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Internal quality of laying hens' commercial eggs according to storage time, temperature and packaging

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ABSTRACT. Current assay evaluates the internal quality of eggs of Hy-Line W-36 hens, according to storage time, temperature and packaging. Two equal experiments, starting one day apart, were conducted with 140 eggs each. The two experiments were divided into two phases, from 1 to 9 days and from 9 to 21 days, in a randomized block design. In the 1st phase, the treatments were arranged in a factorial 2 x 3+1, packaging (with or without), time (3, 6 and 9 days), with control on the 1st day. In the 2nd phase, treatments were arranged in a factorial design 2 x 2 + 1, packaging (with or without), cooling (with or without), and control on the 9th day. Egg weight, albumen, yolk and shell percentage, yolk index and Haugh unit were evaluated. The internal quality was reduced ($p < 0.05$) during storage and the internal quality of eggs kept at room temperature decreased ($p < 0.05$), whereas eggs stored under refrigeration showed the same quality ($p > 0.05$) on the 9th and 21st days. Packaging assured better quality ($p < 0.05$), but not similar to the quality of refrigerated eggs. Results showed that the internal quality of the eggs was worse when there was no refrigeration during storage time and that packages provided better internal quality, although not as effective as cooling.

Keywords: storage of eggs, type of packaging, Haugh unit.

Qualidade interna de ovos de poedeiras comerciais em função do tempo, temperatura e embalagem de armazenamento

RESUMO. Objetivou-se avaliar a qualidade interna de ovos de poedeiras comerciais da linhagem Hy-Line W-36®, em função da temperatura, tempo e embalagem. Foram conduzidos dois experimentos, que iniciaram com um dia de diferença, cada um com 140 ovos. Cada experimento foi dividido em duas fases, sendo de um a nove dias e de nove a 21 dias. O delineamento foi em blocos casualisados. Na primeira fase, os tratamentos foram arranjados em fatorial 2 x 3 + 1, embalagem (com ou sem), tempo (3, 6 e 9 dias), e um controle no primeiro dia. Na segunda fase, o arranjo foi 2 x 2+1, embalagem (com ou sem), refrigeração (com ou sem), e um controle no nono dia. Avaliou-se o peso do ovo, percentagem de albúmen, gema e casca, índice gema e unidade Haugh. A qualidade interna reduziu ($p < 0,05$) durante o armazenamento, e os ovos mantidos no ambiente apresentaram redução ($p < 0,05$) na qualidade interna, enquanto que os ovos sob a refrigeração apresentaram a mesma ($p > 0,05$) qualidade no nono e no 21º dia. A embalagem melhorou ($p < 0,05$) a qualidade, no entanto, não com a mesma eficiência que a refrigeração. Conclui-se que a qualidade dos ovos piora com o armazenamento se não houver refrigeração e a utilização de embalagem gera melhor qualidade interna, no entanto, não é tão eficaz quanto à refrigeração.

Palavras-chave: armazenamento de ovos, tipo de embalagem, unidade Haugh.

Introduction

Eggs, naturally packaged in shells to maintain their quality and their nutritional rates, are highly nutritional food (Pelícia et al., 2007). However, eggs are perishable food and their quality decreases as time passes, between laying and commercialization. Their condition may be worsened by different factors (Barbosa, Sakomura, Mendonça, Freitas, & Fernandes, 2010) even though conservation techniques that minimize loss of egg quality are extant (Freitas et al., 2011).

Storage time certainly affects eggs' quality since it reduces quality due to its direct relationship with pH increase and to lowering of Haugh units, albumen height and egg weight. The above changes are due to gas exchanges and to the passage of water from the albumen to the yolk by osmosis (Carvalho et al., 2007; Leandro et al., 2005).

Temperature is one of the factors that most affects egg quality during storage. The best procedure is the conditioning of eggs in a refrigerator immediately after laying to warrant a healthier product during a longer time (Carvalho et al., 2003). However, in Brazil, eggs are stored at room temperature in commercial outlets due to the lack of legislation on egg storage at lower temperatures till their purchase by the consumer (Xavier et al., 2008).

Adequate packaging may be a strategy to increase egg shelf-life, protect the product and focus certain brands to the consumer (Scatolini-Silva et al., 2013). When eggs are inadequately packaged, the albumen's biochemical reactions occur faster and eggs become liable to contamination and to a shorter shelf-life (Moura, Oliveira, Thiebaut, & Melo, 2008).

Although several studies show that egg quality is affected by time, temperature and packaging during storage (Carvalho et al., 2007; Scatolini-Silva et al., 2013; Xavier et al., 2008), they have not provided results on the internal quality by simulating the daily practice of Brazilian consumers who purchase eggs stored without any refrigeration and placed in fridges only after their acquisition.

Current assay assesses the internal quality of commercial eggs according to package, temperature and storage time by simulating the purchase of eggs by consumers, or rather, eggs are stored at room temperature in commercial outlets and later placed under refrigeration at home.

Material and methods

Breeding procedures for laying hens in current assay were approved by the Committee for Ethics in Research of the Faculdade de Zootecnia e Engenharia de Alimentos of the Universidade de São Paulo, São Paulo State, Brazil (no. 14.1.541.74.0).

Since the 280 eggs for current assay were the production of two consecutive days, two similar experiments were conducted with one-day difference in between. Each experiment comprised 140 eggs from 61-week-old commercial hens, lineage Hy-Line W-36®.

Each experiment was divided into two phases. The first phase comprised 1 to day 9 in which all the eggs were conditioned to room temperature: 50% of the eggs were packaged with a chloride polyvinyl film whilst the other 50% did not receive any package. The second phase comprised 9 to day 21 in which 50% of the eggs of each treatment of the first phase were put under refrigeration and simulated what consumers do when they buy eggs on the market and store them under refrigeration or at room temperature at home.

Temperature and relative air humidity in the room and the fridge were measured daily with a digital hygrometer (CE Thermometer Hygrometer, GM8039). Mean room temperature was 28.1°C and mean relative humidity was 38.8%, whereas mean temperature and mean relative humidity in the fridge reached respectively 6.4ºC and 18.8%.

The experimental design in the two phases was formed by two randomized blocks, with each experiment taken as a unit. In the first phase, treatments were arranged in a 2 x 3 + 1 factorial design where the factors consisted of package (with or without), time (three, six and nine days) and control (eggs from day 1). In the second phase, treatments had a 2 x 2 + 1 factorial design, composed of the factors packaging (with or without), refrigeration (with or without) and control (eggs from day 9).

Ten eggs from each experimental condition on days 1, 3, 6, 9 and 21 were assessed for the variables egg weight, Haugh units, yolk index, albumen percentage, yolk percentage and shell percentage. Digital Egg Tester® (model DET6000) was employed to calculate the weight of the egg and Haugh's unit. The yolk was then removed and placed on a plane and smooth surface to measure its diameter by a digital caliper (Caliper 0-150 mm) and its height by an analogic altimeter (Egg Quality Micrometer). Yolk index was evaluated by the ratio between height and diameter of the yolk. Albumen, yolk and shell were weighed by a 0.0001 g precision analytic scale and weights were given in percentage of egg weight (Carvalho et al., 2007).

Data were verified for discrepant measurements and Cramer von Mises's normality test and Brown-Forsythe's variance homogeneity test were performed. Data were then submitted to analysis of variance and means were compared by tukey's test at 5% probability. Factors and control were compared by Dunnett's test (5%) and Statistical Analysis System (SAS, 2001) was employed.

Results

There was no significant interaction between factors on the variables under analysis in the two phases (Table 1 and 2).

Table 1 shows results of the first phase. PVC-packaged eggs evidenced a better yolk index when compared to that of eggs without any package, regardless of the other variables. Although storage time did not affect the weight of the egg, the other internal quality indexes gradually worsened over time. Control eggs (day 1) had better indexes of internal quality when compared to the other factors, excepting egg weight and albumen percentage, which did not differ from control.

Table 1. Weight of egg (WE; g), albumen (%), yolk (%), shell (%), yolk index (YI) and Haugh unit (HU) for stored eggs at room temperature, packed with or without PVC film over time (experiment´s first phase).

Factors	WE	Albumen	Yolk	Shell	YI	HU
Control (1st day)	62.04	56.05	29.55	14.40	0.375	87.23
Package						
With PVC film	60.39	55.77	31.74★	12.35★	0.296 a★	64.10★
Without PVC film	60.41	55.81	31.53★	12.52★	0.286 b★	62.48★
Time (days)						
3	60.96	56.87 a	29.84 a	13.03 a★	0.344 a★	73.69 a★
6	60.39	55.46 b	32.11 b★	12.40 b★	0.282 b★	61.97 b★
9	59.83	55.14 c	33.01 c★	11.85 c★	0.237 c★	53.44 c★
Analysis of variance						
Block	0.8525	0.0257	0.0459	0.0964	0.2776	0.0164
Package (P)	0.9966	0.9613	0.6679	0.4048	0.0027	0.2029
Time (T)	0.5733	0.0045	<0.0001	<0.0001	<0.0001	<0.0001
Interaction P x T	0.7657	0.1255	0.1223	0.1187	0.3519	0.3779
CV (%)	7.73	4.47	7.31	7.59	6.91	11.37

CV = coefficient of variation. Means followed by different letters within the same factor differ by tukey's test (5%). Means with an asterisk (★) differ significantly when compared to control, by Dunnett's test (5%).

Table 2 gives results of the second phase. Eggs packed in PVC film had better shell percentage, Haugh unit and yolk index when compared to non-packaged eggs. Refrigerated eggs had better results for internal quality than eggs conditioned at room temperature for the variables under analysis, except for shell percentage. Egg weight, yolk percentage, shell percentage, yolk index and Haugh unit in control treatment (9th day) did not differ significantly when compared with the same variables in refrigerated eggs Table 2). Results demonstrate that stored eggs under refrigeration on the 9th day maintained the same unchanged internal quality until the 21st day, regardless of packaging.

Table 2. Weight of egg (EW; g), albumen (%), yolk (%), shell (%), yolk index (YI) and Haugh unit (HU) for stored eggs at room temperature or in fridge, with or without PVC film, (experiment's second phase).

Factors	PO	Albumen	Yolk	Shell	YI	HU
Control (9th day)	59.83	55.14	33.01	11.85	0.237	53.44
Packaging						
With PVC film	57.9★	56.29	34.24★	9.47 b	0.190 a★	50.67 a★
Without PVC film	57.97★	55.02	34.32★	10.66 a	0.164 b★	46.1 b★
Storage						
Room temperature	56.55 b★	53.42 b	36.1 a★	10.48	0.131 b★	41.76 b★
Refrigerated	59.07 a	57.22 a★	32.97 b	9.81	0.231 a	52.6 a
Analysis of variance						
Block	0.5568	0.0237	0.7844	<0.0001	0.4672	0.0531
Packaging (P)	0.8890	0.2136	0.6554	0.0025	<0.0001	0.0394
Storage (S)	0.0147	<0.0001	<0.0001	0.0832	<0.0001	<0.0001
Interaction P x S	0.3022	0.6370	0.1017	0.0863	0.1104	0.1014
CV (%)	5.38	3.90	6.04	10.76	5.81	9.13

CV = coefficient of variation. Means followed by different letters within the same factor differ by tukey's test (5%). Means with an asterisk (★) differ significantly when compared to control, by Dunnett's test (5%).

PVC package improved the yolk index during the first phase, and the yolk index and Haugh unit in the second phase, perhaps due to a lower liquefaction rate of albumen which hindered the yolk from absorbing water from the liquefied albumen (Figueiredo et al., 2011). Several studies showed that packaging may be highly efficient in protecting egg quality (Moura et al., 2008). However, it is not as efficient as refrigeration and it is not sufficient to mitigate the effect of storage at 25°C (Scatolini-Silva et al., 2013).

Internal egg quality worsened during the storage period in the two phases for non-refrigerated eggs. Degradation in quality is due to the loss of carbon dioxide and water during the storage period, with a reduction in the weight of eggs. Further, physical and chemical processes occur which degrade albumen structure and produce water linked to protein molecules, which passes from the albumen to the yolk through osmosis. The yolk becomes flattened, its quality worsens and the Haugh unit decreases (Santos et al., 2009).

As a rule, eggs kept at refrigeration temperature were better when compared to eggs maintained at room temperature. In fact, high temperatures (over 25°C) increase the speed of physical and chemical reactions in the egg during storage and reduce its quality (Leandro et al., 2005; Xavier et al., 2008). From the commercial point of view, the best strategy is that eggs go from the farm directly to the fridge, between 0 and 4°C (Carvalho et al., 2003). In current study, room temperature reached 28.1°C and refrigeration temperature 6.5°C. Consequently, 21-day-old eggs stored under refrigeration had the same quality as 9-day-old eggs stored at room temperature. The above reveals the efficiency of storage of egg at a refrigeration temperature of 6.4°C, as in current research, at lower ones.

Since in Brazil eggs are not placed under refrigeration in commercial outlets, it is highly recommended that consumers immediately store eggs under refrigeration at their homes.

Conclusion

Egg quality depends in storage time. PVC packaging reduces losses and maintains the eggs' internal qualities when stored. However, refrigeration is more efficient than PVC packaging.

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