Effect of beeswax, gelatin and *Aloe vera* gel coatings on functional properties and visual sensory attributes of chicken eggs stored under room temperature

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Abstract- Surface coating is an inexpensive and effective method to preserve the internal quality and prolong the shelf life chicken eggs. Mineral oil is one of the commercial type coating materials with proven results. Therefore, this study was planned to determine the effect of beeswax, gelatin and *Aloe vera* gel coatings on functional properties of chicken eggs. Four hundred and fifty (450) brown shell eggs of 32 weeks old Lohmann classic brown layers were obtained and randomly divided into five groups as ninety (90) eggs per group. Four egg groups were randomly coated with one of the four coating materials: mineral oil, beeswax, *A. vera* gel and gelatin. Remaining group was uncoated and considered as the control group. Then, all eggs were stored for six weeks under room temperature (30°C) and relative humidity of 70 - 75 %. Beeswax and gelatin maintained the similar ($P > 0.05$) gelling strength to mineral oil coated eggs. There was no significant ($P > 0.05$) difference in foaming stability of uncoated and coated eggs. The present study demonstrated that beeswax and gelatin can be introduced as an alternative egg coating material to mineral oil due to their similar effect of preserving functional properties of eggs during storage under room temperature.

Index Terms- Beeswax, chicken eggs, coatings, functional properties, gelatin

I. INTRODUCTION

As an excellent source of protein, chicken eggs are among the most nutritious food consumed globally and their production has represented an important segment of the world food industry (Stadelman, 1995). However, shell eggs are highly susceptible to internal quality deterioration and bacterial growth during storage. As soon as eggs are laid, the aging process begins, altering their chemical, physical, microbial and function properties. Although the shell can be considered as natural barrier, shell eggs have short shelf life and are extremely fragile which can cause a serious economic loss to the poultry industry (Caner, 2005; Wong *et al*., 1996).

Interior quality deterioration of fresh shell eggs can be delayed significantly by maintaining storage temperature near the freezing point (Zeidler, 2002). Numerous food grade coating materials have also proven to be efficient in reducing the mass transfer by sealing pores. Further, eggs coated with different protein-based coatings have prolonged the internal quality due to the reduction of the breakage of eggshell and egg microbial contamination (Wong *et al*., 1996). Edible coating maintains the functional properties of foods by decreasing moisture loss and gas transport (O_2 and CO_2) (Donhowe and Fennema, 1994). Considerable amount of research works has been done on coating shell eggs with edible coating materials and different results in terms of efficacy of prolonging the shelf-life and improving internal qualities of eggs were obtained depending on type of the coating material (Ikame and Enelamah, 1985).

Our previous study compared the potential of beeswax, *Aloe vera* gel and gelatin as an egg coating materials to preserve the physical quality and enhance the shelf life of chicken eggs (Mudannayaka *et al*., 2016). Beeswax is a product of honey bees with natural antimicrobial substances (Zanoschi *et al.,* 1991). Due to these anti-microbial and barrier properties against moisture and gases, beeswax has been utilized in food processing as packaging and coating material. *A. vera* is a tropical and sub-tropical plant, which contains colorless and odorless gel in leaves. This gel can act as a protective layer against oxygen and moisture. Therefore, it has been used as surface coating of fruits to preserve quality during storage (Supapvanich *et al*., 2016). Gelatin is obtained by controlled hydrolysis of fibrous insoluble protein collagen, which is widely found as major component of the skin, bone and the connective tissues of animals. It is used to encapsulate the moisture or oil phase in food ingredients and pharmaceuticals. Due to its barrier properties, there is an increasing interest to use gelatin as a surface coating material (Gennadios *et al*., 1994). We compared the effect of above three coatings with mineral oil which is currently used to preserve the internal quality of eggs (Waimaleongora-Ek *et al*., 2009; Jirangrat *et al.*, 2010) and found that beeswax and gelatin can be successfully used to preserve the internal quality of chicken eggs (Mudannayaka *et al*., 2016). Therefore, this study was carried out to further evaluate the effect of beeswax, gelatin and *A. vera* gel coatings on functional properties of chicken eggs.

II. MATERIALS AND METHODS

A. Selection of Eggs

Four hundred and fifty (450) brown shell eggs were obtained from 32 weeks old Lohmann classic brown layers at local producer

(NEL Farm, Mangalaeliya, Sri Lanka). All the Layers in the farm had been vaccinated for salmonella at chick stage so eggs were free of vertically transmitted *Salmonella* spp. The eggs were obtained from battery cages therefore had lesser dirt and egg were furthermore cleaned by wiping with piece of steel wool to clean any possible dirt on shell. All the eggs were selected less than 6 hours after laying and were in the range of 49 g - 64 g. In addition, eggs were unfertile and free of cracks and defects. Eggs were placed in clean egg creates in room temperature after been brought to laboratory and all the eggs were randomly divided in to five treatment groups as ninety (90) eggs per treatment.

B. *Preparation and application of Coating Materials*

During the preparation of coating solutions and application, sterile latex gloves were worn to avoid any possible contaminations. Mineral oil (viscosity 26.35 mPa s at 20°C, weight per ml at 25°C = 0.828gm, light absorption at 240-280 nm = 0.031, transparent, colorless, odorless, food grade) was obtained from Glorchem Enterprise (No 141, Bankshall Street, Colombo 11, Sri Lanka). Eggs were immersed individually in mineral oil solution for 1 minute (Mudannayaka *et al*., 2016) for the coating. Crude beeswax is commonly available in local shops in Sri Lanka. Beeswax was cut into small pieces and put into a clean 500ml beaker. The content was heated in a water bath at 40°C until it became a liquid and cooled until the wax become semi solid state and coated on eggs by rubbing wax on egg surface by hand (Mudannayaka *et al*., 2016). Fresh *A. vera* leaves were taken from the *A. vera* plants grown in Wayamba University, Makandura premises, Sri Lanka. Then, outer cover of the *A. vera* leaves was scraped by clean knife and thin layer of gel was directly applied on eggs manually (Mudannayaka *et al*., 2016). 10% Gelatin solution was prepared by mixing commercial gelatin powder with distilled water while heating in a water bath (80°C) for 10 minutes. After the solution becomes cool eggs were immersed individually by hand in the gelatin solution for 1 minute (Mudannayaka *et al*., 2016).

C. *Storage of coated eggs*

After coating, all the coated eggs were dried at room temperature for 24 hours. Uncoated eggs served as control and mineral oil coated eggs served as positive control. Then all the eggs (90 eggs per treatment) were placed in small end down position in labeled open molded plastic eggs trays and stored in room temperature (30° C) and relative humidity of 70 % - 75 % for six weeks. Using three replicates per treatment albumin pH, gelling strength, foaming capacity and foaming stability were measured after 24 h from coating (0 week) and by weekly intervals for 6 weeks of storage period.

D. *Determination of Albumin pH*

Albumen and yolk were separated into 50 ml beakers and thin and thick albumen were mixed thoroughly. Then albumen pH was measured with pre calibrated digital pH meter (Starter 3000, OHAUS, USA) at 25°C. Three replicates per treatment were taken at each week.

E. *Determination of gelling strength*

Whole eggs were broken into 50ml plastic containers and homogenized at 12,000 rpm for one minute with homogenizer. Then homogenized eggs were kept in a preheated water bath at 85°C for 30 min with continuous stirring. After gel had been formed samples were removed from the water bath and cooled to room temperature. Then gels were removed from the containers and cut into equal size gel cubes. Subsequently gelling strength was measured by penetrometer (FT 011, David Bishop Instruments, London).

F. *Measurement of foaming properties*

Foaming capacity (%) and foaming stability (%) were measured to evaluate forming properties. 15 ml of well mixed whole eggs were put into 50 ml beakers and whipped for 1 min with homogenizer at 12000 rpm to make foam. After 30 seconds of foam formation, initial volume of foam and the liquid phase were measured. Then volume of the liquid phase was measured in 5 min intervals for 1 h. Foaming capacity (%) was calculated as, (volume of foam / volume of the initial liquid phase) ×100%. Foaming stability (%) was calculated as, [(volume of the initial liquid phase – volume of drainage) / volume of initial liquid phase] ×100% (Ferreira *et al*., 1995).

G. *Visual sensory evaluation*

After 6 weeks of storage period visual sensory evaluation was done with 30 untrained panelists to evaluate consumer preference for coated eggs with different coating materials. Preference for surface color, surface odor, surface glossiness, surface smoothness and overall acceptability of uncoated and coated eggs were evaluated using a scoring system as: 5 = like very much, 4 = like slightly, 4 = neither like nor dislike 2 = dislike slightly and 1 = dislike very much.

H. *Statistical analysis*

Data were analyzed using general linear model procedure considering the main effects of coating, storage time at 95% confidence level. When main effect was significant, the Tukey's comparison test was performed to identify significant differences within treatments in a particular week and differences within storage period in a particular treatment. Minitab statistical software (version15.1.1, USA) was used for analysis. Mean values of scores given by 30 panelists for each visual sensory attribute in each treatment were calculated and analyze using hedonic scale of Microsoft excel, 2007.

III. RESULTS AND DISCUSSION

A. *Effect of beeswax, A. vera gel and gelatin coatings on gelling strength*

Gelling strength tests the heat stable gelling properties of egg albumen. During the first 3 weeks, no significant differences (P > 0.05) of gelling strength among treatment groups were observed (Figure 1). After 4th week significant differences between treatments were observed up to 6th week of storage period. Uncoated and *A. vera* gel coated eggs obtained significantly higher (P < 0.05) gelling strength than other treatments (Figure 1). Gelling strength of beeswax and gelatin coated eggs was similar (P > 0.05) to mineral oil coated eggs throughout the storage period of eggs. According to Donovan and Mapes (1976), during storage, ovalbumin in egg white is converted to s-ovalbumin which is an extra heat stable form (denaturation at 92.5°C) in comparison to

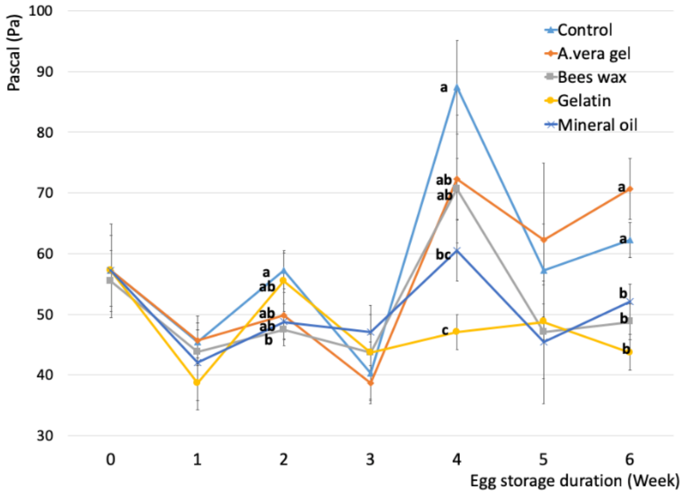

Figure 1. Change of gelling strength of control and coated eggs during 6 weeks of storage at 30°C. Different letters (a to c) with in a particular week are significantly different at P < 0.05.

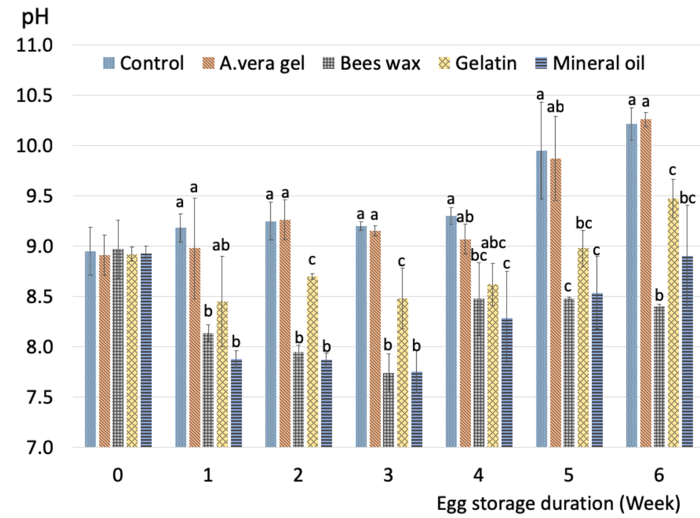

Figure 2. Albumen pH of control and coated eggs during 6 weeks of storage at 30°C. Bars represent mean ± SD; means with different letters (a to c) with in a particular week are significantly different at P < 0.05.

to ovalbumin (denaturation at 84.0°C). According to Donovan and Mapes (1976), during storage, ovalbumin in egg white is converted to s-ovalbumin which is an extra heat stable form (denaturation at 92.5°C) in comparison to ovalbumin (denaturation at 84.0°C). S-ovalbumin has slightly lighter molecular weight than ovalbumin and its relative quantity in the egg weight can increase during storage period. Both pH and temperature also affect the s-ovalbumin formation, in a way that formation of s-ovalbumen increases with increasing pH of albumen (Smith and Back, 1962). During the storage dissolved CO_2 in egg albumen migrates through the shell to the environment and leads to increase of egg white pH (Health, 1977; Smith 1931). When eggs are coated with oil, whey concentrate protein or stored under refrigeration, this conversion is delayed as a result of lower CO_2 loss via egg shell pores (Alleoni and Antunes, 2004). Results in present study agree with these observations. As mentioned above higher gelling strengths were observed in uncoated and *A. vera* gel coated eggs at 6 week of storage. As shown in the figure 2 we observed the pH of control and *A. vera* gel coated eggs was significantly ($p < 0.05$) higher than other eggs at week 6. This may be due to higher CO_2 loss of control and *A. vera* gel coated eggs. At the same time lower gelling strength was observed in beeswax, gelatin and mineral oil coated eggs. Observation of lower pH rise of beeswax, gelatin and mineral oil coated eggs describes that these coatings can block the CO_2 migration from egg white to environment. As reported previously although beeswax and mineral oil improved the physical properties of eggs during storage (Mudannayaka *et al*., 2016) their effectiveness to maintain the gelling strength lasted only for 5 weeks.

B. Effect of beeswax, A. vera gel and gelatin coatings on foaming properties

Egg albumen has excellent foaming properties, which can affect by protein interactions with ovomucin, lysozyme and to a lesser extent ovomucoid, ovotransferrin and ovoalbumin. Foaming properties can be evaluated by foaming capacity (FC) and foam stability (FS) (Ferreia *et al.*, 1995). At the beginning of the study all uncoated and coated eggs had same foaming capacity (FC) and FC of coated eggs gradually increased with storage period (Table 1). After 4 weeks of storage period uncoated eggs had significantly lower ($P < 0.05$) FC, whereas, beeswax and gelatin coated eggs achieved significantly higher ($P < 0.05$) FC than other coated eggs. But after 6 weeks of storage period at 30°C, there was no significant difference ($P > 0.05$) in FC between all egg groups. As shown in Table 2, although the foaming stability (FS) of all the treatment groups varied with storage period, no significant difference ($P > 0.05$) was observed between uncoated and coated eggs when compared at each week. These results suggests that beeswax and gelatin coatings can improve the forming properties of chicken eggs up to 4 weeks of storage at room temperature. It should note that the functional properties of eggs are highly influenced by several factors such as hen's age, storage time, beating time, homogenization, temperature and pH (Lomakina and Mikova, 2006). Since we maintained similar conditions for all the treatments, influence of those factors on the results is negligible.

Table 1. Foaming capacity of uncoated and coated eggs during 6 weeks of storage at 30° C

Coating	0 wk	1 wk	2 wk	3 wk	4 wk	5 wk	6 wk
Control	$22.44 \pm 2.14^{A,a}$	$18.89 \pm 1.93^{B,a}$	$13.33 \pm 3.33^{B,a}$	$36.66 \pm 3.34^{C,a}$	$27.77 \pm 1.93^{A,a}$	$45.55 \pm 1.92^{D,a}$	$53.33 \pm 3.33^{D,a}$
***A. vera* gel**	$23.11 \pm 3.01^{A,a}$	$22.22 \pm 3.85^{A,ab}$	$30.00 \pm 3.06^{AB,b}$	$34.66 \pm 3.46^{B,a}$	$32.22 \pm 3.85^{B,ab}$	$45.55 \pm 1.92^{D,a}$	$51.11 \pm 1.92^{D,a}$
Bees wax	$22.22 \pm 1.92^{A,a}$	$24.43 \pm 1.93^{A,ab}$	$14.66 \pm 1.76^{B,a}$	$35.33 \pm 4.06^{C,a}$	$42.22 \pm 1.92^{D,c}$	$43.33 \pm 0.00^{D,a}$	$54.00 \pm 2.40^{E,a}$
Gelatin	$23.11 \pm 3.01^{A,a}$	$26.66 \pm 3.34^{A,b}$	$23.33 \pm 3.33^{A,b}$	$41.55 \pm 3.08^{C,a}$	$36.67 \pm 2.31^{C,bc}$	$41.11 \pm 1.92^{C,a}$	$53.00 \pm 1.00^{D,a}$
Mineral oil	$22.22 \pm 1.92^{A,a}$	$21.11 \pm 0.10^{A,ab}$	$32.22 \pm 1.92^{B,bc}$	$36.33 \pm 3.51^{BC,a}$	$32.22 \pm 3.85^{BC,ab}$	$41.11 \pm 1.92^{C,a}$	$52.00 \pm 1.75^{D,a}$

Different superscripts of means ± SD within a row (A to D) and column (a to c) are significantly different at p < 0.05.

Table 2. Foaming stability of uncoated and coated eggs during 6 weeks of storage at 30° C

Coating	0 wk	1 wk	2 wk	3 wk	4 wk	5 wk	6 wk
Control	93.44 ± 1.50^{A}	98.00 ± 0.00^{B}	95.99 ± 1.15^{CD}	91.77 ± 1.39^{A}	97.11 ± 1.02^{BC}	92.00 ± 2.91^{AD}	93.33 ± 0.00^{A}
***A. vera* gel**	94.44 ± 3.85^{ABC}	94.66 ± 4.05^{ABC}	96.44 ± 1.02^{A}	93.33 ± 2.90^{AB}	94.88 ± 1.68^{AB}	88.67 ± 2.31^{C}	92.66 ± 2.40^{B}
Bees wax	94.00 ± 3.52^{ABCD}	94.00 ± 0.00^{A}	98.00 ± 0.67^{B}	92.89 ± 1.39^{CA}	93.78 ± 2.04^{CA}	88.66 ± 2.40^{D}	92.33 ± 0.00^{C}
Gelatin	94.44 ± 0.38^{A}	96.89 ± 1.02^{B}	97.11 ± 0.77^{B}	91.78 ± 3.08^{A}	96.88 ± 0.39^{B}	90.66 ± 3.71^{A}	92.66 ± 3.52^{A}
Mineral oil	94.44 ± 1.92^{A}	96.00 ± 2.40^{AB}	94.44 ± 3.85^{ABC}	93.33 ± 3.33^{ABC}	96.66 ± 0.00^{B}	89.11 ± 1.92^{C}	94.44 ± 2.77^{B}

Means ± standard deviations of 3 measurements. Different superscripts (A to F) of means ± SD within a row are significantly different at $p<0.05$. All the means ± SD with in a column (particular week) are not significantly different at $p>0.05$.

C. Visual sensory evaluation

Visual appraisal is the first sense that consumers use in making a decision to purchase products (Caner and Cansiz, 2007). Figure 3 shows the differences in consumer preference for visual sensory attributes of uncoated and coated eggs. Gelatin coated eggs were highly preferred for odor, surface glossiness, surface smoothness and overall acceptability except surface color. But, *A. vera* gel and beeswax coated eggs were less accepted in all the evaluated attributes compared to uncoated and other coated eggs. This explained that gelatin could improve the visual and sensory attributes of coated eggs than uncoated and mineral oil coated eggs. Because of beeswax coated eggs were less accepted in visual sensory attributes better application methods could be developed to improve the appearance and surface characteristics.

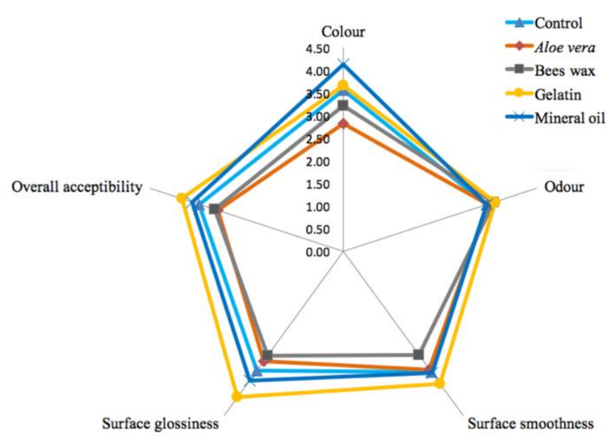

Figure 3. Differences in visual sensory attributes of control and coated eggs after 6 weeks of storage.

IV. CONCLUSION

Coating eggs with Beeswax, gelatin and *A. vera* gel show similar gelling strength and forming stability compared with mineral oil coated eggs. Further the effect of beeswax and gelatin on forming capacity was higher than the mineral oil coated eggs and uncoated eggs after one month of storage. Ability of these two coating materials to save the physical properties during storage of eggs was previously reported. Therefore, beeswax and gelatin can be introduced as alternative egg coating materials for mineral oil which has ability to keep overall quality of chicken eggs during storage.

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