LWT - Food Science and Technology 44 (2011) 2349–2355

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Chitosan-soybean oil emulsion coating affects physico-functional and sensory quality of eggs during storage

Wisdom Wardy [a,b], Damir Dennis Torrico [a], Wannita Jirangrat [a], Hong Kyoon No [c], Firibu K. Saalia [b], Witoon Prinyawiwatkul [a,*]

[a] Department of Food Science, Louisiana State University Agricultural Center, Baton Rouge, LA 70803-4200, USA
[b] Department of Nutrition and Food Science, University of Ghana, Box LG 134, Legon, Accra, Ghana
[c] Department of Food Science and Technology, Catholic University of Daegu, Hayang 712-702, Republic of Korea

ARTICLE INFO

Article history:
Received 22 February 2011
Received in revised form
5 July 2011
Accepted 6 July 2011

Keywords:
Chitosan
Egg quality
Emulsion coating
Haugh unit
Soybean oil
Sensory discrimination

ABSTRACT

Effects of soybean oil (SO) and chitosan-soybean oil (CH:SO = 40:60) emulsion as coating materials for preserving internal quality of eggs were evaluated during 7 and 15 weeks storage at 25 °C and 4 °C, respectively. Consumers ($n = 150$) assessed surface properties and purchase intent of freshly coated eggs. Noncoated eggs deteriorated from *AA* to *B* grade after 1 week while coated eggs retained *A* grade up to 5 weeks at 25 °C. Amongst coatings, CH:SO emulsion maintained a lower albumen pH while SO was better at reducing weight loss. Effect of refrigeration on albumen pH was minimal. Weight loss of coated eggs was <3% after 7 weeks at 25 °C. Emulsion capacity and emulsion viscosity were minimally affected by coating and refrigeration, and their trends were more correlated to the yolk index at 25 °C than at 4 °C. Only SO-coated eggs were not sensorially smoother than noncoated eggs; however, CH:SO emulsion-coated eggs had the least shell colour changes (ΔE^*, values at day 0 as a reference) during storage at 25 °C. All coated eggs had 85% positive purchase intent. SO and CH:SO emulsion coatings significantly extended egg shelf-life compared to that of noncoated eggs at room and refrigerated storage.

1. Introduction

Eggs are consumed worldwide as food and afford innumerable culinary applications. They are, however, highly perishable and can rapidly lose their internal quality via the loss of moisture and carbon dioxide through pores of the eggshell. Shell coatings and refrigerated storage provide adequate means of egg preservation although coating alone has been found to be effective during short-term storage (Caner, 2005; Wardy, Torrico, Prinyawiwatkul, No, & Saalia, 2010). Various coatings from hydrocolloids, lipids, and their composites have been used to extend the shelf-life of shell eggs (Biladeau & Keener, 2009; Suppakul, Jutakorn, & Bangchokedee, 2010). Although edible films perform less efficiently than their synthetic counterparts in terms of prolonging the shelf-life of food products, they maintain an advantage of being biodegradable (Callegarin, Gallo, Debeaufort, & Voilley, 1997).

Oil coating of the shell has been documented as a method of preserving egg internal quality and reducing weight loss due to their sealing characteristics, hydrophobicity and stability during long-term storage (Caner, 2005; Jirangrat, Torrico, No, & Prinyawiwatkul, 2010; Obanu & Mpieri, 1984). Oil spraying, however, can cause delays in marketing of eggs owing to prolonged drying times compared to other coatings. Soybean oil is a cost-effective coating material for preserving the internal quality of eggs and extending their shelf-life (Wardy et al., 2010).

Edible film from chitosan, a deacetylated form of chitin obtained from shellfish waste, provides excellent oxygen barrier properties along with its antimicrobial activity (Kim, No, & Prinyawiwatkul, 2007; No, Park, Lee, & Meyers, 2002). Chitosan when used as a coating can modify the internal atmosphere (Bhale et al., 2003), and its solution is dried much faster (less than 15 min) than oil-based materials (one day or longer) when applied on eggshell (Torrico et al., 2010, 2011). Chitosan films are, however, hydrophilic and can interact with water molecules increasing their permeation rate (Wong, Gastineau, Gregorski, Tillin, & Pavlath, 1992). Our preliminary work found that three emulsions of chitosan solution (CH) and soybean oil (SO) (CH:SO = 40:60, 50:50 and 60:40 ratios) were as equally effective as SO but were more effective than CH as a coating material in preserving the internal quality (weight loss, Haugh unit, yolk index and albumen pH) of eggs at room and

* Corresponding author. Tel.: +1 225 578 5188; fax: +1 225 578 5300.
E-mail address: wprinya@lsu.edu (W. Prinyawiwatkul).

0023-6438/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.lwt.2011.07.009

refrigerated temperature storage. Among these emulsions, CH:SO = 40:60 was the most desirable due to the lowest weight loss of eggs. Coating with CH:SO emulsion may well provide effective moisture transfer barriers to prevent microbiological and physicochemical degradation of eggs while minimising marketing delays.

The purpose of this work was to compare the effects of SO and an emulsion of CH and SO (CH:SO = 40:60) as coating materials on the physico-functional quality of eggs stored for 7 weeks at 25 °C and 15 weeks at 4 °C as well as to evaluate consumer perception of freshly coated eggs.

2. Materials and methods

2.1. Materials and preparation of coating solutions

White-shelled large eggs from 52 weeks old Hyline W-36 birds were obtained from Cal Maine Foods (Jackson, MS, USA). Chitosan (CH, molecular weight of 223 kDa, acid soluble and white-coloured powder prepared from crab leg shell) obtained from Biotech (Mokpo, South Korea) and soybean oil (SO, Great value®, WalMart, AR, USA) were used as coating materials for the eggs. CH with the final pH of 4.52 was prepared by dissolving chitosan in 1 mL/100 mL (v/v) acetic acid at 2 g/100 mL (w/v) concentration (Kim, Youn, No, Choi, & Prinyawiwatkul, 2009). An emulsion of CH and SO with CH:SO = 40:60 ratio was prepared by dispersing 1 mL/100 mL of Tween® 80 (Polyoxyethylene-20-sorbitan monooleate, reagent grade; Amresco® Inc., Solon, OH, USA) emulsifier in CH to which SO was subsequently added. The resulting mixture was homogenised for 3 min at low speed and another 6 min at high speed using a hand blender (Hamilton Beach, Model 59780, Southern Pines, NC, USA) at 25 ± 2 °C.

2.2. Experimental design and storage of eggs

Eggs were collected after being laid from 2 different rows of the multiple-level cage within the same facility. Eggs upon arrival from the farm were screened for defects (crack, breakage and surface cleanliness) and desirable weight range (50–70 g; eggs outside this range were excluded to reduce variation). After screening, six eggs from each row of the multiple-level cage were randomly assigned to each treatment (a total of 12 eggs; 6 eggs per each of the two replicates). Each egg was weighed with a balance (Model TS400S; Ohaus Corp., Florham Park, NJ, USA) to record the initial weight. All eggs were stored in the cold room (approximately 4 °C) before the next day coating. Before coating, eggs were kept at room temperature (approximately 25 °C) for 2 h to avoid water condensation on the egg surface that could interfere with coating. The coating material was applied to the entire surface of each egg with a sponge brush and left to dry on racks in the horizontal position at room temperature. Two coating treatments: SO and CH:SO = 40:60 emulsion, and one uncoated control were evaluated in this study. Upon drying, the coated eggs were placed small end down (Kim et al., 2009) on egg racks and stored at both room temperature (25 ± 2 °C) and in a cold room at 4 °C. Quality measurements were done on two replicates (six eggs/replicate) per each treatment (twelve eggs total/treatment) weekly for 7 weeks at 25 °C and at intervals of 5 weeks for 15 weeks at 4 °C.

2.3. Measurement of physico-functional quality

2.3.1. Haugh unit, yolk index, weight loss and albumen pH

The weight (W) of the egg (g) was measured using a balance (Model TS400S, Ohaus Corp., Florham Park, NJ, USA). The height of yolk (mm) and albumen (H, mm) was measured using a tripod micrometer (Model S-6428, B.C. Ames Inc., Melrose, MA, USA). The Haugh unit was calculated as $100 \log (H - 1.7W^{0.37} + 7.57)$ (Haugh, 1937). Egg grade was based on the United States Standards for Quality of Individual Shell Eggs (USDA, 2000). A digital caliper (General Tools & Instruments, NY, USA) was used to measure the yolk width (mm), and the yolk index computed as [yolk height (mm)/yolk width (mm)] (Stadelman, 1995).

Weight loss (%) of the coated whole egg during storage was calculated as {[initial whole egg weight (g) after coating at day 0−whole egg weight (g) after storage]/initial whole egg weight (g) after coating at day 0} × 100. Weight loss (%) of the control non-coated whole egg was calculated as {[initial whole egg weight (g) at day 0−whole egg weight (g) after storage]/initial whole egg weight (g) at day 0} × 100. The pH of the albumen was measured using a pH meter (Accumet® AP61, Fisher Scientific, Pittsburgh, PA, USA).

2.3.2. Emulsion capacity (EC) and emulsion viscosity (EV)

Emulsion capacity (EC) of egg yolk was determined following the method of Waimaleongora-Ek, Garcia, No, Prinyawiwatkul, and Ingram (2009). Red-coloured oil was used to enhance view of emulsion collapse, and was prepared by adding 0.3 g of biological stain (Oil Red O, 19819-6; Sigma–Aldrich, St. Louis, MO, USA) to a litre of soybean oil (Great Value®; WalMart, AR, USA). Fifteen grams of yolk (from a pool of three eggs; each egg yolk was manually separated from the albumen and placed in a plastic container) was mixed with 20 mL of soybean oil and 10 mL of vinegar, and emulsified at high speed using a hand blender (Hamilton Beach, Model 59780; Southern Pines, NC, USA) for 2 min. Then, 2 g of the resulting emulsion was taken and emulsified with 9 mL of 0.1 mol/L NaCl solution and 30 mL of red-coloured oil at low speed for 2 min. Additional red-coloured oil was dispensed from a burette at a speed of 0.1 mL s^{-1} while stirring at low speed until the emulsion broke. The breakpoint at which phase inversion occurred was considered as the EC (Prinyawiwatkul, Beuchat, McWatters, & Phillips, 1997). EC was expressed as mL of soybean oil added per g of egg yolk. Three measurements from each of the three replicates (three eggs were used for each replicate) were made for each treatment.

Emulsions containing 80% of the amount of oil needed to reach the breakpoint in EC determination were used for emulsion viscosity (EV) measurements (Prinyawiwatkul et al., 1997). Viscosity was measured at 25 °C with a viscometer (model DV-II +, Brookfield Engineering Labs Inc., Middleboro, MA., USA) at 30 rpm using a T-C spindle from the Helipath Spindle Set, with data gathered in Wingather V2.1 software (Brookfield Engineering Labs Inc.). Twenty readings were recorded from each of triplicate samples of emulsions (three eggs were used for each replicate) prepared per treatment.

2.3.3. Shell colour

Colour of the eggshell was measured using a portable Minolta spectrophotometer (Model CM-508d, Minolta Camera Co. Ltd., Osaka, Japan) with 2° standard observer, D_{65} illuminant, and a 1.1 cm aperture of the sensor during 7 weeks storage at 25 °C. Eggs were carefully selected for absence of inherent colour patches and dirt, and a smooth shell surface. Three measurements from each of three replicates were made at the same locations weekly for each treatment and averaged. Results were noted as L^* (lightness), a^* (+ for redness and − for greenness) and b^* (+ for yellowness and − for blueness), H° (hue, H° = 0 for red, H° = 90 for yellow) and C^* (chroma). ΔE^* was calculated weekly using the equation $[(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$, where $\Delta L^* = L^*_{\text{treatment}} - L^*_{\text{reference}}$; $\Delta a^* = a^*_{\text{treatment}} - a^*_{\text{reference}}$; $\Delta b^* = b^*_{\text{treatment}} - b^*_{\text{reference}}$. ΔE^* indicates the magnitude of colour differences between eggshell samples and their day 0 (reference) values.