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Original scientific paper

Innovative coating approach: vacuum impregnation with chia mucilage and sage infusion for turkey fillets

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A R T I C L E I N F O

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A B S T R A C T

This study aimed to investigate the application of chia mucilage and/or sage infusion as an antioxidant using the vacuum impregnation (VI) technique for coating turkey fillets. Fillets were divided into four groups; one was soaked in deionized water (C) and the following groups were fillets separately immersed in chia mucilage (CM), chia mucilage including sage infusion (CMS), and fresh turkey fillets without any treatment (B). Their impact on the physicochemical properties and sensory attributes was evaluated during 7 days of storage at 4°C. VI was effective in increasing moisture contents and coating solution uptake. It was observed that the application of VI increased the L* value and hardness while decreasing springiness and cohesiveness. The incorporation of CM or CMS using VI retarded lipid oxidation. Both CM and CMS influenced the sensorial properties of turkey breast. Taken together, the utilization of natural material coatings with VI revealed a suitable technique to improve meat quality and reduce waste in the meat industry.

1. Introduction

Turkey breast meat faces a considerable challenge in terms of its limited shelf life, even when stored under cold conditions, necessitating the employment of novel technologies to prolong its freshness (*Elmas et al*., 2020). Cold storage typically affords turkey meat a restricted shelf life of approximately two days. Thus, it becomes imperative to identify approaches that can preserve its quality for an extended duration. In order to extend the shelf life of fresh or minimally processed meats, edible films and coatings have gained recognition as viable solution. These films and coatings act as a protective barrier on the surface of foods, hindering deterioration meats (*Jooyandeh et al*., 2022). Vacuum impregnation (VI) is a widely employed method in the food industry for facilitating the infusion of various ingredients, such as salt, binding agents, coating materials, antioxidants, and antimicrobial agents, into different products. The VI technique plays a pivotal role in enhancing mass transfer across the pores of animal or vegetable tissues by utilizing varying levels of pressure. This technique aims to utilize the empty spaces within the food to impregnate substances. To prevent the deterioration of quality, VI has proven to be highly effective in integrating a coating solution into a porous solid matrix, resulting in a thicker and more uniform coating (*Kırmızıkaya and Çınar*, 2018; *Panayampadan et al.,* 2022).

Chia seeds (*Salvia hispanica* L.) and their mucilage offer great potential as a nutritional, functional, and pharmaceutical material in the food

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industry. When chia seeds come into contact with water, they release a highly transparent and thick solution that adheres to the seed coat. Chia mucilage serves as an innovative source for developing edible coatings and films (*Brütsch et al*., 2019; *Akhavan et al.,* 2022). Sage (*Salvia officinalis* L.), an aromatic plant from the Lamiaceae family, is renowned for its medicinal properties. Sage has been documented to possess potent antibacterial, antifungal, and antioxidant characteristics (*Walch et al.*, 2011; *Yazgan,* 2020). Although several coating materials have been utilized in meat products (*Gagaoua et al*., 2021; *Li et al.*, 2023; *Smaoui et al.,* 2022), there is a notable gap in research regarding the application of chia mucilage and sage infusion as antioxidant agents and also the use of VI in turkey fillets. Consequently, the primary goal of this study was to enhance the shelf life of chilled fresh turkey breast by enhancing its technological and oxidative stability. The aim was to achieve this by employing chia mucilage either alone or in conjunction with sage infusion, which acts as an antioxidant agent.

2. Materials and methods

2.1. Materials

Chia mucilage was prepared according to the method of *Yüncü et al*. (2022). Subsequently, the mixture was transferred to centrifuge tubes and centrifuged at 4100 rpm for 10min (NF400, Nüve, Turkey). The resulting solution was then filtered to eliminate the seeds and obtain pure chia mucilage. Sage infusion was prepared using the method described by *Yıldırım et al*. (2000). The chia mucilage was mixed with the sage infusion to achieve a final concentration of 1.5% extract. Turkey breast was cut into similarly shaped fillets, 1 cm thick and weighing about 10±1 g. The fillets were randomly divided into four groups, one was soaked in deionized water (C), and the other groups were separately immersed in chia mucilage (CM), chia mucilage including sage infusion (CMS), with the ratio of fillets to solution being nearly 1:3, and the fourth group was fresh turkey breast without any treatment (B). VI was imposed according to the method applied by *Zhao et al.* (2021). The treated fillets were individually placed in ziploc bags and stored at 4°C for 7 days. Analysis of the samples was conducted on days 0, 3, 5, and 7 to assess their quality characteristics and changes over time.

2.2. Methods

The moisture and ash content were determined according to AOAC (2012) procedures. Protein content was assessed using the Dumas method with an automatic nitrogen analyzer (FP 528 LECO, USA). Fat content was evaluated following the methodology described by *Flynn and Bramblet* (1975). The pH of the samples was measured in triplicate using a pH meter (WTW pH 3110 set 2, Germany) equipped with a penetration probe. The uptake of the coating solution was determined by calculating the weight differences of the fillets before and after the VI process. Thiobarbituric Acid Reactive Substances (TBARS) value was measured using the method outlined by *Witte et al.* (1970). Surface color analysis was conducted using a portable colorimeter (CR400, Konica-Minolta, Japan). For sensory evaluation, warm fillets from each group were randomly served to a panel of five graduate students from the Food Engineering Department at Ege University. The panel assessed the samples for attributes such as appearance, color, texture, juiciness, flavor, and overall acceptability. All analyses were performed in triplicate. Statistical analysis was carried out using the IBM SPSS Statistics program (version 25.0), employing one-way and two-way analysis of variance (ANOVA). Differences among the means were examined using Duncan's multiple range test at a confidence level of 95%.software.

3. Results and discussion

3.1. Chemical composition, coating solution uptake and pH

The total moisture content ranged from 74.2% to 77.50%, protein content ranged from 21.27% to 23.87%, fat content ranged from 0.36% to 0.84%, and ash content ranged from 0.73% to 1.08% across the fillets (Table 1). The fillets treated with VI exhibited higher moisture content compared to the untreated fillets (B) ($P<0.05$). This could be attributed to the enhanced coating degree of the fillets when using the VI technique, as supported by the findings on coating solution uptake. Similar findings were reported by *Zhao et al.* (2021). The addition of chia mucilage and sage infusion resulted in increased coating uptake in the fillets when VI was applied. VI treatment of turkey fillet with deionized water (C) produced the lowest coating uptake followed by the chia mucilage treatment (CM). The presence of chia mucilage in the coating solution could enhance its

Table 1. Chemical composition, coating solution uptake, and pH of turkey fillets

Fillet group	Protein (%)	Moisture (%)	Fat (%)	Ash (%)	Coating solution uptake (%)	pH
B	23.87[a]±0.19	74.2[b]±0.36	0.84[a]±0.08	1.08[a]±0.13	0.00[d]±0	5.80[a]±0.01
C	22.23[b]±0.98	76.44[a]±0.91	0.60[b]±0.05	0.73[c]±0.06	1.30[c]±0.22	5.76[b]±0.01
CM	21.27[b]±0.34	77.50[a]±0.32	0.43[c]±0.01	0.80[bc]±0.04	4.37[b]±0.24	5.71[c]±0.01
CMS	21.36[b]±0.34	77.38[a]±0.36	0.36[c]±0.05	0.89[b]±0.03	4.96[a]±0.40	5.78[b]±0.03

All values are means ± SD, with the different letters showing significantly different (P<0.05). B, fresh turkey breast without any treatment; C, deionized water; CM, chia mucilage; CMS, chia mucilage including sage infusion.

ability to interact with the meat surface, leading to improved solution absorption efficiency. However, the combination of sage infusion with chia mucilage enhanced the viscosity of the solution and improved its adhesion to the surface of the fillets. Therefore, the highest solution uptake was observed in the CMS treatment. Similarly, the process yield of tilapia fillets was increased by coating them with fish gelatin and grape seed extract (*Zhao et al*., 2019). The pH of the turkey fillets ranged from 5.71 to 5.80, with the highest pH observed in the untreated fillets (B), followed by the fillets treated with deionized water (C) and chia mucilage including sage infusion (CMS). Therefore, the addition of sage infusion did not significantly increase the pH values beyond that of the untreated (B) fillets.

3.2. Color

The L* (lightness), a* (redness), and b* (yellowness) values of the turkey breast fillets ranged from 45.89 to 51.65, 3.61 to 5.26, and 3.24 to 4.25, respectively (Table 2). The application of VI resulted in an increase in the brightness (L*) of the turkey fillets. This can be attributed to the fact that the coating solution fills the gaps and voids within the meat, leading to a more uniform distribution of light and ultimately causing an overall increase in the lightness of the fillets. It should be acknowledged that variations in the composition of the coating solution, processing conditions, and the inherent characteristics of different meat species can contribute to differences in the observed color changes. The incorporation of sage infusion altered the a* and b* values. This suggests that sage infusion contributed to the development of a less pronounced red color and an enhanced yellow hue in the turkey fillets. CM or CMS treatment caused a decrement in a* value. These reductions in a* values could be associated with denser texture and thicker appearance of chia mucilage compared to the water, and to the natural color of the sage infusion, which could have influenced the overall redness of the fillets. B, C, and CM treatments had similar b* values. Additionally, the use of sage infusion increased the b* value, and similar results were reported by *Cegiełka et al.* (2022) in chicken meatballs treated with sage.

3.3. Lipid oxidation

Fresh turkey meat is prone to oxidative changes due to the presence of lipids and endogenous enzymes. The application of coating solution and the use of antioxidants affected TBARS values (P<0.05). The initial TBARS values ranged

Table 2. Color parameters of turkey fillets

Fillet group	L*	a*	b*
B	45.89[c]±1.02	3.61[c]±0.29	3.30[b]±0.11
C	49.28[b]±0.42	5.26[a]±0.41	3.24[b]±0.68
CM	51.65[a]±0.18	4.40[b]±0.34	3.66[b]±0.20
CMS	51.14[a]±0.50	3.80[c]±0.12	4.25[a]±0.22

All values are means ± SD with the different letters showing significantly different color parameters (P<0.05). B, fresh turkey breast without any treatment; C, deionized water; CM, chia mucilage; CMS, chia mucilage including sage infusion.

Table 3. TBARS values of turkey fillets during storage at 4°C

Fillet group	0 days	3 days	5 days	7 days
B	0.84^{bt}±0.02	0.99^{az}±0.00	1.54^{ax}±0.03	1.31^{ay}±0.01
C	1.02^{axy}±0.01	0.91^{bz}±0.08	0.96^{byz}±0.01	1.08^{bx}±0.02
CM	0.57^{cy}±0.01	0.43^{cz}±0.01	0.70^{cx}±0.05	0.77^{dx}±0.06
CMS	0.46^{dz}±0.01	0.32^{dt}±0.02	0.73^{cy}±0.03	0.98^{cx}±0.05

All values are means ± SD of three replicates. The means within the same column with different superscripts (a-d) are different. The means within the same row with different superscripts (X-Z) are different. B, fresh turkey breast without any treatment; C, deionized water; CM, chia mucilage; CMS, chia mucilage including sage infusion.

from 0.46 to 1.02 mgMA/kg (Table 4). The highest TBARS value was observed in samples coated with water initially; however, the infusion of chia mucilage and sage reduced oxidation, and the lowest values were detected in the CMS treatment (P<0.05). While the untreated fillets (B) exhibited a continuous increase in oxidation values during storage, the other groups showed fluctuations (P<0.05). In the untreated (B) fillets, oxidation occurred at the highest level among the four groups, whereas the application of coating solution resulted in lower TBARS values due to the barrier properties of the coatings, which prevented contact between turkey meat and oxygen. Also, *Kanatt et al.* (2013) reported that chitosan coating was able to reduce oxidation in ready to cooked meat products. Furthermore, the presence of phenolic compounds in the chia mucilage and sage infusion led to the lowest values observed in the CM and CMS treatments throughout storage, with oxidation not exceeding 1 mgMA/kg in these groups. *Mariutti et al.* (2011) reported that the use of sage infusion was effective in controlling lipid oxidation. In line with our findings, sea bass fillets coated with chia mucilage and propolis extract resulted in lower TBARS values compared to the control (*Coban and Coban,* 2020).

3.4. Sensory evaluation

The sensory evaluation results of VI turkey fillets are presented in Figure 1. Coating with chia mucilage or chia mucilage and sage influenced the appearance and color attributes of the turkey fillets. The inclusion of sage infusion in the coating solution resulted in a decrease in the sensory scores for appearance and color. One potential explanation is the presence of certain chemical compounds in the sage infusion that interact with the pigments responsible for color in turkey meat. Chitosan coating con-

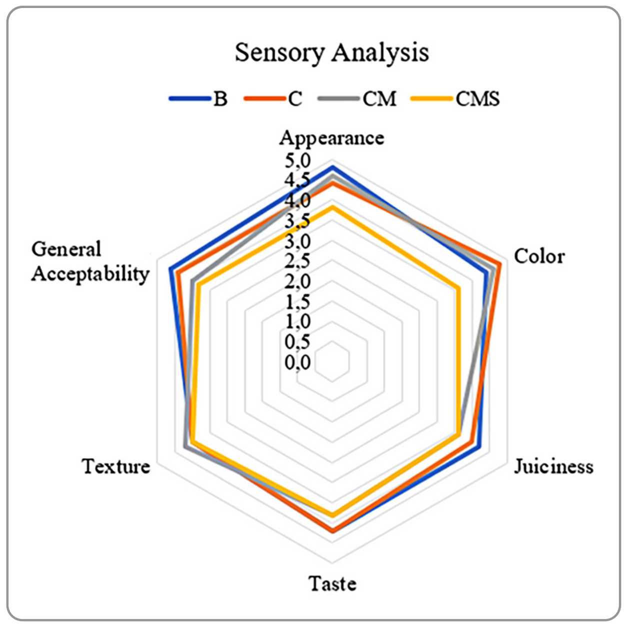

Figure 1. Sensory properties of turkey fillets. B, fresh turkey breast without any treatment; C, deionized water; CM, chia mucilage; CMS, chia mucilage including sage infusion.

sisting of grape seed extract and oregano essential oil also decreased the color and taste scores of turkey meat (*Mojaddar Langroodi et al.,* 2021). However, it can be inferred that the implemented procedure yielded acceptability levels comparable to those of the control group. A similar result was also reported in grass carp slices where fillets coated with chitosan containing plant extracts by VI (*Zhao et al.*, 2021).

4. Conclusion

Favorable impacts of VI on physicochemical properties, oxidation stability, and coating solution uptake were seen in turkey fillets. The results of the instrumental analysis (texture and color) showed that VI had a significant effect on the turkey fillets compared to the fillets treated with deionized water. Sensory analysis showed that chia mucilage/sage infusion affected the evaluated parameters. In general, chia mucilage coating alone and a combination of chia mucilage with sage infusion had similar effects on the quality of fillets. However, sage infusion had a slightly adverse effect on sensorial properties.

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