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EFFECT OF LAUREL EXTRACT AND COOKING TIME ON QUALITY AND OXIDATIVE STABILITY OF SOUS-VIDE COOKED TURKEY BREAST

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ABSTRACT
This study investigates the effects of laurel extract (LE) and different sous-vide cooking durations on the quality parameters of marinated turkey breast meat. For this purpose, samples were cooked for 90 min (SP90) or 120 min (SP120) using the sous-vide method, with additional groups including laurel extract (SP90E, SP120E). The samples were stored at +4°C for 9 days, and analyzed at three-day intervals for marinade absorption, cooking loss, pH, color, lipid and protein oxidation, texture profile, sensory, and microbiological properties. Cooking duration did not affect cooking loss, while LE addition and prolonged cooking time led to darker color. At all storage stages, LE-treated samples showed lower TBARS and carbonyl values regardless of cooking time, whereas LE-free samples had decreased sulfhydryl content. Cooking duration, LE, and storage time influenced color, appearance, and flavor, but no significant differences were found in texture or overall acceptability at the end of storage. Microbiological analyses confirmed that all samples remained safe for consumption throughout storage.
Keywords: Sous-vide cooking, laurel extract, lipid oxidation, protein oxidation, turkey breast meat

DEFNE EKSTRAKTI KULLANIMI VE PİŞİRME SÜRESİNİN SOUS-VİDE PİŞİRİLMİŞ HİNDİ GÖĞÜS ETİ KALİTESİ VE OKSİDATİF STABİLİTESİ ÜZERİNE ETKİSİ

ÖZ
Bu çalışmada marinat uygulanan hindi göğüs etlerinin kalite parametreleri üzerine defne ekstraktı ve farklı sürelerde uygulanan sous-vide pişirmenin etkileri incelenmiştir. Bu amaçla örnekler, sous-vide yöntemi kullanılarak 90 dk. (SP90) veya 120 dk. (SP120) süreyle pişirilmiş olup, ek olarak her bir pişirme süresi için defne ekstraktı (LE) eklenen gruplar da değerlendirilmiştir (SP90E, SP120E). SP120E). Marinat absorbsiyonu, pişirme kaybı, pH, renk parametreleri, lipid ve protein oksidasyonu, doku profili, duyusal özellikler ve mikrobiyolojik özellikler, +4°C'de 9 gün depolama süresi boyunca 3 günlük aralıklarla değerlendirilmiştir. Pişirme süresi, pişirme kayıpları üzerine etkili bulunmamıştır. Defne ekstraktı ilavesi ve pişirme süresinin uzatılması örneklerin renginin koyulaşmasına neden olmuştur. Depolamanın tüm aşamalarında, defne ekstraktı eklenen örnekler, pişirme süresinden

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bağımsız olarak daha düşük TBARS ve karbonil değerleri göstermiştir, buna karşın LE içermeyen örneklerde sülfhidril içeriği azalmıştır. Defne ekstraktı eklenmeyen örneklerde, sülfidril miktarında azalma gözlenmiştir. Pişirme süresi, defne ekstraktı ve depolama süresi, hindi göğüs etinin renk, görünüm ve lezzet gibi duyusal özelliklerini etkilemekle birlikte, depolama sonunda gruplar arasında doku veya genel kabul edilebilirlik açısından anlamlı bir fark gözlenmemiştir. Depolama sonunda yapılan mikrobiyolojik analizler, tüm örneklerin tüketim için uygun olduğunu göstermiştir.
Anahtar kelimeler: Sous-vide pişirme, defne ekstraktı, yağ oksidasyonu, protein oksidasyonu, hindi göğüs eti

INTRODUCTION

Turkey meat is considered a healthier alternative to red meat due to its high protein-to-calorie ratio, low cholesterol content, low fat level, and balanced n-6 to n-3 PUFA (polyunsaturated fatty acid) ratio, (Marangoni et al, 2015; Akoğlu et al., 2018). Turkey meat production in Türkiye increased by 16.7% from 2023 to 2024, rising from 44,540 tons to 52,000 tons (Anonymous, 2024). Also, the proportion of poultry in global meat consumption has been steadily increasing. This trend is attributed to economic and societal factors: in low-income developing countries, poultry is preferred over red meat due to its lower cost, whereas in high-income countries, poultry is favored for its perceived convenience and health benefits as a dietary choice (OECD-FAO, 2023).

With advancing technology and changing lifestyles, conscious consumers demand food that is not only highly nutritious but also easy to prepare, minimally processed, has an extended shelf life, and tastes good. Consequently, the food industry has been continuously striving to develop new poultry meat products, particularly ready-to-eat options, to meet consumer preferences for convenience and nutritional value (Resurreccion, 2004).

Sous-vide (SV) cooking is a precise and controlled method utilized for the production of ready-to-eat food products. This technique involves vacuum-sealing food and cooking it at accurately regulated low temperatures for extended periods, which enhances the retention of moisture, flavor, and nutritional value (Akoğlu et al., 2018, Jeong et al., 2018). The SV method is a gourmet cooking commonly used for preparing foods, particularly meat and fish. The sous-vide cooking is also employed in the production of ready-to-eat meat and fish products, ensuring consistency in texture and doneness (Przybylski et al., 2021). SV cooked meats are typically marinated and /or seasoned and ready for consumption, requiring only reheating in their packaging in the consumer's kitchen. This technique typically involves low temperatures (50–80°C) and extended cooking times, depending on the type of meat (Pulgar et al., 2012). These relatively low temperatures help retain the meat's juiciness while enhancing its flavor and tenderness (Aguilera, 2018; Bıyıklı et al., 2020). In this method foods are placed into vacuum sealed plastic bags and submerged in water bath or steam oven (Ruiz-Carrascal et al., 2019). The temperature and time parameters used in SV cooking are crucial. Temperature, in particular, plays a critical role as it induces changes in the texture of meat products through protein denaturation (Zielbauer et al., 2016).

Turkey meat is prone to oxidation based on its PUFA content. Besides this, warmed-over flavour (WOF) develops in heat treated, refrigerated and reheated meats by oxidation of membrane phospholipids. These oxidative reactions occurring in fats during processing and storage cause significant changes in the flavor and nutritional value of the product (Mielnik et al., 2008). Protein oxidation is another quality problem, which eventuates loss in essential amino acids and functional properties of proteins via changing in protein or peptide structure (Mariutti and Bragagnolo, 2017). Protein oxidation can initiate with same oxidants catalyzed lipid oxidation but also associated with presence of secondary lipid oxidation products (Jiang and Xiong, 2016).

The *Laurus nobilis*, commonly known as laurel plant, is predominantly cultivated in the Mediterranean region. Its dried or fresh leaves are widely utilized in culinary applications due to their

aromatic properties, contributing to the sensory profile of various food products (Polovka and Suhaj, 2010; Ouchikh et al., 2011). The antioxidant compounds in laurel leaves are primarily include phenolic compounds, flavonoids, tannins, and essential oils such as 1,8-cineole, eugenol, and methyleugenol. Additionally, it contains bioactive compounds like quercetin, kaempferol, and catechins, which contribute to its strong antioxidant activity (Muñiz-Márquez et al., 2013).

In recent years, the food industry has shown a significant trend toward exploring the use of natural additives as alternatives to synthetic additives in food formulations. Antioxidants are widely used as additives to limit oxidative reactions (Falowo et al., 2014). Natural extracts act as a natural antioxidant by means of their phenolic compounds (Škerget et al., 2005; Shah et al., 2014). There are limited studies on using laurel extract as a natural antioxidant in sous-vide cooked meats. Besides this, as far as we can observe, there are no studies investigating the oxidative changes in marinated turkey meat cooked using the sous-vide method. The aim of this study was to investigate the effects of sous-vide cooking on marinated turkey breast with and without the addition of laurel extract (LE) by applying two different cooking durations at 61°C, with samples stored at +4°C for 9 days. Quality parameters and oxidative changes were evaluated throughout the storage period.

MATERIAL AND METHODS

Materials

Turkey breast muscles (*Pectoralis major*), from approximately 80-95 days old, 6-7 kg female hybrid turkey were kindly donated by Pınar Et Industry Co. (İzmir, Turkey). Marination ingredients (salt and food grade citric acid) were purchased from local market in İzmir, Turkey. Laurel leaves powder and sous-vide bags (thickness of 90 ±3 μm, 160 cc/m²/day oxygen permeability, <8 g/m².day water vapor permeability) were granted by Defne Dış Ticaret ve Tarım Ürünleri AŞ (İzmir, Turkey) and Fitpak Ambalaj ve Kimya San. Tic. AŞ (Manisa, Turkey), respectively. All other reagents were analytical grade.

Preparing laurel extract

The extraction process was performed based on the previously described by Akcan et. al (2017) with some modifications. Firstly, laurel leaves were grounded by using hammer mill (Brook Crompton, Series 2000, England) then were screened (Prüfsieb Jel 200, Germany) and particles which have more than 500 μm particle size were used for the extraction methods. 15 g screened leaves were weighed onto filter paper for each sample then samples with papers were folded and put into a jar. This was followed by the addition of 100 mL of a mixture of ethanol: water (80:20, v/v). The sample was heated in a shaking water bath for 4 h at 40º C. The combined supernatant was then filtered through a 0.45-μm Millipore nylon filter and evaporated in a rotary evaporator (IKA) until removed the alcoholic portions then stored at 80º C.

Experimental design and sous-vide cooking process

Figure 1 shows the experimental design and process progression. Fresh turkey breast meat, (71.36% moisture, 21.98% protein, 0.81% fat, and 1.17% ash), was portioned into approximately 240 g slices with an average thickness of 1.5–2 cm. The meat portions were perforated with needles to facilitate the penetration of a marinade solution containing 1.2% NaCl, 2% citric acid (w/v), and 150 mg/kg laurel extract (LE) for antioxidant-added groups.

The fillets were marinated for 1 h in a tumbler (Suhner Wastro MGH-20, Swiss model) at 8°C and 20 rpm. After the tumbling/marinating process, turkey breast meats were placed into sous-vide cooking bags (90±3 μm, oxygen permeability 160 cc/m²/day, water vapor permeability <8 g/m²/day) and vacuum-sealed (Komet, Plusvac 24). The samples were subsequently sous-vide cooked at 61°C for 90 or 120 min using a Sous-vide Creative Series device (Poly Science, ÖRKA). After cooking, the samples were immediately cooled in ice water for 30 min and stored at +4 °C. Analyses were conducted at 3-day intervals for 9 days.

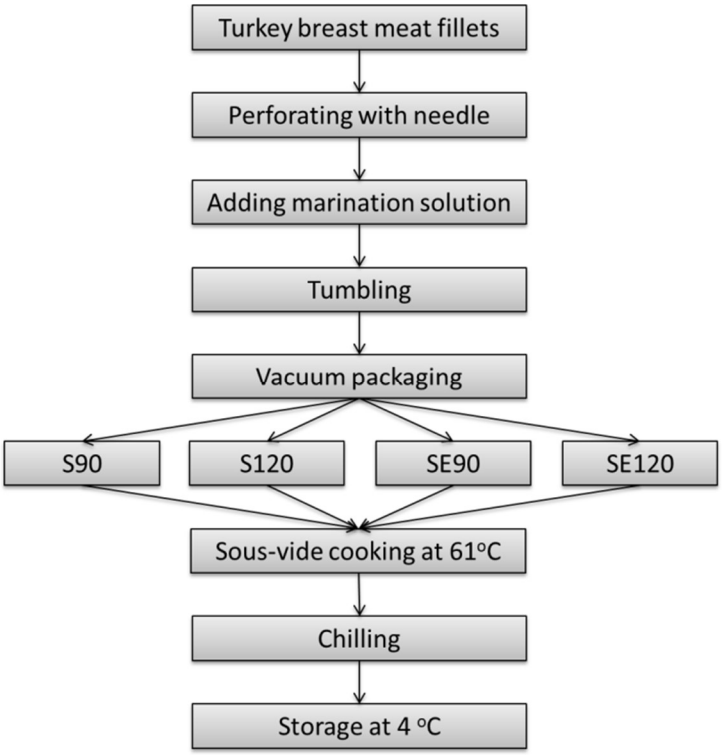

Figure 1. Production flow chart of sous-vide cooked turkey breast meat
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min +LE

Methods

Total phenolic content analyses of Laurel extract

The Folin-Ciocalteu (FC) method, as described by Escarpa and González (2001) and modified by Akcan et al. (2017), was used to determine the total phenolic content of LE. A 30 µL of the extract and 150 µL of FC reagent were added sequentially to a test tube containing 2.37 mL of distilled water. After 8 min, 450 µL of saturated Na_2CO_3 was added to the mixture. The sample was then incubated for 30 min at 40°C, and the absorbance was measured at 750 nm using a Biochrom Libra S70 spectrophotometer (UK) against a blank. The results were expressed as milligrams of gallic acid equivalent per gram of extract.

DPPH analyses of Laurel extract

The DPPH radical scavenging activity of LE was assessed using the method described by Brand-Williams et al. (1995) and modified by Yeşilsu and Özyurt (2019). Extract concentrations ranging from 0.1 to 0.15 mg/ml were utilized to determine the IC50 value.

Marinade uptake

Marinade uptake was calculated by the following equation;

Marinade uptake (g / 100g) = 100 * (W_m – W_r) / W_r (1)

Where W_m is marinated weight, W_r is raw weight of meat.

Cooking loss

The cooking loss was calculated by recording the weights of the samples before and after cooking using the following equation:

% Cooking Loss = [(Raw sample weight- Cooked sample weight) / Raw sample weight] × 100 (2)

pH

The pH value was measured at three different points on each sample using a portable penetration-type pH meter (WTW pH 3110 Set 2, Germany).

Instrumental colour

Color parameters were measured after blooming for 30 min using a portable color measurement device (Konica Minolta CM-5) based on the CIE Lab (L* for brightness, a* for redness, and b* for yellowness) color system. Before measurement, the colorimeter was calibrated using white and black standards. Measurements were performed at three different locations on the surface of each sample.

Peroxide value (PV)

The peroxide analysis was performed according to AOAC (2012) procedure. For this, 10 g of sample was blended with 60 mL of chloroform for 2 min. The mixture was filtered through Whatman No. 1 filter paper, and 25 mL of the filtrate was transferred into a 250 mL ground-glass Erlenmeyer flask. Then, 30 mL of glacial acetic acid and 2 mL of saturated potassium iodide solution were added, and the mixture was manually swirled for 2 min. The flask was sealed and kept in the dark for 5 min. Afterwards, 100 mL of distilled water and 2 mL of 1% freshly prepared starch solution were added. The samples were titrated with 0.1 N sodium thiosulfate solution until the blue-purple color disappeared. The peroxide value was calculated in milliequivalents (mEq)/kg of sample using the following equation:

$$PV\,\frac{(mEqO2)}{kg} = \frac{SxN}{WS}x100$$

S: Volume of sodium thiosulfate used for titration
N: The normality of sodium thiosulfate solution
WS: Weight of the sample

Thiobarbituric acid reactive substances

The 2-thiobarbituric acid reactive substances (TBARS) value was determined using a modified version of the extraction method described by Witte et al. (1970). Twenty grams of the sample was homogenized with Ultra-Turrax (6000 rpm, Ultra-Turrax® T25basic, UK) in 50 mL of a 4°C extracting solution containing 20% trichloroacetic acid in 2 M phosphoric acid. The resulting slurry was quantitatively transferred to a 100 mL volumetric flask with 40 mL of water, diluted to 100 mL with water, and homogenized again. A 50 mL portion of the homogenate was filtered through Whatman No. 1 filter paper. Subsequently, 5 mL of the filtrate was mixed with 5 mL of 2-thiobarbituric acid (0.02 M in distilled water) in a test tube, which was stoppered, shaken, and heated in a boiling water bath for 35 min. The absorbance of the thiobarbituric extracts was measured at 532 nm, using 1,1,3,3-tetraethoxypropane as the standard. The results were expressed as TBARS values (mg malonaldehyde/kg sample), which was calculated by multiplying the absorbance by 5.2. Each sample was analyzed in triplicate at each storage time.

Total carbonyl content

Total carbonyl content analysed by using the method of Oliver et al., (1987). Sample (1g) was minced and homogenized in a 1:10 (w/v) ratio using 20 mM sodium phosphate buffer (pH 6.5) containing 6 M NaCl with an ultraturrax for 30 seconds. Two 0.2 mL aliquots were taken and placed in 2 mL Eppendorf tubes. Proteins were precipitated with 1 mL cold 10% TCA and centrifuged at 4200×g for 5 min. One pellet was treated with 1 mL of 2 M HCl for protein concentration, while the other was treated with 0.2% DNPH in 2 M HCl for carbonyl measurement. After 1-hour incubation at room temperature, samples were precipitated with 10% TCA and washed three times with ethanol acetate (1:1, v/v) to remove excess DNPH. The pellets were dissolved in 1.5 mL of 20 mM sodium phosphate buffer with 6 M guanidine HCl (pH 6.5), stirred, and centrifuged at 4200×g for 2 min. Protein concentration was determined by absorption at 280 nm using BSA as the standard, and carbonyl content was expressed as nmol carbonyl per mg of protein using an absorption coefficient of 21.0 nM−1 cm−1 at 370 nm for protein hydrazones.

Determination of sulfhydryl groups

A modified version of the Ellman (1959) method was employed to determine the sulfhydryl (thiol)

content in the samples. Initially, 0.5 g of the sample was homogenized with 10 mL of 0.05 M phosphate buffer (pH 7.2). Following homogenization, 1 mL of the mixture was taken and diluted with 9 mL of phosphate buffer containing 6 mM ethylenediaminetetraacetic acid (EDTA), 0.6 M NaCl, and 8 M urea. The resulting solution was centrifuged at 14,000 rpm for 15 min in a chilled centrifuge. A 3 mL aliquot of the supernatant was then treated with 0.01 M DTNB (5,5'-dithiobis 2-nitrobenzoic acid) prepared with sodium acetate (0.04 M) and incubated at 40°C for 15 min. After incubation, the absorbance of the sample was measured at a wavelength of 412 nm.

Texture profile analysis

Texture Profile Analysis (TPA) was performed using a texture analyzer (TA-XT2, Stable Micro Systems, Haslemere, UK) with four replications for each sample. Parameters such as hardness (N), adhesiveness, springiness (mm), cohesiveness, gumminess (N), and chewiness (N·mm) were determined based on the force and time curves generated during testing. The samples, prepared as cubes measuring 2 cm × 2 cm × 1 cm, were compressed twice to 50% of their original height. The testing conditions included a load cell of 30 kg, a crosshead speed speed of 2 mm/s, and a crosshead and test speed of 1 mm/s. An aluminum cylindrical probe with a diameter of 36 mm was used for the compression tests.

Sensory analysis

Sensory evaluation of sous-vide-cooked turkey breast was conducted by a group of 14 untrained volunteers (7 men and 7 women) from the Food Engineering Department. A nine-point hedonic scale was used to evaluate the samples in terms of color, appearance, juiciness, flavor, texture, and overall acceptability, where 9 indicated "like extremely" and 1 indicated "dislike extremely." For oxidized flavor, a separate 9-point scale was employed, where 9 indicated "very intense" and 1 indicated "not present at all."

The samples stored under refrigeration were heated at 61°C for in a sous-vide cooking device prior to sensory evaluation, then cut into approximately 2x3x1.5 cm pieces and served. Samples were presented to the panelists on plates coded with randomly assigned three-digit numbers.

Microbiological analysis

For the determination of total aerobic mesophilic bacteria (TAMB), 1 mL from each prepared dilution was aseptically transferred to a sterile Petri dish containing Plate Count Agar (PCA) medium. The Petri dishes were then incubated at 30 °C for 24 h. At the end of the incubation period, colonies formed between 30 and 300 were counted and recorded as TAMB (BAM, 2001). *Salmonella spp.* detection was performed following the guidelines of TSI (2020), while the detection of *Listeria monocytogenes* was carried out using the Bio-Rad Real-Time PCR Method.

Statistical analysis

The entire experiment was independently repeated twice, and the analyses were carried out in triplicate. The data was assessed with General Linear Model (GLM) procedure in SPSS program (version 22.0, IBM, USA). SPSS for Windows version 25.0 (Armonk, NY: IBM Corp.) was used for statistical analysis. Four different treatments (S90, S90E, S120, S120E) and storage (0, 3, 6, and 9 days) were assigned as fixed effects while each replicate, day of sensory evaluation, panellist, and the number of sessions were supposed as random effects. The mean values of data obtained from treatments before and during storage were compared by one way and two way ANOVA respectively. Sensory scores among samples were settled by using MANOVA (multivariate analysis of variance). The significant differences (95% confidence level) between the treatments and storage time were observed by Duncan's Multiple Range Test when any factor effect was found.

RESULTS AND DISCUSSION

Total phenolic content and DPPH free radical scavenging activity of laurel extract

The antioxidant effect of LE is primarily attributed to its high content of phenolic compounds and flavonoids such as quercetin, luteolin, and kaempferol. These bioactive compounds neutralize free radicals and prevent

lipid peroxidation by acting as hydrogen donors, metal chelators, and radical scavengers (Škerget et al., 2005; Dias et al., 2014).

The total phenolic content of LE was calculated as 373.19 mg GAE/ g extract (87.9 mg GAE/ g laurel powder). Akcan et al. (2017) reported that the TP content of LE was 81.68 mg GAE/ 100 g extract while Fernández et al. (2019) measured it as 110.43 mg GAE/ g extract, even though using a similar solvent and extraction method. The reasons for the variability of total phenolic content may result from using different origins of laurel plant, diversity of extraction time, temperature and solvent, differences in phenolic acid equivalent and the extraction method (Vinha et al., 2015; Akcan et al., 2017).

The DPPH radical scavenging activity of LE was determined to be 23.79%, which is lower than the 76.11% reported by Vinha et al. (2015) as the lowest value among studies using different ethanol: water ratios as the solvent. In the same study, the total phenolic (TP) content of laurel powder was reported as 43.03 mg GAE/g, which is significantly lower than the TP content found in our study (87.9 mg GAE/g). Since antioxidant activity is closely linked to the total phenolic content, we believe this variation is due to differences in extract concentrations used during the analysis. To standardize comparisons, the IC50 value, representing the extract concentration required to achieve 50% inhibition of the DPPH radical, was calculated as 0.11 mg/ml in our study. Fernández et al. (2019), who used the same solvent concentration as ours, reported an IC50 value of 0.257 mg/ml, which is higher than our findings. This discrepancy is likely due to the additional steps in our method, such as re-treating the laurel powder with solvent to extract more phenolics and increasing the surface area accessible to the solvent. However, the oxidative stress index (OSI) is principally important in the assessment of antioxidant-oxidant loads of the plant extracts. As a result, LE exhibited higher antioxidant activity at lower concentrations, attributed to its higher phenolic content. In this regard, LE can be a good alternative as a natural preservative against to synthetic antioxidants which have negative effects on human health.

Marinate uptake

Marinade uptake is a critical aspect of meat processing that influences both the sensory qualities and the overall quality of the final product. Marinade uptake is influenced by various factors, including the composition of the marinade, the method of application, and the inherent characteristics of the meat itself (Çimen et al., 2024). Understanding these factors is essential for optimizing the marination process and enhancing the quality of turkey breast meat. The marinade uptake was calculated as 5.85% in groups with extract incorporation and 7.21% in extract-free groups, indicating that the presence of LE in the marinade had no effect on marinade uptake. Previous studies have reported that the marinade uptake of tumbled poultry breast meat ranges from 3.51% to 31.94% (Lopez et al., 2012; U-chupaj et al., 2017). The variability in these findings may be attributed to differences in the marination process. While short-term marination was used in the referenced studies, the application of long-term marination in our study could lead to water release due to the formation of a more fragile structure in the meat. This structural change might explain the observed marinade uptake values in comparison to the broader range reported in the literature.

Cooking loss

During cooking, proteins undergo denaturation, water evaporates, and melted fat is lost, all of which contribute to the reduction in the cooked weight of meat products. Cooking procedure affects the juiciness of meat; longer cooking times and temperature applications result in more protein denaturation and muscle fiber shrinkage hence losing more moisture (Ayub and Ahmad, 2019).

The cooking loss ranged from 13.86% to 15.02% (Figure 2). Sous-vide cooking has been shown to result in lower cooking losses compared to traditional cooking methods (Hong et al., 2015; Rasinska et al., 2019). This study further demonstrates that marination effectively reduces cooking losses even more when combined with

sous-vide cooking. Hong et al. (2015) reported that cooking loss was 12.41% in sous-vide cooked chicken breast. In another study, it was found that cooking loss was 11.2% with the application of marination including %1 citric acid in chicken breast before sous-vide cooking (Hong et al., 2016).

Although some researchers have observed that increasing sous-vide cooking time induces cooking loss (Babür et al., 2019; Bıyıklı et al., 2020; Park et al., 2020), cooking time was found to have no significant effect on the cooking losses of the samples. This finding may be attributed to the marinade application applied to the samples prior to cooking. Nyam et al. (2023) concluded that lower cooking losses were obtained when sous-vide cooking at 60 ℃ for a long time than at 70 ℃ for a shorter time. Moreover, Ayub and Ahmad (2019) were also stated that increase in cooking loss is associated with increasing cooking temperature. This consequent agreed with the results of a study carried out by Zhang et al. (2022) in sous-vide cooked duck legs at different temperatures (60-70-80 °C).

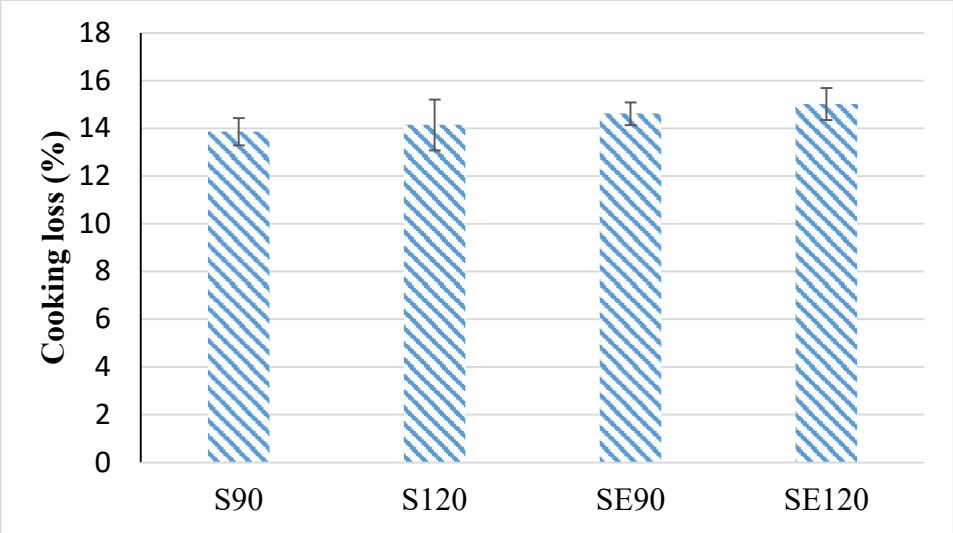

Figure 2. Cooking loss of sous-vide cooked turkey breasts
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min +LE

pH

The changes in pH values of the samples during storage are shown in Figure 3. pH values of sous-vide cooked samples were measured between 5.52 and 5.94. Similarly, Park et al. (2020) recorded pH values between 5.89 and 6.07 in sous-vide cooked chicken breasts at different time and temperature treatments (60-70°C/1-2-3h). In sous-vide cooked chicken breast ham (60°C/2h) incorporated with brine solutions containing 1.5% and 0.75% NaCl, the pH values were measured as 5.83 and 5.89, respectively (Song et al., 2023).

Both cooking time and the use of LE were found to have a significant effect on pH value (P <0.05). On day 0, S120 and SE120 treatments consistently showed higher pH values compared to the 90 min samples (S90 and SE90). This indicates that longer cooking times lead to greater protein denaturation, water loss, and concentration of soluble components, all of which contribute to higher pH levels. Moreover heating induces pH increase, generally associated with breaking bonds containing imidazole, hydroxyl and sulfhydryl groups (Oz and Seyyar, 2016). Similar results were stated in sous-vide cooked turkey cutlets (Bıyıklı et al., 2020) and chicken sausages (Naveena et al., 2017). The pH

values of 120 min samples increased more noticeably during storage, particularly in S120. S120's pH rose from approximately 6.00 on Day 0 to 6.20 on Day 6, before slightly decreasing or stabilizing by Day 9. The extended cooking time likely caused more significant protein breakdown and water evaporation, which accelerated changes in pH during storage. pH values tend to increase slightly over time, particularly in the S120 and SE120 groups, likely due to ongoing biochemical changes. The laurel extract demonstrated a clear stabilizing effect on pH throughout the storage period. Samples treated with the extract (SE90 and SE120) consistently showed less variation in pH compared to the non-treated samples (S90 and S120) at all time points.

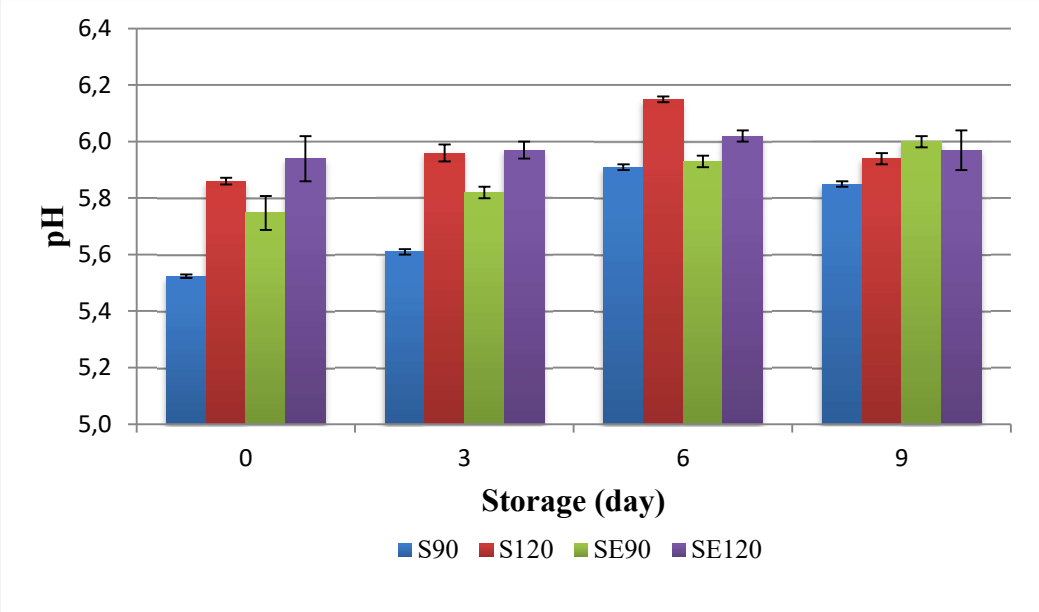

Figure 3. The pH values of sous-vide cooked turkey breast
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min +LE

Color Parameters (L*, a*, b*)

Color parameters are shown in Table 1. The sous-vide cooking time and the addition of LE extract had a significant impact on the color parameters ($P < 0.05$) of turkey breast meat during refrigerated storage. Notably, the L* values (lightness) exhibited variations both between samples and over the storage period. In general, the SE groups (SE90 and SE120) exhibited significantly lower L* values compared to the S groups (S90 and S120) ($P < 0.05$) due to the effect of the laurel extract. The L* value (77.17) of S90 was the highest among all samples on Day 0 indicating a lighter color. In contrast, the SE90 group had a lower L* value (74.47), suggesting a darker appearance, likely due to the pigments from the laurel extract. The L* value of the S120 group (74.95) was higher than that of the SE120 group (72.47) on Day 0. This indicates that the longer cooking time contributed to a darker appearance in SE120 due to the laurel extract. Similar results were substantiated by Akcan et al., (2017) in meatballs covered by a film treated with laurel extract. Laurel extract contains natural pigments such as chlorophyll, flavonoids, and other phenolic compounds (Evert et al., 2013). These pigments impart a darker appearance to the samples which reduces the lightness. Moreover, during the marination and cooking process, the compounds in the laurel extract may interact with meat proteins, further enhancing the darker appearance by altering the surface light reflectance. In the S120 group, lightness remained relatively stable over time, with a slight increase on Day 9 (76.07) compared to Day 0 (74.95), indicating that longer sous-vide cooking may help

preserve or enhance lightness during storage. Similarly, Bıyıklı et al., (2020) in turkey cutlet and Babür et al., (2019) in beef revealed that the increase in sous-vide cooking time decreased the L* values.

Table 1. Color parameters of sous-vide cooked turkey breasts

L*				
Sample	Day 0	Day 3	Day 6	Day 9
S90	$77.17^{a,x}\pm0.82$	$76.13^{a,xy}\pm0.1$	$75.20^{a,yz}\pm0.11$	$74.16^{b,z}\pm0.77$
S120	$74.95^{b,xy}\pm0.79$	$74.67^{ab,xy}\pm1.36$	$74.30^{a,y}\pm0.18$	$76.07^{a,x}\pm0.73$
SE90	$74.47^{b,x}\pm0.34$	$72.82^{c,y}\pm0.54$	$71.37^{b,z}\pm0.57$	$74.80^{b,x}\pm0.52$
SE120	$72.47^{c,y}\pm0.58$	$73.76^{bc,x}\pm0.21$	$71.68^{b,y}\pm0.98$	$71.81^{c,y}\pm0.4$
a*				
Sample	Day 0	Day 3	Day 6	Day 9
S90	$1.99^{b,y}\pm0.64$	$2.69^{xy}\pm0.37$	$3.02^{x}\pm0.45$	$2.55^{xy}\pm0.26$
S120	$2.36^{b,y}\pm0.08$	$2.68^{xy}\pm0.64$	$3.28^{x}\pm0.35$	$2.81^{xy}\pm0.36$
SE90	$1.66^{b,z}\pm0.28$	$2.23^{y}\pm0.05$	$2.94^{x}\pm0.23$	$2.41^{xy}\pm0.48$
SE120	$3.72^{a,x}\pm0.78$	$2.39^{y}\pm0.28$	$2.89^{xy}\pm0.23$	$2.76^{y}\pm0.44$
b*				
Sample	Day 0	Day 3	Day 6	Day 9
S90	$7.69^{c,z}\pm0.47$	$11.16^{y}\pm0.36$	$12.26^{a,x}\pm0.19$	$10.35^{b,y}\pm0.68$
S120	$11.59^{a,y}\pm 0.7$	$11.83^{xy}\pm0.35$	$12.24^{a,xy}\pm0.08$	$12.68^{a,x}\pm0.42$
SE90	$11.50^{a}\pm0.2$	11.19 ± 0.80	$11.14^{b}\pm0.61$	$11.95^{a}\pm0.94$
SE120	$9.93^{b,y}\pm1.26$	$11.78^{x}\pm0.04$	$12.59^{a,x}\pm0.59$	$12.56^{a,x}\pm0.65$

^{a,c} Means marked with different letters on the same column are significantly different (P <0.05).
^{x,y} Means marked with different letters on the same row are significantly different (P <0.05).
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min +LE

On Day 0, the a* value of the SE120 samples was found to be higher than that of the other samples. However, on the subsequent storage days, there were no significant differences in the a* values among the samples. a* values increased during storage, peaking on Day 6, with a slight decrease by Day 9. The increase in a* values during storage, peaking on Day 6, followed by a slight decrease by Day 9, reflects changes in color development potentially due to oxidative or biochemical processes. The initial increase observed may be attributed to factors such as the presence of natural antioxidants like laurel extract and/or marinade ingredients, which can enhance color stability.

On Day 0, the b* value of S90 (7.69) was significantly lower than that of S120 (11.59) (P < 0.05). The increase in cooking time caused an increase in b* values in the extract-free groups after cooking (Day 0), while it caused a decrease in SE120 group. These results can be explained by the increase in the b* value in meat associated with the formation of metmyoglobin by heating (Roldán et al., 2013) and inhibition of metmyoglobin formation by extract treatment (Yu et al., 2002). Yellowness values increased during storage in S90, S120, and SE120 treatments but remained more stable in the SE90 treatment. Higher sous-vide temperatures (S120 and SE120) could alter protein structure and increase interactions between pigments and other compounds, enhancing yellow tones during storage. In contrast, the SE90 treatment's lower temperature may have preserved protein integrity and limited these interactions.

Peroxide value

Peroxide value (PV) is an important indicator of primary lipid oxidation in turkey meat. It measures the concentration of peroxides, which are initial oxidation products formed during the degradation of unsaturated fats (Rasinska et al., 2019). Peroxide value measured during +4 °C storage and after sous-vide cooking of turkey breast meats, was given Figure 4. The addition of LE and cooking time had no significant effect on the peroxide values of the samples on day 0 (P >0.05). The PVs of the samples at the beginning of storage were found to be similar. On day 3, PV ranged between 0.39-0.95 meqO_2/kg The peroxide values of SE90 and SE120 samples were similar across all storage days. The addition of laurel extract effectively inhibits lipid oxidation, reducing peroxide formation and maintaining lower values throughout storage. The PV of the samples with LE added (SE90 and SE120) were found to be lower than those of the samples with no added LE. The flavonoids found in the structure of laurel extract exhibit antioxidant activity by acting as reducing agents, hydrogen donors, metal chelators, or radical scavengers due to the hydroxyl groups attached to their ring structure (Dias et al., 2014). The peroxide values decreased until day 6, but on day 9, the peroxide values of all samples increased. The peroxide values of all samples decreased starting from the 6th day of storage. This decline can be attributed to the breakdown of primary oxidation products (peroxides) into secondary oxidation compounds, such as aldehydes and ketones, as storage progresses (Echegaray et al., 2022). Changes in cooking time did not have a significant effect on the peroxide values of the groups on different storage days (P >0.05). In a study where cooking temperatures of 65, 70 or 75°C were used, turkey chops were cooked sous-vide with time combinations of 20, 40 or 60 minutes, and it was found that changes in cooking time did not affect peroxide values (Bıyıklı et al., 2020).

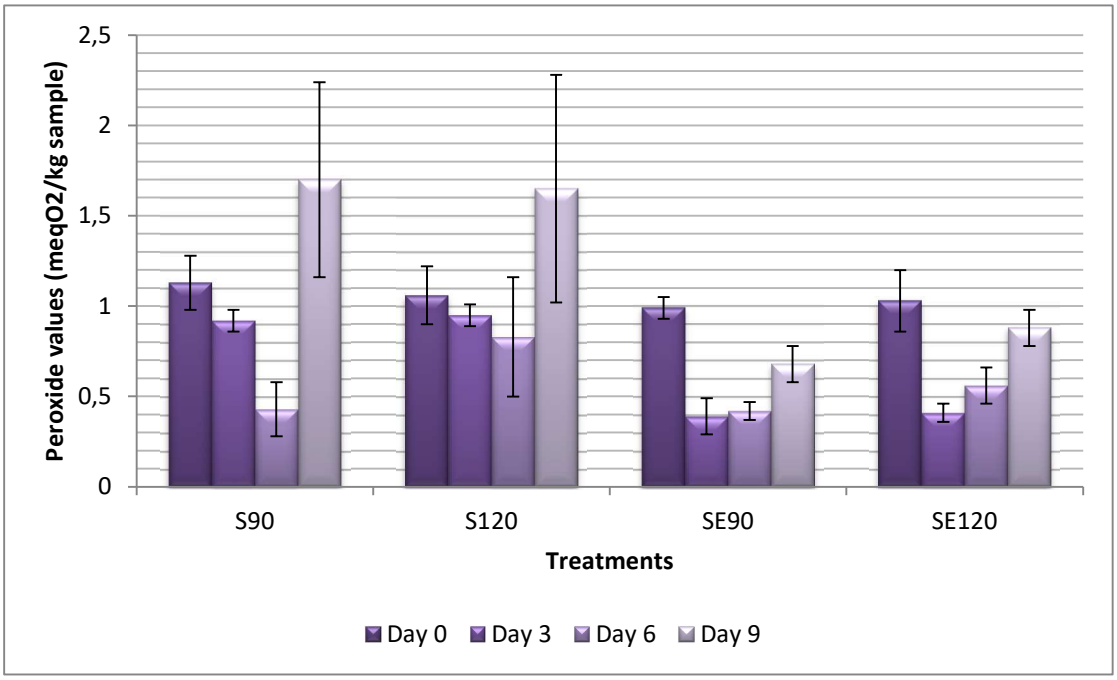

Figure 4. Peroxide values of sous-vide cooked turkey breasts
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min +LE

Thiobarbituric acid reactive substances

TBARS values of samples are given in Figure 5. The TBARS values in meat and meat products cooked using the sous-vide method typically range from 0.5 to 2 mg malondialdehyde (MA)/kg sample (Can and Harun, 2015). Consistent with this range, TBARS values in the present study were found to be between 0.34 and 1.13 mg MA/kg sample after cooking (on day 0). On day 0, cooking time was found to significantly affect the TBARS value in samples without added LE (P<0.05). Roldan et al. (2014) observed that an increase in sous-vide cooking time led to a decrease in TBARS values in lamb meat. In contrast, other studies have reported that sous-vide cooking time had no significant effect on TBARS values in various types of meat Pulgar et al., 2012; Oz and Seyyar, 2016; Bıyıklı et al., 2020). Cooking time had no significant effect in samples with added LE (P >0.05). This effect of LE was also observed at other stages of storage. At all stages of storage, the TBARS values of the samples with added LE were found to be lower than those of the other samples, regardless of the cooking time. Previous studies have shown that various natural extracts effectively delay MDA formation during storage. For instance, laurel and sage extracts in meatballs (Akcan et al., 2017), grape seed extract (Mielnik et al., 2006), and rosemary extract in sous-vide cooked minced turkey breasts (Yu et al., 2002) have all been reported to exhibit this protective effect. In the SE90, the TBARS value remained constant throughout the storage period, while the TBARS values of the S90 and S120 increased on day 3 and then decreased afterwards. During storage increasing TBARS values, as an indicator of advanced lipid peroxidation, was an expected result. The decrease in TBARS values is attributed to the reactions occurring at the later stages of storage, where lipid oxidation products such as malondialdehyde interact with primary amino groups, phospholipids, DNA, and amino acids in the meat. These interactions result in the binding or transformation of free MDA into more stable compounds, ultimately leading to a measurable reduction in TBARS values over time (Roldan et al., 2014; Bıyıklı et al., 2020). At the end of storage, TBARS values ranged between 1.61 and 0.26 mg MDA/kg sample. The limit value for the rancid taste caused by lipid oxidation in cooked turkey breast meat, as perceived by consumers, is reported to be 3.4 mg MDA/kg sample (Sickler et al., 2013). In the present study, the TBARS values determined for all treatments were observed to remain below the limit of 3.4 mg MDA/kg sample throughout the storage period.

Total carbonyl content

Carbonyl formation, a key indicator of protein oxidation, can result from the oxidation of amino acids in the presence of reactive oxygen species or metals, the cleavage of polypeptide chains, or the binding of amino acids such as histidine, cysteine, and lysine to lipid peroxidation products (Ergezer et al., 2016; Papuc et al., 2016). The carbonyl content of sous-vide cooked samples during the storage is presented in Figure 6. Initially, the carbonyl content of the samples ranged between 0.17 and 0.37 nmol carbonyl/mg protein. In samples without the addition of LE, extending the cooking time from 90 minutes to 120 minutes led to a significant increase in carbonyl content throughout all storage periods (P < 0.05). In samples with added extract, this effect was observed only on days 0 and 3. Prolonged cooking time at a specific temperature has been reported to increase carbonyl content in bovine meat (Santé-Lhoutellier et al., 2008), pig meat (Traore et al., 2012), and sous-vide cooked lamb meat (Roldan et al., 2014). It was observed that at the end of the storage, the extract-incorporated groups had significantly lower carbonyl contents when a similar cooking time was applied. Al-Hijazeen et al. (2018) studied the effects of different ratios of oregano essential oil and tannic acid as antioxidants and reported that the carbonyl content of sous-vide cooked ground chicken breast and thigh meat ranged between 0.98 and 1.05 nmol carbonyl/mg protein. An increase in carbonyl content was detected in all samples throughout the storage period (P <0.05). By the end of storage, the carbonyl levels were approximately 3 to 5 times higher compared to the levels measured initially (day 0).

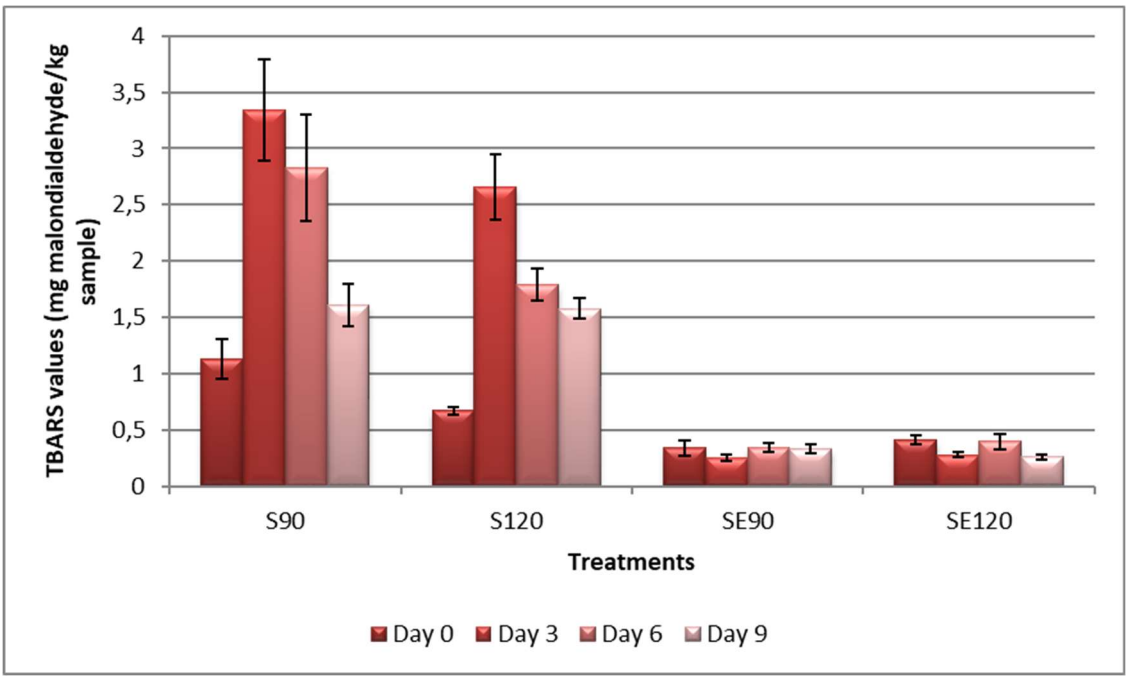

Figure 5. TBARS values of sous vide cooked turkey breasts
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min

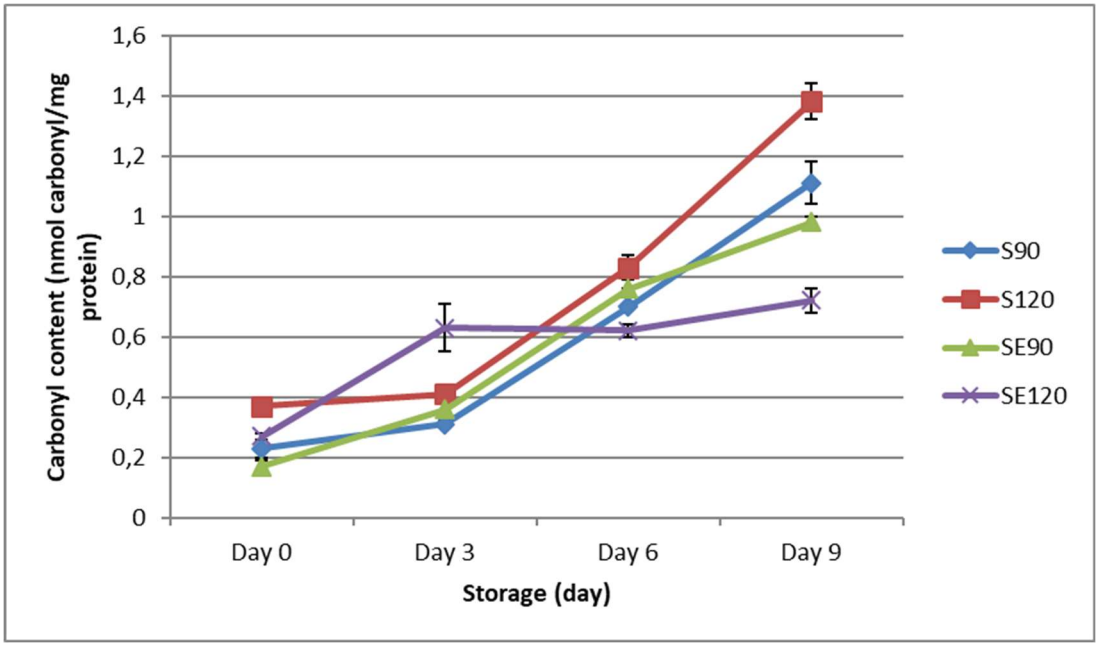

Figure 6. Carbonyl content of sous vide cooked turkey breasts
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min

The reduction in sulfhydryl content due to their conversion into intra- and intermolecular disulfide bonds is another indicator of protein oxidation in meat and meat products (Zahid et al., 2020). Figure 7 shows the changes in sulfhydryl content of sous-vide cooked turkey breast meat during cold storage over a period of 9 days. The total sulfhydryl content is expected to decrease during storage due to oxidation, and supporting studies have been reported in the literature (Shi et al., 2014; Turgut et al., 2016; Zahid et al., 2020). Sulfhydryl content after sous-vide cooking ranged between 23.73 and 31.74 nmol sulfhydryl/mg sample, similar to a study which was performed on sous-vide cooked chicken (Silva et al., 2016). SE90 treatment had the highest sulfhydryl content on day 0 (P <0.05). Present of LE and reduced cooking time may have prevented the oxidation of sulfhydryl groups. At the end of storage, samples with added extract exhibited the highest sulfhydryl content (P <0.05), indicating that LE functioned as an effective antioxidant regardless of cooking time during cold storage. The LE extract reduces the rate of sulfhydryl loss by inhibiting oxidative reactions through its phenolic compounds' free radical scavenging and metal-chelating properties (Fernandez et al., 2019). This protective effect preserves protein functionality and slows protein oxidation, as seen in SE90 and SE120. Similarly, previous studies have demonstrated the protective effect of antioxidants on sulfhydryl groups, such as pomegranate peel extract in beef meatballs (Turgut et al., 2016), grape seed and clove bud extracts in silver carp (Shi et al., 2014), and clove extract in cooked beef patties (Zahid et al., 2020).

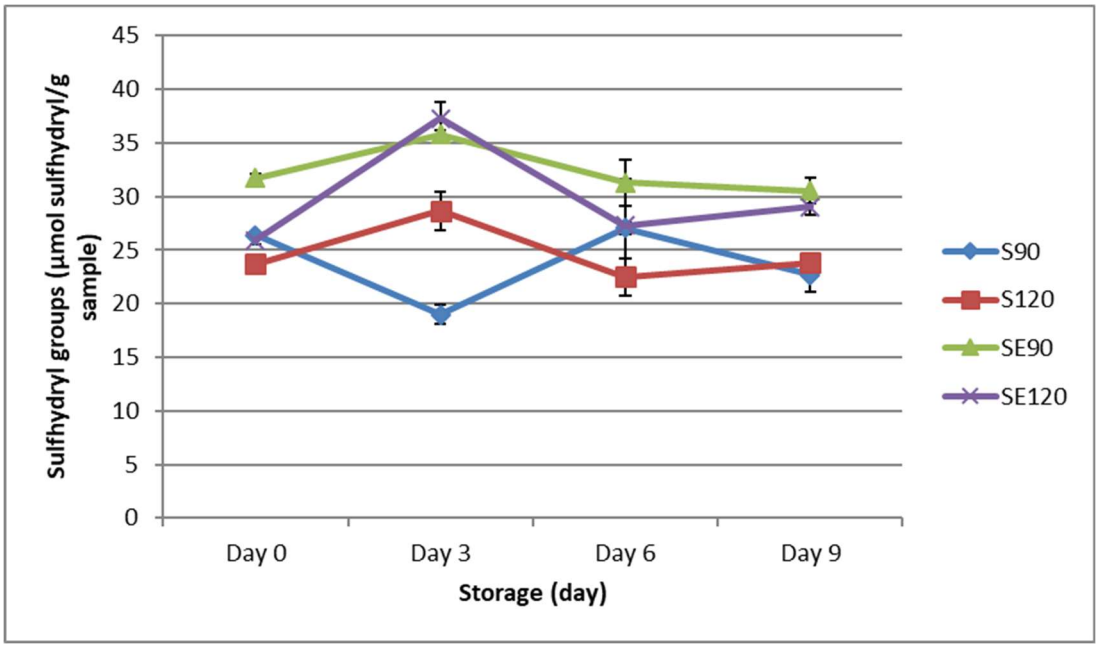

Figure 7. Sulfhydryl groups of sous vide cooked turkey breasts
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min

Texture Profile Analysis

The results of the texture profile analysis are presented in Table 2. On day 0, the SE120 samples exhibited significantly higher hardness compared to the other groups (P<0.05), correspondingly, the SE120 samples also recorded the highest chewiness values (P<0.05). Throughout storage, the hardness of the samples showed variation. Longer cooking time at a higher temperature likely led to greater protein denaturation and water loss, which can increase hardness and chewiness initially. Extended sous-

vide cooking can also cause the meat fibers to compact, contributing to a firmer texture (Bıyıklı et al., 2020). By the end of the storage period, the hardness values of the extract-incorporated samples were not significantly different from their initial values on day 0 ($P > 0.05$). Notably, the SE90 samples demonstrated the lowest hardness at the conclusion of storage ($P < 0.05$) Silva et al. (2016) reported that the prolonged sous-vide cooking time conduces to a decrease in the hardness of jerky chicken, while Pulgar et al. (2012) in pork ceeks and Roldán et al. (2013) in lamb loin observed the direct opposite effect. Similarly, we measured an increase in hardness values in laurel extract added samples by increasing cooking time ($P < 0.05$), but distinctively, extract-free samples had no significant alterations in hardness values ($P > 0.05$). It is obvious that, excluding the prolonged cooking time, some factors like meat source, meat type and presence of extract may cause variances in hardness value of sous-vide cooked meat.

Springiness means recovering the former shape of food when the effect that causes deterioration on shape disappears (Bıyıklı et al., 2020; Erdemir and Karaoğlu, 2021). Zhang et al. (2022) reported that the springiness values tended to decrease as the cooking time increased. In our study, the lowest springiness was measured in the SE90 sample, while the highest was in the S90 sample, both on the first and last day of storage ($P < 0.05$). Interestingly, the highest cohesiveness value was measured in SE90 sample ($P < 0.05$).

Cohesiveness is defined as a degree of difficulty in breaking down the internal structure of the food (Erdemir and Karaoğlu, 2021). Park et al. (2020) used different cooking temperature and tims (60-70°/1-2-3 hours) on chicken breast sous-vide cooking and reported that springiness and cohesiveness values of samples were not statistically affected by cooking time.

Chewiness is related to required energy to make ready the food to swallow and related with the mastication quantity and time (Bıyıklı et al., 2020; Erdemir and Karaoğlu, 2021). It was shown that the addition of laurel extract in sous-vide cooked turkey breast induces to decrease in chewiness with the storage, means less force is required to masticate the food. On the contrary, it was observed that the chewiness values of extract-free samples increased in the last day of storage. Similarly, Akoğlu et al. (2018) were mentioned that the chewiness of the sous-vide cooked turkey cutlet increased at the end of the 35 days of storage. Nevertheless, when the data was deeply investigated to compare with our results for similar storage days, there were no significant changes in chewiness values on the days until the 28th ($P > 0.05$). These results were in good agreement with the findings of our study for SE90 samples.

Sensory analysis

Addition of laurel extract not only increases product quality and shelf life, but also affects sensorial attributes, which obligates sensory analysis. The sesory scores were presented in

Color and appearance play a crucial role in assessing cooked meat quality and are among the most influential properties affecting consumer preferences (Ayub and Ahmad, 2019). The color scores of turkey breast meat ranged between 6.43 and 7.93. The lowest score after cooking was observed in SE90 group ($P<0.05$), which increased by the end of storage ($P<0.05$). It was determined that an increase in cooking time raised the color score in groups with extract, while the addition of extract reduced the color score in groups cooked for 90 minutes. No significant differences were observed between treatments on other storage days ($P>0.05$). Cooking time and LE addition exhibited a similar effect on appearance scores as well. The addition of LE resulted in a decrease in flavor scores on days 0 and 3 of storage for both cooking durations, while this effect was not observed on the other storage daysIt was stated that the increase in the amount of extract used affects the sensory quality (Akcan et al., 2017). The oxidative flavor scores of the samples showed no significant differences on the first and last days of storage ($P > 0.05$). Meat texture, which is closely related to its protein structure, is primarily evaluated based on tenderness and juiciness (Roldán et al., 2013).

Cooking time had no significant effect on texture, with similar texture scores recorded on days 6 and 9 ($P > 0.05$). Prolonged cooking time did not significantly influence overall acceptability scores ($P > 0.05$). Additionally, no significant differences were observed in extract-free samples throughout storage or among all treatments on the final day ($P > 0.05$). Cooking time, LE addition, and storage duration influenced sensory attributes such as color, appearance, and flavor of turkey breast meat, but no significant differences were observed in texture or overall acceptability among treatments by the end of storage. At the end of storage, all sensory parameters were statistically insignificant ($P > 0.05$)

Table 2. Texture profile analysis of sous vide cooked turkey breast

	Day 0	Day 3	Day 6	Day 9
Sample		Hardness (N)		
S90	$53.64^{b,z}\pm2.51$	$71.39^{a,y}\pm13.9$	$77.00^{a,xy}\pm4.93$	$90.12^{a,x}\pm12.48$
S120	$51.25^{b,y}\pm1.12$	$53.66^{b,y}\pm6.5$	$52.11^{b,y}\pm12.35$	$79.20^{ab,x}\pm7.92$
SE90	$55.10^{b,yz}\pm9.98$	$71.97^{a,xy}\pm7.37$	$74.60^{a,x}\pm17.67$	$52.60^{c,z}\pm5.38$
SE120	$76.01^{a,x}\pm2.67$	$51.84^{b,y}\pm10.96$	$66.44^{ab,x}\pm7.17$	$73.47^{b,x}\pm4.25$
Sample		Springiness(mm)		
S90	$0.61^{a,x}\pm0.01$	$0.58^{xy}\pm0.08$	$0.52^{y}\pm0.01$	$0.58^{a,xy}\pm0.03$
S120	$0.58^{b}\pm0.01$	0.57 ± 0.03	0.52 ± 0.09	$0.55^{b}\pm0.03$
SE90	$0.53^{c,yz}\pm0.02$	$0.59^{x}\pm0.03$	$0.57^{xy}\pm0.04$	$0.51^{c,z}\pm0.02$
SE120	$0.57^{b,x}\pm0.03$	$057^{x}\pm0.04$	$0.54^{xy}\pm0.01$	$0.51^{c,y}\pm0.02$
Sample		Cohesiveness		
S90	$0.49^{b,z}\pm0.01$	$0.51^{z}\pm0.02$	$0.53^{b,y}\pm0.01$	$0.60^{a,x}\pm0.01$
S120	$0.52^{b,y}\pm0.02$	$0.54^{y}\pm0.02$	$0.58^{a,x}\pm0.01$	$0.52^{c,y}\pm0.01$
SE90	$0.54^{a}\pm0.02$	0.53 ± 0.01	$0.53^{b}\pm0.02$	$0.55^{b}\pm0$
SE120	$0.52^{b,x}\pm0.01$	$0.53^{x}\pm0.01$	$0.51^{b,xy}\pm0.03$	$0.48^{d,y}\pm0.01$
Sample		Gumminess(N)		
S90	$25.98^{b,z}\pm0.69$	$36.12^{ab,y}\pm5.44$	$40.84^{xy}\pm2.38$	$48.33^{a,x}\pm7.68$
S120	$24.52^{b,y}\pm2.3$	$29.61^{bc,y}\pm3.55$	$30.17^{y}\pm6.84$	$38.18^{b,x}\pm5.75$
SE90	$27.56^{b,y}\pm6.54$	$41.75^{a,x}\pm4.87$	$38.09^{xy}\pm10.51$	$33.28^{b,xy}\pm3.13$
SE120	$42.56^{a,x}\pm2.59$	$26.78^{c,z}\pm5.69$	$32.22^{yz}\pm4.68$	$36.91^{b,xy}\pm0.67$
Sample		Chewiness(N)		
S90	$16.14^{b,y}\pm1.61$	$21.03^{ab,xy}\pm5.35$	$22.01^{xy}\pm1.65$	$23.79^{a,x}\pm4.4$
S120	$15.23^{b,y}\pm0.73$	$15.85^{b,xy}\pm1.52$	$15.95^{xy}\pm5.9$	$21.58^{ab,x}\pm4.01$
SE90	$14.65^{b,y}\pm3.4$	$24.21^{a,y}\pm2.66$	$17.32^{x}\pm4.52$	$17.06^{b,y}\pm1.09$
SE120	$23.29^{a,x}\pm1.79$	$17.34^{b,y}\pm4.26$	$17.06^{y}\pm2.69$	$18.70^{b,y}\pm0.7$

^{a,c} Means marked with different letters on the same column are significantly different ($P < 0.05$).

^{x,y} Means marked with different letters on the same row are significantly different ($P < 0.05$).

S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min +LE

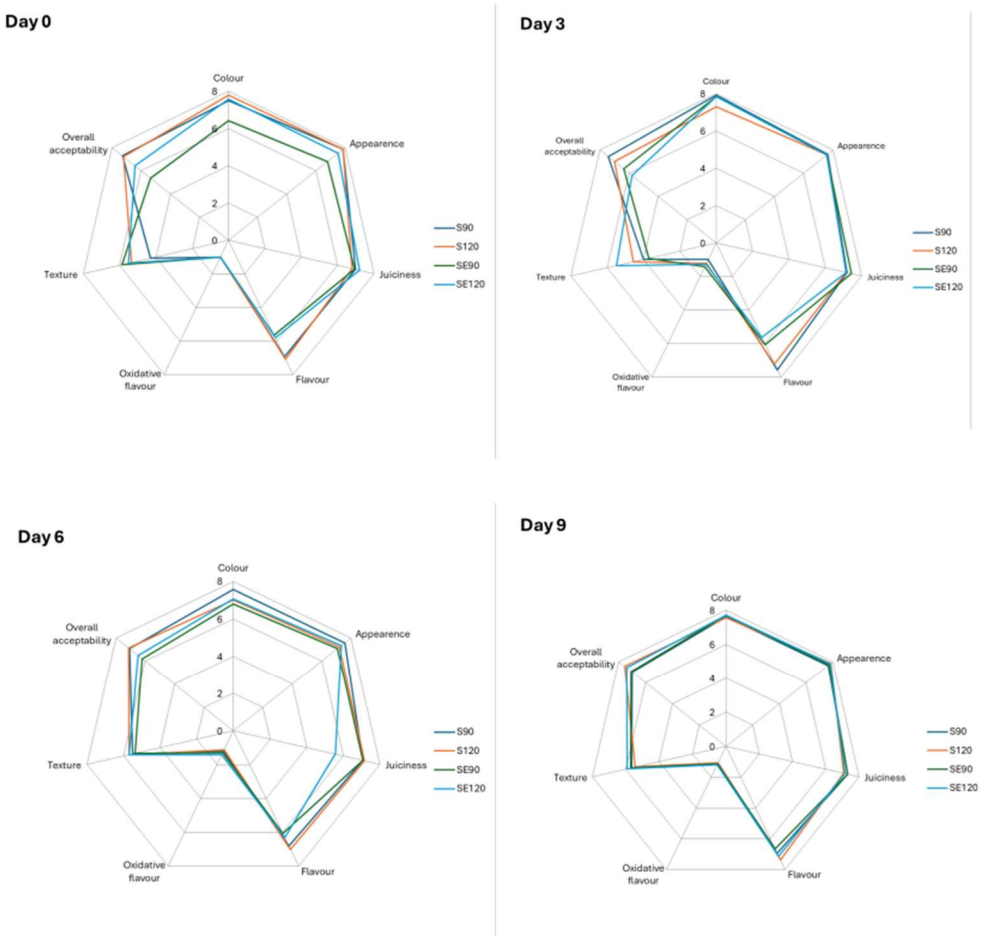

Figure 8. Sensory evaluation of sous vide cooked turkey breasts
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min

Microbiological analysis

Neither *Salmonella* nor *Listeria monocytogenes* was detected in raw or sous-vide cooked samples on both day 0 and day 9. The total aerobic mesophilic bacteria (TAMB) counts of sous-vide cooked turkey breast during cold storage are presented in Table 3. According to the Turkish Food Codex Regulation on Microbiological Criteria (2011), the acceptable limit for TAMB counts is 5 log cfu/g. In raw turkey breast meat, TAMB was measured as 3 log cfu/g. After sous-vide cooking, an increase in TAMB values was observed in all treatments except for the S120 treatment. This increase may have been caused by contamination from processing equipment such as chopping boards, knives, vacuum bags, tumblers, or water used in the marinade. Despite this, TAMB values in all samples remained below the regulatory limit. Additionally, the antimicrobial activity of laurel extract (LE) became evident by day 6 of storage.

Table 1. Total aerobic bacteria counts of sous-vide cooked turkey breast during cold storage

	Total Aerobic Bacteria (log cfu/g)			
Treatments	Day 0	Day 3	Day 6	Day 9
S90	$3.38^{c,z}\pm0.14$	$4.00^{b,y}\pm0.35$	$4.30^{b,xy}\pm0.15$	$4.60^{a,x}\pm0.22$
S120	$2.65^{d,z}\pm0.06$	$4.90^{a,x}\pm0.04$	$4.78^{a,x}\pm0.17$	$4.30^{b,y}\pm0.03$
SE90	$4.65^{b,x}\pm0.11$	$4.70^{a,x}\pm0.08$	$3.92^{c,y}\pm0.13$	$4.04^{c,y}\pm0.07$
SE120	$4.92^{a,x}\pm0.04$	$4.95^{a,x}\pm0.04$	$4.30^{b,y}\pm0.18$	$3.78^{d,z}\pm0.08$

[a,c] Means marked with different letters on the same column are significantly different (P <0.05).
[x,y] Means marked with different letters on the same row are significantly different (P <0.05).
S90: Sous-vide cooked at 90 min, S120: Sous-vide cooked at 120 min, SE90: Sous-vide cooked at 90 min +LE, SE120: Sous-vide cooked at 120 min +LE

In a previous study, turkey cutlets cooked using the sous-vide technique at 65°C for 40 minutes showed that total mesophilic bacteria counts exceeded 5 log cfu/g after 35 days of storage at 4°C and after 21 days at 12°C. The researchers also reported that *Listeria monocytogenes* and *Salmonella* pathogens were absent in all samples, but long-term storage negatively impacted sensory quality (Akoğlu et al., 2018). Similarly, Bıyıklı et al. (2020) investigated sous-vide cooking of turkey cutlets at combinations of 65-70-75°C for 20-40-60 minutes. They found no *Salmonella* species in any samples; however, *Listeria* species were detected in raw meat and in sous-vide cooked samples processed at 65°C for 20 minutes. Their findings also indicated that sous-vide cooking reduced TAB counts by approximately 2 log cfu/g. Furthermore, Nyam et al. (2023) reported that the total mesophilic aerobic count of raw chicken breast meat was 6.36 log cfu/g. After sous-vide cooking, the counts ranged between 2.81 and 4.49 log cfu/g, which is consistent with our results.

CONCLUSIONS

This study highlights the potential of laurel extract as an effective antioxidant in improving the quality and stability of marinated turkey breast meat during sous-vide cooking and refrigerated storage. The incorporation of LE significantly reduced lipid and protein oxidation, as evidenced by lower TBARS and carbonyl values, regardless of cooking time. Furthermore, the use of LE did not negatively impact the sensory attributes of the meat, even with extended cooking durations. While cooking time alone had no significant effect on cooking losses, longer sous-vide durations contributed to increased protein oxidation in samples without LE. Additionally, the microbiological analysis confirmed that all samples remained within safe consumption limits throughout the storage period.

The findings suggest that LE is a promising natural antioxidant for maintaining the quality, flavor, and oxidative stability of sous-vide cooked turkey breast, particularly for extended cold storage. This approach provides a practical and consumer-friendly solution for the food industry, catering to the growing demand for healthier, minimally processed, and ready-to-eat poultry products.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with any individuals or institutions regarding this article.

AUTHOR CONTRIBUTIONS

Meltem Serdaroğlu: overall conceptualization, methodology, reviewing and editing the manuscript, supervision and administration. Esra Derin: formal analysis, drafting the original manuscript, visualization of data. We certify that the English in this manuscript has been carefully reviewed and corrected.

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