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Effects of Egg Albumin Film Containing Coriander Extract on Some Quality Properties of Chicken Drumsticks during Refrigerated Storage

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HIGHLIGHTS

- Coating treatment had no negative effect on the *L** values of samples during storage.
- Coating had no negative effect on the pH values of samples (except for EWF2, EWF6).
- Coating with and without CLE decreased the TBA values of samples during storage.

Abstract

In this study, the effects of the egg white film coatings containing different levels (0%, 2%, 4%, and 6%) of coriander leaf extracts (CLE) and 0.1% BHT on some quality parameters of chicken drumsticks were investigated during refrigerated storage for 7 days. Chicken drumsticks were formed as follows: the uncoated chicken drumsticks (Control), chicken drumsticks coated with the egg white film solutions (EWF), chicken drumsticks coated with the EWF solutions with 2% CLE (EWF2), chicken drumsticks coated with the EWF solutions with 4% CLE (EWF4), chicken drumsticks coated with the EWF solutions with 6% CLE (EWF6), and chicken drumsticks coated with the EWF solutions added 0.1% BHT (EWFBHT). TBA, colour, and pH values were measured on the 1st, 3rd, 5th, and 7th days of the chicken drumsticks. Excluding EWF2 and EWF6, no significant changes were found regarding the pH values of uncoated and coated chicken drumsticks during refrigeration for 7 days ($P > 0.05$). TBA values of samples showed an increase during the refrigerated storage. The highest TBA values were calculated on the 7th day ($P < 0.05$). *L** values of chicken drumsticks were not affected by coating treatment ($P > 0.05$). With regard to Control and EWF4, the highest *a** values were found on the first day, and then the value decreased ($P < 0.05$). In terms of *b** values, except for the EWF6 group, the *b** values of samples increased during the refrigerated storage. The highest *b** values were measured on the 7th day ($P < 0.05$). The results state that EWF solution with and without CLE could be a potential natural antioxidant coating to enhance some quality attributes of chicken drumsticks during refrigerated storage.

Keywords: Colour; *Coriandrum sativum* L.; Egg white film; Natural antioxidant; Oxidative stability.

1. Introduction

Consumers prefer chicken meat to other types of meat throughout the world, considering their high population, price advantage and desirable nutritional composition for human life (Ilansuriyan et al. 2015; Pereira and Vicente 2013). Chicken drumstick as raw meat contains nutritional components such as protein, vitamins and minerals, and fatty acids which are inclined to oxidative degradation (Domínguez et al. 2019).

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Now that chicken is recognized as perishable, the poultry industry and researchers have set sights on adopting new approaches to enhance the quality attributes of poultry meat, especially chicken meat (Khorshidi et al. 2021).

Taking into account the fact that conventional packaging from synthetic materials is non-biodegradable and non-renewable, curious scientists and innovative food industries are closely interested in edible coatings aimed to enhance meat quality as well as products from meat by decreasing moisture loss, and lipid oxidation giving rise to the rancidity and colour degradation of meat as well as poultry meat (Bharti et al. 2020; Campos et al. 2011).

Concerning easily accessible protein resources, egg white is of significance and versatility (Mihalca et al. 2021). Ovalbumin, ovotransferrin from egg proteins and lysozyme from egg white display antioxidant attributes, in which ovalbumin is the main component of egg white (Benedé and Molina 2020). Chang et al. (2018) reported that the antioxidant, antimicrobial and anticancer activities of peptides from egg call attention to contribute to human health.

Protein-based films are not only exceptional barriers to oxygen but they are also able to carry antimicrobials, and antioxidants to prolong the shelf life of meat, poultry as well as seafood (Janes and Dai 2012; Ustunol 2009). The coriander (*Coriandrum sativum* L.) is grown mainly in the Middle Eastern and Mediterranean regions. It is regarded as a healing plant, whose leaves show antioxidant activity (Nadeem et al. 2013). According to Boby et al. (2021), 1% long coriander leaf extract was suggested as a natural antioxidant for chicken meatballs.

Although there are several studies on egg albumen coatings in the reduction of lipid oxidation in cooked and uncooked poultry (Armitage et al., 2002), egg white protein-based coatings on frozen atlantic salmon (Rodríguez-Turienzo et al., 2016), egg white protein powder on chicken patties (EL-Sayed et al., 2018), there is a lack of study in which egg albumin film containing CLE as natural antioxidants on the quality parameters of refrigerated chicken drumsticks. Therefore, the aim of the present study is to analyse the effects of egg albumin film containing coriander extract as natural antioxidants on lipid oxidation, and the physicochemical, pH and colour attributes of chicken drumsticks during refrigerated storage for 7 days.

2. Materials and Methods

2.1. Materials

The coriander (*Coriandrum sativum* L.) used in the study was purchased from the local greengrocers in Konya, Türkiye. Chicken drumsticks were obtained from a local market in Konya. Egg white protein powder was obtained from a company (Alfasol Kimbiotek Chemical Agents Inc., Istanbul, Türkiye). There is no need to obtain an ethics committee number. 1.0 N NaOH solution, glycerol and all other chemicals needed for solution preparation are of analytical purity and were obtained from Sigma Chemical Co. (St. Louis, MO, USA).

2.2. Preparation of coriander extracts

Coriander leaf extract was obtained using the method described by Konak (2018) with a slight modification. After washing the coriander leaves for 5 seconds under drinkable water, they were dried under laboratory conditions (18-20 °C) and in the shade for a week. The dried coriander leaves were ground into powder, and then water was added to the coriander leaves. 2.5 g of ground coriander leaves were blended with 50 mL of distilled warm water. The mixture was stirred for 30 minutes with a magnetic stirrer (750 rpm) and filtered with Whatman No. 1 filter paper.

2.3. Preparation of egg white film solution

Edible EWF solution was prepared by modifying the study of Armitage et al. (2002). 80 mL of distilled water was added to 7 g of egg white protein in 1 L glass beaker and stirred for 1 hour at room temperature with a magnetic stirrer (150 rpm), and then 2 mL of glycerol was added. Then, the pH of the solution was

adjusted to 9.0 using 1.0 N NaOH. The solution was kept in a water bath (Nuve BM 402, Türkiye) at 60 °C for 40 min.

2.4. Application of coatings on chicken drumsticks

Different levels (0%, 2%, 4%, and 6%) of CLEs and BHT (0.1%) were added to the EWF solutions. Six different groups were prepared, including the uncoated control group. Then, the drumstick samples were immersed in the solutions containing different levels of coriander extracts and BHT for one minute and the coating procedure was repeated in duplicate.

2.5. Experimental design

Six groups of chicken drumsticks were formed: the uncoated chicken drumsticks (Control), chicken drumsticks coated with the egg white film solutions (EWF), chicken drumsticks coated with the EWF solutions with 2% CLE (EWF2), chicken drumsticks coated with the EWF solutions with 4% CLE (EWF4), chicken drumsticks coated with the EWF solutions with 6% CLE (EWF6), and chicken drumsticks coated with the EWF solutions added 0.1% BHT (EWFBHT). TBA, colour and pH analyses were performed on the 1st, 3rd, 5th and 7th days of the chicken drumsticks samples stored at 4 °C.

2.6. Proximate composition

Moisture (hot air oven), fat (ether extraction) and protein (Kjeldahl) contents of the Chicken drumsticks were determined according to standard methods of the AOAC (AOAC, 2000). Moisture (%) was determined after drying a 3 g sample at 105 °C to maintain a constant weight. By appealing to the Kjeldahl method, protein (g protein/100 g sample) was analysed. Factor 6.25 was used for the conversion of nitrogen to crude protein. By using a Soxhlet fat extractor, fat content (g fat/100 g sample) was determined.

2.7. pH measurement

The pH values of the drumstick samples in each group were determined by using a pH meter (Testo 205 T-Handle pH Meter, Germany) (Lambooij et al. 1999).

2.8. Determination of TBARS number

10 g drumstick samples were blended with 97.5 mL distilled water using an Ultra-Turrax homogenizer (WiseTis HG–15D, Daihan Scientific Co., Seoul, Korea). The mixture was transferred to a 250 mL balloon. After adding 2.5 mL HCl, 3-5 glass beads and 3 drops of antifoam, the balloon was heated. After collecting 50 mL of distillate, 5 mL of distillate was taken with the help of variable adjustable volume pipettes and transferred to screw cap glass test tubes. Then 5 mL of TBA reagent was added into the tube and was kept in a boiling water bath for 35 min. The absorbance was read according to the method described by Tarladgis et al. (1960) spectrophotometrically (Optizen POP, UV/VIS Spectrophotometer, Mecasys Co., Korea) at 530 nm against a reagent blank. The TBA numbers of drumstick samples were recorded as milligrams of malonaldehyde per kilogram of samples.

2.9. Colour measurements

Colour measurements of the chicken drumstick sample were carried out with a colorimeter (Konica, Minolta CR 400, Osaka, Japan). L^* (lightness), a^* (redness), and b^* (yellowness) parameters were read according to Hunt et al. (1991). The results were averaged as means of the values measured from five different parts for each chicken drumstick sample.

2.10. Statistical analysis

A completely randomised factorial design was employed to compare the six treatments (Control, EWF, EWF2, EWF4, EWF6 and EWFBHT). Analysis results were subjected to analysis of variance (ANOVA) using the generalized linear mixed model. MINITAB for Windows Release 16.0 was used to evaluate the results. Tukey Multiple Comparison Test was applied to determine if the differences between group means were significant at a 95% confidence level ($p < 0.05$)(Snedecor and Cochran 1989). The results were expressed as

the mean ± standard error. Each parameter experienced two replications with triplicate samples for a total of 36 samples each day.

3. Results and Discussion

3.1. Proximate composition of chicken drumsticks

The proximate composition of chicken drumsticks was calculated as: 72.75% moisture, 18.36% total protein, and 5.08% crude fat. Our results were similar to the findings of the previous studies (Ananey-Obiri et al. 2020; Demirhan and Candoĝan 2017; Khorshidi et al. 2021).

3.2. pH values

In terms of pH values, uncoated and coated chicken drumsticks refrigerated for 7 days are shown in Table 1. Excluding EWF2 and EWF6, no significant changes were found in the pH values of uncoated and coated chicken drumsticks during refrigeration for 7 days ($P > 0.05$). Similarly, Rodríguez-Turienzo et al. (2016) found that egg white protein-based coating did not affect the pH values of Atlantic salmon (*Salmo salar*) after 4 months of frozen storage ($P > 0.05$). Results from our study are similar to the findings of Harliani et al. (2020), in which no significant effect was made on the pH of beef nuggets with egg white ($P > 0.05$). However, for the group of EWF2 and EWF6, while the lowest pH values were determined on the first day, the highest pH values were read on day 7 ($P < 0.05$). A possible explanation for the differences in pH values is likely to the differences in the initial microflora of samples (Katiyo et al. 2020). In the present study, changes regarding the pH values of chicken drumsticks were insignificant except for the 3rd day. On the 3rd day, the highest pH value was read in the EWF6 ($P < 0.05$).

3.3. TBA values

TBA values of uncoated and coated chicken drumsticks during refrigerated storage for 7 days are presented in Table 2. TBA values of samples showed an increase during the refrigerated storage. On the 7th day of the storage, the highest TBA values were calculated ($P < 0.05$). Similarly, a significant increase in TBA values was obtained by Mansour et al. (2023) in chicken drumsticks coated at 50 °C with alginate edible coating.

Generally, TBA numbers of the EWF group that was coated and the groups that were added coriander extract at different levels with the coating (EWF2, EWF4, EWF6) were found to be lower than that of the Control as well as EWFBHT groups. Similarly, Mansour et al. (2023) informed that alginate edible coating and lauric arginate (LAE) exhibited lower TBARS values than uncoated chicken drumstick samples. A similar trend in TBA numbers was observed by Aboul-Anean, El-Sayed, and Bakhy (2018) who applied edible film with egg white protein powder on chicken patties during 30 days of cold storage. Similarly, Yerlikaya and Şen Arslan (2021) determined that the highest TBA numbers were found on control groups with no extract while the lowest TBA numbers found on the samples with 10% EEP (ethanolic propolis extract) on chicken sausages. The calculated lower TBA numbers could arise from the differences between the preparation and application of edible coating methods.

3.4. Colour properties

Colour parameters of uncoated and coated chicken drumsticks during refrigerated storage for 7 days are given in Table 3. Coating treatment did not affect L^* values of uncoated and coated chicken drumsticks during refrigerated storage for 7 days ($P > 0.05$). Concerning L^* values, the differences in colour parameters of whey protein isolates (WPI) and egg white powder protein (EP) groups were measured to be insignificant by Dursun and Erkan (2014) who prepared edible coating from concentrate WPI and EP to prolong the shelf life of hot-smoked rainbow trout for a period of 6 weeks refrigerated storage.

With regard to Control and EWF4, the highest a^* values were found on the first day, and then the value decreased ($P < 0.05$). A similar trend in a^* value was charted by Venkatachalam and Lekjing (2020) who used chitosan-based edible film and added clove essential oil and nisin to extend the pork patties' shelf-life during

15 days of refrigerated storage. This reduction was referred to as the aggregation of metmyoglobin (Papuc et al. 2017) as well as the appearance of oxidative reactions regarding meat and meat products (Munekata et al. 2020).

In terms of *b** values, except for the EWF6 group, the *b** values of samples increased during the refrigerated storage. The highest *b** values were measured on the 7th day ($P < 0.05$). On the contrary, Olcay and Sarıçoban (2022) listed the lowest *b** values of control and egg white edible films added 5% hops (*Humulus lupulus* L.) extract on hamburgers during refrigerated storage for 7 days. A possible reason for the adverse trend would be the differences in the variety of extracts and colour of edible films, additional levels, and samples.

4. Conclusion

The present study proved to be beneficial to enhance the quality parameters of chicken drumsticks during refrigerated storage for 7 days. The egg albumin film coating with and without CLE decreased the TBA numbers of chicken drumsticks in comparison to control and EWFBHT groups during refrigerated storage for 7 days, which is much lower than the spoilage limit. Coating treatment had no negative effect on the *L** values of chicken drumsticks as well as pH values of samples (except for EWF2 and EWF6) during refrigerated storage. Egg white film coating containing CLE, used as a natural antioxidant in the study, may contribute to scientific studies to reduce or limit the use of synthetic antioxidants. In this way, it can be useful for the emergence of new edible film materials with different tastes and flavours. EWF coating would play an important role in the coating of protein-rich innovative products.

Table 1. pH values of uncoated and coated chicken drumsticks during refrigerated storage for 7 days

Treatment	pH (Sample numbers for each day are 36)			
	Day 1	Day 3	Day 5	Day 7
Control	6.04 ± 0.10^{Aa}	6.04 ± 0.04^{Ab}	6.33 ± 0.08^{Aa}	6.56 ± 0.20^{Aa}
EWF	6.16 ± 0.01^{Aa}	6.09 ± 0.001^{Ab}	6.35 ± 0.10^{Aa}	6.29 ± 0.03^{Aa}
EWF2	6.18 ± 0.01^{Ba}	6.14 ± 0.04^{Bab}	6.41 ± 0.04^{Aa}	6.46 ± 0.05^{Aa}
EWF4	6.29 ± 0.11^{Aa}	6.16 ± 0.04^{Aab}	6.42 ± 0.10^{Aa}	6.44 ± 0.03^{Aa}
EWF6	6.18 ± 0.05^{Ba}	6.41 ± 0.10^{ABa}	6.22 ± 0.03^{Ba}	6.60 ± 0.05^{Aa}
EWFBHT	6.13 ± 0.27^{Aa}	6.06 ± 0.01^{Ab}	6.41 ± 0.08^{Aa}	6.50 ± 0.31^{Aa}

Mean±std. error.

Different capital letters (A–B) in the same row and lower-case letters (a-b) in the same column indicate significant ($P < 0.05$) differences.

Control: uncoated chicken drumsticks, EWF: chicken drumsticks coated with the egg white film solutions, EWF2: chicken drumsticks coated with the egg white film solutions with 2% coriander leaf extract, EWS4CLE: chicken drumsticks coated with the egg white film solutions with 4% coriander leaf extract, EWF6: chicken drumsticks coated with the egg white film solutions with 6% coriander leaf extract, EWFBHT: chicken drumsticks coated with the egg white film solutions added 0.1% BHT.

Table 2. TBA values of uncoated and coated chicken drumsticks during refrigerated storage for 7 days

Treatment	TBA (mg MA/kg sample) (Sample numbers for each day are 36)			
	Day 1	Day 3	Day 5	Day 7
Control	0.07 ± 0.02^{Ba}	0.04 ± 0.005^{Ba}	0.22 ± 0.02^{Ba}	0.72 ± 0.06^{Aa}
EWF	0.02 ± 0.004^{Ba}	0.06 ± 0.01^{Ba}	0.12 ± 0.01^{Ba}	0.61 ± 0.09^{Aa}
EWF2	0.04 ± 0.01^{Ba}	0.08 ± 0.002^{Ba}	0.12 ± 0.01^{Ba}	0.60 ± 0.10^{Aa}
EWF4	0.04 ± 0.01^{Ba}	0.05 ± 0.001^{Ba}	0.12 ± 0.02^{Ba}	0.65 ± 0.03^{Aa}
EWF6	0.06 ± 0.02^{Ba}	0.04 ± 0.01^{Ba}	0.16 ± 0.04^{Ba}	0.52 ± 0.02^{Aa}
EWFBHT	0.08 ± 0.02^{Ba}	0.10 ± 0.03^{Ba}	0.21 ± 0.03^{Ba}	0.56 ± 0.06^{Aa}

Mean±std. error.

Different capital letters (A−B) in the same row and lower-case letters (a-b) in the same column indicate significant ($P < 0.05$) differences.

Control: uncoated chicken drumsticks, EWF: chicken drumsticks coated with the egg white film solutions, EWF2: chicken drumsticks coated with the egg white film solutions with 2% coriander leaf extract, EWS4CLE: chicken drumsticks coated with the egg white film solutions with 4% coriander leaf extract, EWF6: chicken drumsticks coated with the egg white film solutions with 6% coriander leaf extract, EWFBHT: chicken drumsticks coated with the egg white film solutions added 0.1% BHT.

Table 3. *L**, *a** and *b** values of uncoated and coated chicken drumsticks during refrigerated storage for 7 days

Analyses	Storage Periods	Treatment (Sample numbers for each day are 36)					
		Control	EWF	EWF2	EWF4	EWF6	EWFBHT
*L**	Day 1	65.67 ± 1.31^{Aa}	63.65±1.95^{Aa}	64.87±1.47^{Aa}	63.41±0.78^{Aa}	63.85±0.40^{Aa}	68.89±0.15^{Aa}
	Day 3	64.36±1.69^{Aa}	62.29±1.77^{Aa}	63.77±0.77^{Aa}	63.26±1.56^{Aa}	64.89±1.13^{Aa}	63.51±1.03^{Aa}
	Day 5	64.19±2.39^{Aa}	63.89±2.65^{Aa}	63.20±1.12^{Aa}	65.98±3.03^{Aa}	64.93±1.01^{Aa}	65.37±1.17^{Aa}
	Day 7	67.32±0.31^{Aa}	66.33±1.63^{Aa}	65.61±0.28^{Aa}	66.40±0.07^{Aa}	65.52±0.18^{Aa}	68.52±1.45^{Aa}
*a**	Day 1	4.60±0.54^{Aa}	3.02±2.17^{Aa}	1.40±0.60^{Aa}	2.37±0.09^{Aa}	2.35±0.02^{Aa}	1.72±0.41^{Aa}
	Day 3	0.82±0.09^{Bb}	1.09±0.07^{Aab}	1.57±0.06^{Aab}	2.17±0.14^{ABa}	1.36±0.47^{Aab}	1.90±0.28^{Aab}
	Day 5	1.92±0.55^{Ba}	0.74±0.04^{Aa}	1.13±0.74^{Aa}	1.37±0.30^{ABa}	0.79±0.42^{Aa}	1.29±0.27^{Aa}
	Day 7	0.66±0.06^{Ba}	1.11±0.29^{Aa}	0.85±0.01^{Aa}	0.99±0.24^{Ba}	1.06±0.06^{Aa}	1.55±0.68^{Aa}
*b**	Day 1	3.04±0.45^{Ba}	2.47±0.93^{Ba}	3.09±0.25^{Ba}	2.68±0.36^{Ba}	2.90±0.86^{Aa}	3.73±0.24^{ABa}
	Day 3	3.43±0.71^{Ba}	1.83±0.98^{Ba}	0.92±0.25^{Ba}	1.89±0.64^{Ba}	1.53±0.35^{Aa}	2.71±0.34^{Ba}
	Day 5	1.82±0.87^{Ba}	3.24±0.73^{Ba}	8.32±2.60^{ABa}	3.00±0.32^{Ba}	3.78±0.65^{Aa}	2.63±1.58^{Ba}
	Day 7	8.92±1.12^{Aab}	10.34±1.02^{Aab}	12.38±0.22^{Aa}	12.20±1.18^{Aab}	5.86±1.42^{Ab}	10.10±1.49^{Aab}

Mean±std. error.

Different capital letters (A−B) in the same column and lower-case letters (a-b) in the same row indicate significant ($P < 0.05$) differences.

Control: uncoated chicken drumsticks, EWF: chicken drumsticks coated with the egg white film solutions, EWF2: chicken drumsticks coated with the egg white film solutions with 2% coriander leaf extract, EWS4CLE: chicken drumsticks coated with the egg white film solutions with 4% coriander leaf extract, EWF6: chicken drumsticks coated with the egg white film solutions with 6% coriander leaf extract, EWFBHT: chicken drumsticks coated with the egg white film solutions added 0.1% BHT.

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