Effect of Bioactive Edible Coating Based on Sodium Alginate and Coriander (*Coriandrum sativum L.*) Essential Oil on the Quality of Refrigerated Chicken Fillet

Mina Kargozari[1*], Hassan Hamedi[2], Seyyed Amir Amirnia[1], Ahmad Montazeri[1], Sara Abbaszadeh[1]

[1] Department of Food Science, Tehran-North Branch, Islamic Azad University, Tehran, Iran
[2] Department of Food Safety and Hygiene, Science and Research Branch, Islamic Azad University, Tehran, Iran

Abstract

Introduction: Meat may decay very quickly and, therefore, use of a suitable preservative is essential. The aim of this study was the evaluation of active edible coating of sodium alginate incorporated with coriander essential oil on the shelf life of chicken fillets.
Materials and Methods: The *Coriandrum sativum* L. essential oil (CEO) was extracted from aerial parts of the plant using Clevenger-type apparatus. The alginate coating containing different concentrations of CEO were prepared. The antimicrobial effect of this combination in culture media and food model, besides their quality changes in term of TVBN, TBARS, and peroxide values were investigated.
Results: Overall, MIC and MBC values ranging from 0.5 to 5 (µg/mL) proved that Gram-positive bacteria were more susceptible to CEO than Gram-negative bacteria. Results showed that coatings of Alg had no significant effect on decreasing the microbial load of aerobic mesophilic, psychrotrophic bacteria, lactic acid, coliform bacteria as well as *Staphylococcus aureus* ($p>0.05$), while the coating of fillet with Alg/CEO showed a significant difference with the other treatments during 12 days of storage ($p<0.05$). The results also showed that TVBN, TBARS and peroxide formation in the samples treated by Alg/CEO was significantly lower than the control group ($p<0.05$).
Conclusion: The application of coriander essential oil in combination with sodium alginate coating enriched the chemical and microbial properties of chicken fillet and increased its shelf life. Concerning organoleptic properties, the coating of Alg with 0.5% CEO scored higher in the sensory evaluation.

Keywords: *Sodium alginate, Coriander essential oil, Chicken fillet, Antimicrobial effect, Shelf life*

Research Article

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Correspondent Author:
Dr. Mina Kargozari
Department of Food Science, Tehran-North Branch, Islamic Azad University, Tehran, Iran
Email: mina_kargozari@ut.ac.ir

Introduction

In addition to the extensive research to identify and use alternative natural and plant-based materials instead of chemical preservatives, scientists were conducted studies to evaluate antimicrobial and antioxidant activities of these materials against spoilage bacteria in meat, poultry, and fish, as well as their use to enhance the shelf life of perishable foodstuffs. [1] Given that some traditional methods of food preservation such as thermal processing, drying, freezing and radiation for some fresh and instant food products are not suitable to reduce the growth of pathogenic micro-organisms [2], industries conducted new packaging technologies such as active and modified atmosphere packaging, as well as natural antimicrobial and antioxidant compounds for prevention from microbiological and chemical changes. [3] Active packaging usually means the incorporation of specific compounds with active function beyond the packaging materials to extend the shelf life of the foodstuffs. [4] Edible coatings containing bioactive polysaccharides, lipids, and proteins could increase the quality of fresh, frozen and processed meat products. Traditional direct applying of the antimicrobial agents onto food surfaces (*e.g.* dipping, spraying or pulverization) may result in the taste changes due to immoderate amounts of the active components. Early evaporation of active agents and inactivation or denaturation of them by food ingredients and also an expeditious migration into the food mass may occur using direct application techniques. [5] Whereas, the slow migration of the substances away from the surface of a packaging material may have a privilege of maintaining the antimicrobial compound at high concentration level over a long period. [6] Besides the use of antimicrobials should be enough to prevent microbial surface growth because that is where the highest level of corruption and contamination occurs. [7] Moreover; for enhancing the efficacy of EOs regarding their volatility, using active packagings based on film forming materials such as proteins and polysaccharides. [8] Polysaccharide films have good barrier properties against gas, but due to their hydrophilic nature exhibit lower resistance to moisture compared to protein films. [9] Film forming ability of alginate provides of its possibility to use as a coverage material in foods. Alginate needs to add of divalent cations such as Ca^{2+} to strengthen its physical properties of resultant gels. [10] Of course, the combinations of natural antibacterial and antioxidant components increase its storage capabilities[11]. Coriander (*Coriandrum sativum* L.) is an annual species native to regions spanning from southern Europe, Eastern Mediterranean, and northern Africa to southwestern Asia. Coriander is grown in many parts of Iran. All parts of the plant are edible, but fruits and vegetative organs of coriander contain essential oils of which maximum value is found in fruits. [12] In addition to many medicinal properties such as gut modulatory, blood pressure lowering and diuretic activities, dried coriander fruits, often called coriander seeds have an inhibitory effect on Gram-positive and Gram-negative bacteria. [13,14] Therefore, the objectives of the present research were to study the effect of the alginate-based coating containing EO of coriander as a new edible active coating on the quality and shelf life of chicken fillet during the cold storage condition.

Materials and Methods

Materials

The fruits of coriander were collected from Jolfa city (West Azerbaijan Province, Iran) during April-May 2016. Sodium alginate was purchased from Sigma-Aldrich Chemical Co. (Oakville, ON, USA). All other chemicals used were of analytical grade and were provided by Merck Chemical Co. (Darmstadt, Germany).

Extraction of coriander essential oil

The seeds of coriander with 650 mL water were placed in a round bottom flask connected to a Clevenger-type apparatus to produce oil in 1.5% (w/w) yield. The hydrodistillation process was completed after 3 h boiling. The oily layer obtained on top of the aqueous distillate was separated and anhydrous sodium sulfate was used to dry the obtained CEO and stored at 4°C until analysis.

Determination of the MIC and MBC

The minimum inhibitory concentration (MIC) and minimum bactericide concentration (MBC) were measured by the broth microdilution method using 96-well microtiter plates as described by the Clinical and Laboratory Standards Institute. [15] The EO of coriander was dissolved in Mueller-Hinton broth (MHB) supplemented with Tween 80 at a final concentration of 0.1% (v/v). Dilutions of the EO (0.1–4 %) were prepared in test tubes and dispensed into the wells of a microtiter plate according to a checkerboard design; each well was then inoculated with 100 mL of the bacterial suspensions include E. coli, S. *Typhimurium*, *L. monocytogenes*, *B. cereus*, and *S. aureus* with 5×10^5 CFU/mL concentration. After incubation at 35°C for 24 h, the wells were examined for the growth of microorganism and the MICs were determined. The MIC was defined as the lowest concentration at which the microorganism did not demonstrate visible growth. MBCs were determined by plating samples from each well demonstrating no visible growth. The MBC was defined as the lowest concentration of antimicrobials that killed at least 99.9% of the initial inoculums. Each experiment was repeated three times.

Edible film preparation of NaAlg/glycerol /CEO

Sodium alginate solution was prepared by dissolving 30 g in 1 L of sterile distilled water at 70°C (3% solution). Afterward, the viscous solutions were left to cool to room temperature and to this 0.1 mL of glycerol was added as a plasticizer. For active edible coating, the different concentrations of CEO (0, 0.5 and 1%) were mixed with alginate solution under magnetic stirring at 55°C. [9] The final solution was homogenized with Ultra-Turrax (Ultra-Turrax, Staufen, Germany) at 7000 rpm for 2 min.

Fillet coating

Chicken fillets were prepared from a production line and transferred to the laboratory in cold conditions. 50 g of the fillet samples were prepared in a sterile condition and 60 fillets were considered for each treatment. To create coating, fillets were soaked in NaAlg/glycerol edible coating solution containing 0, 0.5 and 1% CEO for 30 s. Then, the coated fillets stood for 2 min, followed by a second immersion in $CaCl_2$ (Sigma-Aldrich Chemical Co.) for 30 sec to achieve better crosslinking. The coated samples were allowed to drain completely in ambient condition for about 30 min. The samples were placed in sterile bags and stored at 4±1°C until testing. The microbiological and chemical evaluation of fillets were conducted at intervals of three days until day 12. The controls were treated similarly in water solution lacking coating materials. [10]

Evaluation of antimicrobial activity of CEO

Bacterial counts were performed by method using de man-rogosa-sharpe agar (MRS) for lactic acid bacteria (LAB), plate count agar (PCA) for psychrotrophic and aerobic mesophilic bacteria (AMB), Baird–Parker agar for *Staphylococcus aureus*, violet red bile agar (VRBA) for coliforms, and dichloran rose bengal chloramphenicol (DRBC) agar for molds and yeasts (MY). 10 g of fillet samples were aseptically taken in 90 mL of peptone water (0.1%), mixed in a sterile bag, and homogenized with Stomacher (BagMixer 400, Interscience, France) at 200 rpm/min for 1 minute. Appropriate decimal dilutions were serially prepared from this dilution in tubes containing peptone water. The inoculated plates were incubated at 37°C for 2 days for total viable counts, *S. aureus*, and coliforms. The incubation condition was 7°C for 10 days for psychrotrophic counts, 30°C for 2 days for LAB, and 25°C for 5 days for MY. All experiments were carried out in duplicate. Samples were taken on days 0 (after dipping treatment), 3, 6, 9, and 12 days of storage and expressed as $\log_{10}$ CFU/g. [11]

Determinations of thiobarbituric acid reactive substances (TBARS)

The TBARS was determined colorimetrically as described by Shams, *et al.* [12]. For extraction, ground meat (10 g) was first mixed with 30 mL of 4% perchloric acid and 1 mL of 0.5% BHT in ethanol and homogenized. Then, the mixture was macerated with a glass rod and allowed to stand for 1 h at ambient temperature (at 25°C). Next, the mixture was centrifuged at 2000 rpm for 10 min, and the mixture was filtered through Whatman # 4 filter paper. Afterward, 5 mL of the new filtrate was taken to mix with 5 mL (0.02 M) aqueous solution of 2-thiobarbituric acid (TBA) in a stoppered test tube, then placed in a boiling water bath for 20 minutes, and subsequently cooled for 5 min in cold water at 0°C. The absorbance of cooled samples was measured at a wavelength of 532 nm by the spectrophotometer against a distilled water blank. The TBARS was measured based on malondialdehyde (MDA) mg/kg of standard sample.

Measuring Total Volatile Base Nitrogen (TVBN)

To measure TVBN, 10 g of sample was mixed with 500 mL of distilled water, 2 g MgO and one drop of silicone to prevent foaming in the round bottom flask. A 250 mL Erlenmeyer flask containing 25 mL of 3% aqueous solution of boric acid, 0.04 mL of methyl red as an indicator for the titration of ammonia was used as the distillate receiver. Titration was performed with 0.1 N hydrochloric acid solution described as TVBN mg per 100 g of chicken fillet.[13] TVBN was calculated as follow:

$$\%TVBN = (V \times C \times 14 \times 100)/10$$

where, V and C stand for the volume of hydrochloric acid and its concentration, respectively.

Measuring peroxide value

Twenty grams of fillet with 100 mL of chloroform/methanol solution was mixed at a portion of 2:1 and blended for 1 minute. After dewatering by potassium chloride, the aqueous phase (lower phase) was collected and used for titration by 0.01 N sodium thiosulfate solution using starch indicator until the yellow color was discharged. A blank was prepared alongside the oil samples. Peroxide value was calculated as follow:

$$\text{Peroxide value} = 10 \times (V1 - V2)/m$$

where $V1$ is the volume of $Na_2S_2O_3$ for determination of test sample in mL, $V2$ is the volume of $Na_2S_2O_3$ for determination of blank solution in mL, and m is mass of test portion in 20 g. [16]

Sensory evaluation

A panel of 10 trained panelists was selected from the staff of the University of Tehran (Department of Food Hygiene) on the basis of their experience in the sensory analysis. The uncoated/coated fillets after cooking in the microwave at 180°C were evaluated based on taste, odor, color, texture, and overall acceptability attributes. The results were expressed on a 9-point hedonic scale. The sensory scores were 9, like extremely; 8, like very much; 7, like moderately; 6, like slightly; 5, neither like nor dislike; 4, dislike slightly; 3, dislike moderately; 2, dislike very much; 1, dislike extremely. [1] The Sensory evaluation of samples was done after 3 days of storage.

Statistical analysis

Experiments were done twice on different occasions with chicken fillet samples. All analyses were run in triplicate for each replicate. Analysis of all data was performed by One-way analysis of variance (ANOVA) and Duncan's New Multiple Range Test in SAS version 9.1. The statistical significance of differences between mean values was proved at $p<0.05$.

Results and Discussion

MIC and MBC of the essential oil

As shown in Table 1, *Coriandrum sativum* EO proved to be effective against a wide range of foodborne pathogens. Overall, the results of MIC and MBC values ranging from 0.5 to 5 (µg/mL) which have also been reported in other studies. [17] All strains studied were inhibited by CEO, with different degrees of inhibition. *B. cereus* was the most sensitive strain, while *S.* Typhimurium was the most resistant to growth inhibition by the tested oil, showing the highest determined MIC 2.5 (µg/mL). The antimicrobial activity of CEO has been reported by many researchers, [17] and some of these studies proved that Gram-positive bacteria were more susceptible to CEO that was consistent with our study[13,18]. It is widely accepted that the antimicrobial activity of EOs depends on major constituents and their concentrations. The inhibitory effects of EOs are mainly due to their major components but the small amounts of minor components might also contribute to the antimicrobial activity. [13] It was also observed that the MBC values were equal to the MIC values for *L. monocytogenes* and *S. aureus*, suggesting the bactericidal activity of CEO. Similar results were previously reported against several foodborne microorganisms, [17,18] indicating that membrane damage is the primary mechanism of action of CEO and leading to cell death.

Table 1. Antimicrobial activity (MIC and MBC) of coriander (*Coriandrum sativum* L.) essential oil (µg mL^{-1}) against Gram-positive and Gram-negative bacterial strains.

	E. coli	*S.* Typhimurium	*L. monocytogenes*	*B. cereus*	*S. aureus*
MIC	2	2.5	1.5	0.5	1
MBC	3	5	1.5	1	1

MIC, minimum inhibitory concentration; MBC, minimum bactericidal concentration.

Antimicrobial activities of CEO

The number of bacteria, as well as total mold and yeast in four different treatment groups, were counted and the results are shown in Fig. 1 and 2 and 3. The number of total bacteria and MY of all samples increased during storage time but the value increased faster for control. Despite a decrease in the number of mesophilic bacteria in Alg group, this difference in comparison with control groups was not significant (similar results were observed for MY counts). This result was in an agreement with Azarakhsh, *et al.* [19], but some studies indicated that coating with Alg causes a significant decrease in microbial count in some products like as rainbow trout, bighead carp, and bream fillets. [10,20,21] In the Alg/CEO 0.5 % group, the count of AMB was 7.1 log at day 12 in which a significant decrease shows in comparison with the control group ($p<0.05$). This effect was highlighted with 1 % CEO (6.5 log at day 12) (Fig. 1 (A)). These results coincide with those reported by other studies

with horsemint (Lee and Mooney, 2012), lemongrass,[19] and cinnamon[22] EOs that enriched alginate coating.
According to Fig. 1 (B) coating, the fillet with Alg reduced the number of psychrotrophic bacteria but this difference was not significant ($p>0.05$). Similar to results of mesophilic, psychrotrophic count of all samples increased during the storage and the combination effect of Alg/CEO was higher than Alg individual antimicrobial effect. Raeisi, *et al.* [23] reported that sodium alginate incorporated with cinnamon and rosemary EOs had a significant effect on psychrotrophic bacteria such as *Pseudomonas* in chicken fillet during cold storage time.

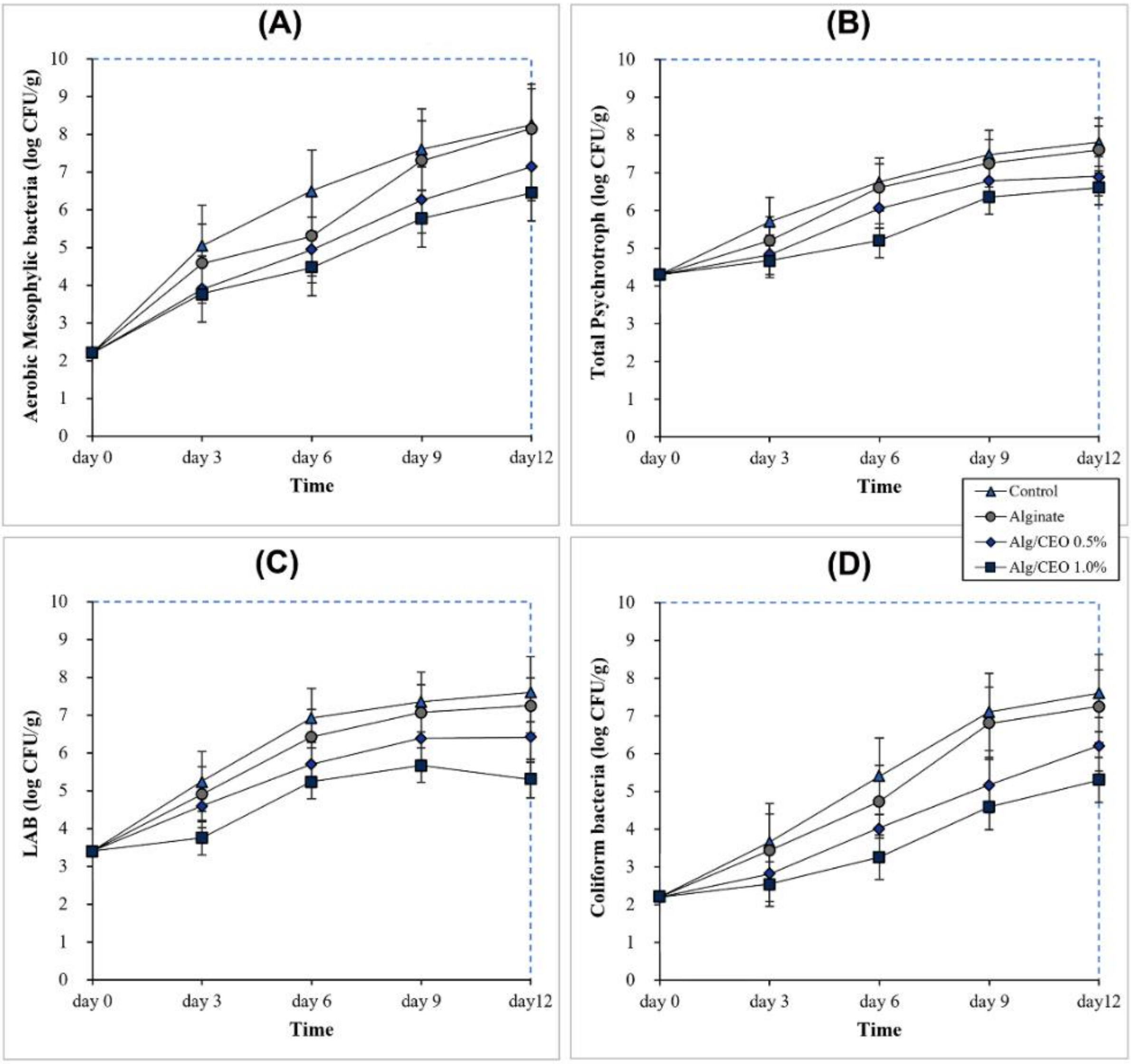

Fig. 1: Antimicrobial effects of active edible coating by alginate incorporated with coriander essential oil (Alg/CEO) in chicken fillet during 12 days storage at 4°C. (A): Total aerobic mesophilic bacteria, (B): Psychrotrophic bacteria, (C): Lactic acid bacteria, (D): Coliform bacteria counts.

LAB are facultative anaerobic species that can be found as a substantial part of the natural microflora of the chicken meat. As shown in Fig. 1 (C), the initial population of LAB in all samples was 3.4 log CFU/g and in control was increased to 7.6 log CFU/g during cold storage. In the Alg group, the number of LAB was recorded as 7.3 log CFU/g on day 12 was not significant in comparison with control. Among the treated samples in this study, Alg/CEO 1% had the lowest value of LAB count which is remarkably less than the control group (5.3 log

CFU/g). The same result was reported by Raeisi, *et al.* [23], where they observed the significant reduction of LAB by sodium alginate with cinnamon and rosemary EOs in chicken fillet during 15 days of storage. In another study, the biodegradable gelatin–chitosan films incorporated with clove, rosemary thyme, and lavender were tested on 6 selected microorganisms; two Gram-positive (*L. acidophilus* and *L. monocytogenes*) and four Gram-negative bacteria (*E. coli*, *P. fluorescens*, *P. phosphoreum* and *S. putrefaciens*), and were found, *L. acidophilus* is one of the most sensitive microorganisms[24]. Coliform bacteria are considered a hygiene indicator of sanitary quality of foods and water and substantial group of the chicken meat microbial flora. In our study, the initial log of coliforms was recorded to be 2.2, and it was reached to 7.6 and 7.3 log on day 12 in control and Alg groups, respectively (Fig. 1.D). Adding 0.5 and 1 % CEO to edible coat caused a significant reduction of coliforms count as compared to control samples ($p>0.05$). Similar results were observed by Raeisi, *et al.* [25] who reported a reduction of 1–2 log cycles in *Enterobacteriaceae* count by using sodium alginate coating with nisin, cinnamon, and rosemary EOs on microbial quality of chicken meat at the end of storage time. Michalczyk, *et al.* [26] also reported a significant reduction in *Enterobacteriac-eae* count following the application of coriander oil to minced beef, which caused a reduction in *Enterobacteriaceae* counts and was able to inhibit undesirable sensory changes due to meat spoilage.

According to results, no significant differences ($p>0.05$) was observed between the growth of *S. aureus* on control and Alg coated samples during storage (Fig. 2). These findings indicate that the Alg coating had no inhibitory effect on the growth of *S. aureus* (similar to psychrotrophic, LAB, and coliforms). Regardless of the percent of EO, incorporating CEO agent in the Alg coating matrix increased the antimicrobial activity of edible coating, and the application of CEO resulted in significant inhibition of *S. aureus* counts after 12 days of storage at 4°C (more than 2 log cycle reduction was observed). After 12 days of storage, the *S. aureus* count reached a value of 7.3 log CFU/g in the control samples, while the use of edible Alg enriched with the highest concentration of coriander maintained the population of *S. aureus* under the 5.3 log CFU/g. The antimicrobial effect was less marked with 0.5 and 1% CEO where a *S. aureus* reduction of approximately 1.2 and 2.1 log, as compared to the control samples, respectively, was observed during the storage period. Several in vitro studies suggested that the incorporation of different EOs into alginate coating improves its antimicrobial properties. In a study conducted by Alboofetileh, *et al.* [27] active nanocomposite films were formed and different EOs were incorporated into alginate-clay nanocomposite film at several concentrations (0.5, 1.0, and 1.5%, w/v) and in vitro antibacterial activity of them was evaluated against *L. monocyte-genes*, *E. coli*, and *S. aureus*. Their results showed that the combination of EO with alginate was effective to control the growth of pathogens in culture media (in vitro). The same result was reported by Benavides, *et al.* [28] in oregano–alginate-based film against the aforementioned strains.

TBARS evaluation

TBARS value, as well as malondialdehyde generated from lipid hydroperoxides by the hydrolytic conditions of the reaction, has been widely used to estimate the extent of lipid oxidation and sensory evaluation in meat product like as chicken fillet. [31]

The results showed that TBARS value of all treatments increased continuously during storage (Fig. 4).

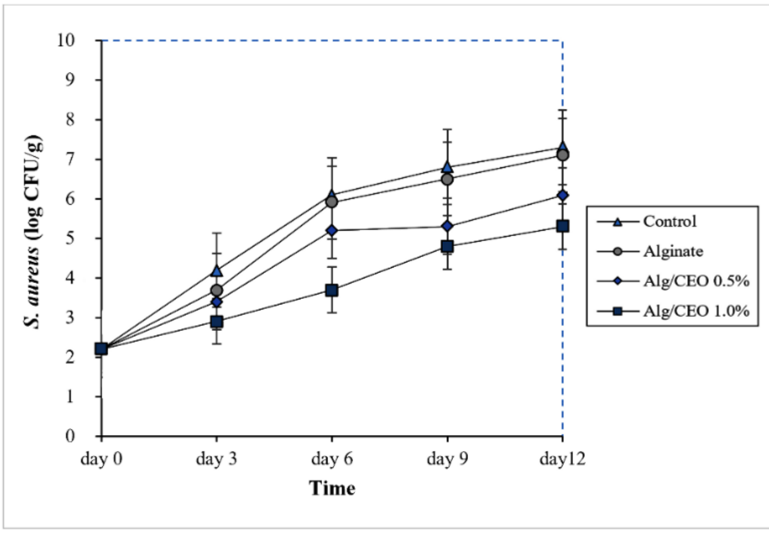

Fig. 2: ***Staphylococcus aureus*** **bacteria count in chicken fillet coated by alginate and coriander essential oil (Alg/CEO) during 12 days storage at 4°C.**

Considering MY count in all samples, after 12 days of storage Alg treatment alone showed no significant difference compared to control ($p>0.05$). The initial count of MY was very low (less than 1.5 log CFU/g), however, during 12-day storage, it increased to the final population of 5.3 and 5.4 log CFU/g for control and Alg samples, respectively. As expected, in general, Alg/CEO coated samples have lower counts than the controls ($p<0.05$), and the lowest values of MY count belonged to 1% CEO with 3.8 log CFU/g on day 12. Results of this study showed Alg/CEO had a notable antifungal activity that caused growth inhibition of molds and yeasts in chicken fillet samples (Fig. 3). These results were in agreement with Raeisi, *et al.* [23] where they reported the sodium alginate with rosemary and cinnamon EOs caused a significant reduction of MY counts at the end of storage time (15 days). Overall, the active films containing EOs are, in general, very effective against yeasts and molds. [29,30]

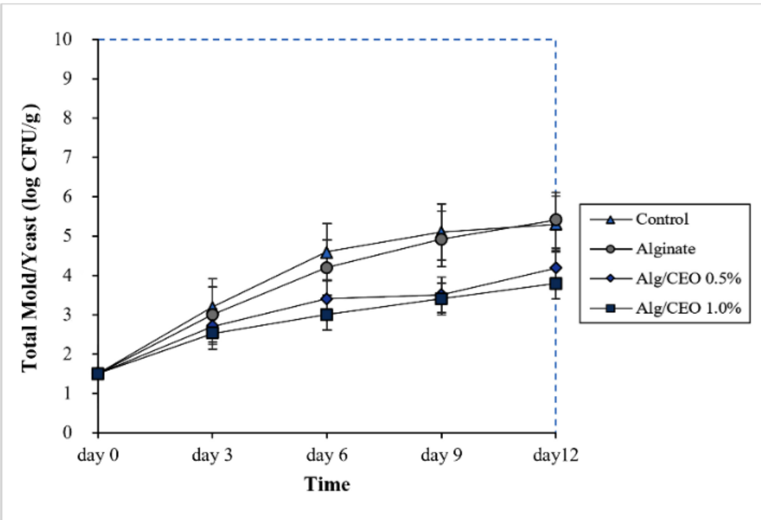

Fig. 3: Total mold/yeast count in chicken fillet coated by alginate and coriander essential oil (Alg/CEO) during 12 days storage at 4°C.

Although a reduction was seen in TBARS formation in Alg coated samples, but this difference was not significant in comparison with the control group ($p>0.05$). This observation was similar to the results from Song, *et al.* [20] and Xiong, *et al.* [31]. As shown in Fig. 4, TBARS formation in the samples treated by Alg/CEO in both concentrations was significantly lower than the control group ($p<0.05$). There was no significant difference recorded between 0.5 and 1% CEO up to day 12 (0.38 and 0.42 mg MDA/kg, respectively). Samples coated by Alg and 1% CEO had less increase of TBARS in respect to other treatments during storage at 4˚C. Xiong, *et al.* [31] evaluated the effects of an alginate-based edible coating containing rosemary and oregano EOs on beef steaks during 14 days storage and reported that the edible coatings decreased lipid oxidation of the meat compared to control and edible coating with 0.1% oregano were more effective than rosemary. The reported TBARS values for this study were reached approximately 1.00, 0.91, 0.61 and 0.53 mg MDA/kg for control, Alg, Alg/rosemary and Alg/oregano, respectively, corresponding to a lipid oxidation decrease of approximately 47 and 39% for active edible coating with essential oil of oregano and rosemary respectively. [31] Lipid oxidation is the main non-microbial factor that cause of quality deterioration in food and negatively affects the shelf life and quality. The oxidative changes in perishable foods perishable foods include meat, poultry, fish, dairy products, and all cooked leftovers give rise to the development of off-flavors, loss of nutrients and bioactive components, and even formation of potentially toxic compounds, thus making these foods unsuitable for consumption.[32,33] The antioxidant properties of some EOs in reducing TBARS especially coriander was reported by Misharina and Samusenko[34] and this antioxidant activity of coriander was exhibited by γ-terpinene, limonene, and linalool. Raeisi, *et al.* [25] showed lower TBARS values for CMC-based coatings incorporated with Zataria multiflora Boiss EO and grape seed extract in rainbow trout fillets compared to control samples during storage. In another study, Song, *et al.* [20] showed that refrigerated bream had lower TBARS values in a sodium alginate-based edible coating with vitamin C and tea polyphenols than the uncoated samples. So active edible coating incorporating a natural antioxidant, such as CEO, may prolong the shelf life of meat products through its antioxidative activities.

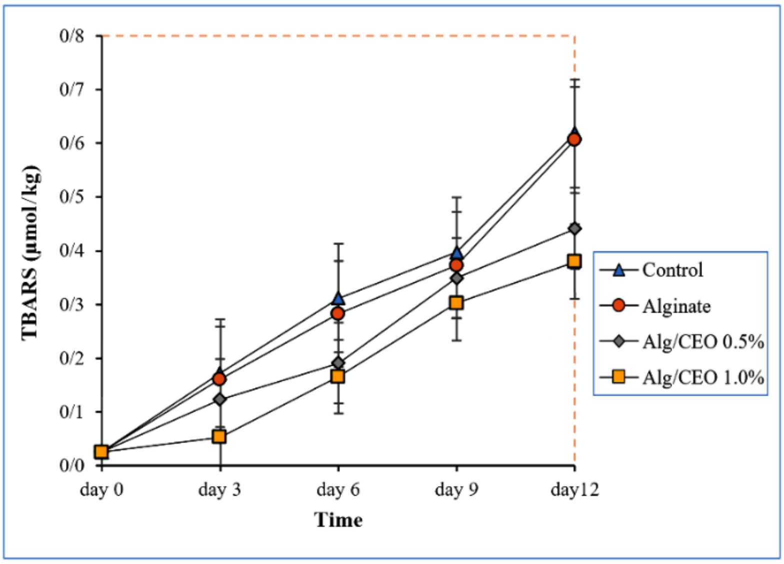

Fig. 4: TBARS value in chicken fillet coated by alginate and coriander essential oil (Alg/CEO) during 12 days storage at 4°C.

Total volatile base nitrogen (TVBN)

TVBN values for treated samples are presented in Fig 5. The initial TVBN values of uncoated fillet samples on day 0 (13.7 mg N 100/g) is indicative of freshness of chicken fillet and is in agreement with veterinary council standards. As results show, the TVBN level in all samples increased gradually by the time of storage and value of control and Alg groups were 43.2 and 41 mg N 100/g on day 12, respectively. TVBN increase in control samples was expected because it is related to bacterial spoilage, [13] but the high amount of TVBN in Alg coated group can be attributed to its low antimicrobial activity. In contrast, Lee and Mooney [10] reported that the TVBN content of bighead carp fillets coated with sodium alginate was significantly lower than the control group in the last 8 days of the storage period ($p<0.05$). However, TVBN value of Alg/CEO 1% samples remained practically below acceptable values (27.6 mg N 100/g on day 9). This is associated with the higher antimicrobial effect of active coated incorporation with EO. This finding was in agreement with Lee and Mooney [10] that showed samples treated with Alg-containing horsemint EO had significantly lower TVBN content during the storage period compared with the Alg and control.

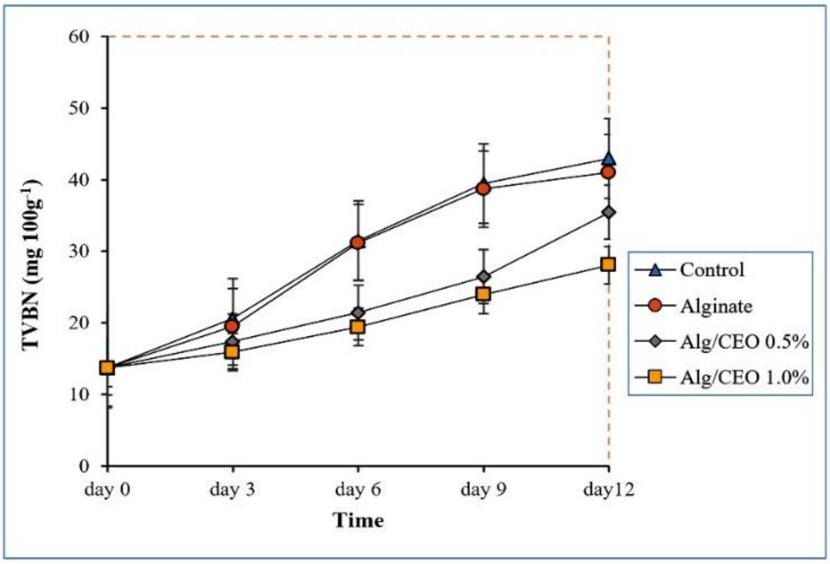

Fig. 5: TVBN value in chicken fillet coated by alginate and coriander essential oil (Alg/CEO) during 12 days storage at 4°C.

Peroxide Value

Detection of peroxide gives the initial evidence of rancidity in food products that possess unsaturated oils or fats. It is used widely and gives a measure of primary oxidation and hydroperoxides. [35] As seen in Fig 6, the PV of the fillets increased gradually in all treatments during the period, but this value in all samples was not significantly different in the first 3 days of our investigation. The Initial PVs were very low (average 0.0135 meq/kg) in the fresh fillets, and this value in specimens containing Alg/CEO was less than control and Alg groups on 9 and 12 days of storage (Fig. 7). No remarkable difference observed in peroxide value between 0.5 and 1% CEO up to day 12, and significant differences ($p<0.05$) were observed only among samples with Alg/CEO and without CEO. The present study showed that active edible coating with CEO postponed primary oxidation of fillet. As explained by Lee and Mooney[10] alginate coating enriched with horsemint (*Mentha longifolia*) EO inhibit the formation and increase of peroxidants in bighead carp fillets during storage at 4°C. Same results also reported by Wang, *et al.* [36] in pork coated by chitosan films containing combined essential oils of cinnamon and ginger (1:1).

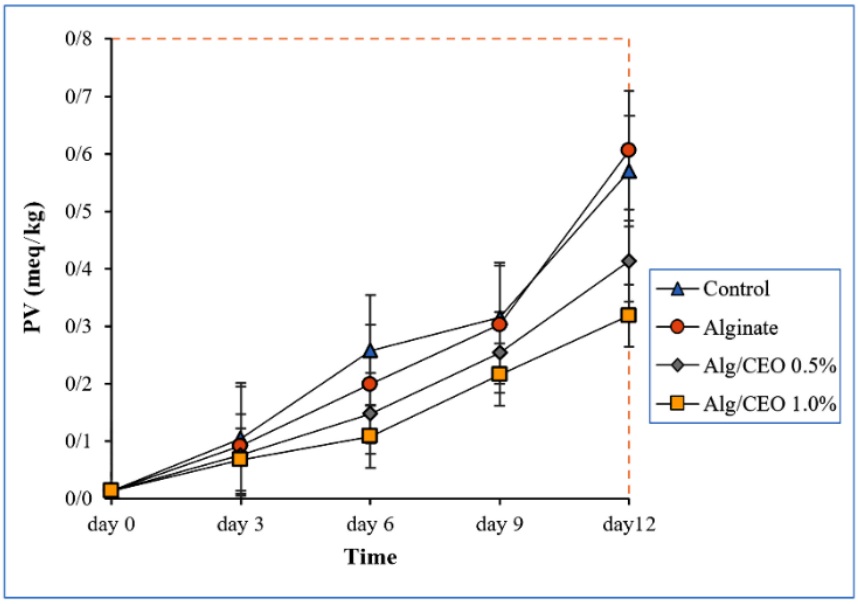

Fig. 6: Peroxide value in chicken fillet coated by alginate and coriander essential oil (Alg/CEO) during 12 days storage at 4°C.

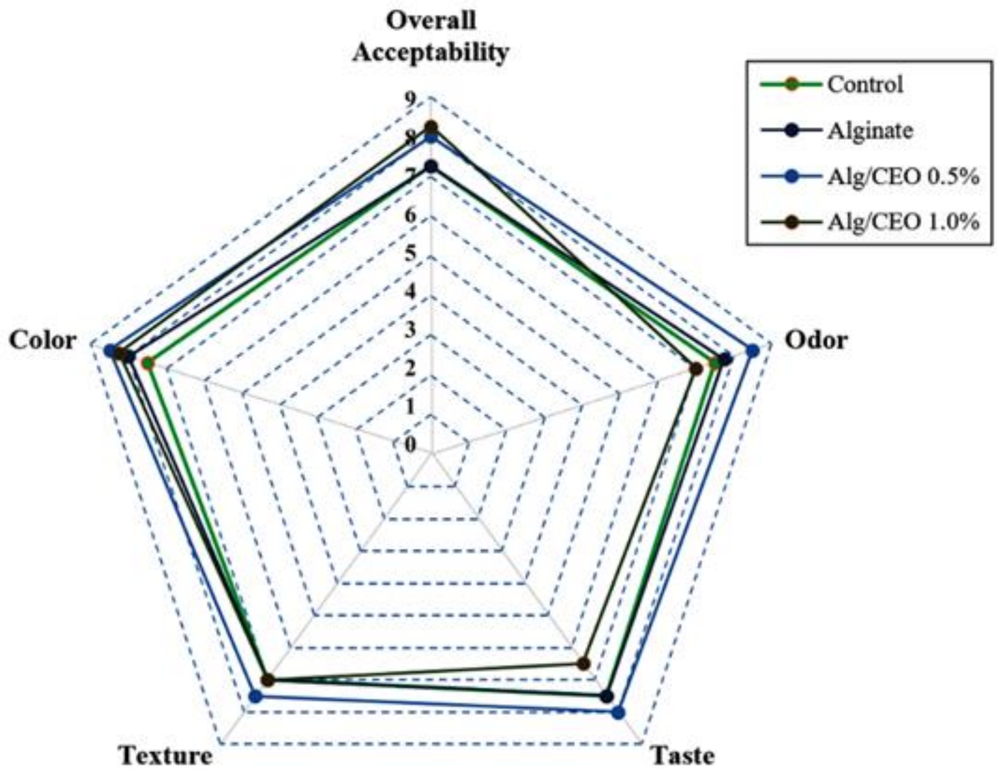

Fig. 7: Sensory evaluation of samples coated by alginate and coriander essential oil (Alg/CEO) during 12 days storage at 4°C.

Sensory evaluation

All samples were evaluated based on 9-point hedonic scale and the score of 7 or more considered satisfactory. The summary of the sensory evaluation includes color, odor, taste, texture and overall acceptance are given in Fig. 7. As the results show the control, Alg, and Alg/CEO 0.5% coated samples had a high value of all sensory parameters during the storage period and there was no significant difference between them. The higher score belonged to Alg/CEO 0.5% samples, and the mean of color, odor, taste, texture and overall acceptability parameters were 8.5, 8.5, 8, 7.5 and 8, respectively, after 3 days of storage The samples coated by Alg and 1% CEO had obviously lower sensory values, while they were still in acceptable ranges. Kulig, *et al.* [37] indicated that sensory properties of raw and cooked meat samples coated with Alginate/Chitosan polyelectrolyte complex had no undesirable influence on pork meat products. Vital, *et al.* [38] also suggested that an alginate-based edible coating containing natural antioxidants (rosemary and oregano EOs) had a significant effect on consumer perception of odor, flavor and overall acceptance of the beef.

Conclusion

The present study showed that sodium alginate coating and coriander essential oil enriched the chemical and microbial properties of chicken fillet and increased its shelf life. The combination of Alg with CEO showed a significantly higher inhibitory effect against a wide range of foodborne pathogens on culture media (in vitro) and samples treated with this active edible coating had a high chemical and microbial quality than uncoated fillets. Antioxidant and antibacterial effects of sodium alginate coating and coriander were more pronounced when the essential oil was used at high concentration. Therefore, alginate and other active coatings like as chitosan, Gelatin, Cellulose, and CMC incorporated with essential oil can be used for to improve food quality and enhance the shelf life of perishable foods like as meat and meat products.

Conflict of interest

The authors declare no conflicts of interest.

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