hens, which had been stored for 1, 3, 5 and 10 days, and verified a lower consistency of thick albumen for older laying hens. According to Stadelman and Cotterill (1994), carbonic acid is a buffer component of albumen, dissociated into water and carbon dioxide. Under natural conditions, the formed carbon dioxide diffuses through the shell and gets lost in the environment. During storage, this loss of carbon dioxide through the membranes and shell leads to a constant weight loss.

Ferreira (2013) evaluated the foam stability of eggs in an organic production system, from hens of different ages and found values below 18% of drained liquid in all eggs regardless of their age. In an experiment by Kraemer (2003), evaluating the stability of egg foam which had been stored for up to 18 days, there was an increase in the amount of fluid drained from the foam due to the increased storage period. These results were also obtained by Alleoni (1997). The results found in this study demonstrate that the foam of eggs of older hens maintain greater stability throughout storage. This can be justified by the fact that with the aging of the productive life of the hens, there is a thickening of the shell of the eggs (Vieira, 2011), causing them to lose more water and thus concentrate the amounts of proteins found in the albumen, and consequently making the foam more stable.

Longer storage periods showed a reduction in Haugh units. The interaction ($p < 0.05$) showed that younger hens produced eggs with higher values than older laying hens in all storage periods. Garcia et al. (2015) evaluated the shelf-life of eggs considering the effects of the storage period (0, 3, 6, 9, 12 and 15 days) and the age of laying hens (31, 38, 45, 50, 78 and 91 weeks) with different chicken breeds showed the same effect in the regression analysis, where the Haugh unit score decreased from 94.03 to 58.61 after 15 days of storage in eggs of laying hens with 38 weeks, and 83.5 to 40.37 for the same storage period in eggs of hens at 91 weeks. In shelf-life studies, similar results were found for 16 (Garcia et al., 2010), 21 (Freitas et al., 2011) and 35 days (Figueiredo, 2012) for egg storage, where the Haugh unit score decreased significantly with an increased storage time.

The measurement of the specific gravity of the eggs can be considered one of the most used techniques to determine the quality of the shell because it is a simple, practical and low-cost process. Roland (1979) analyzed the eggshell quality of 32, 44, 56 and 68-week-old laying hens, and also verified that the specific gravity decreased significantly as the hens got older, obtaining values of 1.089; 1.084; 1.082 and 1.078g / cm3, respectively. Ingram et al. (2011) found values of 1.078; 1.078 and 1.074g / cm3, studying egg quality of 30, 40- and 50-week-old laying hens. The amount of calcium during the laying cycle is constant, however, in the eggshell thickness is reduced as hens get older. With the increase of the laying age, hens lay bigger eggs with less quantity of calcium per unit of surface during its formation, with a thinner shell and decreasing its specific gravity, mainly when in brown-egg chicken breeds (Lemos, 2015).

Eggs from older laying hens had superior internal quality in the first days of storage, but with a high susceptibility of losses when stored for up to 42 days. Laying hens with 40 weeks of age, show better internal quality of eggs when compared to 50- and 60-week-old hens, when stored for up to 42 days. The albumen pH was not affected by the age of the laying hens but increased significantly with a longer storage period. The shelf life of eggs was affected by the age of laying hens and storage time. A higher albumen foam stability provides better end results in egg white products, such as soufflés, cakes and breads. For the food industry this may be of great interest.

4 CONCLUSIONS

The shelf life of organically produced eggs can be extended up to 42 days for 70 week-old laying hens. Eggs lose their qualitative properties throughout their shelf life, regardless of the age of laying hens, however, they remain within the appropriate consumption standards for up to 42 days of storage. Fresh eggs presented better chemical and physical quality when compared to eggs which had been stored for longer periods of time. Loss of albumen quality is the factor that most affects egg quality in older laying hens.

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