Agrária - Revista Brasileira de Ciências Agrárias
ISSN (on line) 1981-0997
v.12, n.1, p.47-50, 2017
Recife, PE, UFRPE. www.agraria.ufrpe.br
DOI:10.5039/agraria.v12i1a5420
Protocolo 5420 - 06/03/2016 • Aprovado em 23/02/2017

Internal quality of eggs coated with cassava and yam starches

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ABSTRACT

The objective of this study was to evaluate the egg quality stored at 25 and 5 °C with and without cassava and yam starches coatings for 28 days. The treatments used were: fresh eggs (T1), without coating stored at 5 °C (T2) and 25 °C (T3), with cassava (T4) and yam (T5), starches coatings. The eggs were analyzed for egg weight; weight loss; albumen, yolk and shell percentages; Haugh Units (HU); yolk color; and yolk and albumen pH. The egg weight, shell percentages, and yolk pH did not vary among the treatments. The weight losses, albumen and yolk percentages of the eggs stored were higher when compared to T1. For HU, T2 did not differ of T1, maintaining the internal egg quality during storage. The other treatments had a reduction ($p \leq 0.05$) of HU with storage. The yolk color of T2 was higher ($p \leq 0.05$) than T1. The eggs stored at 25 °C not differ between themselves. The albumen pH of T3 was higher than of T1. The albumen pH of T2 and T5 were the lowest. Thus, the egg quality decreased with time and storage temperatures. The eggs stored with cassava and yam starches coatings had a reduction of internal quality for HU. However, for the parameters albumen pH, the coating of yam starch had good results, keeping the quality of the eggs during storage.

Key words: Albumen pH; color; edible coatings; Haugh unit; storage

Qualidade interna de ovos com cobertura de fécula de mandioca e amido de inhame

RESUMO

O objetivo deste estudo foi de avaliar a qualidade de ovos armazenados à 25 °C e 5 °C com e sem coberturas de amidos de mandioca e inhame por 28 dias. Os tratamentos utilizados foram: ovos frescos (T1), sem cobertura armazenados à 5 °C (T2) e à 25 °C (T3), com coberturas de fécula de mandioca (T4) e amido de inhame (T5). Foram realizadas as seguintes análises: peso do ovo; perdas de peso; percentuais de albúmen, gema e casca; Unidades Haugh (UH); cor da gema; e pH da gema e do albúmen. Peso dos ovos, percentuais de casca e pH da gema não variaram entre os tratamentos. Perdas de peso, percentuais do albúmen e gema dos ovos armazenados foram maiores quando comparados com T1. Para UH, T2 não diferiu de T1, mantendo a qualidade interna dos ovos durante a estocagem. Os demais tratamentos apresentaram redução ($p \leq 0,05$) da UH com o armazenamento. A cor da gema de T2 foi maior ($p \leq 0,05$) do que a de T1. Os ovos armazenados à 25 °C não diferiram entre si. pH do albúmen de T3 foi maior do que de T1. pH do albumen de T2 e T5 foram os menores. Assim, a qualidade dos ovos diminuiu com o tempo e as temperaturas de estocagem. Os ovos armazenados com cobertura de fécula de mandioca e amido de inhame tiveram redução da qualidade interna para UH. No entanto, para pH do albúmen, o revestimento de amido de inhame obteve bons resultados, mantendo a qualidade dos ovos durante o armazenamento.

Palavras-chave: pH do albumen; cor; cobertura comestível; unidades de Haugh; armazenamento

Introduction

Chicken eggs are one of complete food for human consumption because they are rich in vitamins, minerals, fatty acids, and proteins that provide several essential amino acids of excellent biological value. However, the nutritional benefits of eggs depend on the quality at the moment purchase. This quality can be determined by several factors that influence on the acceptability (Akyurek & Okur, 2009).

The primary causes for changes in egg quality during storage depend upon several factors such as microorganisms, first egg quality, and storage temperature. During storage, the egg deterioration occurs faster at high temperatures (30 to 40 °C) than at refrigerated temperatures (0 to 4 °C) (Akter et al., 2014). However, the cold chain increases the cost of production, which may be the cause of most of the eggs that are sold in the Brazilian market are at room temperature.

In this context, some researchers have evaluated methods of low-cost to prolong the shelf life of eggs. An alternative is the surface treatments of the eggshell, such as the use of biodegradable coatings that act as a gas exchange controller. The gas exchanges are responsible for pH, protein and nutritional properties changes (Biladeau & Keener, 2009; Jo et al., 2011; Caner & Yuceer, 2015).

A good alternative to produce biodegradable coatings is found in cassava and yam starches, widely used in the vegetables and fruits preservation (Durango et al., 2006; Chiumarelli et al., 2010; Ojeda et al., 2014). The cassava starch forms a translucent gel with high bright, durable, non-toxic, low-cost and with a tendency to retrogradation. The yam starch has a high tendency to retrogradation and great capacity for forming films with a homogeneous matrix, the stable structure at room temperature with excellent water barrier properties (Alves et al., 1999; Mali et al., 2005).

Thus, the objective of this study was to evaluate the stability of eggs stored at room temperature (25 °C) and refrigeration temperature (5 °C) with and without a starch coating of cassava and yam for 28 days.

Materials and Methods

The materials used were fresh tubers of yam (*Dioscorea alata*), without mechanical and pathological injuries, cassava starch and plasticizer (inverted sugar and glucose) obtained from a local market. A sample of 125 white eggs extra type has been achieved from a commercial farm.

For the production of edible coatings, yam starch was extracted according to Alves et al. (1999), with modifications. The starch coatings were prepared as previously described by Al-hassan & Norziah (2012). Thus, the starch coating solutions were prepared at ratio of 75% cassava or yam starch and 25% plasticizer (inverted sugar and glucose), representing 2.5% of the coating. Covers cassava and yam starch were dissolved in distilled water and were heated to 95 °C and maintained at that temperature for 10 min. The coating application was made by immersion on the filmogenic solution for 3 seconds, for polymerizing on the egg. Then, the eggs were placed in Petri dishes at room temperature (25 °C) for 30 min to drying the coating.

At zero day, all eggs were identified, weighed and distributed in a complete randomized design with five treatments and five replications of five eggs per treatment, totaling 125 eggs. In Table 1 are presented the treatments.

It was performed the analysis of egg weight; Haugh units; shell, albumen, and yolk percentages; yolk and albumen pH and yolk color in the eggs at the zero-day and after 28 days of storage. The storage eggs were made at a temperature (5 or 25 °C) and humidity controlled (70%).

For eggs quality characteristics analysis, firstly eggs were individually weighed in the semi-analytical balance with an accuracy of 0.01 g (Shimadzu, BL3200H, Tokyo, Japan) for determination of average egg weight. After, each egg was broken out on to a flat surface where yolks were separated from the whites and then weighed. The shells were washed and 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 by the egg weight.

Haugh Units were calculated from the measurements of albumen height 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 (Silversides & Budgell, 2004). The yolk color analysis was determined using the Roche fan colorimeter (Ahn et al., 1999). The yolk and albumen pH were measured directly by pHmeter digital (ATAGO, DPH-2, Tokyo, Japan).

Statistical analyses were performed using the Statistical Analysis System (SAS, version 9.2) at 5% probability for significance. Initially, were analyzed the data the eggs stored for 28 days and the difference between the means was obtained by SNK test (5% probability). After to evaluate the difference between the results obtained after storage compared to fresh eggs, the data obtained at day zero were added, and the difference between the means was obtained by Dunnett's test (5% probability)

Table 1. Treatments of eggs with and without coating of cassava or yam starch stored for 28 days.

Treatment	Temperature (°C)	Coating presence	Starch source
T1	-	-	-
T2	25	No	
T3	5	No	
T4	25	Yes	Cassava
T5	25	Yes	Yam

T1 = control (fresh eggs); T2 = uncoated eggs stored at 25 °C; T3 = uncoated eggs stored at 5 °C; T4 = eggs coated with cassava starch stored at 25 °C; T5 = eggs coated with yam starch stored at 25 °C.

Results and Discussion

The results for egg weight and shell, albumen, and yolk percentages of eggs with and without coatings of cassava or yam stored for 28 days are presented in Table 2. The egg weight did not observe differences ($p > 0.05$) among the treatments evaluated (Table 2).

Table 2. Egg weight and shell, albumen, and yolk percentages of eggs with and without coatings of cassava or yam stored for 28 days (n=5).

Variables	Eggs types				
		Stored (28 days)			
	Fresh (T1)	at (5 °C)	at (25 °C)		
		Uncoated (T2)	Uncoated (T3)	Coated starch	
				Cassava (T4)	Yam (T5)
Eggweight (g)	66.75±0.38	64.22±1.30 ^{a}	62.60±3.13 ^{a}	64.42±0.93 ^{a}	65.59±0.64 ^{a}
Weight loss (%)	0.00 ±0.00	4.61 ±0.57 ^{a*}	5.49 ±1.18 ^{a*}	4.36± 0.27 ^{a*}	4.27 ±0.36 ^{a*}
Albumen (%)	62.92±3.01	58.56±2.00 ^{a*}	56.97±2.66 ^{a*}	56.73±1.36 ^{a*}	57.06±1.49 ^{a*}
Yolk (%)	28.63±1.19	31.47±2.27 ^{a*}	32.78±2.78 ^{a*}	33.07±1.55 ^{a*}	32.88±1.70 ^{a*}
Shell (%)	9.69±0.23	9.98±0.36 ^{a}	10.25±0.43 ^{a}	10.21±0.37 ^{a}	10.06±0.37 ^{a}

$^{a-b}$ Means followed by the same letters are not significantly different by Newman−Keuls test (p < 0.05). *Means different when compared to fresh eggs by Dunnett test (p < 0.05).

The weight losses of the eggs stored for 28 days were higher when compared to fresh eggs ($p \leq 0.05$). However, among the stored treatments there was no difference ($p > 0.05$) on the eggs weight loss (Table 2). Thus, there did not influence of temperature and not edible coatings in preventing weight loss.

Caner & Yuceer (2015) evaluated the effectiveness of various coatings (whey protein isolate, whey protein concentrate, zein, and shellac) on the weight loss stored for 42 days at 24 °C. These authors observed lower weight loss to treatments with edible coatings and concluded that these coatings were the ability to block pores on the surface of the eggs.

For edible coating of starches, according to Liu (2005), the gas transfer occurs through the non-crystalline regions of the material (amorphous areas), and the advancement of recrystallization process reduced the amorphous regions, offering less space for gas transfer. However, in the present study, the cassava and yam starches coatings were not efficient in reduction of weight loss during storage.

The albumen percentages of eggs stored for 28 days were lower ($p \leq 0.05$) than fresh eggs. However, among the stored treatments there was no difference ($p > 0.05$) (Table 2). The reduction of albumen percentages may also occur due to ovomucin protein desnaturation and, water and CO_2 losses of albumen to the environment and migration for yolk (Jo et al., 2011).

The yolk percentages of eggs stored for 28 days were higher ($p \leq 0.05$) than fresh eggs. However, among the stored treatments there was no difference ($p > 0.05$) (Table 2). Increase in the yolk percentages occurs because of water migration from albumen to yolk, due to the osmotic pressure gradient and the higher storage temperature, that weakens the vitelline membrane by making the larger and more flattened when the egg yolk is observed on a flat surface after breaking the shell (Biladeau & Keener, 2009).

For the shell percentages, there were no differences ($p > 0.05$) between the treatments (Table 2).

For Haugh Units, only eggs stored at 5 °C (T2) did not differ ($p > 0.05$) to the fresh eggs (T1), maintaining the internal quality of eggs during storage. The other treatments had a reduction ($p \leq 0.05$) of Haugh Units values with storage (Table 3). This result indicating that the albumen became less viscous with storage and consequently the albumen height reduced, resulting in lower Haugh Units values. Different results were reported by Caner & Cansiz (2007), evaluating the internal quality of eggs coated with chitosan. These authors indicated that the coating provided lower decrease on Haugh Unit values when compared with uncoated eggs.

According to Yuceer & Caner (2014), the eggs can be graded as: AA, HU >72; A, HU = 71 − 60; B, HU = 59 − 31; and C, HU <30. Therefore, the fresh eggs and eggs stored at 5 °C were classified as B, and others treatments were classified as low quality (C).

The yolk color the eggs stored under refrigeration (T2) had higher ($p \leq 0.05$) values when compared to fresh eggs (T1). The eggs stored at room temperature (25 °C) with and without edible coatings not differ between themselves (Table 3).

Jiang et al. (1992) also observed increase on the coloring of egg yolks stored for 42 days at refrigerated temperature (4 °C). These authors reported it remains unknown the exact cause for this increase in the egg color.

For edible coatings, Jo et al. (2011) also reported similar results using chitosan coverages. These authors did not observe significant differences in the yolk color of eggs with and without coverages stored under refrigeration and at room temperature (25 °C).

For the yolk pH, did not observed differences ($p > 0.05$) among the treatments evaluated ($p > 0.05$) (Table 3). Therefore, the yolk pH was stable during storage for 28 days. According to Shang et al. (2004), during storage alkali ions such as sodium, potassium, and magnesium migrate albumen to yolk being exchanged by hydrogen ions, causing an increase in yolk pH. This increase could induce desnaturation of the proteins

Table 3. Haugh Units, yolk color, and, yolk and albumen pH of eggs with and without coatings of cassava or yam stored for 28 days (n=5).

Variables	Eggs types				
		Stored (28 days)			
	Fresh (T1)	at (5 °C)	at (25 °C)		
		Uncoated (T2)	Uncoated (T3)	Coated starch	
				Cassava (T4)	Yam (T5)
Haugh Unit	58.45±4.19	58.84±6.45 ^{a}	18.41±9.64 ^{b*}	21.68±5.41 ^{b*}	22.29±9.04 ^{b*}
Yolk color	6.20 ±0.84	7.47 ±0.30 ^{a*}	7.13 ±0.30 ^{b}	6.87± 0.69 ^{b}	6.60 ±0.37 ^{b}
Yolk pH	6.22±0.62	6.72±0.63 ^{a}	6.44±0.24 ^{a}	6.48±0.37 ^{a}	6.36±0.26 ^{a}
Albumen pH	9.14±0.09	9.00±0.07 ^{b}	9.30±0.00 ^{a*}	9.22±0.08 ^{a}	9.08±0.04 ^{b}

$^{a-b}$ Means followed by the same letters are not significantly different by Newman−Keuls test (p < 0.05). *Means different when compared to fresh eggs by Dunnett test (p < 0.05).

and increase the consistency of the yolk. The increase in pH occurs yolk slowly, not being perceived major changes. Thus, the albumen pH is the most used parameter of egg quality.

The albumen pH the eggs uncoated eggs stored at 25 °C (T3) were higher ($p \leq 0.05$) than fresh eggs (T1). The uncoated eggs stored at 5 °C (T2) and eggs coated with yam starch (T5) were lower ($p \leq 0.05$) than others treatments (Table 3).

In fresh eggs the albumen pH range from 7.6 to 7.9. The increase in pH of albumen occurs because of dissociation of carbonic acid (H_2CO_3), one of the components of the buffer system of albumen, forming water and carbon dioxide. This reaction is accelerated when the storage temperature of the eggs is high. Under natural conditions, the CO_2 diffuses through the shell and is lost at the environment, and the pH of the albumen increases, making the pH of the albumen alkali (Biladeau & Keener, 2009). Thus, taking into consideration that egg quality may be measured by the albumen pH (Caner & Yuceer, 2015), the coating of yam starch was efficient in maintaining the egg quality.

Conclusion

Thus, there was decreased egg quality in function of time and storage temperatures.

The eggs kept at a refrigerated temperature showed better values for Haugh Units.

The eggs stored with a coating of cassava and yam starch had a reduction of internal quality for Haugh Units. However, for the parameters albumen pH, the coating of yam starch had good results, keeping the quality of the eggs during storage for 28 days at room temperature (25 °C).

Acknowledgements

The authors acknowledge to Brazilian National Council for Scientific and Technological Development (CNPq) and Foundation for Research and Scientific Development and Technological of Maranhão (FAPEMA) for the financial support and scholarship.

Literature Cited

Ahn, D.; Sell, J.L.; Jo, C.; Chamruspollert, M.; Jeffrey, M. Effect of dietary conjugated linoleic acid on the quality characteristics of chicken eggs during refrigerated storage. Poultry Science, v. 78, n. 6, p. 922–928, 1999. https://doi.org/10.1093/ps/78.6.922.

Akter, Y.; Kasim, A.; Omar, H.; Awis, Q. S. Effect of storage time and temperature on the quality characteristics of chicken eggs. Journal of Food, Agriculture & Environment, v. 12, n. 3-4, p. 87–92, 2014. http://japr.oxfordjournals.org/content/14/3/548.full.pdf. 5 Mar. 2016.

Akyurek, H.; Okur, A. A. Effect of Storage Time, Temperature and Hen Age on Egg Quality in Free-Range Layer Hens. Journal of Animal and Veterinary Advances, v. 8, n. 10, p. 195–1958, 2009. http://dx.doi.org/=javaa.2009.1953.1958.

Al-hassan, A. A.; Norziah, M. H. Starch-gelatin edible films: Water vapor permeability and mechanical properties as affected by plasticizers. Food Hydrocolloids, v. 26, n. 1, p. 108–117, 2012. http://dx.doi.org/10.1016/j.foodhyd.2011.04.015.

Alves, R. M. L.; Grossmann, M. V. E.; Silva, R. S. S. F. Gelling properties of extruded yam (*Dioscorea alata*) starch. Food Chemistry, v. 67, n. 2, p. 123-127, 1999. http://dx.doi.org/10.1016/S0308-8146(99)00064-3.

Biladeau, A. M.; Keener, K. M. The effects of edible coatings on chicken egg quality under refrigerated storage. Poultry Science, v. 88, n. 6, p. 1266-1274, 2009. http://dx.doi.org/10.3382/ps.2008-00295.

Caner, C.; Cansiz, O. Effectiveness of chitosan-based coating in improving shelf-life of eggs. Journal of the Science of Food and Agriculture, v. 87, n. 2, p. 227-232, 2007. http://dx.doi.org/10.1002/jsfa.2698.

Caner, C.; Yuceer, M. Efficacy of various protein-based coating on enhancing the shelf life of fresh eggs during storage. Poultry Science, v. 94, n. 7, p. 1665–1677, 2015. http://dx.doi.org/10.3382/ps/pev102.

Chiumarelli, M.; Pereira, L. M.; Ferrari, C.C.; Sarantópoulos, C. I. G. L.; Hubinger, M. D. Cassava starch coating and citric acid to preserve quality parameters of fresh-cut "Tommy Atkins" mango. Journal of Food Science, v. 75, n. 5, p. E297–E304, 2010. http://dx.doi.org/10.1111/j.1750-3841.2010.01636.x.

Durango, A. M.; Soares, N. F. F.; Andrade, N. J. Microbiological evaluation of an edible antimicrobial coating on minimally processed carrots. Food Control, v. 17, n. 5, p. 336–341, 2006. http://dx.doi.org/10.1016/j.foodcont.2004.10.024.

Jiang, Z.; Ahn, D. U. Ladner, L.; Sim, J. S. Influence of feeding full-fat flax and sunflower seeds on internal and sensory qualities of eggs. Poultry Science, v. 71, n. 2, p. 378–382, 1992. http://dx.doi.org/10.3382/ps.0710378.

Jo, C.; Ahn, D. U.; Liu, X. D.; Kim, K. H.; Nam, K. C. Effects of chitosan coating and storage with dry ice on the freshness and quality of eggs. Poultry Science, v. 90, n. 2, p. 467–472, 2011. http://dx.doi.org/10.3382/ps.2010-00966.

Liu, Z. Edible films and coatings from starches. In: Han, J. H. (Ed.). Innovations in Food Packaging. Oxford: Academic Press, 2005. p. 318–332.

Mali, S.; Grossmann, M.V. E; García, M. A.; Martino, M. N.; Zaritzky, N.E. Mechanical and thermal properties of yam starch films. Food Hydrocolloids, v. 19, n. 1, p. 157–164, 2005. http://dx.doi.org/10.1016/j.foodhyd.2004.05.002.

Ojeda, G. A.; Sgroppo, S. C.; Zaritzky, N. E. Application of edible coatings in minimally processed sweet potatoes (*Ipomoea batatas* L.) to prevent enzymatic browning. International Journal of Food Science & Technology, v. 49, n. 3, p. 876–883, 2014. http://dx.doi.org/10.1111/ijfs.12381.

Shang, X. G.; Wang, F. L.; Li, D. F.; Yin, J. D.; Li, J. Y. Effects of dietary conjugated linoleic acid on the productivity of laying hens and egg quality during refrigerated storage. Poultry Science, v. 83, n. 10, p. 1688–1695, 2004. http://dx.doi.org/10.1093/ps/83.10.1688.

Silversides, F. G.; Budgell, K. The relationships among measures of egg albumen height, pH and whipping volume. Poultry Science, v. 83, n. 10, p. 1619–1623, 2004. https://doi.org/10.1093/ps/83.10.1619.

Yuceer, M.; Caner, C. Antimicrobial lysozyme-chitosan coatings affect functional properties and shelf life of chicken eggs during storage. Journal of the Science of Food and Agriculture, v. 94, n. 1, p. 153–162, 2014. http://dx.doi.org/10.1002/jsfa.6322.