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Evaluation of Chemical and Microbial Spoilage of Chicken Fillet Coated with Chitosan, Ginger Essential Oil (*Zingiber officinale*) and Medlar concentrate (*Mespilus germanica* L.) during refrigerated storage

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Abstract

Lipid oxidation and microbial growth are the most important factors affecting the quality and corrosivity of the meat in refrigerated storage conditions. In this study, the effect of using chitosan, Medlar concentrate, ginger essential oil alone and in combination with each other on improving the quality and shelf life of chicken meat kept in the refrigerator was investigated.8 groups in this study during 12 days were stored at refrigerator and Microbial (aerobic mesophilic & Psychotrophic Plate count) and chemical (PV, TBA, TVB-N) and. sensory parameters were measured at days 0, 4, 8 and 12. Total phenol and reducing power tests were also performed to evaluate the antioxidant properties .Based on the results of GC/MS, the major compounds of ginger essential oil were α-Zingiberene (36.54%), β-Sesquiphellandrene (16.45%) and trans-γ-Cadinene (10.27%) were formed. The results of this study showed that the chitosan-coated treatment containing 2% ginger essential oil and medlar concentrate, decreased the microbial parameters significantly (P<0.05) as compared to control group during the storage period (P<0.05).the oxidation indices of chicken meat samples had significantly fewer changes (P<0.05), had the strongest antioxidant and sensory effect on other groups during storage. The results of microbiological, chemical and sensory analysis of this study showed that the effect of chitosan coating containing 2%ginger essential oil and medlar concentrate was effective in increasing the shelf life and quality of chicken meat for 12 days during storage in the refrigerated condition.

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Keywords
Chicken fillet
Chitosan coating
Ginger essential oils
Medlar concentrate
Spoilage

Introduction

Long-term storage of meat in the refrigerator leads to undesirable changes such as oxidation and hydrolysis of fats. These changes are due to enzymatic, chemical, and microbial activities that lead to low quality and product corruption (Fan *et al*., 2009). For this purpose, the use of edible coatings with natural origins with or without antimicrobial and antioxidant compounds is an effective method to maintain quality of meats such as chicken, fish, etc. (Rahnemoon, Sarabi Jamab, Javanmard Dakheli, & Bostan, 2018; Vásconez, Flores, Campos, Alvarado, & Gerschenson, 2009). Chitosan is among

edible polysaccharide coatings resulted from chitin of hard shells such as crabs and shrimp that has antioxidant and antimicrobial and antifungal properties (Fan *et al*., 2009; Sathivel, 2005) and is has many applications in food industry to cover fruits and vegetables (Jianglian & Shaoying, 2013), different kinds of meat (Gennadios, Hanna, & Kurth, 1997), egg (Kim, Daeschel, & Zhao, 2008), and cheese (Duan, Park, Daeschel, & Zhao, 2007; Kanatt, Chander, & Sharma, 2008). Bazargani-Gilani, Aliakbarlu, & Tajik (2015) showed that the use of pomegranate extract and chitosan coating enriched by thyme oil increases chicken mean shelf life, decreases peroxide index, TBARs, and protein oxidation in treatment samples (Bazargani-Gilani *et al*., 2015).

Nowadays, the use of herbal ingredients and extracts instead of synthetic materials has been very popular. The use of natural materials such as extracts and concentrates that create desirable odor and taste in food that have antioxidant properties is increasing (Hosseini, Razavi, & Mousavi, 2009). Common medlar is found in Iran and is available in late autumn and is used in traditional medicine for different aspects such as neurons, mouth ulcers, bowel diseases, gastric ulcer, constipation treatment, etc. (Nabavi, Nabavi, Ebrahimzadeh, & Asgarirad, 2011). Also, it is reported that this fruit has antimicrobial and antioxidant properties (Qin, Kang, Zhang, Qi, & Wang, 2012). Cushnie & Lamb (2005) reported that common medlar has antimicrobial properties due to the existence of organic acids such as gallic acid as well as the presence of phenolic compounds (Cushnie & Lamb, 2005). Mamashloo, Sadeghi, Ghorbani, Alami, & Khomeiri (2012) reported antioxidant activity (80%) fir common medlar (1 mg/mL) (Mamashloo *et al*., 2012).

Zingiber (*Zingiberene officinale Rosc*) is mainly cultivated in Eastern Asia and tropical regions. Zingiber is used in bakery products, spices, pickles, and sauces to create taste (Singh *et al*., 2008). Also, it is used in traditional medicine to treat diseases such as cough, sinusitis, sore throat, fever, and influenza (Şener *et al*., 2017). The antimicrobial and antifungal properties of Zingiber are reported in various studies (Şener *et al*., 2017; Sharma, Singh, & Ali, 2016; Singh *et al*., 2008). The objective of this study was to investigate the antioxidant and antimicrobial effects of chitosan, common medal extract, and Zingiber extract (2%) on chicken meat in refrigerator to increase storage time.

Materials and methods

Preparation of concentrate and essential oil

Zingiber oil was prepared from Exir Gole Sorkh in Mashhad and common medlar concentrate was prepared from the local market in Amol. Identification and analysis of Zingiber coumpounds were performed by GC-MS (Thermoquest Trace GC 2000 Finnigan, England). All chemicals were bought from Sigma and Merck companies.

Preparation of coating and concentrate

To prepare chitosan solution, first, acetic acid solution 1% volume was prepared (Lungu & Johnson, 2005) and then, chitosan solution 2% w/v was prepared. After complete dissolution (for a night under room temperature on magnetic stirrer), glycerol 75% was added to the solution (Lungu & Johnson, 2005) and tween 80, 0.25% (v/v) was added as emulsifier and mixed on stirrer for 30 min under room temperature (pH around 5.8) and after solution homogenization, to ensure complete dissolution of chitosan and glycerol, the solution was mixed for 15 min under a temperature of 45 °C (Lungu & Johnson, 2005). Finally, Zingiber oil 2% was added to suspension and the final suspension was homogenized with stirrer for 10 min (Yingyuad *et al*., 2006). Also, common medlar concentrate was diluted by adding distilled water and Brix 1.39 was prepared by Calze ophthalmic refract meter.

Preparation of chicken fillet and coating the samples

Fresh chicken meat was prepared the market and transferred to the laboratory and filled was prepared from it. All fillets were washed with distilled water and placed on sterile dewatering mesh and coated for treatment in the prepared solutions through immersion. After drying, samples were packed in a zip and stored in the refrigerator with a temperature of 4 °C. Eight treatment groups including the control sample, butylated hydroxyl toluene (BHT) sample (positive control), sample with chitosan coating, sample with Zingiber oil 02%, sample with chitosan coating and Zingiber oil 2%, sample with common medlar concentrate, chitosan coating sample with common medlar concentrate, and chitosan coating sample with Zingiber oil 2%, and common medlar concentrate were exposed to chemical and sensory tests in days 0, 4, 8, and 12.

Chemical tests

Measurement of total phenol concentration of common medlar

In order to examine phenolic compounds, the Folin-Ciocalteu method was used in which Folin-Ciocalteu is the reagent and gallic acid is the standard. Common medlar concentrate was dissolved in 2 mL (1400 μL of ethanol+600 μL of water) and then, distilled water, Folin-Ciocalteu reagent, and sodium carbonate were added to 500 μL of concentrate and after 2 h, optical absorption was measured by Pharmacia (LKB, Novaspec, England) at the wavelength of 730 nm (Teets & Were, 2008).

Assessment of reducing power (RP)

To carry out this test, 2.5 mL of sodium phosphate buffer and 2.5 mL of potassium ferric cyanide 1% were added to 0.03 g of the sample and they were exposed to a temperature of 50 °C for 20 min. Then, 2.5 mL of trichloroacetic acid solution 10% was added to the pipes and it was centrifuged. After that, 2.5 mL of the supernatant was mixed with 2.5 mL of distilled water and 0.5 mL of ferric chloride 0.1% and after 10 min, it was read at the wavelength of 700 nm (Huang *et al*., 2011).

Determination of peroxide value (PV)

For Peroxide Value (PV), fat extraction is carried out. For this purpose, 150 g of chicken fillet was homogenized adding 250 mL of chloroform with homogenizer (IKA, Germany) and was filtered and for dehydration, it was filtered by another filter that contained dry sodium sulfate. Finally, it was placed in Oven 105 °C to be dried (Pearson, 1976). To carry out peroxide test, 0.3 g of fat was mixed with 9.8 mL of chloroform-methanol; then, 0.05 mL of ammonium thio cyanate, 0.05 mL of iron chloride solution II was added to the tubes. After storage for 5 min under the room temperature, optical absorption 500 nm was read. By using the following relationship, peroxide as mEq peroxide in kg/oil was estimated.

$$\text{Peroxide Value} = (As - Ab) \times m / 55.84 \times m_0 \quad (1)$$

Where As: sample absorption, Ab: blank absorption, m: calibration curve slop, m_0: sample weight based on g, and iron atomic weight is 55.84 (Shantha & Decker, 1994).

Measurement of thiobarbituric acid (TBA)

In order to measure oxidation in samples, TBA index was carried out using (Wrolstad *et al*., 2005). Here, 10 g of the sample was homogenized adding 1 mL of BHT 0.1% and 20 mL of trichloroacetic acid 5%. The mixture was filtered with Watman filter paper 42 and using trichloroacetic acid, it reached 50 mL. 5 mL of the filtered fluid was added to 5 mL of thiobarbituric acid 0.02 molar. Then, it was exposed to Bonnie Marie 100 °C for 1 h. After cooling, optical absorption was read at the wavelength of 532 nm using

spectrophotometer. Blank included 5 mL of distilled water and 5 mL of thiobarbituric acid (Wrolstad *et al*., 2005).

Measurement of total volatile basic nitrogen (TVB-N)

To measure TVB-N, first, 10 g of chicken fillet was mixed with 10 mL of distilled water and poured into balloon containing 2 g of magnesium oxide and 300 mL of distilled water. At the steam outlet, a container containing 3% of boric acid and several drops of methyl red reagent was placed. In the end, titration was carried out with sulfuric acid 5%. Volatile bases are expressed based on mL nitrogen per 100 g of meat (Jeon, Kamil, & Shahidi, 2002).

Microbial tests

For microbial assessment, in days 1, 4, 8, and 12, 25 g of each treatment was selected for microbial test homogenized with 225 mL of peptone water 0.1% with 200 rpm for 1 min. Then, other dilutions were prepared. Aerobic mesophilic bacteria and cryogenic bacteria were counted in agar plate with incubation for 48 h/37 °C and for 10 days under 7 °C (Shavisi, Khanjari, Basti, Misaghi, & Shahbazi, 2017).

Sensory assessment

Examination of qualitative properties by performed by 10 trained experts and the samples were scored from 0 to 9. The results were expressed by 9-point hedonic scale. The assessment was based on total acceptability (color, odor and texture). Nine was the highest score and 0 was the lowest score and scores below 6 were unacceptable (Goulas & Kontominas, 2005).

Data analysis method

First, Kolmogorov-Smirnov test was used to examine data normality with three replications and Levene test was used to examine variance equality. Then, samples were analyzed by one way ANOVA and SPSS 20. A significant difference between samples was determined using Duncan test and the significance level was (P>0.05). Kruskal-Wallis nonparametric test was carried out to determine the effect of storage time on the results. All tests were carried out with three replications.

Results and discussion

Zingiber essential oil compounds

According to the results of essential oil analysis, 26 compounds in 96.42% of Zingiber were specified. The major compounds of Zingiber essential oil are Alpha zinjiberm 36.54%, Beta Sesqui phellandrene 16.45%, and trans gamakaddine 10.27% (Table 1).

Amiri, Mohamadi, Saadatmand, & Taheri (2016) analyzed chemical compounds of using GC-MS and the main compounds included alpha-Zingiberene 28.25%, Beta-sesquiphellandrene 15.65%, alpha-curcumine 15.23%, and trans gama cadinene 11.88% and the main compounds of Indian Zingiber are alpha-Zingiberene 35.67%, Beta-sesquiphellandrene 15.27%, trans gama cadinene 9.25%, and E-Citral 0.06% (Amiri *et al*., 2016), consistent with the findings of this study, introduced alpha-Zingiberene, Camphene, Curcumene and Beta-sesquiphellandrene as the main compounds of the essential oil (Burt, 2004; Singh, Maurya, Catalan, & De Lampasona, 2005).

By comparing the main compounds of Zingiberene essential oil in various studies, it is observed that there are differences in rate and main compounds of Zingiberene constituents that can be due to geographical differences, plant type, harvesting time, environmental conditions, cooling method, and essential oil preparation that lead to difference in rate and type of compounds.

Table 1. The results of Zingiberene essential oil analysis

Row	Compound	Detention time	Rate	Detention index
1	Camphene	4.67	0.40	949
2	Linalool	8.11	1.20	1100
3	Borneol	9.91	4.49	1172
4	Alpha terpineol	10.52	0.11	1196
5	Z- citral	11.80	0.20	1244
6	E- citral	12.57	1.66	1273
7	2-Undecanone	13.12	0.51	1294
8	Beta caryophyllene	16.48	0.73	1425
9	Alpha Curcumene	18.10	4.40	1489
10	beta Selinene	18.16	1.70	1491
11	Alpha Zingiberene	18.37	36.54	1500
12	Cis gamma cadinene	18.40	3.30	1505
13	Trans gamma cadinene	18.70	10.27	1513
14	Zonarene	18.83	0.60	1519
15	Beta Sesquiphellandrene	19.13	16.45	1532
16	Trans gamma Bisabolene	19.24	0.17	1537
17	Zeta nerolidol	19.69	0.12	1556
18	Spatulenol	19.91	4.10	1557
19	Tumerol	20.30	0.33	1583
20	Alpha Cedrol	20.51	0.50	1594
21	10-epi gamma Eudesmol	21.10	1.03	1618
22	Gamma Eudesmol	21.31	1.43	1627
23	Hinesol	21.49	1.10	1635
24	Beta Eudesmol	22.40	2.90	1659
25	Alpha Bisabolol	22.36	0.60	1674
26	Nuciferal	22.97	1.50	1702
27	Cuparophenol	24.11	0.86	1775
28	Benzyl salicylate	26.20	0.15	1877
29	Shogaol	34.35	0.20	2298
	Total		96.42	

Assessment of phenolic compounds of common medlar

Total phenol in common medlar concentrate is 1.220±0.25 mg of gallic acid in 1 g of concentrate. In a study by (Mamashloo *et al*., 2012), phenolic compounds of common medlar were investigated. Total phenol in Estonia extract (7.437), methanol extract (5.086), ethanol extract (4.106), and aqueous extract (1.240) are reported for 100 g of the dry matter (Mamashloo *et al*., 2012).

RP results

Reducing Power (RP) test is according to the ability of phenol compounds in converting Fe^{3+} to Fe^{2+} that according to the results, the yellow color changes to green and blue and optical absorption increases (Roginsky & Lissi, 2005). In this test, RP power, from maximum to minimum level, is related to chitosan coating containing Zingiberene 2% and common medlar concentrate, chitosan coating with common medlar concentrate, chitosan coating containing Zingiber 2%, Zingiber essential oil 2%, common medlar concentrate, chitosan coating, BHT, and the control sample (Fig. 1). RP of chitosan coating contains essential oil 2% and common medlar concentrate that is significantly higher than other samples and the control sample and BHT (P<0.05). Chitosan coating RP with BHT is reported at a stable level and no significant difference was observed (P>0.05). (Mamashloo *et al*., 2012) assessed RP power of various concentrations of common medlar concentrations and the results showed that with increased concentration, RP power of the extracts increased (Mamashloo *et al*., 2012). This is consistent with RP power assessment of various concentrations in our study and the desirable effect of employing chitosan in combination with the essential oil and concentrate of common medlar. The desirable effect of employing chitosan is consistent in combination with the essential oil and concentrate of common medlar.

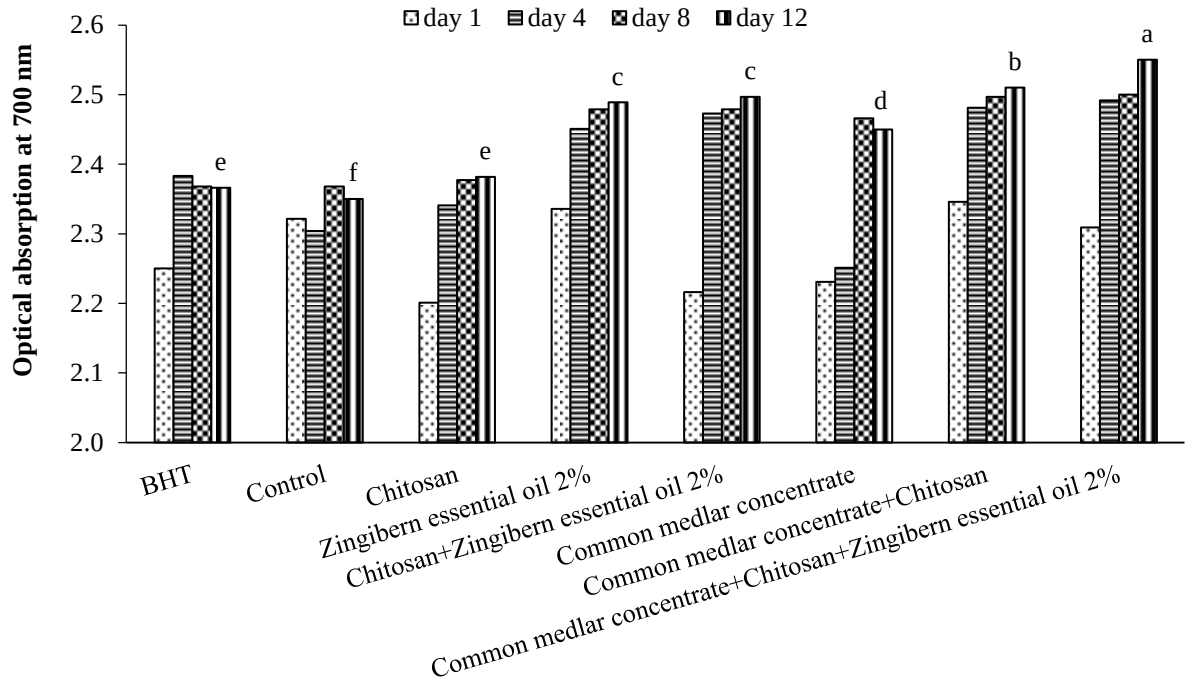

Fig. 1. The RP power of various treatments in chicken breast fillet stored at 4 °C
*Different lowercase letters (a, b, c) in each chart indicate a significant difference (P<0.05) in various treatments.

Investigating PV index changes

Fat oxidation is a major problem in meat that leads to undesirable odor and taste. Peroxides in the first oxidation level are formed through binding of oxygen to the double bond of unsaturated fatty acids. For this reason, primary fat oxidation is assessed measuring peroxide rate (Kanatt *et al*., 2008). The measured rates of peroxide index are shown in Fig. (2). The control sample has the highest peroxide index and shows a significant difference from other treatments (P<0.05). In the last day of storage, the highest rate of peroxide index was observed in control samples and reached to 2.4 mEq/kg and the lowest peroxide rate was reported for the sample coated with chitosan containing Zingiber essential oil 2% and common medlar concentrate and this rate is due to this condition that the treatment has high amounts of antioxidant materials, especially phenolic materials in common medlar concentrate. The difference between the measured peroxide index for chitosan coated samples and essential oil and samples with concentrate and essential oil 2% was statistically justifiable (P<0.05). Molaee Aghaee, Kamkar, Akhondzadeh Basti, Khanjari, & Kontominas (2015) investigated the effect of packaging with biodegradable chitosan films and formulated with *Sllium sativum* L. on chemical properties of chicken fillet in 14 days and the results showed that PV values in control samples were higher and this difference was significant (P<0.05). Also, in the 10th day, PV values in all samples increased significantly and continued until the last day. However, in samples containing the highest extract level of 2% this process advanced with slightest slop. In the end, the lowest peroxide value was observed for samples with film 1% (Molaee Aghaee *et al*., 2015).

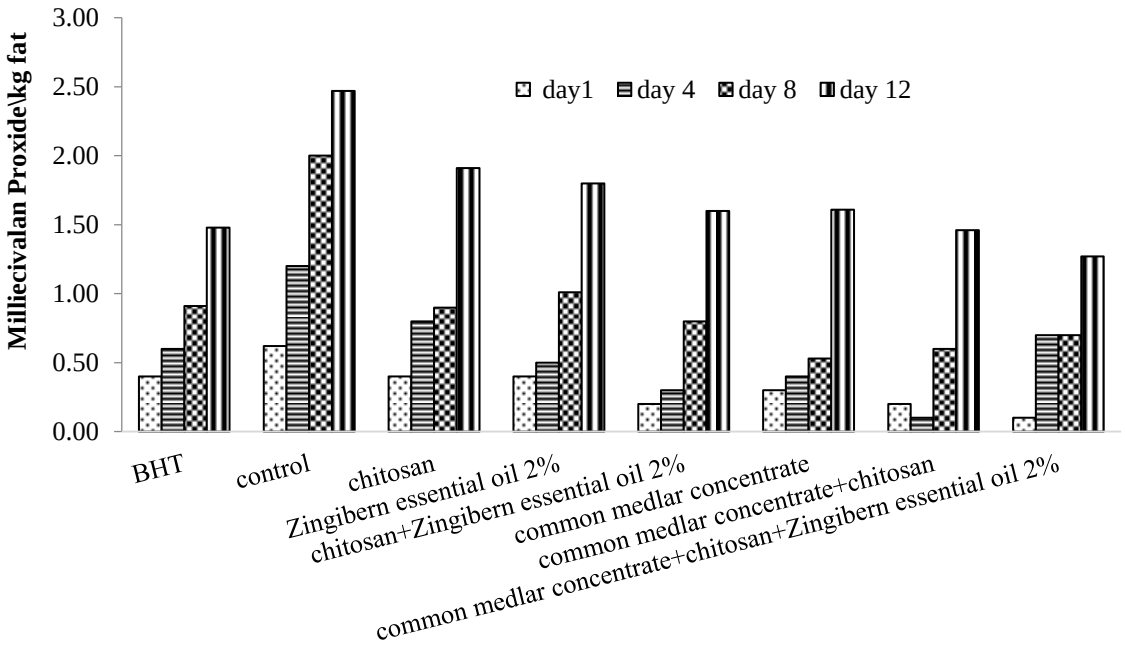

Fig. 2. Peroxide changes (PV) in various treatments of chicken breast fillet stored at 4 °C
*Different lowercase letters (a, b, c) in each chart indicate a significant difference (P<0.05) in various treatments.

Investigating TBA index changes

Fat oxidation in meat causes compounds such as aldehyde and ketones that lead to change in taste and decreased nutritional value. Thiobarbituric acid is used to indicate secondary fat oxidation (Radha krishnan *et al*., 2014). According to the results, with increased storage time, TBA in various samples increases that the highest level is observed in 12 days for the control group while this index in the coated samples was significantly lower than the control samples (P<0.05) and the lowest level was related to chicken fillet coated with chitosan containing Zingiber 2% and common medlar concentrate that can be related to the antioxidant property and PV ability of Zingiber and common medlar concentrate and chitosan coating in reducing meat oxidation (Fig. 3). TBA index difference in the coated samples was not significant (P>0.05) and this difference was observed between chitosan, extract/chitosan, and concentrate and no significant difference was observed between other treatments (P>0.05). TBA index has a wide use to assess fat oxidation degree. With this index, Malondialdehyde is measured. The allowed rate for TBA index is 2 mg of Malondialdehyde/g (Byun *et al*., 2003; Teets & Were, 2008). In the current study, this index did not go beyond the determined range. Radha krishnan *et al*. (2014) investigated the effect of different extracts on the storage of chicken meat and reported that increased thiobarbituric acid in samples containing various extracts was significantly weaker than the control group (Radha krishnan *et al*., 2014) and this is consistent with our studies. Various studies such as Fazlara, Pourmahdi, Zarei, & Karimi (2017) and Petrou, Tsiraki, Giatrakou, & Savvaidis (2012) investigated the effect of chitosan coating, essential oil, and extracts on decreased TBA relative to the control group (Fazlara *et al*., 2017; Petrou *et al*., 2012).

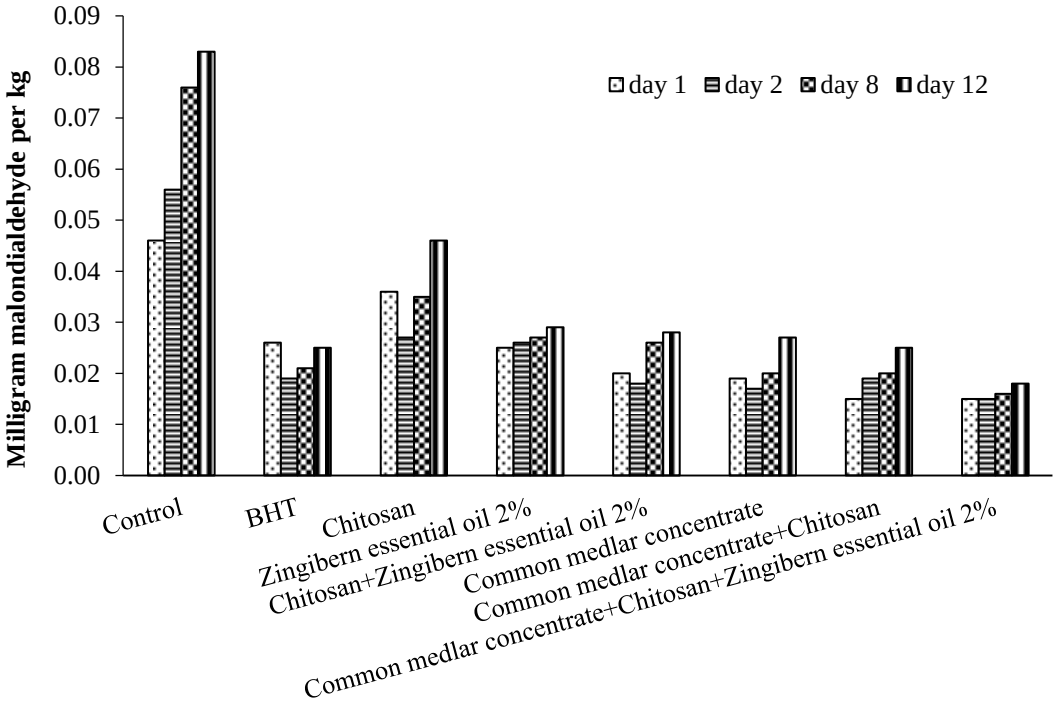

Fig. 3. Thiobarbituric acid changes in various treatments of chicken breast fillet stored at 4 °C
*Different lowercase letters (a, b, c) in each chart indicate a significant difference (P<0.05) in various treatments.

Investigating TV-N index changes

In terms of TVB-N changes over the storage period, the highest TVN rate was observed in the control samples and the obtained difference with other treatments was significant (P<0.05), so that the control sample after 8 days became inconsumable in terms of TVB-N index. However, the coated samples were consumable until the end of the storage period (Fig. 4).

As can be seen in the figure, after storage in refrigerator for 12 days, the measured values for all treatments except the control sample were lower than 20 mg/100 g that are acceptable. Also, chitosan is lower than 25 mg/100 g and still is within the acceptable range. The acceptance range for chicken meat is 25 mg/100 g. The lowest TVB-N value was observed in chitosan coated samples containing Zingibern 2% and common medlar that is lower than other samples that is surely due to the antioxidant effect of the extracts and the protective effect of chitosan coating. TVB-N is used to assess bacterial corruption and enzymatic activity and usually includes materials resulted from bacterial corruption and is used as an index to assess the products. Ranjbaryan, Rezazadeh Bari, Almasi, & Amiri (2017) investigated the effect of sodium caseinate coating containing cinnamon essential oil on increased shelf life of chicken breast fillet for 12 days in refrigerator. The results showed that over time, in all treatments, TVN has a significant increasing trend (P<0.05) (Ranjbaryan *et al.*, 2017).

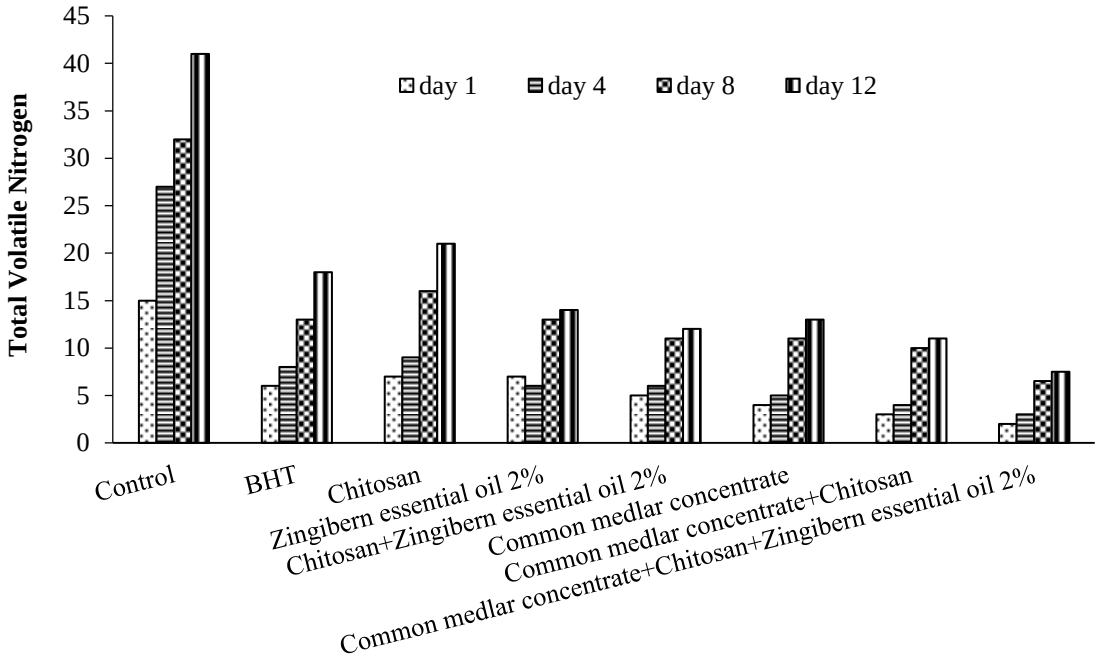

Fig. 4. Total volatile nitrogen bases changes in different chicken breast fillets stored in refrigerator (4±1 °C)
*Different lowercase letters (a, b, c) in each chart indicate a significant difference (P<0.05) in various treatments.

Among the treatments, TVN rate during storage periods in treatments with coating and essential oil was lower than other treatments that is due to the strong antibacterial property of cinnamon. Hakim, Fazlara, & Tadayoni (2017) reported that chitosan containing mountainous essential oil could reduce TVB-N rate in chicken meat significantly (P<0.05), so that the control sample became corrupted in 9 days, but chitosan coated sample containing mountainous essential oil in 15 days became corrupted (Hakim *et al*., 2017) and this is consistent with our results. Also, due to low pH of common medlar concentrate in treatments, bacterial growth reached to the minimum level and this led to enhanced quality of treatments over the storage period.

Investigating microbiological properties

The means of aerobic mesophilic bacteria and cryophilic bacteria over the storage period are presented in Table (2). Generally, over the storage period in refrigerator, microbial flora significantly increased in all samples (P<0.05) and this increase was higher in the control sample. Over the storage period, aerobic mesophilic bacteria number after 8 days reached to 7 log cfu/g while in other treatments, after 12 days, it reached to 6.75 log cfu/g. BHT and Zingiber essential oil 2% showed to significant antimicrobial effect (P>0.05). The minimum increase was observed in chitosan + essential oil 2% + common medlar concentrate that after 12 days reached to 4.1 log and showed the maximum antimicrobial effect. About cryophilic bacteria, after 12 days, the control bacteria were higher than 8 log while the highest decrease was related to chitosan+essential oil 2%+common medlar concentrate that after 12 days, this index reached to 4.32 log. The minimum rate was related to chitosan, BHT, essential oil 2% and chitosan + essential oil 2% and no significant difference was observed.

Table 2. Aerobic mesophilic bacteria and cryophilic bacteria logarithm (Log cfu /g) in various chicken fillet treatments over the storage period

Microbial tests	Treatments	Test days			
		0	4	8	12
Aerobic mesophilic bacteria	Control	3.45±0.23	4.23±0.50	7.00±0.21	-
	BHT	3.34±0.40	3.21±0.50	5.10±0.02	6.78±0.14^{A*}
	Chitosan	3.22±0.56	3.75±0.01	5.50±0.13	6.27±0.02^{B}
	Zingiber essential oil 2%	3.10±0.14	3.55±0.62	5.60±0.12	6.46±0.04^{A}
	Chitosan+Zingiber essential oil 2%	2.90±0.20	3.20±0.15	5.10±0.07	6.20±0.09^{B}
	Common medlar concentrate	2.70±0.06	3.10±0.14	4.80±0.12	5.60±0.10^{C}
	Chitosan+common medlar concentrate	3.20±0.13	2.80±0.20	3.90±0.11	4.80±0.30^{C}
	Chitosan+common medlar concentrate+Zingiber oil 2%	2.03±0.10	2.22±0.10	3.10±0.02	4.10±0.01^{D}
Cryophilic bacteria	Control	4.20±0.02	4.26±0.22	6.12±0.32	8.10±0.01^{A}
	BHT	3.90±0.21	4.21±0.12	4.90±0.56	6.92±0.02^{B}
	Chitosan	4.20±0.02	4.76±0.21	5.02±0.82	7.20±0.11^{B}
	Zingiber essential oil 2%	4.00±0.01	4.20±0.74	5.20±0.12	7.30±0.20^{B}
	Chitosan+Zingiber essential oil 2%	4.10±0.23	4.25±0.45	5.00±0.09	7.10±0.30^{B}
	Common medlar concentrate	3.20±0.12	3.90±0.52	4.20±0.02	5.02±0.10^{C}
	Chitosan+common medlar concentrate	2.65±0.16	3.20±0.25	3.85±0.22	4.90±0.02^{C}
	Chitosan+common medlar concentrate+Zingiber oil 2%	2.20±0.12	2.82±0.16	3.52±0.23	4.32±0.31^{D}

* Upper cases (A, B, C) in each column show a significant difference (P<0.05) in different treatments.

Bacterial counting results are consistent with Duan, Cherian, & Zhao (2010) who reported that using chitosan coating, aerobic mesophilic and cryophilic bacteria decrease significantly over the storage period (Duan *et al*., 2010). Yingyuad *et al*., 2006) obtained similar results in using chitosan coating 2% in pork (Yingyuad *et al*., 2006). The results of this study are consistent with Yingyuad *et al*. (2006) and Fan *et al*. (2009) who showed that the use of chitosan coating in mean samples decreases pH relative to the control samples that is due to acidic chitosan coating on meat and its microbial growth inhibition properties (Fan *et al*., 2009; Yingyuad *et al*., 2006). In this study, employing common medlar concentrate that naturally has organic acids and phenolic compounds, the antimicrobial effects are enhanced. The antimicrobial activity mechanism of common medlar concentrate, in addition to reducing pH, leads to phenolic compounds reaction with microbial cells membrane protein and inhibition of glycosyltransferases that finally leads to microbial cell membrane decomposition (Ismail, Sestili, & Akhtar, 2012).

Assessment of sensory index

Sensory assessment scores showed a considerable decrease in all samples until the end of the storage period (Fig. 5). In chicken samples, sensory scores above 10 were acceptable for consumption. In this assessment, the control sample received lower scores than other treatments. Also, composite treatments showed higher acceptability than other treatments, so that until the 12th day, they were acceptable for the panel members while the control sample, was unacceptable on the 8th day and the sample with chitosan coating containing Zingber essential oil 2% and common medlar concentrate received the highest scores on the last day. Generally, samples containing chitosan coating and common medlar concentrate and essential oil, in addition to chemical tests, were effective in sensory tests compared with other treatments in maintaining chicken breast fillet quality. In a study by (Latou, Mexis, Badeka, Kontakos, & Kontominas, 2014), chicken fillets coated with chitosan with packaging in the modified atmosphere, could be acceptable until the 14th day in terms of sensory index while the control sample lost its acceptability after 5 days (Latou *et al*., 2014).

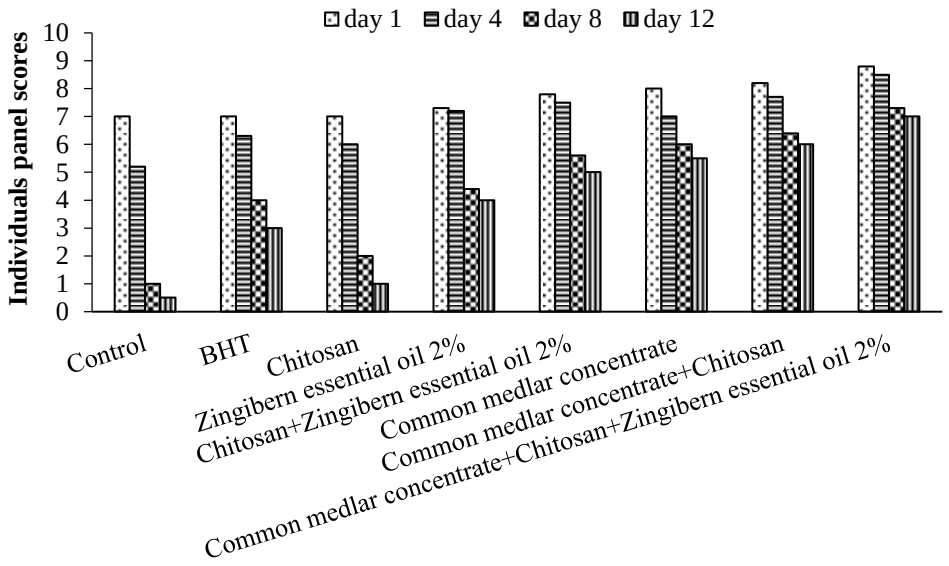

Fig. 5. Sensory score changes in terms of total acceptability in various chicken breast fillet treatments stored in the refrigerator
*Different lowercase letters (a, b, c) in each chart indicate a significant difference (P<0.05) in various treatments.

Conclusions

According to the results of this study, it was specified that simultaneous use of common medlar concentrate, chitosan with Zingiber extract 2% increases shelf life of chicken fillet for 12 days compared with the treatments without coating. Therefore, with more studies, these coatings can be used in food industry and the related sciences for optimal use of plant compounds and other effective compounds and replace them with chemical preservatives.

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ارزیابی فساد شیمیایی و میکروبی فیلۀ مرغ پوشش‌داده‌شده با کیتوزان، اسانس زنجبیل و کنسانترۀ ازگیل، طی نگهداری در دمای یخچال

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چکیده

اکسیداسیون لیپیدها و رشد میکروبی ازجمله عوامل مؤثر بر خصوصیات کیفی و فسادپذیری گوشت در طی نگهداری است. در این مطالعه به‌کارگیری پوشش خوراکی کیتوزان، کنسانترۀ ازگیل، اسانس زنجبیل به تنهایی و در ترکیب با یکدیگر برکاهش فساد شیمیایی و افزایش زمان ماندگاری گوشت مرغ نگهداری‌شده در دمای یخچال موردبررسی قرارگرفت. ۸ گروه موردبررسی طی یک دورۀ ۱۲ روزه در دمای یخچال نگهداری‌شده و ازنظر شاخص‌های شیمیایی اکسیداسیون اولیه (PV) ، ثانویه (TBA) و شاخص بازهای فرار (TVB-N) و میکروبیولوژیکی (شمارش باکتری‌های مزوفیل هوازی و سرمادوست)، ارزیابی حسی در روزهای صفر، ۴، ۸ و ۱۲ موردبررسی قرار گرفتند. تست توتال فنل و قدرت احیاکنندگی نیز به‌منظور بررسی خواص ضداکسایشی انجام گردید. براساس نتایج حاصل از دستگاه گاز کروماتوگراف-طیف‌سنج جرمی (GC-MS) ترکیبات اسانس زنجبیل آلفا-زینجیبرن (۳۶/۵۴ درصد)، بتا-سسکوایفلاندرن (۱۶/۴۵ درصد) و ترانس-گاما-کادینن (۱۰/۲۷ درصد) بودند. نتایج نشان داد که در تیمارهای پوشش‌داده‌شده با کیتوزان حاوی اسانس زنجبیل ۲ درصد و کنسانترۀ ازگیل شمارش شاخص‌های میکروبی ذکرشده در مقایسه با گروه کنترل به‌صورت معنی‌داری کاهش یافت ($P<۰/۰۵$) و شاخص‌های اکسیداسیون در مدت زمان نگهداری، تغییرات کمتری داشته و با اختلاف معنی‌دار ($P<۰/۰۵$)، قوی‌ترین اثر ضداکسایشی و حسی نسبت به سایر گروه‌ها را به خود اختصاص داد. نتایج میکروبیولوژیکی، شیمیایی و حسی این مطالعه نشان داد که اثر پوشش کیتوزان همراه با کنسانترۀ ازگیل و اسانس ۲ درصد باعث حفظ کیفیت و افزایش ماندگاری به مدت ۱۲ روز در در شرایط یخچالی شد.

واژه‌های کلیدی: اسانس زنجبیل، پوشش کیتوزان، فساد، فیلۀ مرغ، کنسانترۀ ازگیل