INTERNAL QUALITY OF EGGS COATED WITH WHEY PROTEIN CONCENTRATE

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ABSTRACT: The functional properties of foods can be preserved when they are coated with edible films, since both the loss of moisture and the transport of O_2 and CO_2 are reduced. The objectives of this work were: to compare weight loss, Haugh units, and albumen pH between fresh eggs and eggs coated with whey protein concentrate (WPC), under six storage periods (3, 7, 10, 14, 21 and 28 days), at 25°C. During the entire storage period, regardless of whether the eggs were coated or not, the Haugh unit values and the weight loss decreased, and differences between values from the first to the last period were lower for coated eggs. Albumen pH increased. The Haugh unit values for coated eggs were similar to those found in literature references when the same storage period was considered.
Key words: WPC coating, egg quality, Haugh unit, weight loss

QUALIDADE INTERNA DE OVOS DE GALINHA COBERTOS COM CONCENTRADO PROTÉICO DE SORO DE LEITE BOVINO

RESUMO: As vantagens de utilizar filmes e coberturas comestíveis podem ser justificadas pela manutenção das propriedades funcionais dos alimentos, através da diminuição da perda de umidade e da diminuição da troca de gases (O_2 e CO_2). Aplicação de cobertura em ovos com casca reduz a perda de peso e mantém a qualidade interna do produto. Os objetivos deste trabalho foram comparar a perda de peso, os valores de unidades Haugh e o pH do albume de ovos com e sem cobertura à base de concentrado protéico de soro de leite, armazenados a 25°C, por 3, 7, 10, 14, 21 e 28 dias. Durante todo o período de armazenamento houve decréscimo dos valores de unidades Haugh e perda de peso, tanto para os ovos com cobertura como para os ovos sem cobertura. O pH do albume aumentou para os ovos com e sem cobertura, a variação dos valores nos ovos com cobertura foi menor do que para os ovos sem cobertura. A cobertura de concentrado protéico de soro de leite reduz o transporte de vapor de água e gás (CO_2) através dos poros da casca do ovo. Essa cobertura mantém o pH da clara de ovo na faixa de 8, durante quatro semanas de armazenamento e, desse modo, consegue manter as características necessárias para boa conservação do produto.
Palavras-chave: cobertura, qualidade do ovo, unidades Haugh, perda de peso

INTRODUCTION

The advantages of edible film and coating utilization can be justified since they maintain the functional properties of foods by decreasing moisture loss and gas transport (O_2 and CO_2), and by delaying the volatilization of aromatic components, in addition to their functionality as vehicles for additives (Kester & Fennema, 1986). The application of coatings on eggs reduces weight loss and maintains their internal quality measured by several indices, such as air cell height, Haugh units, yolk index, and egg white pH (Imai, 1981).

Wong et al. (1996) observed that chicken eggs coated with zein-based films had lower water loss and maintained their Haugh unit values during the storage period, when compared with eggs treated with solutions containing egg albumin, soybean protein isolate, wheat gluten and mineral oil. Coating also improved shell breaking strength to a certain extent, by generating a protective barrier. Li et al. (1985) packaged eggs with acrylonitrile and found no difference in Haugh units. Thus, they concluded that controlling the atmosphere is an efficient method of preserving shell egg quality at room temperature for a 7-week period.

Hill & Hall (1980), Imai (1981), Curtis et al. (1985), Bacurau et al. (1994), and Wong et al. (1996) tested treatments in fresh eggs before they were distributed and sold, in order to increase their shelf life. These studies included selection for shell strength, washing treatments, application of sanitizers and mineral oils, as well as the use of refrigeration.

Research in Brazil has suggested that the quality of marketed eggs is generally not good (Gardner et al., 1980), and it is extremely aggravated by the long period between the classification and the marketing of eggs, in addition to high room temperatures and to the absence of quality storage factors, such as refrigeration and shell treatment (Morais et al., 1997).

Considering that new egg storage alternatives are essential to maintain the internal quality of eggs and that whey is a byproduct of the dairy industry, it is important to evaluate the application of this type of coating as a means of preserving the desirable qualities of this product. The objective of this work was to study the effect of the application of a whey protein concentrate coating on fresh eggs, on weight loss, internal quality (expressed as Haugh units), and albumen pH, during storage for four weeks at room temperature.

MATERIAL AND METHODS

One hundred and fifty fresh chicken eggs, of the "Hy-line" line, variety W-36 were used, and 10 fresh eggs were selected and separated from the rest of the group, for Haugh unit and albumen pH determinations. The other eggs were sanitized with a 1% sodium hypochlorite solution for 30 s (Oliveira, 1997). The eggs were then divided into two groups: one of them received a whey protein concentrate (WPC) coating, while the other group did not receive the coating. To apply the coating, the eggs were immersed in the WPC solution for 1 minute and dried at room temperature for 24 h. The eggs were then stored in egg cartons, inside a Biological Oxigen Demand (BOD) incubator at 25ºC. The relative humidity ranged from 70 to 78% during the experiment. The weight loss, Haugh unit, and albumen pH were measured after 3, 7, 10, 14, 21 and 28 days. The experiment was repeated three times, with the same number of eggs.

Protein Coating - the coating solution was prepared according to method of Gennadios et al. (1993); 10.78 g of whey protein concentrate (WPC) (8% protein) and 3.5 g glycerol were placed in a beaker which was completed to 100 g with water (w/w). The solution was homogeneized until completely dissolved and placed in a double boiler at 90ºC for 30 minutes, and then cooled to 25ºC; the pH was adjusted to 7.0 with a 1.0 mol L^{-1} NaOH solution.

Egg weight loss - calculated by subtracting the final weight from the initial weight, and expressed as a percentage.

Egg internal quality - measured with a high precision micrometer that determines albumen height. This system uses the Haugh unit formula (Haugh, 1937).

$$HU = 100 \log (H + 7.57 - 1.7W^{0.37})$$

where: HU = Haugh units; H = thick egg white height (mm); W = egg weight (g) (Roush, 1981).

Statistical analysis - The experimental design was a 2×6 factorial scheme, where the factors were coating (with and without) and time (3, 7, 10, 14, 21, 28 days). Multiple comparisons of the means were performed, for all storage times, including time zero (fresh eggs), by means of an orthogonal contrast [treatments (all storage times for coated and non-coated eggs) × fresh eggs]. Means were compared by Tukey test ($P < 0.01$).

RESULTS AND DISCUSSION

An interaction ($P < 0.01$) was found between factor time and factor coating for egg weight loss, internal quality and albumen pH. Therefore, we performed the partitioning of the data, and the results were analyzed within each storage period. The fresh egg results (day 0) were used as a reference for egg quality.

Weight loss was affected by WPC application and by storage time. Both coated and non-coated eggs lost weight during storage (Figure 1). Weight losses in coated eggs were smaller than in non-coated eggs (Figure 1). The greatest weight losses in both coated and non-coated eggs occurred on the fourth week of storage, reaching values of 4.8% and 6.0%, respectively. Wong et al. (1996) measured a 4.2% weight loss in eggs coated with wheat gluten. In eggs coated with soybean protein isolate, the loss was 6.5%, while in eggs coated with mineral oil this value was 9.2%, after 28 days of storage. The weight loss in eggs coated with WPC was 0.6% higher than in eggs coated with gluten, and 1.7% and 4.4% smaller than in eggs coated with soybean protein isolate and mineral oil, respectively.

On the 3rd day, a 100% difference between egg groups was detected (coated eggs = 0.37% and non-coated eggs = 0.74%), although, from the 7th to the 21st day the difference was around 50%. On the 28th day, however, this difference was even lower, reaching 23%. The whey protein has hydrophilic amino acid residues that allow the passage of water molecules. The glycerol used to provide a uniform coating causes the hydrogen bonds to break, resulting in water loss during storage (Mchugh & Krochta, 1994).

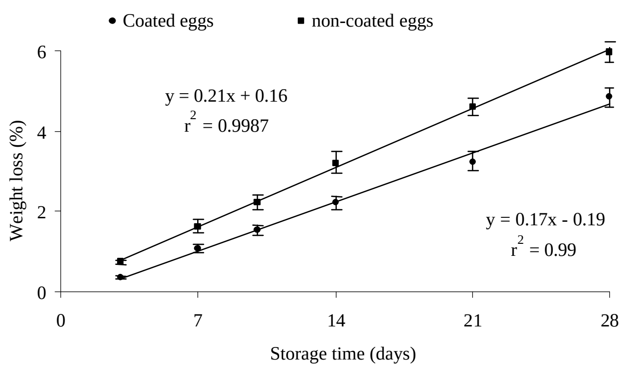

Figure 1 - Weight loss in eggs without and with whey protein concentrate coating as a function of storage time.

Overall, there was a decrease in egg internal quality, both in non-coated and in coated eggs (Figure 2). However, the variation in coated eggs (from 79 to 67 HU) was smaller than in non-coated eggs (from 62 to 14 HU), until the end of the storage period. Alleoni & Antunes (2001) stored eggs at 8°C and measured approximately 60 Haugh units, at the end of a 21-day period. When these results are compared with those obtained for eggs coated with WPC, a 10-HU difference is evident, since coated eggs showed 70 HU, during the same storage period.

After three days, the eggs coated with WPC showed 79 HU, while non-coated eggs showed 62 HU. Wong et al. (1996) measured 69 HU for gluten-coated eggs, 73 HU for eggs coated with soybean protein isolate and 69 HU for eggs coated with mineral oil, while Herald et al. (1995) found 70 HU for gluten-coated eggs, during the same storage period. The HU values for non-coated eggs were 21% smaller than the HU values for WPC-coated eggs. This difference increased as the storage period progressed. After one week, the difference was 33%.

The HU value in non-coated eggs stored for seven days was 52.1; in coated eggs it was 77.4, during the same storage period. Morais et al. (1997) obtained 77.2 HU for freshly-laid eggs; at five days of storage at 23°C this value dropped to 58.4 HU, and at seven days the value had decreased to 53.5 HU.

At 10-days storage, the HU values in eggs coated with WPC were 39% higher than in non-coated eggs. At two weeks, this difference increased to 73%; at three weeks it was 71%, and finally at four weeks a 79% difference was measured. From the tenth to the fourteenth day, the difference between the two groups increased, and again some stabilization in this difference was observed, with the variation ranging from 70 to 80%. The decrease in HU values is associated with a reduction in egg quality. Alleoni & Antunes (2001) also found that the Haugh units score decreased considerably with storage time at room temperature (25°C).

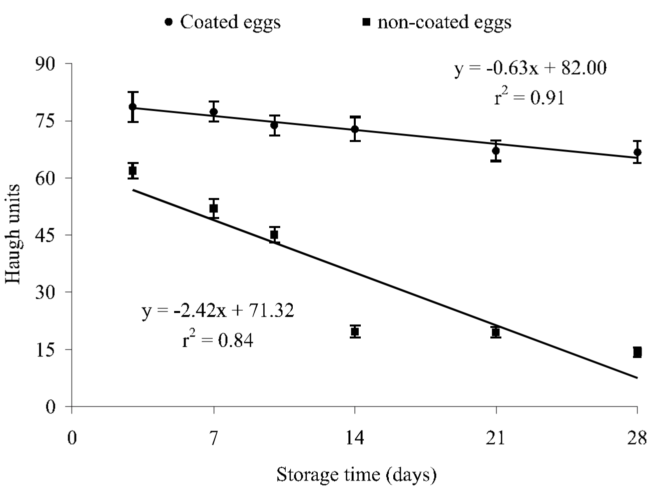

Figure 2 - Haugh units in eggs without and with whey protein concentrate coating as a function of storage time.

On the 28th day, the HU value was 67 for coated eggs. During the same storage period, Wong et al. (1996) obtained 52; 51; and 35 HU for eggs coated with gluten, soybean protein isolate, and mineral oil, respectively. The WPC coating showed a higher HU value when compared with the other coatings, in the same storage period.

Excellent quality eggs, according to the North-American standard, present a HU value of 72 (Oliveira (1992) cited by Morais et al. (1997)). In this experiment, the HU values for coated eggs indicated an excellent quality, with 79 HU after 3 days, 77 HU after 7 days, 74 HU after 10 days, and 73 HU after 14 days of storage. Non-coated eggs showed a different response, since from the third day of storage the HU value was 62.

Bacurau et al. (1994) found that eggs coated with potassium sorbate plus mineral oil, at 28 days of storage at 28°C, showed a 65 HU value, thus not differing from eggs coated with mineral oil. This result is similar to the value obtained in the present study for eggs coated with WPC, (67 HU at 28 days at 25°C). Li et al. (1985) obtained 60 HU for eggs coated with mineral oil and stored at refrigeration temperature, during the same storage period.

Cherian et al. (1996) fed birds with diets enriched with non-saturated fatty acids added with tocopherols, and stored the collected eggs for up to 40 days at 4°C. A decrease in HU values in all treatments during the storage period was recorded. In the first ten days, eggs from hens fed sunflower oil plus tocopherols showed 91.1 HU, while eggs from birds fed sunflower oil only showed 83.4 HU. At 40 days of storage the HU valves in all treatments ranged from 71 to 75 HU. In our work, a correlation existed between Haugh units and weight loss in coated and non-coated eggs (Figures 4 and 5).

In experiments conducted with eggs coated with wheat gluten and stored for up to 28 days at room temperature, Wong et al. (1996) did not find a drastic decrease in HU values, weight loss, and pH when compared with eggs that received maize zein, egg albumin, and soybean protein isolate coatings, or with non-coated eggs. The HU values was not changed in eggs coated with wheat gluten films and stored for 28 days at room temperature (Herald et al., 1995). Lan & Lien (1999) reported that a mineral oil coating showed the best results for weight loss and HU. Protein-based coatings, especially whey protein isolate coating (as compared to soybean and wheat gluten protein isolates), are promising since they increase shell breaking strength and delay the deterioration of the internal quality of eggs by hindering the penetration of bacteria (Xie et al., 2002).

The albumen pH in coated eggs was lower than in non-coated eggs, for all storage periods (Figure 3). Albumen pH for non-coated eggs ranged from 9.09 (3-day

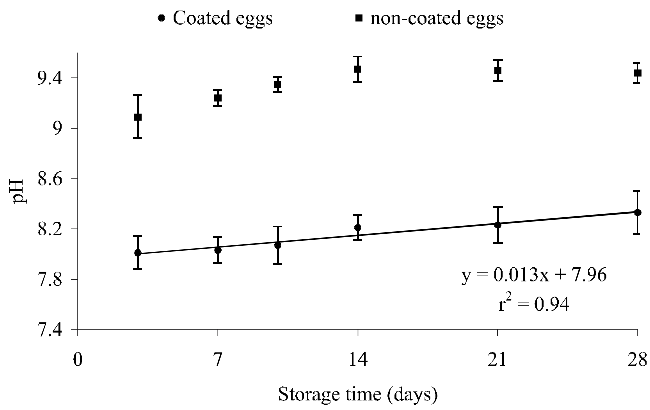

Figure 3 - Albumen pH in eggs without and with whey protein concentrate coating as a function of storage time.

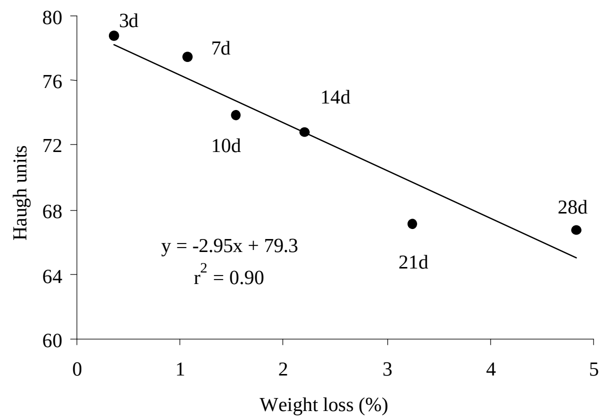

Figure 4 - Haugh units and weight loss in eggs coated with whey protein concentrate during the storage period.

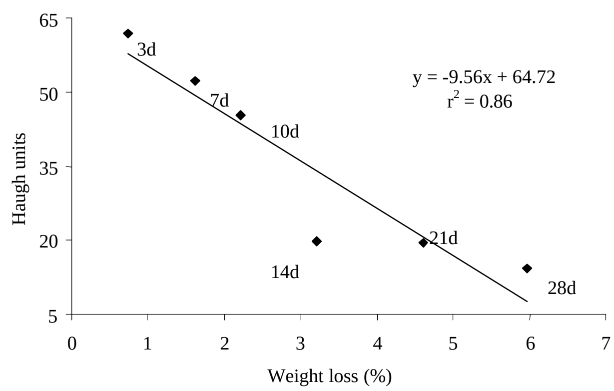

Figure 5 - Haugh units and weight loss in eggs without whey protein concentrate coating during the storage period.

old eggs) to 9.44 (28-day old eggs) (Figure 3). Walsh et al. (1995) found pH for fresh eggs around 7.5 and around 9.5 for eggs stored for 14 days, at 23.9°C. They concluded that the application of CO_2 to the eggshell could be beneficial to maintain albumen quality, during 14 days. At 23.9°C during 14 days of storage, the egg white pH of eggs that received CO_2 was 8.2, the same for WPC-coated eggs, in the same storage period. Ahn et al. (1999) worked with diets containing linoleic acid and found that the albumen pH increased after seven days (pH 9.36) of storage, in relation to fresh eggs (pH 9.05), but remained unchanged until 21 days of storage (pH 9.24), at refrigeration temperature.

For coated eggs, albumen pH ranged from 8.01 to 8.33, over four weeks of storage (Figure 3). Considering coated eggs alone, during the entire storage period, there was a 5% increase in pH, while for non-coated eggs this increase was 19%. The albumen pH of coated eggs at 28 days of storage was 8.33. Alleoni & Antunes (2001) obtained similar results with eggs stored at 8°C, during the same storage period. The albumen pH increases as the egg loses CO_2 (Burley & Vadehra, 1989) and as the storage temperature increases (Goodrum et al., 1989). The fine layer of albumen could be a primary barrier for gas diffusion, and it also helps to maintain albumen quality, which could prevent the free diffusion of CO_2 under long storage periods. The albumen pH increases with storage time, but does not increase as the animal becomes older (Silversides & Scott, 2001).

The albumen pH stability of the eggs, in the present work, was consistent with the results obtained by Pardi (1977), who stated that the rate at which CO_2 is lost is high right after the egg is laid, decreasing with time and then keeping the pH stable. Bacurau et al. (1994) worked with eggs coated with potassium sorbate at 18%, mineral oil, potassium sorbate plus mineral oil, and non-coated eggs, during 28 days and stored at 2°C and 28°C. In this experiment, the refrigeration temperature was more efficient to control egg weight and pH increase, maintaining a satisfactory egg quality until the end of the storage period. All coatings maintained the egg white pH values from 8.5 to 8.6 at the 2°C temperature, as compared to 8.4 in fresh eggs.

The WPC coating had an important effect controlling the pH of coated eggs, i.e., it worked as a barrier that reduced CO_2 loss during storage. According to Bacurau et al. (1994), potassium sorbate was efficient in controlling albumen pH in eggs, especially at the final stage of storage (28 days). The albumen pH reached 8.5, and eggs coated with mineral oil also showed pH of 8.4 at 28°C, during the same period. Ouattara & Simard (1998) analyzed eggs kept in plastic packaging and eggs coated with commercial cotton oil stored at 28°C for up to 45 days. The cotton oil coating was the most effective in reducing weight loss, and the eggs showed higher Haugh unit values. According to those authors, plastic packagings inhibit CO_2 loss and can prevent the egg white pH from raising (Walsh et al., 1995), but the plastic packaging only prevents weight loss.

Egg quality measurements are based on the albumen height of fresh eggs, and are partially determined by the line and age of the hens. Siversides & Scott (2001) suggest that albumen pH should be considered as a measure of quality, because it is not affected by the age or by the line of the hens. If albumen pH is considered as a quality index, WPC coating can maintain the fresh egg characteristics during the 28 days of storage at 25°C. However, if the HU value is to be considered as a quality index, this coating is not so effective, due to the variation in these values between fresh eggs (85.2 HU) and eggs stored for 28 days (67.8 HU), even when this value is associated with good egg quality. In addition, if egg weight after 28 days is to be considered, the difference between the egg groups with and without coating is reduced. The WPC coating is not an effective barrier against the loss of water vapor, because its proteins are hydrophilic. Egg weight loss during storage does not interfere with the functional properties of egg white proteins.

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