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THE EFFECTS OF MARINATION WITH ROSEHIP INFUSION ON QUALITY PARAMETERS OF TURKEY BREAST FILLETS

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ABSTRACT
This research investigates the effects of using rosehip infusion as a marinade on the physicochemical, technological, textural properties, and oxidative stability of turkey breast meat. The chemical composition, technological properties, color and textural parameters, pH, and lipid oxidation of marinated turkey samples were determined. Marinades used in reformulated groups were prepared with rosehip at different concentrations (10 g (R1), 15 g (R2), and 20 g (R3)/150 mL). Rosehip-infused marinated samples exhibited lower pH, altered color parameters, enhanced water holding capacity and cooking yield, and increased marinade uptake (especially in R3). In texture analysis, it was observed that the hardness of the samples decreased, while the values of cohesiveness and springiness increased. Notably, rosehip infusion demonstrated antioxidative effects, lowering TBARS values compared to the control. In summary, marination with rosehip infusion presents a promising method to improve the technological and textural qualities of turkey breast meat while protecting against lipid oxidation.
Keywords: Turkey meat, marinades, rosehip, texture, tenderness, lipid oxidation

KUŞBURNU İNFÜZYONU İLE MARINASYONUN HİNDİ GÖĞÜS FİLETOLARININ KALİTE PARAMETRELERİ ÜZERİNDEKİ ETKİLERİ

ÖZ
Bu araştırma, kuşburnu infüzyonunun marinat olarak kullanılmasının hindi göğüs etinin fizikokimyasal, teknolojik, tekstürel özellikleri ve oksidatif stabilitesi üzerindeki etkilerini incelemektedir. Marine edilmiş hindi örneklerinin kimyasal kompozisyonu, renk parametreleri, teknolojik özellikleri, tekstür parametreleri, pH ve lipid oksidasyonu belirlenmiştir. Yeniden formüle edilmiş gruplarda kullanılan marinat çözeltileri farklı konsantrasyonlardaki kuşburnu ile hazırlanmıştır (10 g (R1), 15 g (R2) ve 20 g (R3)/150 mL). Kuşburnu infüzyonu ile marine edilmiş örnekler daha düşük pH, değişen renk parametreleri, geliştirilmiş su tutma kapasitesi ve pişirme verimi ile artan marinat emilimi (özellikle R3'te) sergilemiştir. Tekstür analizinde örneklerin sertliği azalırken yapışkanlık ile esneklik değerlerinin arttığı gözlenmiştir. Özellikle kuşburnu infüzyonu, kontrol grubuna kıyasla TBARS değerlerini düşürerek antioksidatif etkiler sergilemiştir. Özetle, kuşburnu

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infüzyonuyla marinasyon, hindi göğüs etinin teknolojik ve tekstürel özelliklerini iyileştirmek ve lipid oksidasyonuna karşı koruma sağlamak için umut verici bir yöntem sunmaktadır.
Anahtar kelimeler: Hindi eti, marinat, kuşburnu, tekstür, gevreklik, lipid oksidasyonu

INTRODUCTION

The association between optimal health and dietary patterns has led individuals to adopt a more conscientious approach toward their daily eating habits, aiming to incorporate diverse components into their diets. Consequently, there is a prevailing preference for the consumption of health-promoting foods that remain economically feasible. Within this framework, turkey meat has gained attention as a scientifically substantiated alternative to beef, owing to its notable attributes such as high protein and low-fat content (Çelen et al., 2016). Furthermore, turkey meat stands out as an excellent source of essential amino acids (alanine, serine, aspartic acid, methionine, glutamic acid, tyrosine, and lysine), vitamins (niacin, vitamin B6), and minerals (phosphorus and selenium), all of which contribute significantly to a healthy diet (Gök and Bor, 2016). Even though turkey breast meat is processed into products, its lower fat content renders it unsuitable for direct consumption in meals. This characteristic leads to a firmer texture, less tender, and comparatively subdued flavor profile compared to turkey thigh meat. Regarding meat quality, tenderness functions as a pivotal parameter indicating its appropriateness for consumption. This factor substantially impacts the gustatory satisfaction, perceived worth, and the consumer's inclination to reacquire the product (Xiong et al., 2020). Therefore, various techniques (mechanical tenderization (puncture and tumbling), high-pressure processing, pulsed electric field, ultrasound, and marination) have been used to improve the tenderness of turkey breast meat (Loyn and Hamm, 1986; Bhat et al., 2018).

Enhancing meat tenderness can be achieved through marination, particularly involving acidic compounds. This method has a historical significance in improving the sensory qualities and moisture retention of meat while also extending its shelf life (Alvarado and McKee, 2007; Kaewthong and Wattanachant, 2018; Çınar and Çolakoğlu, 2004). Notably, marination offers numerous benefits such as improving aroma, flavor, and addressing color deficiencies (Barbanti and Pasquini, 2005). Several studies have substantiated the positive effects of marinating turkey breasts, which include improvements in texture, sensory characteristics, and the ability to slow down oxidative changes (Gök and Bor, 2016; Serdaroğlu et al., 2007; Augustyńska-Prejsnar et al., 2019). An alternative way to describe marination in terms of its effects on tissue morphology is by influencing the pH of the tissue, causing it to deviate from its isoelectric point, which creates space between the myofilaments and allows for better water retention (Önenç et al., 2004). A variety of ingredients, including wine, vinegar, fruit juices, fermented milk products, oils, and salt, have been extensively employed in marinating various types of meat (Goli et al., 2014). Additionally, the inclusion of fruit and vegetable juices and extracts in marinades has been explored due to their antioxidant and antimicrobial properties (Nile and Park, 2014; Afrin et al., 2016; Kalaycıoğlu and Erim, 2019; Sarıcaoğlu et al., 2019; Van de Welde et al., 2019; Şengün et al., 2021).

Rosehip, the pseudo-fruit of the rose bush, particularly *Rosa canina* L. is known for its abundant polyphenols and vitamin C content, making it an excellent source (Fan et al., 2014). Rosehip contains 2-3 times more ascorbic acid than kiwi, 3-5 times more than peppers, and 5-6 times more than citrus fruits. The high polyphenol content, including flavonoids and phenolic acids, in rosehip tea contributes to its antioxidative potential (Karhan et al., 2004). These compounds have been found to scavenge free radicals, bind metal ions, and inhibit lipid peroxidation. Promising results have been observed in studies investigating the effect of rosehip on lipid oxidation in various food matrices (Rivera et al., 2022; Vlaicu et al., 2022). Research on the utilization of rosehip infusion for marinating meat products, especially turkey breast meat, has been limited. From this point of view, this study aims to investigate the effects of marinating turkey breast meat with rosehip infusion on various aspects, including physicochemical characteristics, technological properties, texture, and lipid oxidation.

MATERIAL AND METHOD

Material

Fresh, skinless turkey breast muscles (with a moisture content of 75.55±0.28%, protein content of 19.91±0.34%, fat content of 1.19±0.10%, and ash content of 3.38±0.35%, pH ranging from 5.91 to 5.93, free from visible blood spatter or bruises) were obtained from a national supermarket chain in sealed 750 g packs (Bolca Hindi Üretim ve Paz. A.Ş.). The muscles were sliced into 1 cm thick, 13 cm long fillets using a fillet knife, with each fillet weighing approximately 100 g. Dried whole rosehip fruits (*Rosa canina* L.) were sourced from a local herbalist in İzmir. The rosehip fruits were ground using a Waring 8011 EB SET2 blender (Stamford, CT) at the second speed for 30 secs to create a rosehip infusion for use as a marinade solution. All chemicals used were of analytical grade and obtained from Sigma-Aldrich Chemie GmbH, Germany.

Preparation of marinated turkey breast and cooking process

Three rosehip infusions (RI1: 67 g/L, RI2: 100 g/L, and RI3: 133 g/L) were prepared as marinade solutions. Specified amounts of rosehip powder were placed within individual filter papers. These mixtures were then infused with distilled water at 100°C for 30 min to achieve the specified concentrations. Distilled water was used as the marinade solution for the control (C) group. The examination of the acquired infusion took place after it had cooled to room temperature (Figure 1).

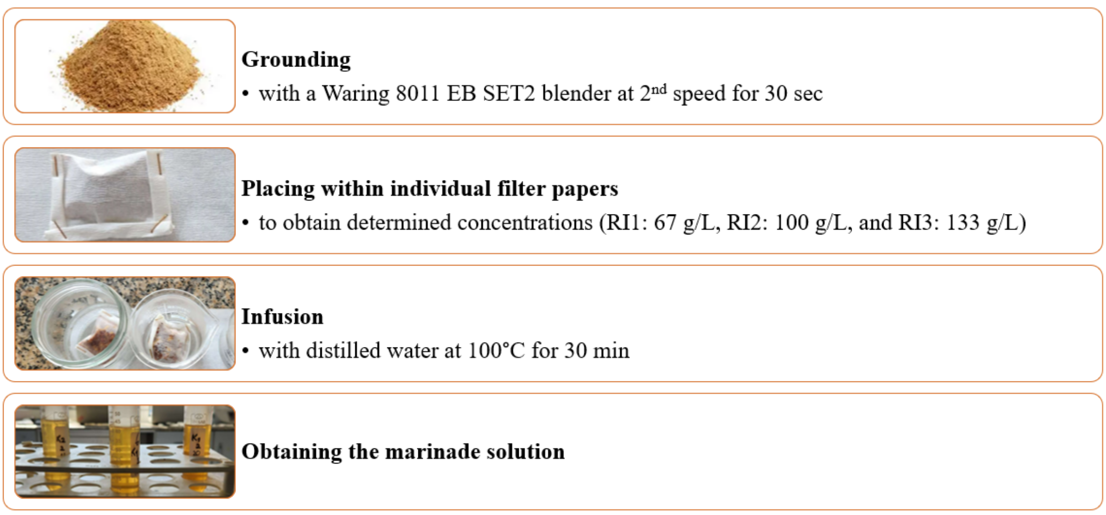

Figure 1 Preparation of the marinades

The turkey breast fillets, along with their respective rosehip infusions (at a ratio of 1:1 w/w meat to marinade), were placed into sous-vide bags (thickness of 90 ±3 µm, an oxygen permeability of 160 cc/m^2/d, and a water vapor permeability of less than 8 g/m^2.d) and allowed to marinate for 4 h at +1ºC. Then marinade liquid was drained from all the samples, and the bags were vacuum sealed for storage. Samples were sous-vide cooked using a WiseBath (Germany) at 80ºC until the core temperature reached 73ºC (Figure 2). Subsequently, the samples were rapidly cooled to room temperature and stored in a refrigeration unit at +1ºC until further analysis. pH measurement, instrumental color evaluation, peroxide, and TBARS (Thiobarbituric Acid Reactive Substances) analysis were performed on days 0, 3, 5, and 7 of the storage periods.

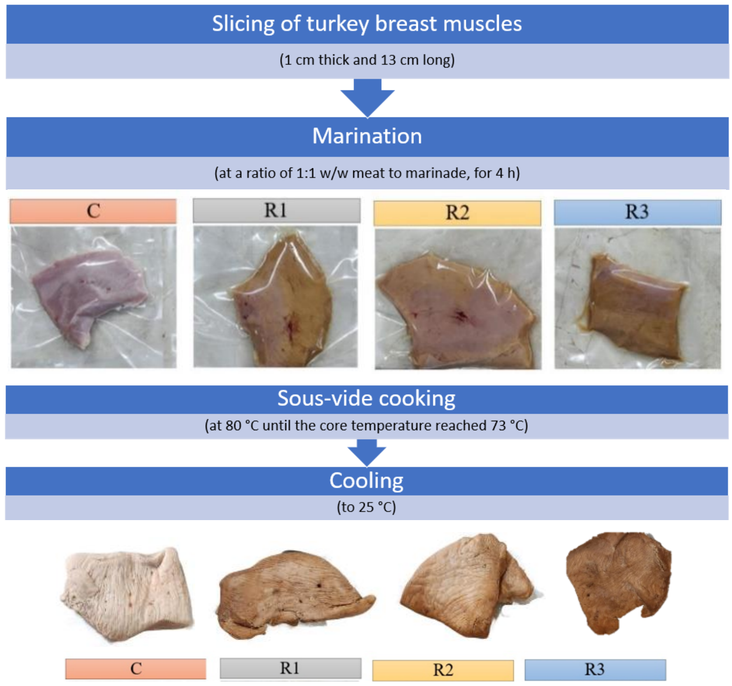

Figure 2 Process flow diagrams production of marinated turkey breasts including the experimental design

Method

Analysis of rosehip infusion

The pH measurements of marinades were measured using a digital pH meter (WTW pH 3110 set 2, Germany) in triplicates. The total phenolic content (TPC) analysis was conducted using a modified Folin-Ciocalteu (FC) method, as outlined by Yılmaz et al. (2015). For this analysis, 30 µL of methanolic sample extract and 150 µL of FC reagent were transferred to test tubes, followed by the addition of 2.37 mL of distilled water. After an 8 min incubation, 450 µL of sodium carbonate was introduced into the mixture. Following a 30 min incubation at 40ºC, absorbance was measured at 750 nm using a spectrophotometer (PG Instruments, T-60, UK). The results were expressed as mg of gallic acid equivalent per g. The DPPH analysis was performed by the method described by Grajeda-Iglesias et al. (2016). In this procedure, 20 µL of a sample diluted in ethanol (at a 1:40 dilution) was combined with 180 µL of a methanolic DPPH solution. After vortexing the microcentrifuge tubes for around 30 secs, they were incubated for 30 min before measuring the absorbance at 515 nm using a spectrophotometer (PG Instruments, T-60, UK). The absorbance readings were used to evaluate anti-radical activity through a linear equation plot.

Analysis of the marinated turkey breast

Chemical composition

The determination of total moisture and ash contents followed the guidelines set by the Association of Official Analytical Chemists (2012). The protein content was measured using a LECO nitrogen determinator (FP528, USA), and the analysis of lipid content was conducted by the method outlined by Flynn and Bramblett (1975).

Instrumental quality

The pH measurements were measured using a digital pH meter (WTW pH 3110 set 2, Germany) in triplicates. The pH level of the samples was monitored during the storage period on days 0, 3, 5, and 7 from three different spots on the fillet. The color parameters of the cooked samples were monitored during the storage period on days 0, 3, 5, and 7 using a digital colorimeter (Chromameter CR 400, Minolta, Japan) to obtain the coordinates lightness (L^*), redness (a^*), and yellowness (b^*) in triplicates from different parts of the samples.

The total color difference (ΔE), Chroma (C*), and hue angle (h°) values were calculated according to AMSA (2012).

For the texture profile analyses (TPA), a TA-XT2 texture analyzer from Stable Micro Systems in Haslemere, UK was utilized. The TPA results were reported in terms of hardness (N), springiness, cohesiveness, gumminess (N), and chewiness (N×mm). The samples used for analysis had dimensions of 2.5 cm in height and 2.2 cm in diameter. During the analysis, the samples were compressed twice to 50% of their original height using specific settings according to García-Segovia et al. (2014): cylindrical probe P36/R, post-test speed of 2 mm/s, crosshead speed of 1 mm/s, and test speed of 1 mm/s. The compression was applied using a load cell with a force of 50 kg.

Technological analyses

The determination of water holding capacity (WHC) was carried out with some modifications to the method described by Hughes et al. (1997). 10 g of sample was weighed (M1) and placed in a glass jar to be heated in a water bath for 10 min at 90 ºC. The jars were then cooled down to room temperature. The samples inside the jars were wrapped up in cotton-based gauze and centrifuged for 15 min at 1400 rpm. The samples liberated from their gauze wrap were weighed (M2) and the difference was used to calculate the water retention rate along with the moisture content of the samples (M3).

$$\% WHC = 1 - (M1 - \frac{M2}{M3}) \times 100$$

Cooking loss was determined by weighing the samples before (M1) and after (M2) the sous-vide cooking process and determining the value based on the difference between the weights. Marinade uptake (%) was calculated from the weight of the samples taken before and after marination.

Lipid oxidation

The peroxide analysis was carried out in accordance with the protocols specified by the Association of Official Agricultural Chemists (2012). A 10g sample (M) was mixed with 60 mL of 96% chloroform at 600 rpm for 2 min. The mixture was filtered, and to the filtrate, 30mL of glacial acetic acid and 2mL of saturated potassium iodide (KI) was added. After 5 min in a sealed flask, 100mL distilled water and 2mL 1% starch solution were introduced. The resulting mixture was shaken and titrated with 0.1 N sodium thiosulfate until a color change from dark purple to pink was observed, and the sodium thiosulfate consumption (C) was recorded for calculation.

$$Peroxide\ Value\ \left({}^{mEq\ O_2}/_{kg}\right) = \left[\frac{(Normality\ of\ Sodium\ Thiosulphate\ x\ C\ x\ 1000)}{M}\right]$$

The Thiobarbituric Acid Reactive Substances (TBARS) were determined following the method of Witte et al. (1970). A 20g sample was used for the TBARS analysis. The sample was homogenized with 50mL of chilled 20% trichloroacetic acid (TCA) using a blender (Sinbo, Turkey) for 2 min. The homogenized mixture was filtered, and the filtrate was then re-filtered through Whatmann No.1 filtering paper into a 100mL flask. The flasks were adjusted with a 1:1 (v/v) mixture of chilled water and TCA as needed. For the analysis, 5 mL samples were combined with 5 mL of 0.02 M thiobarbituric acid (TBA) and heated in a water bath at 80 ºC for 35 min. After cooling to room temperature, absorbance was measured at 532 nm using a spectrophotometer (PG Instruments, T-60, UK) with a blank sample of 1:1 (v/v) TCA and distilled water. Results were expressed as TBA values (mg malonaldehyde/kg sample), calculated by multiplying the absorbance by 5.2. Both peroxide and TBARS analyses were conducted throughout the storage period to monitor lipid oxidation.

Statistical assessment

Production was carried out with 15 packages from each group (C, R1, R2, and R3), each containing 3 slices of turkey steak. The analyses of the relevant parameters for each treatment were performed in triplicate. The results were expressed as the mean and standard error of data obtained from three independent batches. The statistical software package SPSS 21.0 (SPSS Inc, Chicago, USA) was used to analyze the data using the General Linear Model (GLM) procedure. Different formulation groups (treatments) and storage days were assigned as fixed factors. while each replicate was considered as a random factor to investigate the effects of marination with rosehip infusion on the quality parameters. One-way Analysis of Variance (ANOVA) was applied to determine if there were statistically significant differences among independent groups. At the same time, two-way ANOVA was used to determine the effects of processing and storage. Duncan's test was used to identify significant differences (P <0.05) among formulations and storage conditions.

RESULTS AND DISCUSSION

Characteristics of Rosehip Infusion

Table 1 provides the phenolic content, DPPH value, and pH values of the marinade solutions. The total phenolic content (TPC) and DPPH values of the marinas varied between 138.50-241.11 mg GAE/g and 33.69-52.62 μmol TE/g, respectively. Increasing the ratio of rosehip powder in the marinade has resulted in higher TPC and DPPH values in the samples (P <0.05). Our TPC results are consistent with the findings reported by Koczka et al (2018). Due to its acidic nature, the increase in the ratio of rosehip powder in the marinade has led to a decrease in the pH values of the samples. The highest pH value was observed in RI1, while the lowest value was detected in RI3 (P <0.05). This observation is consistent with the results reported in a prior study (Orhan et al., 2012).

Table 1 Characteristics of marinade solution

Marinade*	pH	Total phenolic content (mg GAE/g)	DPPH (μmolTE/g)
RI1	3.71±0.01[a]	138.50±0.10[c]	33.69±0.18[c]
RI2	3.64±0.01[b]	165.15±0.05[b]	47.59±0.01[b]
RI3	3.58±0.06[c]	241.11±0.10[a]	52.62±0.08[a]

*RI1: 67 g/L rosehip powder, RI2: 100 g/L rosehip powder, RI3: 133 g/L rosehip powder. [a-c]Different letters in the same column indicate a significant difference (P < 0.05). Data were presented as the mean ± standard deviation.

Physicochemical Properties

The physicochemical properties of marinated turkey breast fillets are given in Table 2. Marination using rosehip infusion significantly affected (P <0.05) the moisture content of turkey breast fillets. The moisture content ranged between 73.83% and 77.44%. Apart from the R1 sample, marination resulted in an increment in moisture content. In a similar study conducted by Serdaroğlu *et al* (2007), it was observed that solutions containing citric acid and grapefruit juice resulted in an increase in moisture content in turkey meat.

Table 2 Physicochemical properties of turkey breasts (%)

Treatments*	Moisture	Marinade uptake	Water holding capacity	Cooking yield
C	75.75±0.58[b]	3.58±0.01[b]	48.08±0.85[ab]	77,22±0.82[b]
R1	73.83±0.55[c]	3.60±0.02[b]	47.19±0.71[b]	76,12±0.13[b]
R2	76.66±0.02[ab]	3.61±0.03[b]	48.12±0.89[ab]	78,70±0.64[a]
R3	77.44±0.79[a]	3.78±0.02[a]	49.50±0.95[a]	79,42±0.68[a]

* C: distilled water. R1: 6.67% rosehip infusion. R2: 10% rosehip infusion. R3: 13.33% rosehip infusion. [a-b] Different letters in the same column indicate a significant difference (P < 0.05). Data were presented as the mean ± standard deviation.

Marinating uptake is a measure of its ability to penetrate the turkey breast fillet. A high amount of absorbed marinade solution increases the effectiveness of the marination process. As shown in Table 2, marinade uptake values varied between 3.58% (C) and 3.78% (R3). Except for R3, there was no statistically significant difference in the marinade uptake values among the samples

(P >0.05). The marination of chicken meat using various vinegar varieties yielded lower marinade uptake values according to the findings of Dilek et al. (2023). Sengun et al. (2021) discovered that the marinate uptake of beef samples marinated in organic fruit vinegar exhibited no significant differences among them.

Water holding capacity (WHC) refers to the meat's capability to retain both its own water and any additional water due to applied pressure (Önenç et al., 2004). Except for R3, the utilization of rosehip infusion for marinating turkey breast fillets did not show improvement in WHC values. The WHC of the samples exhibited a range between 47.19% (R1) and 49.50% (R3), with the highest value being evident in the R3 group, similar values were recorded for R2 and C groups (P >0.05). It has been documented that as the pH of muscle proteins falls below their isoelectric point, carboxyl groups acquire protons, resulting in an overall increase in positive charge. This phenomenon leads to the formation of a region within the structure that retains water, driven by the repulsive force between similarly charged protein groups (Offer and Knight, 1988). Similarly, Ünal et al (2022) reported that marinating chicken breast fillets with lemon and grapefruit juice caused an increase in water retention capacity.

The cooking yield varied within the range of 76.12% (R1) to 79.42% (R3). Although the R1 treatment showed cooking loss similar to the control, the R2 group exhibited similarities to the R3 group (P >0.05). It can be stated that an increase in the concentration of rosehip in the marinade formulation is associated with an improvement in cooking yield. Previous studies indicated that turkey breast samples treated with higher concentrations of citric acid and grapefruit juice exhibited decreased cooking losses (Serdaroğlu et al., 2007). Similarly, marination with black carrot juice yielded the lowest cooking losses in turkey breast samples (Gök and Bor, 2016). It can be stated that the R3 group, marinated with the highest concentration of rosehip powder, possesses the desired technological characteristics.

Texture Parameters

The results of the texture profile analysis are shown in Table 3. The marination treatment significantly affected all textural parameters (P <0.05). Hardness values of samples ranged between 4.44 (R3) to 5.07 (C) N. While no significant differences were found between the control and the R1 treatment, a decrease in hardness was noted for the R2 and R3 treatments (P <0.05). Similar to our results, the hardness value of turkey breast meat decreased with acidic marination, according to previous studies (Gök and Bor, 2016; Serdaroğlu et al., 2007; Goli et al., 2014). The reduction in hardness was attributed to the increase in tenderness caused by the acidic marinade (Serdaroğlu et al., 2007). Ünal *et al* (2022) marinated chicken breast fillets with apple cider vinegar and 0.2 M acetic acid, noting that the treated fillets exhibited reduced hardness values compared to the control treatment. Marinating in an acidic solution reduces the meat's pH, which subsequently enhances meat tenderness by increasing the solubility of collagen and myofibrillar proteins, as well as swelling of the myofibrillar system (Ehsanur Rahman et al., 2023). Springiness is a significant texture parameter frequently employed to evaluate meat's tenderness and resilience (Novaković and Tomašević, 2017). Increased springiness implies that the meat exhibits excellent elasticity and is less prone to becoming excessively tender or mushy during cooking or chewing. Springiness values of the samples showed significant differences from the control group; R1 had lower springiness (0.35), whereas R2 and R3 exhibited higher springiness than C (0.37) (P <0.05). In a study on beef steak, the use of balsamic and grape vinegar in the marination process decreased the springiness value compared to the control group (Fencioğlu et al., 2022). The cohesiveness values of the samples increased regardless of the concentration of rosehip powder (P <0.05). Gumminess values exhibited notable changes among samples (P <0.05). Although the highest value was found in R1, R2 and R3 had significantly lower gumminess values compared to the control group (P <0.05).

Table 3 Textural properties of turkey breasts

Treatments*	Hardness (N)	Springiness	Cohesiveness	Gumminess (N)	Chewiness (N.mm)	Resilience
C	5.07±0.04[a]	0.37±0.01[b]	0.38±0.01[d]	2.41±0.04[ab]	0.92±0.09[a]	0.14±0.01[c]
R1	4.97±0.06[a]	0.35±0.01[c]	0.44±0.01[b]	2.43±0.08[a]	0.84±0.01[a]	0.16±0.01[b]
R2	4.81±0.06[b]	0.38±0.01[a]	0.42±0.02[c]	2.27±0.06[b]	0.73±0.05[b]	0.17±0.01[b]
R3	4.44±0.11[c]	0.38±0.02[a]	0.47±0.01[a]	1.76±0.11[c]	0.52±0.03[c]	0.19±0.01[a]

* C: distilled water. R1: 6.67% rosehip infusion. R2: 10% rosehip infusion. R3: 13.33% rosehip infusion. [a-d] Different letters in the same column indicate a significant difference (*P* < 0.05). Data were presented as the mean ± standard deviation.

Chewiness values followed a similar trend with hardness values. High quality meat is often associated with lower chewiness scores, indicating a more acceptable and tender texture (Sasaki et al., 2014). No significant differences were recorded between C and R1 treatments. The lowest chewiness was found in R3 samples. Our results show that R2 and R3 marinade solutions increase the tenderness of turkey breast meat. A similar result was shown in a study when chicken breast meat was marinated in 100% lemon juice (Ünal et al., 2022). Resilience values were significantly influenced by the marinade concentration. All marinated samples had higher resilience values than the control group (*P* <0.05). The improvement of textural properties in turkey breast meat can be attributed to the acidic characteristics of rosehip infusion.

the pH of Marinated Turkey Meat

The pH values of turkey breast fillets during storage are provided in Table 4. The effect of marination on the pH values of turkey breast samples was found to be significant. On the first day of storage, the pH values ranged from 5.75 (R3) to 5.90 (C), and the samples marinated with rosehip exhibited lower pH values compared to the control group (*P* <0.05). Similarly, in turkey breast samples marinated with aronia, grape, and hawthorn, the highest pH value was observed in the control group (Dilek et al., 2023). Except for the 3rd day of storage, the lowest pH values were generally observed in the R3 group (*P* <0.05). This is attributed to the higher concentration of rosehip used in marinating the samples in the R3 group (Table 1). Marinating turkey breast meat with different fruit juices such as black mulberry, grape, and pomegranate resulted in a decrease in pH values (Gök and Bor, 2016). Throughout storage, the pH values of the R1 and R2 groups were mostly similar to the control groups.

Table 4 pH values of turkey breasts

Treatments*	Storage	C	R1	R2	R3
pH	0	5.90±0.03[aY]	5.86±0.04[aY]	5.86±0.02[aY]	5.75±0.03[bY]
	3	5.86±0.01[aY]	5.75±0.04[bZ]	5.82±0.02[aZ]	5.72±0.05[bY]
	5	5.99±0.03[aX]	6.01±0.07[aX]	5.98±0.01[aX]	5.89±0.04[bX]
	7	5.97±0.02[aX]	5.81±0.02[bYZ]	5.83±0.01[bZ]	5.73±0.02[cY]

* C: distilled water. R1: 6.67% rosehip infusion. R2: 10% rosehip infusion. R3: 13.33% rosehip infusion. [a-c]Different letters in the same row indicate a significant difference. [X-Z] Different letters in the same column indicate a significant difference (*P* < 0.05). Data were presented as the mean ± standard deviation.

Instrumental Color Parameters

The color of poultry meat is an important quality parameter as the visual appearance of meat ultimately impacts the consumer's purchasing decision and the final acceptance of the cooked product during consumption (Nusairat et al., 2022). Color parameters of the samples (L*, a*, and b*) are presented in Table 5, and color indices (Hue angle, Chroma, and ΔE) are shown in Table 6. The marination process significantly affected the color of the turkey breast meat (P <0.05). Marinating with rosehip infusion has caused the samples to have lower brightness and higher redness and yellowness values compared to the control samples. The increase in a* (redness) and b* (yellowness) values can be explained by the reddish-yellow color displayed by rosehip infusion. In contrast to our findings, acid-marinated turkey breast samples showed notably higher L* values in comparison to the control, as documented by Serdaroğlu et al. (2007). A comparable result was noted in turkey breast samples marinated and cooked with black mulberry, red grape, and pomegranate, as indicated by a reduction in L* values and an increment in a* and b* values (Gök and Bor, 2016). The variation in the quantities of color contributing substances in marinade formulation can result in differing marinade colors, thereby influencing the appearance of marinated meat (Serdaroğlu et al., 2007).

Table 5 Color parameters of turkey breasts

Treatments*	Storage	C	R1	R2	R3
L*	0	67.52±1.57^{a,Y}	60.63±1.25^{b,}	61.21±1.19$^{b, X}$	52.93±0.69^{c,Y}
	3	70.98±1.74^{a,X}	61.53±1.15^{c,}	61.33±1.09$^{b, X}$	51.78±1.29^{c,Y}
	5	73.44±1.32^{a,X}	61.62±1.78^{b,}	55.64±0.78^{d,Z}	58.10±0.61^{c,X}
	7	72.76±1.39^{a,X}	61.15±0.65^{b,}	58.40±0.17^{c,Y}	57.47±0.35^{c,X}
a*	0	4.53±0.26^{c,X}	8.75±0.27$^{b, Y}$	8.63±0.26$^{b, Y}$	9.74±0.44^{a,Y}
	3	1.58±0.33^{c,Z}	10.86±0.46^{a,X}	7.31±0.21^{b,Z}	10.41±0.37^{a,X}
	5	0.52±0.23^{d,T}	6.47±0.43^{c,Z}	9.40±0.28^{a,X}	7.71±0.34^{b,Z}
	7	2.36±0.44^{b,Y}	6.98±0.57^{a,Z}	7.31±0.48^{a,Z}	7.56±0.13^{a,Z}
b*	0	13.87±0.34^{c}	21.63±0.32^{a,X}	17.00±1.52^{b,Y}	21.06±0.49^{a,X}
	3	14.06±0.86^{d}	21.79±0.15^{a,X}	16.31±0.40^{c,Y}	20.30±0.63^{b,X}
	5	13.86±0.55^{c}	14.88±0.97^{c,Y}	19.10±0.60^{a,X}	17.55±0.09^{b,Y}
	7	14.59±0.35^{b}	14.88±0.99^{b,Y}	15.55±0.48^{b,Y}	16.93±0.39^{a,Y}

* C: distilled water. R1: 6.67% rosehip infusion. R2: 10% rosehip infusion. R3: 13.33% rosehip infusion. $^{a-d}$ Different letters in the same row indicate a significant difference (P < 0.05). $^{X-T}$ Different letters in the same column indicate a significant difference (P < 0.05). Data were presented as the mean ± standard deviation.

Table 6 Color indices of turkey breasts

Treatments*	Color indices		
	Hue angle	Chroma	ΔE
C	71.90±1.23^{a}	14.59±0.29^{c}	-
R1	67.99±0.49^{b}	23.33±0.36^{a}	11.22±1.19^{b}
R2	63.01±1.37^{d}	19.07±1.47^{b}	9.54±1.96^{b}
R3	65.19±0.49^{c}	23.20±0.63^{a}	17.11±0.98^{a}

* C: distilled water. R1: 6.67% rosehip infusion. R2: 10% rosehip infusion. R3: 13.33% rosehip infusion. $^{a-d}$ Different letters in the same column indicate a significant difference (P < 0.05). Data were presented as the mean ± standard deviation.

The storage period was found to have an effect on the color values of the samples. During storage, the L* values of the R1 samples remained constant, while an increase was observed in the control and R3 samples, and a decrease in the R2 samples. At the end of the storage, the a* value was found to be lower in all sample groups compared to the initial value. While the yellowness of the control samples remained unchanged during storage, the yellowness of all experimental groups infused with rosehip infusion decreased during storage.

The hue angle represents the transition of color between red and yellow, with greater angles indicating a reduced presence of red in the product (Tapp et al., 2011). Due to having the highest (P <0.05) hue angle value, the C treatment exhibits lower redness in comparison to the treatments marinated with rosehip infusion. This finding is in alignment with the results of a^* value measurements (Table 5). For meat products, chroma value refers to the intensity or saturation of color present on the meat's surface. Consistent with the hue angle findings, the C treatments can be characterized as having a diminished chroma value (P <0.05) compared to the other samples, implying a "muted or pale" appearance. Conversely, the samples marinated with rosehip infusion exhibited more vivid and intense colors. Additionally, it was observed that chicken breast muscle treated with acidic solutions displayed notably elevated chroma values (Gheisari and Motamedi, 2010). The measurement of the total color difference (ΔE) was conducted between the marinated and the control samples. The ΔE values of samples were determined as 11.22 and 9.54, respectively, with no statistically significant difference observed between these groups (P >0.05). Since these values are higher than 6, it can be said that there is a noticeable color difference compared to the control. Since the ΔE value of the R3 group is greater than 12, there is a substantial and distinct color difference compared to the control group, implying that panelists would readily perceive this distinction. A similar result has been observed in chicken breast samples marinated with grapefruit and lemon juice (Gheisari and Motamedi, 2010).

Oxidative Changes

Lipid peroxidation plays a significant role in reducing the quality of meat and meat products during storage. This process can lead to undesirable changes in flavor, color, texture, and nutritional value, while also resulting in the production of toxic compounds (Taheri et al., 2018). In order to evaluate the lipid oxidation, samples were subjected to peroxide analysis and the peroxide values are presented in Table 7. When examining the initial peroxide values of the samples, it is observed that there is no significant difference. The impact of marination with rosehip infusion on peroxide values was not found to be statistically significant during the 0th and 3rd days of storage (P >0.05). On the other hand, the highest peroxide value (2.0 meqO_2/kg) was observed in the R3, while the lowest value (1.03 meqO_2/kg) was recorded in the C group on the 5th day of the storage (P <0.05). Previous researchers reported that marinating turkey breast muscles in acetic acid, and chitosan + cumin caused lower peroxide values than the control (Taheri et al., 2018). On the 7th day, the peroxide values ranged between 1.33 and 2.50 meqO_2/kg. Except for C and R2, the peroxide values of samples decreased steadily during the storage period. This phenomenon can be associated with the conversion of hydroperoxides into secondary oxidation products. The peroxide values observed in all samples remained considerably lower than the suggested acceptable threshold of 10 meq O_2/kg of meat fat, as indicated by Evranuz (1993).

Table 7 Peroxide values (meqO_2/kg) of turkey breasts

Treatments*	Storage	C	R1	R2	R3
Peroxide value	0	3.45±0.42^{X}	3.46±0.12^{X}	4.10±0.78^{X}	3.30±0.46^{X}
	3	2.33±0.30^{Y}	2.13±0.81^{Y}	1.80±0.40^{YZ}	2.13±0.46^{Y}
	5	1.03±0.06$^{d.Z}$	1.79±0.02$^{b.Y}$	1.57±0.06$^{c.Z}$	2.00±0.01$^{a.Y}$
	7	2.16±0.20$^{b.Y}$	1.33±0.10$^{c.Y}$	2.50±0.19$^{a.Y}$	1.33±0.11$^{c.Y}$

* C: distilled water. R1: 6.67% rosehip infusion. R2: 10% rosehip infusion. R3: 13.33% rosehip infusion. $^{a-d}$ Different letters in the same row indicate a significant difference (P < 0.05). $^{X-Z}$ Different letters in the same column indicate a significant difference (P < 0.05).

The TBARS values of the turkey breasts are given in Table 8. The TBARS values ranged between 0.14 (R3) and 1.27 (C) mg MA/kg at the beginning of the storage, while no significant differences were recorded between R1 and R2 treatments (P >0.05). During each measurement period throughout storage, the TBARS values of marinated samples were found to be lower than the control sample. TBARS values at each evaluating period were significantly higher in control samples compared to marinated counterparts. The probable cause behind the marinated samples, exhibiting lower TBARS values compared to the control samples, can be attributed to the presence of vitamin C and phenolic compounds. The antioxidative activity of rose hip is attributed to its rich levels of vitamin C and total phenolic content, as demonstrated by Larsen et al. (2003). Furthermore, Gruenwald et al. (2019) reported that vitamin E and carotenoids are also recognized as components that play a role in enhancing antioxidative activity.

Table 8 TBARS values (mg MA/kg sample) of turkey breasts

Treatments*	Storage	C	R1	R2	R3
TBARS	0	1.27±0.04$^{a.Z}$	0.26±0.11$^{b.Z}$	0.29±0.01$^{b.Z}$	0.14±0.01$^{c.T}$
	3	1.46±0.11$^{a.Y}$	0.43±0.06$^{b.Y}$	0.24±0.01$^{c.T}$	0.25±0.01$^{c.Z}$
	5	0.90±0.03$^{a.T}$	0.58±0.02$^{b.X}$	0.52±0.03$^{c.Y}$	0.58±0.16$^{b.Y}$
	7	1.91±0.02$^{a.X}$	0.63±0.01$^{c.X}$	0.64±0.01$^{c.X}$	0.67±0.01$^{c.X}$

* C: distilled water. R1: 6.67% rosehip infusion. R2: 10% rosehip infusion. R3: 13.33% rosehip infusion. $^{a-c}$ Different letters in the same row indicate a significant difference (P < 0.05). $^{X-T}$ Different letters in the same column indicate a significant difference (P < 0.05).

On the 7th day, while the highest value was found in C, the lowest value was observed in R1 and R2. TBARS values of C, R1, and R3 treatments increased until day 3. Overall, the differences among marinated samples were not statistically significant on the 7th day of storage. TBARS levels in all treatments remained below the acceptable rancidity level (<2 mg Malonaldehyde/kg) (Witte et al., 1970).

CONCLUSION

The utilization of marinades containing various concentrations of rosehip in turkey breast samples enhanced the textural and technological properties of the samples. Additionally, due to the high antioxidative effect of rosehip, it was observed that the samples were protected against lipid oxidation. While there was a significant increase in the a* and b* values of the turkey breast sample, no adverse effects were detected in their chemical composition. Therefore, it can be suggested that rosehip powder at a level of 133 g/L may be a natural alternative source for use as a marination solution. Further studies might be conducted to evaluate the shelf life and storage conditions of turkey breast fillets treated with rosehip infusion marination. This could address practical concerns related to the applicability of rosehip infusion as a marination solution on an industrial scale.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this study.

CONTRIBUTIONS

MS: Project administration and methodology, conceptualization, supervision, data curation and data analysis, writing original draft; ÖYB: Conceptualization, supervision, formal analysis, resources, data curation and data analysis, writing original draft; MK: Formal analysis, resources, writing original draft.

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