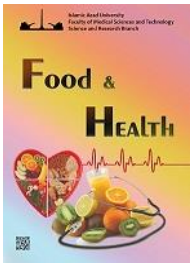

Food & Health Journal
Journal homepage: fh.srbiau.ac.ir

Shelf-life extension of chicken meat using gelatin-chitosan film containing cinnamon essential oil at refrigeration condition

Seyed Alireza Kasaiyan [1, 2], Negin Noori [3], Afshin Akhondzadeh Basti [3*], Ali Khanjari [3]

[1] Department of Food Hygiene, Faculty of Veterinary Medicine, Garmsar branch Islamic Azad University, Garmsar, Iran
[2] Department of Food Technology, Faculty of Veterinary Medicine, University of Leon, Leon, Spain
[3] Department of Food Hygiene and Quality Control, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran

ARTICLE INFO

Original Article

Article history:
Received 22 December 2021
Revised 18 April 2022
Accepted 24 May 2022
Available online 20 June 2022

Keywords:
Gelatin-chitosan film
Cinnamon essential oil
Chicken meat

ABSTRACT

Antimicrobial packaging is an innovative active packaging, especially for meat and meat products. The present study has been carried out with the objective of prolonging the shelf life of chicken meat by using gelatin-chitosan (GC) film containing different concentrations of *Cinnamon zeylanicum* essential oil (CZEO) (0, 0.3, 0.6, and 0.9% v/v) at the refrigerated condition for 12 days. The obtained results indicated that the microbial count of samples wrapped with the films incorporated with the CZEO was significantly lower than control and remained below the acceptable limit of meat (7 log CFU/g). The total volatile base nitrogen (TVB-N) was 7.11 mg/100 g and after 6 days reached 30.18 mg/100 g in control, whereas it was lower than 25 mg/100 g for samples wrapped with GC films containing 0.6% and 0.9% CZEO. Compared with the control sample, the levels of peroxide value (POV) of the wrapped samples with GC films incorporated CZEO at 0.3%, 0.6 and 0.9% were decreased by 2.07, 3.23, and 3.4 meq peroxide oxygen/1000 g lipid, respectively, at the end of storage time. As a result, the integration of CZEO into GC film can extend the shelf life of the chicken meat in refrigerated conditions for at least 12 days without any unfavorable organoleptic properties.

1. Introduction

Chicken meat is a very popular food all over the world and its consumption has raised in many countries in the past decades. Some of the reasons for the popularity of this product are its relatively low production cost, low-fat content, and high nutritional value (1). This type of food is highly sensitive to decay and has a short shelf life. Petroleum-based plastics are the most dominant non-biodegradable materials used in the packaging industry (2, 3). The commonly produced packages made of synthetic polymers like polyethylene, polyvinyl chloride, polypropylene, and polystyrene cause the generation of non-degradable physical wastes and dispersion of bioenvironmental pollutants. Due to the global concern about the lack of petroleum resources and environmental problems attributed to these materials, the strategy of replacing them with biopolymers has been scheduled (3-5). In recent years, biopolymers such as chitosan, starch, and gelatin have increasingly gained the interest of the food packaging industry due to their compatibility with the environment (6-9). Gelatin is a water-soluble protein derived from collagen by controlled hydrolysis at high temperatures in the presence of water (10). Recent research noted that gelatin film has low antioxidant activity (11). Chitosan is a polycationic polysaccharide acquired from chitin by deacetylation. It was documented that chitosan films exhibited good antimicrobial and antioxidant properties (12-14). Many published literatures reported the incorporation of essential oils into the biopolymers improves the antioxidant and antibacterial activity of films (15-17). Cinnamon with the scientific name *Cinnamomum zeylanicum* is a shrub belonging to the *Lauraceae* family (18, 19). Cinnamon and its derivatives are well known for biological and pharmacological characteristics like antimicrobial, antioxidant, and anti-tumor (20). The current study has been carried out to investigate the possibility of shelf-life extension of chicken meat using the gelatin-chitosan film containing

*Corresponding author: Department of Food Hygiene and Quality Control, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran.

E-mail address: aakhond@ut.ac.ir (Afshin Akhondzadeh Basti).

cinnamon essential oil under refrigerated conditions.

2. Materials and methods

2.1. Essential oil extraction and analysis

At first, the dried inner bark of *Cinnamomum zeylanicum* was crushed and transferred for steam distillation to a Clevenger-type apparatus for 3h. The obtained essential oil was kept in an opaque glass tube under refrigeration conditions (4±1ºC). The components of the essential oil were analyzed by gas chromatography coupled with mass spectrometry according to the methodology described previously by Talebi et al. (21).

2.2. Sample preparation

The chicken meat was provided from the Iran Boorchin slaughterhouse (Eslamshahr, Iran) and transferred to the food hygiene laboratory under cold conditions within 45 min. Then, about 60g of test samples were weighted and placed between two layers of prepared active films and transferred aseptically to sterile bags followed by refrigerated storage for 12 days (9).

2.3. Preparation of gelatin-chitosan films

The gelatin-chitosan (GC) film was prepared by the casting technique according to the method previously described by Hematizad et al. (9). Firstly, 3% chitosan and 4 % bovine gelatin solutions were dissolved individually in distilled water containing 1% acetic acid and pure distilled water, respectively. Next, glycerol (1%) as a plasticizer was integrated into the solution and magnetically stirred on a hotplate/magnetic stirrer at 50˚C for 2 h. Subsequently, different concentrations of *Cinnamomum zeylanicum* essential oil (CZEO) (0, 0.3, 0.6 and 0.9 % v/v) were incorporated to the final solution. All mixture homogenized at 12,000 rpm for 2 min. Following the procedure, films were formed and dried in 12 cm diameter glass Petri dishes at ambient temperature (25 ˚C).

2.4. Microbial analysis

Assessment of microbiological evolution of samples was performed by homogenizing 10 g of each sample in the stomacher (Interscience, France) with 90 mL of peptone water (0.1%) solution and serial dilutions (1: 10) were prepared. Total bacteria count (TBC), was enumerated on plate count agar at 30 ˚C for 24−48 h and the same culture medium was used for determining psychrotrophic bacteria (PSC) at 7 ˚C for 10 days; *Pseudomonas* spp. assessed, on *Pseudomonas* agar supplemented with CFC (Cetrimide, Fucidine, Cefaloridine) and incubated at 25˚C for 48 h; and Enterobacteriaceae estimated on Violet Red Bile Glucose agar (VRBGA), incubated at 37˚C for 24 h were measured periodically at 0, 1, 3, 6, 9 and 12 days (39).

2.5. Chemical analysis

The total volatile base nitrogen (TVB-N) and peroxide value (POV) of the specimens were evaluated by the methods described by Yildiz et al. (22) and Bagheri et al. (23), respectively.

2.6. Sensory Evaluation

The sensory evaluation of the specimens was carried out by 6 trained organoleptic panel members. Test specimens were cooked and then served at 60˚C in individual booths with random three-digit blind codes. The sensory indices including color, odor, and taste characteristics of chicken meat were scaled from 1 (corresponding to a least liked sample) to 5 (corresponding to a most liked sample) points on day 1 (9).

2.7. Statistical analysis

At first, the transformation of microbiological data to logarithms of the number of colony-forming units (CFU/g), was performed, and then statistical analysis of chemical and transformed microbiological data was done by using a one-way analysis of variance (ANOVA) followed by Tukey's test. The pattern of microbiological and chemical changes over time was analyzed by repeated measure tests (SPSS 16 software, Chicago, IL, USA) (9).

3. Results

3.1. Chemical composition of CZEO

The dominant constitute of CZEO used in the present study was cinnamaldehyde (78.42%), alpha-copen (7.25%), cinnamaldehyde dimethyl acetal (1.57%), A similar finding is reported by Boito et al. (24) and Yu et al., (25), who noted that CZEO was rich in cinnamaldehyde.

3.2. Microbial analysis

Based on the obtained results, the TBC was 4.35 Log CFU/g in the control group at the beginning of the study and was found to increase on day 3 to over 7.17 Log CFU/g and 9.56 Log CFU/g on the last day (Fig. 1). The TBC was significantly higher in the control group compared to the other treatments for all studied days except for days 1 and 3 for pure GC film ($p<0.05$). Although the TBC was lower in the samples wrapped with the GC containing 0.9% CZEO in the course of the study in contrast to the samples wrapped with GC film containing 0.6% CZEO, the difference was not statistically significant ($p>0.05$). The obtained results are suggestive of the antimicrobial properties of the used film; this is consistent with the findings of the prior studies which declared considerable differences between active antimicrobial films integrated with different concentrations of investigated EOs (26-29). The key role of PTC in the spoilage of food under refrigerated

conditions are documented. In the present study, the initial count of PTC was 3.60 Log CFU/g in the chicken meat samples and it was found to increase to 6.53 Log CFU/g on day 6 to 9.74 Log CFU/g on day 12 for control samples (Fig. 2).

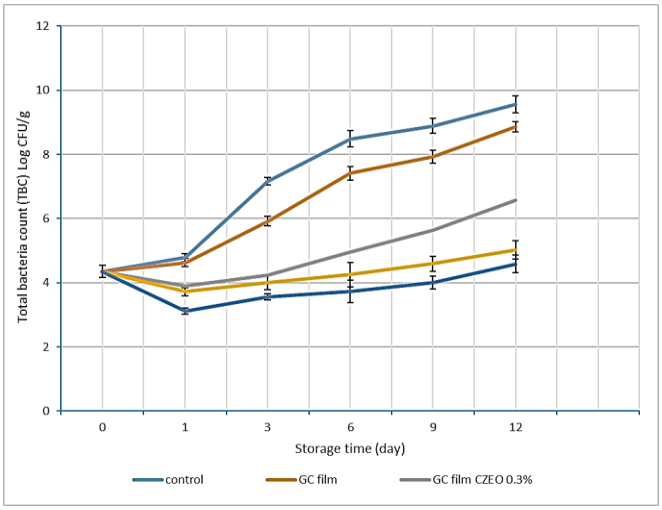

Fig. 1. Changes in total bacteria count (TBC) of chicken meat during refrigerated storage (Gelatin-chitosan (GC) film and *Cinnamomum zeylanicum* essential oil (CZEO)).

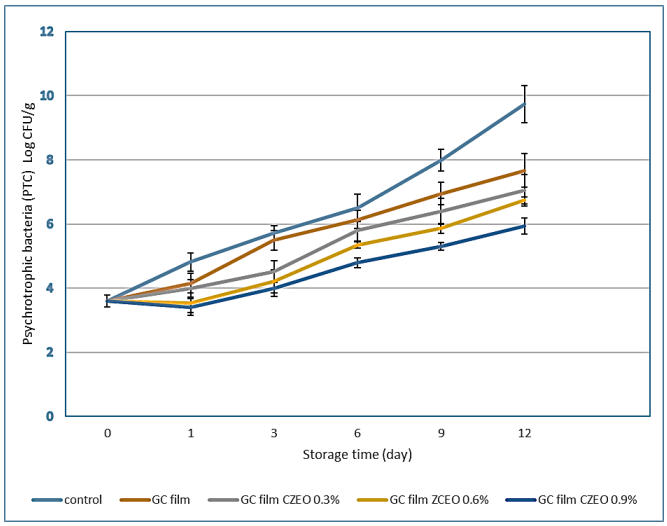

Fig. 2. Changes in psychrotrophic bacteria (PTC) of chicken meat during refrigerated storage (Gelatin-chitosan (GC) film and *Cinnamomum zeylanicum* essential oil (CZEO)).

The PTC of the samples wrapped with the films incorporated with 0.3%, 0.6%, and 0.9% CZEO was found significantly decreased in contrast to the control group ($p<0.05$). Also, the PTC of the samples wrapped with the net GC films was found significantly decrease from the ninth day of the study ($p<0.05$) in contrast to the control group. Researchers have noted similar results indicating that various films containing different EOs could retard the growth of PTC population in refrigerated meat (9, 28, 30, 31). The growth of Enterobacteriaceae in meat under refrigerated conditions could result in spoilage and health hazards. The effect of CZEO on the growth of Enterobacteriaceae in chicken meat during storage time is given in Fig. 3.

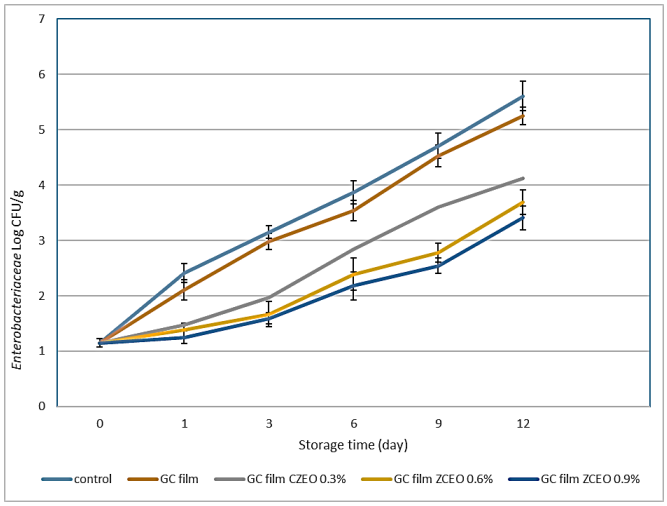

Fig. 3. Changes in *Enterobacteriaceae* count of chicken meat during refrigerated storage (Gelatin-chitosan (GC) film and *Cinnamomum zeylanicum* essential oil (CZEO)).

It is shown that Enterobacteriaceae count in chicken meat wrapped with GC films containing different concentrations of CZEO was decreased significantly (1.49–2.20 log CFU/g) in comparison with the control at the end of the storage period. These results are in line with prior studies reporting a reduction in *Enterobacteriaceae* count by wrapping meat with biodegradable films containing various EOs during storage at refrigeration (9, 32, 33). Based on the results of this study, the PSC was found significantly increased ($p<0.05$) in the control samples and samples wrapped with pure GC film in comparison to other treatments for all the studies days Fig. 4. These results are in accordance with previous studies showed a considerable reduction in PSC count by wrapping with antimicrobial activity of biodegradable films incorporated with different concentrations EOs (34-36). The results obtained from the microbial analysis counts indicated that the integration of the CZEO to the GC film result in a significant reduction in the microbial count of chicken samples.

3.3. Chemical analysis

The measurement of the TVB-N index is one of the core indicators for determining the freshness of chicken meat. The amount of the TVB-N in the samples was increased for all the study days in a significant manner ($p<0.05$). The amount of TVB-N in the control specimens was 7.11 mg/100g at the beginning of the study and it was found to increase to 23.98 and 45.87 mg/100g on the sixth and twelfth day, respectively (Fig. 5). A significant difference was evidenced for all of the treatments packaged with active GC film in terms of TVB-N in comparison to the control group ($p<0.05$). The lowest amount of TVB-N in the entire course of the study was seen in samples wrapped with GC films containing 0.9% CZEO. The

reason for the lower TVB-N value in treated samples could be attributed to the slower rate of bacterial growth in the samples wrapped with GC films in contrast to the control group and thereafter reduced accumulation of non-protein compounds. These results are consistent with other research declaring a reduction in TVB-N by wrapping the meat with biopolymers containing various EOs during storage at refrigeration conditions (30, 37, 38).

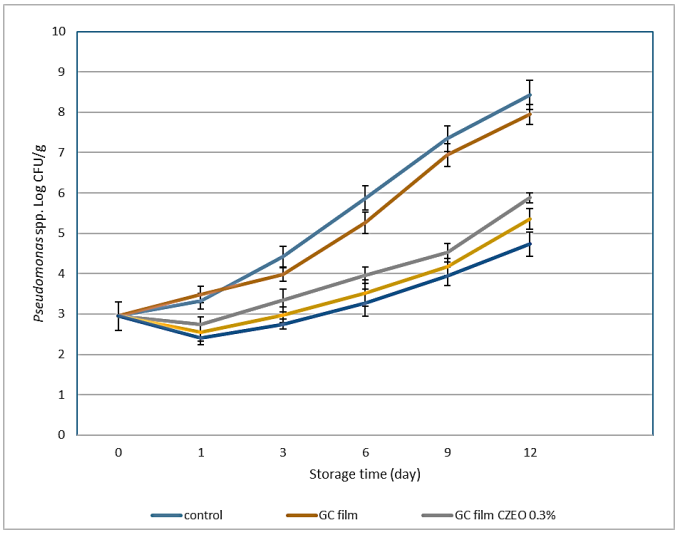

Fig. 4. Changes in *Pseudomonas* spp. count (PSC) of chicken meat during refrigerated storage (Gelatin-chitosan (GC) film and *Cinnamomum zeylanicum* essential oil (CZEO)).

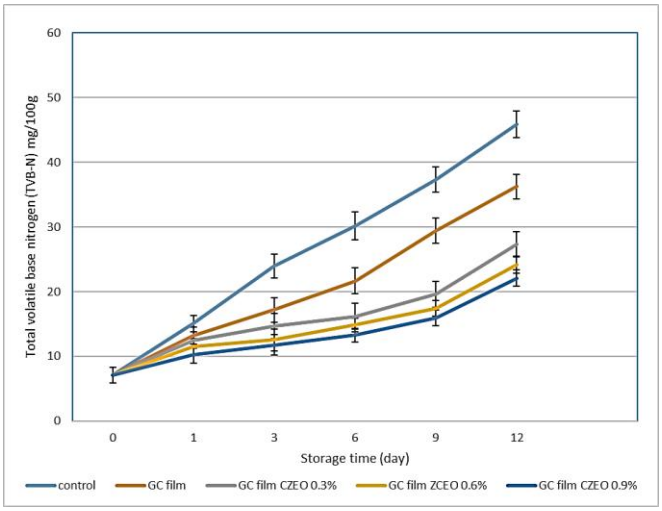

Fig. 5. Changes in total volatile base nitrogen (TVB-N) of chicken meat during refrigerated storage (Gelatin-chitosan (GC) film and *Cinnamomum zeylanicum* essential oil (CZEO)).

The evolution of oxidative rancidity of the samples is presented as PV in Fig. 6 in our study, the initial POV of samples was 0.27 meq peroxide oxygen/1000 g lipid which reached 5.76 meq peroxide oxygen/1000 g lipid at the end of day 12 of storage for control samples. The samples wrapped with the net GC films or GC films containing different concentrations of the CZEO, showed lower POV than the control samples ($p<0.05$) which is good in agreement with previous studies (9, 30, 39).

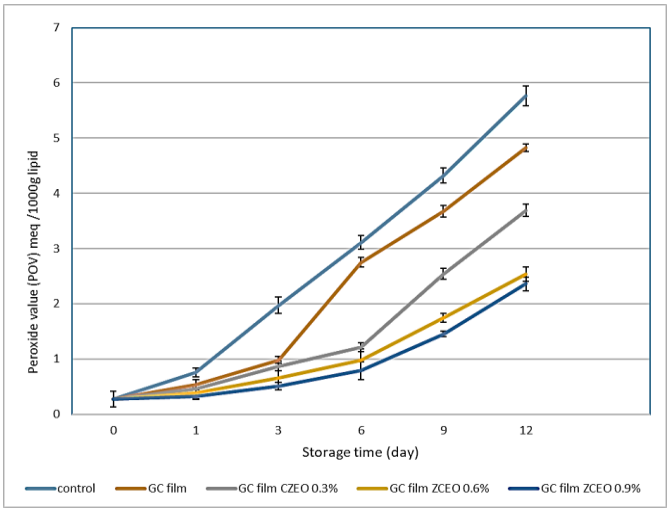

Fig. 6. Changes in peroxide value (POV) of chicken meat during refrigerated storage (Gelatin-chitosan (GC) film and Cinnamomum zeylanicum essential oil (CZEO)).

3.4. Sensory evaluation

As it can be seen in Fig. 7, the present work revealed an early insignificant negative influence of the CZEO on the taste and odor characteristics of the chicken meat samples ($p>0.05$).

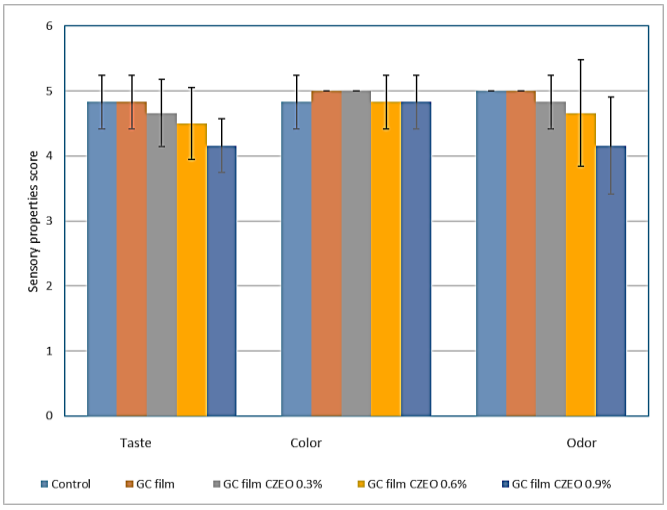

Fig. 7. Sensory properties of chicken meat during refrigerated storage (Gelatin-chitosan (GC) film and Cinnamomum zeylanicum essential oil (CZEO)).

4. Conclusion

Based on the results obtained in the present research, the integration of CZEO into GC film can extend the shelf life of chicken meat in refrigerated conditions for at least 12 days without any unfavorable organoleptic properties.

References:

1. Chouliara E, Karatapanis A, Savvaidis I, Kontominas M. Combined effect of oregano essential oil and modified atmosphere packaging on shelf-life extension of fresh chicken breast meat, stored at 4 C. *Food Microbiology*. 2007;24(6):607-17.
2. Bisht B, Lohani U, Kumar V, Gururani P, Sinhmar R. Edible hydrocolloids as sustainable substitute for non-biodegradable materials. *Critical Reviews in Food Science and Nutrition*. 2022;62(3):693-725.
3. Nanda S, Patra BR, Patel R, Bakos J, Dalai AK. Innovations in applications and prospects of bioplastics and biopolymers: A review. *Environmental Chemistry Letters*. 2021:1-17.
4. Meereboer W, Misra M, Mohanty AK. Review of recent advances in the biodegradability of polyhydroxyalkanoate (PHA) bioplastics and their composites. Green Chemistry. 2020;22(17):5519-58.
5. Roy P, Mohanty AK, Misra M. Microplastics in ecosystems: their implications and mitigation pathways. *Environmental Science: Advances*. 2022;1(1):9-29.
6. Kouhi M, Prabhakaran MP, Ramakrishna S. Edible polymers: An insight into its application in food, biomedicine and cosmetics. *Trends in Food Science & Technology*. 2020;103:248-63.
7. Udayakumar GP, Muthusamy S, Selvaganesh B, Sivarajasekar N, Rambabu K, Banat F, et al. Biopolymers and composites: Properties, characterization and their applications in food, medical and pharmaceutical industries. *Journal of Environmental Chemical Engineering*. 2021;9(4):105322.
8. Díaz-Montes E, Castro-Muñoz R. Trends in chitosan as a primary biopolymer for functional films and coatings manufacture for food and natural products. *Polymers*. 2021;13(5):767.
9. Hematizad I, Khanjari A, Basti AA, Karabagias IK, Noori N, Ghadami F, et al. In vitro antibacterial activity of gelatin-nanochitosan films incorporated with *Zataria multiflora* Boiss essential oil and its influence on microbial, chemical, and sensorial properties of chicken breast meat during refrigerated storage. *Food Packaging and Shelf Life*. 2021;30:100751.
10. Alipal J, Pu'ad NM, Lee T, Nayan N, Sahari N, Basri H, et al. A review of gelatin: Properties, sources, process, applications, and commercialisation. *Materials Today: Proceedings*. 2021;42:240-50.
11. Kavoosi G, Dadfar SMM, Mohammadi Purfard A, Mehrabi R. Antioxidant and antibacterial properties of gelatin films incorporated with carvacrol. *Journal of Food Safety*. 2013;33(4):423-32.
12. Mujtaba M, Morsi RE, Kerch G, Elsabee MZ, Kaya M, Labidi J, et al. Current advancements in chitosan-based film production for food technology; A review. *International Journal of Biological Macromolecules*. 2019;121:889-904.
13. Priyadarshi R, Rhim J-W. Chitosan-based biodegradable functional films for food packaging applications. *Innovative Food Science & Emerging Technologies*. 2020;62:102346.
14. Flórez M, Guerra-Rodríguez E, Cazón P, Vázquez M. Chitosan for food packaging: Recent advances in active and intelligent films. Food Hydrocolloids. 2022;124:107328.
15. Ju J, Chen X, Xie Y, Yu H, Guo Y, Cheng Y, et al. Application of essential oil as a sustained release preparation in food packaging. *Trends in Food Science & Technology*. 2019;92:22-32.
16. Syafiq R, Sapuan S, Zuhri M, Ilyas R, Nazrin A, Sherwani S, et al. Antimicrobial activities of starch-based biopolymers and biocomposites incorporated with plant essential oils: A review. *Polymers*. 2020;12(10):2403.
17. Akhter R, Masoodi F, Wani TA, Rather SA. Functional characterization of biopolymer based composite film: Incorporation of natural essential oils and antimicrobial agents. *International Journal of Biological Macromolecules*. 2019;137:1245-55.
18. El-Hack A, Mohamed E, Alagawany M, Abdel-Moneim A-ME, Mohammed NG, Khafaga AF, et al. Cinnamon (*Cinnamomum zeylanicum*) oil as a potential alternative to antibiotics in poultry. *Antibiotics*. 2020;9(5):210.
19. Shivani AC, Chaudhary P. A Review on the use of Health Benefits of *Cinnamon zeylanicum*. *International Medico-legal Reporter Journal*. 2020;3(1),124-7.
20. Othman ZS, Maskat MY, Hassan NH. Optimization of Cinnamaldehyde extraction and antioxidant activity of Ceylon cinnamon extract. *Sains Malaysiana*. 2020;49(5):995-1002.
21. Talebi F, Misaghi A, Khanjari A, Kamkar A, Gandomi H, Rezaeigolestani M. Incorporation of spice essential oils into poly-lactic acid film matrix with the aim of extending microbiological and sensorial shelf life of ground beef. *LWT - Food Science and Technology*. 2018;96:482-90.
22. Bagheri R, Izadi Amoli R, Tabari Shahndasht N, Shahosseini SR. Comparing the effect of encapsulated and unencapsulated fennel extracts on the shelf life of minced common kilka (*Clupeonella cultriventris caspia*) and Pseudomonas aeruginosa inoculated in the mince. *Food Science & Nutritio*n. 2016;4(2):216-22.
23. Yildiz E, Sumnu G, Kahyaoglu LN. Monitoring freshness of chicken breast by using natural halochromic curcumin loaded chitosan/PEO nanofibers as an intelligent package. *International Journal of Biological Macromolecules*. 2021;170:437-46.
24. Yu T, Yao H, Qi S, Wang J. GC-MS analysis of volatiles in cinnamon essential oil extracted by different methods. *Grasas y Aceites*. 2020;71(3):e372-e.
25. Boito JP, Da Silva AS, dos Reis JH, Santos DS, Gebert RR, Biazus AH, et al. Insecticidal and repellent effect of cinnamon oil on flies associated with livestock. *Revista MVZ Córdob*a. 2018;23(2):6628-36.
26. Raeisi M, Tabaraei A, Hashemi M, Behnampour N. Effect of sodium alginate coating incorporated with nisin, *Cinnamomum zeylanicum*, and rosemary essential oils on microbial quality of chicken meat and fate of Listeria monocytogenes during refrigeration. *International Journal of Food Microbiology*. 2016;238:139-45.
27. Smaoui S, Hlima HB, Tavares L, Ennouri K, Braiek OB, Mellouli L, et al. Application of essential oils in meat packaging: A systemic review of recent literature. *Food Control*. 2022;132:108566.
28. Takma DK, Korel F. Active packaging films as a carrier of black cumin essential oil: Development and effect on quality and shelf-life of chicken breast meat. *Food Packaging and Shelf Life*. 2019;19:210-7.
29. Melo AAMd, Geraldine RM, Silveira MFA, Torres MCL, Fernandes TH, Oliveira ANd. Microbiological quality and other characteristics of refrigerated chicken meat in contact with cellulose acetate-based film incorporated with rosemary essential oil. *Brazilian Journal of Microbiology*. 2012;43:1419-27.
30. Kamkar A, Molaee-Aghaee E, Khanjari A, Akhondzadeh-Basti A, Noudoost B, Shariatifar N, et al. Nanocomposite active packaging based on chitosan biopolymer loaded with nano-liposomal essential oil: Its characterizations and effects on microbial, and chemical properties of refrigerated chicken breast fillet. *International Journal of Food Microbiology*. 2021;342:109071.
31. Babolanimogadam N, Khanjari A, Akhondzadeh Basti A, Sajjadi Alhashem SH, Teimourifard R, Amiri F. Effect of chitosan coating contain Ajwain essential oil on the shelf-life of chicken breast meat during refrigerated condition. *Food & Health*. 2020;3(2),20-4.
32. Fernández-Pan I, Mendoza M, Maté JI. Whey protein isolate edible films with essential oils incorporated to improve the microbial quality of poultry. *Journal of the Science of Food and Agriculture*. 2013;93(12):2986-94.
33. Sharafati Chaleshtori F, Taghizadeh M, Rafieian-kopaei M, Sharafati-chaleshtori R. Effect of chitosan incorporated with cumin and eucalyptus essential oils as antimicrobial agents on fresh chicken meat. *Journal of Food Processing and Preservation*. 2016;40(3):396-404.
34. Emiroğlu ZK, Yemiş GP, Coşkun BK, Candoğan K. Antimicrobial activity of soy edible films incorporated with thyme and oregano essential oils on fresh ground beef patties. *Meat Science*. 2010;86(2):283-8.
35. Sani MA, Ehsani A, Hashemi M. Whey protein isolate/cellulose nanofibre/TiO2 nanoparticle/rosemary essential oil nanocomposite film: Its effect on microbial and sensory quality of lamb meat and growth of common foodborne pathogenic bacteria during refrigeration. *International Journal of Food Microbiology*. 2017;251:8-14.
36. Sayadi M, Mojaddar Langroodi A, Amiri S, Radi M. Effect of nanocomposite alginate-based film incorporated with cumin essential oil and TiO2 nanoparticles on chemical, microbial, and sensory properties of fresh meat/beef. *Food Science & Nutrition*. 2022;10(5):1401-13.
37. Dong Z, Xu F, Ahmed I, Li Z, Lin H. Characterization and preservation performance of active polyethylene films containing rosemary and cinnamon essential oils for Pacific white shrimp packaging. *Food Control*. 2018;92:37-46.
38. Hu J, Xu Y, Majura JJ, Qiu Y, Ding J, Hatab S, et al. Combined effect of the essential oil and collagen film on the quality of pacific mackerel

(*Pneumatophorus japonicus*) fillet during cold storage. *Foodborne Pathogens and Disease*. 2021;18(7):455-61.
39. Shavisi N, Khanjari A, Basti AA, Misaghi A, Shahbazi Y. Effect of PLA films containing propolis ethanolic extract, cellulose nanoparticle and *Ziziphora clinopodioides* essential oil on chemical, microbial and sensory properties of minced beef. *Meat Science*. 2017;124:95-104.