The Edible Coatings for Maintaining Eggs Quality and Minimize Eggshell Breakage: A-Review

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Abstract

Eggs are one of the finest food that offering human the complete balance of essential nutrients. The egg-shell, a thin mineral structure, is a porous and breathable material which allowed movement of moisture and CO₂ and protects the egg contents against mechanical-impact, dehydration, and microorganism contamination. During transport, eggs with poor-shell strength can become cracked increasing the opportunity for microbial contamination and making the eggs unmarketable. Edible films can be used as a “skin”, providing a partial barrier to moisture, O₂ and CO₂, improving egg’s mechanical handling. Coating eggs may increase shell-strength and potentially decrease the number of cracked eggs.

Key words: coating, egg, egg quality, shelf life, shell strength.

Yumurta Kalitesinin Korunması ve Kabuk Kırılmalarının Azaltılması için yenilebilir Kaplamalar: Derleme

Özet

Yumurta, insana günlük tüketilmesi gerekli olan besin öğelerinin tamamını dengeli bir şekilde sunan en iyi besindir. Yumurta kabuğu, ince mineral yapısı ile gözenekli ve nefes alabilen, nem ve CO₂ geçişine izin veren, yumurta içeriğini mekanik etkilere, dehidrasyon ve mikrobiyel kontaminasyona karşı koruyan bir malzemedir. Nakliye esnasında zayıf kabuk yapısına sahip yumurtalar kırılmak mikrobiyel kontaminasyona yola açabilmeekte ayrıca yumurtanın pazarlanmasını önlemektedir. Yenilebilir filmler “skin” olarak kullanılabilmekte böylelikle rutubet, O₂ ve CO₂ geçişine karşı bariyer görevi görmektedir. Ayrıca yumurtanın elleleme (siniflandırma, aktarma, paketleme, paletleme, etiketleme, nakliye, vd.) sürecinde

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mukavemetini de arttırmaktadır. Kaplamalar yumurtanın kabuk dayanıklılığını artıramaktadır ve olası kırık sayısının azaltılmasına ve kullanılamamaktadır.

Anahtar kelimeler: kaplama, yumurtta, yumurta kalitesi, raf ömrü, kabuk mukavemeti.

Introduction

Eggs are one of the few foods that are widely consumed throughout the world; thus, eggs represent an important segment of the world food industry and an important commodity in international trades. Eggs are one of the finest food that offering human the complete balance of essential nutrients with proteins, vitamins, minerals and fatty acids with great biological value and the lowest cost. A hen egg is composed of three main parts: shell, albumen (egg white) and yolk, and their distributions out of the total egg weight are 9-11%, 60-63%, and 28-29%, respectively. The egg shell is composed of a thin film of cuticle, a calcium carbonate layer (composed by a vertical crystal layer, palisade layer, and mammillary knob layer), and two shell membranes (inner and outer membranes). Moreover, egg shells contain a large number of pores (in excess of 7,500 per egg) that allow permeation of water and gases (Zeidler, 2002). The cuticle protects the egg from moisture loss and invasion of microorganisms to a certain extent but it can be easily removed by washing with water in industrial processes. The egg albumen occurs in four layers: the chalaza, inner thick white, the inner. The main components of a hen egg are lipids (12%), proteins (12%) and water (75%) with additional small amounts of carbohydrates and minerals thin white (inner liquid), the outer thick white (dense) and the outer thin (outer liquid) layer. Eggs are highly susceptible to internal quality deterioration and microbial contamination since the moment of lay. During storage, a thinning of the albumen and an increase in the size of the air cell is observed mainly due to water loss. Carbon dioxide (CO₂) migration throughout the egg shell leads to an increase in albumen pH and a decrease in the vitelline (yolk) membrane strength, thus causing interior quality deterioration. During the storage of shell eggs, changes in physical, chemical, biological, and functional characteristics of egg albumen constituents may occur principally due to storage conditions such as time, temperature, and relative humidity (Caner and Cansiz, 2007, 2008). The albumen pH can be used as an indicator of the albumen quality of (Scott and Silversides, 2000). Freshly laid eggs contain
1.44-2.05 mg CO₂/g of albumen (Biladeau and Keener, 2009) and have an albumen pH value of 7.6-8.7. During storage, carbon dioxide escapes via eggshell pores, resulting in increased albumen pH value up to 9.6-9.7.

The egg shell, a thin mineral structure, is a porous and breathable material which allowed movement of moisture and carbon dioxide and protects the egg contents against mechanical impact, dehydration, and microorganism contamination. This mass transfer may cause physical and chemical changes in albumen and yolk while at the same time increase the vulnerability of pathogens contamination and rate of egg deterioration. They undergo chemical and microbial contamination, highly reducing their shelf life. Increasing the shelf-life of eggs may increase export sales. During transport and marketing, eggs with poor-shell strength can become cracked increasing the opportunity for microbial contamination and making the eggs unmarketable. The eggshell is the natural packing material for the egg contents, and as a result, it is important to obtain high shell strength, to resist all impacts an egg is subjected to during the production chain (Stadelman and Cotterill, 1995). Factors associated with the level of quality loss are time, temperature, humidity, air movement, and handling. Coating materials are effective methods to preserve the internal quality of eggs and prevent microbial contamination. Thin layer or a coating, is an integral part of a food and may be eaten with the food, it qualifies as ‘edible’ packaging. Coatings are either applied to or formed directly on foods, while films are self-supporting structures that can be used to wrap food products (Figure 1).

![Figure 1. Main functions of edible films and coatings in food packaging applications (Salgado et al., 2015).](image-url)
Coating of eggs is thus an alternative and effective way to preserve the internal quality. Various coating materials have been applied to the surface of egg shells for preserving the internal quality of eggs. These include synthetic polymers, polysaccharides, proteins and oils. The physical and chemical characteristics of these components are very different; therefore, they would influence the functionality of the materials formed (Figure 2.).

![Figure 2. Edible films and coatings compositions (Salgado et al., 2015).](image)

One of the approach to preserving eggs shell has been directed to the development of coating materials, made of lipid, carbohydrate and proteins to protect eggs shell cuticle. Edible film also has the potential to act as a skin to protect mass transfer and mechanical damage to shell. Edible films can be used as a “skin” for fresh eggs of food products, providing a partial barrier to moisture, oxygen and carbon dioxide, improving mechanical handling properties. Coating eggs increases the shell strength and potentially decrease the number of cracked eggs. With the large number of eggs produced, even a small percentage improvement in the overall quality of eggs shell and egg shells could result in minimizing cracked or broken percentage lead to significant savings to the commercial egg industry. The goal of this review discusses the use of different edible coatings (polysaccharides, proteins, lipids and composite) on fresh eggs to minimize shell’s breakage and sealing pores (moisture loss, oxygen) for increasing shelf life. Estimates are that more than 10% of eggs produced in the
hen house are uncollectible or break before intended use. The first 2-5 percent is lost simply, due to from which may be shell less, cracked or broken (unsuitable for collection). Another 3-8 percent is lost during collection, moving through the belts, cleaning, packing and transportation to the end user (Gupta, 2008). Therefore, every effort must be directed towards improving shell quality and reducing egg breakage. Consequently, improving shell strength of eggs will potentially decrease the number of cracked eggs while resulting in significant savings to the industry. Shell eggs also undergo a sequence of considerable interior (functional) quality changes and microbial contamination during the storage (Jones et al., 2004). The eggshell, with porous structure, allows carbon dioxide and moisture to escape while allowing contaminants such as bacteria and odours to enter the egg (Berrang et al., 1999; De Reu et al., 2006; Leleu et al., 2011). They are highly perishable and can rapidly lose their internal qualities via the loss of moisture and carbon dioxide through the pore during storage (Caner and Cansiz, 2007, 2008; Yuceer and Caner, 2014).

It is proven that some protection methods such as eggshell coating minimize deterioration in interior egg quality. The edible films, which are not detrimental to human health, have a barrier property against oxygen, carbon dioxide and humidity movement from eggs. Some conservation methods including oil coating, dipping in low temperature, freezing, high temperature and drying and also the coating of egg shell with chitosan, whey protein and shellac are used for protection of interior egg quality (Copur et al., 2009). Being the breathable material, eggshells permit moistness and carbon dioxide to infuse over the pores. This infusion reasons fluctuations in albumen, yolk resulted in weight loss. So, there is a need to seal pores on eggshell to lessen evaporation and leakage of carbon dioxide. There would be minimum changes in internal quality of egg as the pores are sealed. Usage of better shielding approaches like coating and edible films could reduce damages. Shell oil coating is one of the previously accepted methods for preservation of egg value. Coatings can increase the overall interior quality and mechanical characteristics of eggshell and could aid to lessen cost-effective damage from breaking (Saeed et al., 2016). Thus it is important to protect the egg shells against mass transfer. A process that seals porous of the eggshell has to be developed not only to reduce mass transfer through eggshell but also to improve shell strength to extend the shelf-life and reduce shell breakage.
It is very challenging to extend the shelf life and the maintain quality of foods. Therefore, development of emerging practices is necessary for preserving the quality of fresh foods. Several technologies, including cold storage, UV, MAP and ozonation have been used for reducing deterioration of the quality while prolonging shelf life of foods (Allende et al., 2006; Debabandya et al., 2013). There has been increasing interest in using coatings as a food preservation method as well as tool to enhance its quality, safety and stability. Such coatings are used as a thin layer to protect prishable foods by controlling the internal gas atmosphere (Allende et al., 2006; Olivas and Barbosa-Canovas, 2005). Using coating of eggshell may increase its strength and potentially decrease the number of cracked eggs. Even a small improvement will result in significant savings for the egg industry. Potentially, a thin protective coating layer should provide a barrier against mass transfer and may preserve viscosity, whipping and foam stability (Caner and Yüceer, 2015; Foegeding et al., 2006; Lomakina and Mikova, 2006).

Various raw edible materials are suitable for coatings of food products: proteins (e.g. whey, corn, soy), polysaccharides (e.g. cellulose derivatives or starches), lipids (e.g. waxes, shellac), and even some synthetic polymers (e.g. polyvinyl acetate) (Atila and Orts., 2009). Selecting a suitable coating for fresh eggshell quality is important to minimized mass transfer, oxidation processes or microbial growth. Barrier and mechanical properties of coatings or films depend on their molecular structure. Therefore, it is important to use appropriate coatings that will provide the best protection for internal quality of fresh eggs.

Protein coatings show potential as value-added applications that might receive little resistance from regulators for food use. Caner and Yüceer (2015), in a study using various coatings (whey protein isolate [WPI], whey protein concentrate [WPC], zein, and shellac) as coating materials of eggs, reported that coatings and storage time had significant effects on Haugh unit, yolk index, albumen pH, dry matter, relative whipping capacity, and albumen viscosity. Uncoated eggs had higher albumen pH (9.56) and weight loss, and lower albumen viscosity (5.73), Haugh unit (HU), and yolk index (YI) during storage. Among the coated eggs, the shellac and zein coated eggs had the highest value of albumen viscosity (27.26 to 26.90), HU (74.10 to 73.61), and YI (44.84 to 44.63) after storage. Shellac (1.44%) was more effective in preventing weight loss than WPC (4.59%), WPI
(4.60%), and zein (2.13%) coatings. All coatings increased shell strength (5.18 to 5.73 for top and 3.58 to 4.71 for bottom) significantly compared to the uncoated eggs (4.70 for top and 3.15 for bottom). The functional properties such as albumen dry matter (14.50 to 16.66 and 18.97 for uncoated) and albumen relative whipping capacity (841 to 891 and 475 for uncoated) of fresh eggs can be preserved during storage when they are coated. The shellac and zein coatings were more effective for maintaining the internal quality of fresh eggs during storage.

Protein based biopolymers such as whey proteins and corn zein have desirable barrier properties (Kirsten et al., 2009). Whey is one of the most promising proteins due to gas barrier properties and glossy appearance (Hossein, 2011). Whey protein (WPC, protein concentration 65-80 % in dry matter, or WPI, protein concentrations over 90% in dry matter), a byproduct of the cheese industry, has excellent nutritional and functional properties and has the potential to be used in edible films. Among other proteins corn zein, obtained from the corn gluten that is a by product of corn industry, has great potential in food packaging applications (Padua and Wang, 2002). Therefore, use of corn zein in coatings of eggshell applications is very attractive because it has better barrier characteristics to moisture and oxygen compared to other proteins. Numerous other food-grade coating materials (mineral oils, waxes, whey protein, soy protein, gluten, chitosan and cellulose-based materials) have also proven to be effective in reducing mass transfer by sealing porous and have been researched extensively (Caner, 2005; Hernandez-Ledesma and Chia-Chien, 2013; Rhim et al., 2004; Waimaleongora-Ek et al., 2009; Wong et al., 1996; Xie et al., 2002). Waimaleongora-Ek et al. (2009), in a study using different viscosities of mineral oil (from 7 to 26 mPa s) as coating materials of eggs, reported that mineral oil with the highest viscosity (26 mPa s) was more effective in preventing weight loss and in preserving albumen quality of eggs compared with that observed for other lower viscosity mineral oil coatings during storage. Wong et al. (1996) reported that eggshells coated with mineral oil possessed a higher $L^*$ value (lightness) than non-coated eggs (87.05 vs. 83.90), possibly due to glossier surface.

Mudannayaka et al. (2016), in a study using mineral oil, beeswax, Aloe vera gel and gelatine as a coating materials of fresh eggs, reported that beeswax and gelatine coated eggs showed significantly (P<0.05) lower weight loss values and preserved albumin and yolk
quality of eggs than control eggs. Eggs coated with mineral oil and beeswax showed similar results for weight loss, HU, YI, albumen and yolk pH. Based on the HU, eggs can be classified into four grades as AA (above 72), A (72-60), B (59-31) and C (below 30). Quality of uncoated eggs, Aloe vera coated eggs and gelatine coated eggs dropped from AA to B and mineral oil and beeswax coated eggs changed from initial AA quality to A quality after six weeks of storage at 30°C. Results of microbiological analysis showed that all coated eggs were microbiologically safe throughout the storage period. The present study demonstrated that, in comparison to the mineral oil and the uncoated eggs, beeswax is a better novel coating material and gelatine can also be successfully used as coating material in preserving the internal quality and extending the shelf life of chicken eggs for six weeks (30°C). However, few research has been conducted using food proteins such as WPC, WPI and corn zein as coatings on shell eggs for extending interior qualities and functional properties. The effects of protein based edible coatings on the preserving internal quality and functional properties of fresh eggs have also not been extensively studied. Thus, the goals of this research were to compare different types of food protein coatings [whey protein isolate, whey protein concentrate, corn zein]. Food grade shellac is also used as 'wax' coating on shell eggs to comparison (Caner and Yüceer, 2015; Musa et al., 2011).

Effects of various concentrations of propolis for egg coating (5%, 8% and 10% of propolis in ethanol) on the interior quality of fresh eggs were evaluated during 4 weeks of storage. During storage, albumen height decreased whereas albumen pH increased. The albumen pH of the uncoated eggs), and the eggs coated with alcohol and 5% propolis was significantly higher than the albumen pH of eggs coated with 8% and 10% propolis. On the other hand, at 4 weeks storage eggs of 8% and 10% had a higher albumen index than the rest of the groups. In conclusion, coating of eggs with 10% propolis extract improved interior egg quality during storage (Copur et al., 2009). Musa et al. (2011), in a study using 5% shellac concentration can be used successfully to improve the internal quality changes in eggs during a storage time. Khattak et al. (2016), in a study revealed that coatings and storage time had significant effects on pH, Haugh unit, weight loss, eggshell breaking strength, foaming properties, total solid of albumen and yolk.
Conclusion
To conclude, the resistance to gas exchange of coated eggs is strongly influenced by the coating's ability to block pores on the surface of the eggs. Coatings, especially zein and shellac coating are promising and most effective coatings since they delay the deterioration of the internal quality. The coatings improved functional properties and also shell strength and could be a viable alternative technology for maintaining the internal quality of eggs during long-term storage. This study highlights the promising use of various coatings to both enhance the functional properties and to reduce the breakage of eggs.

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CONGRESS BOOK

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May 2018
FOREWORD

On the behalf of the Organising Committee, it is a great pleasure and honour for us to welcome you all to the “International Poultry Science Congress of WPSA Turkish Branch’2018”.

This congress will provide a platform for the exchange of new ideas, information and to build up and to strength professional relationships.

We would like to express our sincere gratitude to the esteemed scientists who have made this congress more meaningful with their presentations and to the sponsors who made this congress possible.

We want to thank all the representatives of Niğde Ömer Hasdemir University, Department of Animal Production and Technologies, Faculty of Agricultural Science and Technologies for their priceless help in the organisation of the congress.

There are 350 scientists from 14 countries participating in the congress.

This is also the first time that we are inviting students to the congress. We hope that it will be an unforgettable experience for them.

We wish you all an enjoyable and productive time during the congress and a wonderful stay in this amazing wonderland right in the centre of Turkey, Cappadocia.

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