OPEN ACCESS Advances in Animal and Veterinary Sciences

Research Article

The Use of *Mentha piperitae folium* and *Zingiber officinale* Freshwater Extract in the Improvement of Some Parameters of Old-Aged Mutton Meat

Dina A. Yousif, Mohamed M.T. Emara, Marwa R.S. Abdallah*

Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University, Egypt.

Abstract | The primary goal of this study was to ascertain whether *Mentha piperitae folium and Zingiber officinale* crude water extracts might be utilized to increase the sensory acceptability of old mutton, particularly the flavor. Three groups of mutton flesh were used in the study; one group had a plain marinade, while the other two groups received 5% fresh water extracts of either *Mentha piperita folium or Zingiber officinale* added to the plain marinade. All samples were marinated for 24 h at 4 °C before being cooked to a final core temperature of 75 °C using either moist or dry thermal processing. The fatty acid profile, pH value, objective color indexes, sensory characteristics, and marinade uptake were all measured in the raw mutton samples. Additionally, the cooked samples were examined for cooking loss, fatty acid composition, shear force, instrumental color parameters, and sensory analysis. The use of both extracts improved the overall sensory attributes, eliminated the unfavorable mutton flavor, improved the fatty acid composition, and produced a more stable color with a higher tenderness score. It has been concluded that the aqueous extracts of *Mentha piperitae folium and Zingiber officinale* can be utilized to improve the quality of old-aged mutton and facilitate its use in further processed meat products without color or flavor problems.

Keywords | Mutton meat, Marination, Tenderness, Fatty acids, Flavor

Received | April 06, 2023; **Accepted** | April 25, 2023; **Published** | June 01, 2023
***Correspondence** | Marwa R.S. Abdallah, Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University, Egypt; **Email:** mrwaragab2017@gmail.com
Citation | Yousif DA, Emara MMT, Abdallah MRS (2023). The use of *Mentha piperitae folium* and *Zingiber officinale* freshwater extract in the improvement of some parameters of old-aged mutton meat. Adv. Anim. Vet. Sci. 11(7): 1144-1151.
DOI | https://doi.org/10.17582/journal.aavs/2023/11.7.1144.1151
ISSN (Online) | 2307-8316

INTRODUCTION

Sheep meat is produced in numerous countries throughout the globe. Egypt produced 55782.68 tonnes out of the 16,209 kilotons of sheep meat produced worldwide in 2021 (FAO, 2021). Sheep are able to produce meat with substantial nutritional content, low fat and cholesterol, and higher levels of polyunsaturated fatty acids, all of which substantiate its nutritional value and potential health advantages.

Consumer preference for a particular species of meat is mostly influenced by its quality characteristics, including sensory characteristics and safety (Watkins et al., 2013). Consumers' post-cooking concerns are primarily limited to flavor and tenderness. Old-aged mutton has a more pronounced and unpleasant flavor which is the major contributor to mutton acceptability as a table meat or a raw meat material for manufacturing meat products (Echegaray et al., 2021). Additionally, the methods of cooking and, the temperature to which the meat is exposed have substantial impacts on the flavor which finally determines its consumer acceptability due to the changes and the flavor molecules released during thermal processing (Watkins et al., 2013). Moreover, consumers are showing an increased interest in the safety of their food (Jongen and Meulenbery, 2005), which forces the processors to utilize specific additives to increase the value and safety of their products to satisfy

Links Researchers

the consumer expectations for healthier food (Hsieh and Ofori, 2007). Due to the potential harm that synthetic compounds might cause to human health, the use of natural additives has become more popular in the food sector, therefore, the use of phytochemicals from plants to improve the quality of meat has grown in importance (Singh et al., 2015).

Various plants and their extracts have bioactive compounds that mitigate the effects of the off-flavor of meat. *Mentha piperita folium* and *Zingiber officinale* are both commonly available worldwide. *Mentha piperita folium* is a medicinal herb that contains abundant levels of bioactive compounds e.g., polyphenols, phenols, terpenoids, and essential oils such as limonene, linalool, dipentene, azulene, and pulegone (Mohammadabadi, 2019). Moreover, *Zingiber officinale* contains a variety of bioactive substances e.g., thiol proteinase, that had antibacterial, antioxidant, and tenderizing effects (Saranya et al., 2016). Therefore, it is thought to be effective to use *Mentha piperita folium* and *Zingiber officinale* as straightforward, trustworthy, and efficient natural ingredients to enhance the overall sensory quality and eliminate the unfavorable mutton flavor. This study set out to ascertain how these natural extracts influenced the meat quality and the unfavorable sensory qualities of mutton.

MATERIALS AND METHODS

Preparation of raw materials

Forty-five hindquarters of five-year-old Baladi Rams raised in a private sheep farm were procured from El-Bassaten Municipal abattoir in Cairo governorate, Egypt immediately after slaughter and carcass preparation. After conditioning at 4 ˚C for 24 h, the right hindquarters of all carcasses were separated into individual muscles. The *Quadriceps femoris* muscles were chunked into 4x4 cm cubes (~150 g), which were then randomly allocated into three groups, and each group was then divided into three replicates.

The extracts of *Mentha piperitae folium* and *Zingiber officinale* were prepared using the technique outlined by Baker et al. (2013). Fresh *Mentha piperitae folium* leaves and *Zingiber officinale* roots were purchased from a local market in Cairo Governorate, Egypt. To eliminate extra moisture, *Mentha piperitae folium* leaves were gently cut apart, cleaned under running water, rinsed with distilled water, and then dried by air. *Zingiber officinale* roots were rinsed and peeled. About 400 g of both plants were mixed separately with 400 ml of distilled water and blended using a blender to obtain a homogeneous mixture. The mixture was run through three layers of gauze to obtain a 560 ml filtrate.

Application of the trial and thermal processing

The sheep meat chops were divided into three groups with three replicates each, the 1st group received only a control marinade adjusted based on a preliminary study to contain 1.8% common salt and 0.3% sodium tripolyphosphate (Lombard and Lanier, 2011). The 2nd group was marinated with the same marinade in addition to 5% *Mentha piperita folium,* and the 3rd group was marinated with 5% *Zingiber officinale.* After treatment with the marinade, all groups were kept for 24 h at 4 C. Triplicate samples from each group were examined without previous thermal treatment, while the other chops were divided into two portions and cooked in two different ways. The 1st portion was packed in polypropylene bags, sealed, and cooked in a boiling water bath (Kottermann D-3165, Germany) to 75 ºC core temperature, while the 2nd was wrapped in aluminum foil and cooked in a hot air oven (HeraeusD-63450 Hanau, Germany) at 180 ºC to 75ºC core temperature. A hand-held thermometer (Hanna HI 985091-1, USA) with a needle thermocouple probe was used to measure the core temperature in the geometric center of the meat cub.

Investigations

Both *Mentha piperitae folium* and *Zingiber officinale* extracts were assayed for their total phenolic contents and antioxidant capacities. Three raw chops from each treatment were examined in triplicate for marinade uptake, pH value, fatty acid profile, sensory qualities, and instrumental color. Additionally, cooked mutton samples were evaluated for cooking loss percentage, fatty acid content, sensory attributes, shear force, and instrumental color indexes in triplicate.

Determination of total phenolic content and antioxidant capacity of *Mentha piperitae folium* and *Zingiber officinale* extracts

The total phenolic content (mg gallic acid equivalent/g) from both *Piperitae piperitae folium* and *Zingiber officinale* extracts was assayed using the Folin-Ciocalteu technique (Sarkis et al., 2014) using a standard curve developed by using 50-500 g/ml gallic acid solutions. The DPPH scavenging activity of both extracts was evaluated using the method of Brand-Williams et al. (1995) with the modification of Bursal and Gulcin, (2011). A freshly prepared working DPPH solution was prepared to achieve an absorbance of about 0.98±0.02 at 517 nm. A 00 µl of the plant extract was combined with 3 ml of the working solution and the absorbance was measured at 517 nm. A control was prepared as above without any sample. The scavenging activity was calculated by the following formula

% Radical Scavenging Activity = (Absorbance control – Absorbance sample) /(Absorbance control)× 100

pH value and marinated uptake of raw mutton

The initial weight of the meat (W_1) and its recorded weight (W_2) after the marination process was used to calculate the marinade uptake as described by Yusop et al. (2010). For evaluation of the pH value, a 5 g sample of each marinated meat chop was blended for 10-15 S with 20 ml of distilled water. Three readings for each sample were taken and the average was computed using a pH meter (Lovibond Senso Direct) with a probe-type electrode (Senso Direct Type 330) (Kandeepan et al., 2009).

Cooking loss percentage and shear force of cooked marinated mutton meat

The meat samples were appropriately weighed after being blotted using blotting paper just before cooking, then cooked, cooled, and weighed again after being blotted. The cooking loss (%) was calculated as the difference in the weights of the sample before and after cooking. For evaluation of the shear force, six 1.3 cm-diameter core samples from each steak were sheared with the longitudinal orientation of the muscle fibers. Each core was sheared once using a Warner-Bratzler shear force (WBSF) device on an Instron Universal Testing Machine (Model 2519 105; Instron Corp., Canton, MA, USA) with a 55-kg tension/compression load cell and a crosshead speed of 200 mm/min. An average shear force value was calculated and recorded for each sample (Shackelford et al., 2004).

Sensory analysis, instrumental color parameters, and fatty acid profile of raw and cooked mutton

Sensory analysis: The sensory analysis was carried out in a sensory laboratory that had partitioned cabinets and individual standard lighting conditions (ISO, 2007) following the guidelines of the American Meat Science Association (AMSA, 2016). Samples from each treatment were randomly assigned for sensory evaluation using a 9-point hedonic scale (9- extremely like to 1- extremely dislike). A total of 25 mutton meat familiar panelists (60% female/40% male, ages 25 to 35) in each assessment were asked to score the raw samples in terms of appearance, odor, consistency, and overall acceptability, as well as for appearance, flavor, juiciness, tenderness, and overall acceptability for cooked samples. In each sensory panel session, each panelist evaluated 3 samples and all the panelists evaluated all groups of the samples. Samples were presented and served to panelists with randomly coded digits.

Instrumental color: The color of mutton samples was measured using Croma meter (Konica Minolta, model CR 410, Japan) equipped with D-625 illuminant with a 52 mm diameter sphere size, 8 mm /11 mm aperture size, and 10° observer angle and calibrated with a white plate. Color was expressed using the Commission International de l'Eclairage (CIE) L^*, a^*, and b^* color system. After 30 min bloom time, the color indexes of each sample surface at each time were measured using a portable colorimeter. The average score of triplicate experiments was recorded and expressed as CIE lightness (L^*), redness (a^*), and yellowness (b^*) (Shin et al., 2008).

Fatty acid profile: The fatty acid content of the samples was extracted in duplicate using Hexane (Folch et al., 1957). The lipid extracts from each sample were saponified for 30 min at 60 °C with 40 ml/g of 0.5 N NaOH in methanol, and the boron trifluoride-methanol complex was then used to methylate the extracts into methyl esters (IUPAC, 1987). By turning the oil into fatty acid methyl esters, the composition of the fatty acids was ascertained. One ml of n-hexane was combined with 15 mg of oil, followed by one ml of sodium methoxide. The samples were chromatographed in a 110-210°C temperature range. The carrier gas (nitrogen) moved at a rate of 22 ml per minute. A known quantity of methyl laurate, an internal standard, was added to each sample. A standard of known composition was analyzed to verify the identity of the fatty acids in the samples. Fatty acid peaks determined by gas chromatography were then used to calculate the amount of individual fatty acids.

Statistical analysis

The entire procedure for the marination of mutton flesh was replicated three times on different days, and measurements of relevant features were made for each batch in triplicate. Three distinct marinades were produced within each replication, followed by either moist or dry thermal cooking. The analysis of variance was performed on the mean values for the measured parameters using linear mixed models (LMM) by the SPSS software for Windows (SPSS 21.0 for Windows; SPSS Inc., Chicago, IL, USA). The marination treatments were treated as a fixed effect and batches as a random effect. Approximate F-ratio tests were run for each fixed effect with critical values set at $P < 0.05$ for statistically significant effects. Predicted means and standard errors were calculated from the models. Pairwise comparisons between means were enabled by the calculation of the least significant difference at a 5% critical value. For each processing treatment, predicted means, standard errors, and the least significant difference at the 5% critical value of each attribute were calculated. Data for heat treatment values were analyzed using a two-way ANOVA with treatment and thermal type as the main effects. The means of the results were further compared using Least significant Difference "LSD" procedure to compare the differences between the groups at $P < 0.05$.

Table 1: Total phenolic content and antioxidant capacity (DPPH) of *Mentha piperitae folium* and *Zingiber officinale* extracts.

Item	Ginger	Mint	SEM
Total phenolic compounds	45.1[a]	14.2[b]	5.38
DPPH	71.6[a]	29.9[b]	4.85

Differences between means with different superscripts exceed the estimate of the least significant difference at a 5% critical value. Comparisons were made on an individual trait level and are not applicable down rows.

Table 2: Value of pH and marinade uptake of raw marinated mutton meat from each treatment (control, ginger, and mint).

Item	Control	Ginger	Mint	SEM
pH value	6.0[b]	5.9[c]	6.2[a]	0.11
Marinade uptake	13.3[b]	19.5[a]	19.8[a]	2.71

Differences between means with different superscripts exceed the estimate of the least significant difference at a 5% critical value. Comparisons were made on an individual trait level and are not applicable down rows.

Table 3: Cooking loss and shear force (Newtons) of marinated mutton meat as affected by treatments and cooking methods.

Item	Moist cooking			Dry cooking			SEM
	Control	Ginger	Mint	Control	Ginger	Mint	
Cooking loss (%)	44.3[c]	38.2[d]	40.0[d]	50.6[a]	46.7[b]	47.8[b]	5.90
Shear force (Newton)	49.7[b]	25.5[d]	31.9[c]	68.6[a]	30.8[c]	46.5[b]	6.55

Differences between means with different superscripts exceed the estimate of the least significant difference at a 5% critical value. Comparisons were made on an individual trait level and are not applicable down rows.

Table 4: Sensory panel scores of raw marinated mutton meat samples with different treatments.

Item	Control	Ginger	Mint	SEM
Appearance	7.3[a]	7.4[a]	5.7[b]	0.33
Odor	5.6[b]	7.3[a]	7.3[a]	0.29
Consistency	6.7[b]	8.0[a]	7.1[a]	0.48
Overall	6.6[b]	7.1[a]	6.7[b]	0.30

Differences between means with different superscripts exceed the estimate of the least significant difference at a 5% critical value. Comparisons were made on an individual trait level and are not applicable down rows.

RESULTS AND DISCUSSION

Total phenolic content and antioxidant capacity of *Mentha piperitae folium* and *Zingiber officinale* extracts

Polyphenols are organic compounds naturally present in a variety of fruits and vegetables. Polyphenols exhibit outstanding antibacterial and antioxidant properties because of their capacity to interact with protein molecules and create complexes that can prevent their oxidation (Munekata et al., 2020). In this regard, the data in Table (1) demonstrated a clear relationship between the DPPH scavenging ability and the polyphenol level of the tested extracts. Samples with a higher phenolic content displayed stronger antioxidant properties. With a total phenolic content of 45.1 and 14.2 mg GAE/g for *Zingiber officinale* and *Mentha piperitae folium extract*, respectively. The DPPH scavenging capacity assay revealed that the *Zingiber officinale* extract had higher antioxidant activity (71.6%) than the *Mentha piperitae folium* extract (29.9%). Oboh et al. (2012) attributed the strong scavenging activity of ginger to its content of antioxidant phytochemicals which also exhibited higher protective impacts. Moreover, a beneficial relationship between the total phenolic compounds and free radical-scavenging activity. Polyphenolic chemicals are strong hydrogen donors and also function well as antioxidants (Wangensteen et al., 2004).

pH value and marinate uptake of raw marinated mutton

The marination procedure significantly changed the pH of the mutton samples. *Zingiber officinale* extract significantly (P <0.05) dropped the pH value to 5.9 compared with the control (6.0), whereas *Mentha piperitae folium* boosted the pH value to 6.2. Numerous studies have shown a connection between the pH value of meat and its ability to retain water (Garg and Mendiratta, 2006). In this respect, *Zingiber officinale and Mentha piperitae folium* considerably improve the quantity of the absorbed marinade, as demonstrated by the fact that both plant extract-treated meat groups significantly enhanced their marinade uptake when compared to the control group ($P < 0.05$). This result was consistent with that reported by Kaewthong et al. (2020), who found that goat meat treated with ginger juice had higher marinade uptake. In the meantime, there was no distinction between the two groups that had been marinated in Zingiber officinale or *Mentha piperitae folium* (Table 2).

Cooking loss and shear force of marinated cooked mutton
Data in Table (3) revealed that the cooking method had a significant impact on the cooking loss percentages, with cooking in hot air oven producing a much higher percentage as compared to moist cooking. These variations could be explained by the variations in pH value, marinade uptake, and Water Holding Capacity (WHC) of meat (Yarmand and Homayouni, 2009). Regardless of the cooking method, it was evident that the use of the plant extracts significantly decreased the cooking loss ($P<0.05$) over the control group. *Mentha piperitae folium* and *Zingiber officinale* extracts both have a hydrolyzing effect on collagen connective tissue, which increased the meat's WHC and reduced the cooking loss because when meat is cooked, the connective tissue produces a gel-like material that blocks the intercellular capillaries and causes the meat to retain more water (Abdeldaiem et al., 2014).

The shear force of mutton samples marinated with extracts *of Mentha piperitae folium or Zingiber officinale* and then cooked with either moist or dry heat decreased significantly ($P < 0.05$) when compared to the control group (Table 3). In general, dry heat-cooked mutton flesh has a significantly ($P <0.05$) higher shear force value than moist heat-cooked ones because the components of both the muscle fibers and connective tissue were destroyed as a result of ginger's potent proteolytic activity, which ultimately reduced the shear force (Nafi et al., 2013).

Sensory analysis

The sensory panel study of raw mutton (Table 4) showed that both treated meat groups had considerably ($P< 0.05$) higher panel ratings than the control group, with the distinctive mutton odor serving as the primary signal of declining mutton quality. Furthermore, samples treated with *Zingiber officinale* got significantly higher ratings ($P < 0.05$) than samples treated with *Mentha piperitae folium*. It was also evident that cooking the mutton marinaded with *Mentha piperitae folium* and *Zingiber officinale* improved all aspects of the eating quality with samples cooked with moist heat receiving higher evaluations than the samples cooked with dry thermal processing. The panelists also scored the *Zingiber officinale* -treated mutton cooked by dry heating significantly ($P<0.05$) higher scores for all sensory criteria when compared with the other groups. Moreover, moist heat cooking of both treated samples earned considerably ($P <0.05$) higher rankings for flavor, juiciness, tenderness, and overall acceptability as compared to the control. The obtained results confirmed the finding of Pawar et al. (2007) that treating goat meat with 5% ginger extract improved the sensory parameters compared to the control, untreated meat. Furthermore, Moeini et al. (2022) observed that the use of dry cooking significantly improved the tenderness, juiciness, and flavor of ginger extract-treated camel meat.

Instrumental color

In comparison to the control group, the raw mutton marinated with *Mentha piperitae folium* and *Zingiber officinale* had significantly ($P <0.05$) higher a* values, furthermore, *Mentha piperitae folium* had significantly ($P <0.05$) lower L* and b* values (Table 6). These findings corroborated those of Moeini et al. (2022), who found that marinading camel flesh in ginger extract greatly increased the a* value. The yellowness (b* value) of the mutton that had been marinated in *Zingiber officinale* was notably higher because of the yellow hue of the ginger extract. The relationship between meat color and its pH could be explained based on the paler color of the flesh results from the brightness reflection at the isoelectric point of the major meat proteins (pH = 5.8) (Hinkle, 2010). An acidic pH speeds up the conversion of myoglobin to metmyoglobin, giving the substance a lighter hue. Additionally, the reduced pH might have caused muscle protein denaturation, which would have increased light reflection (Alvarado and Sams, 2003). The instrumental color indices were affected by both the type of heat treatment and the contents of the marinade. Meat that had been treated with *Mentha piperitae folium* had a much lower a* value than meat that had been treated with *Zingiber officinale*. Furthermore, dry cooking after treatment with *Zingiber officinale* resulted in enhanced L*, b*, and a* values. Regardless of the method of cooking, the color analysis showed that adding *Zingiber officinale* extract considerably boosted the color of the meat in both raw and cooked samples.

Fatty acid profile

The data in Table (7) showed that total unsaturated fatty acids (TUFA) were more abundant than saturated fatty acids (SFA) in both raw and cooked mutton, and mono-unsaturated fatty acids (MUFA) content was the highest, whereas polyunsaturated fatty acids (PUFA) had lower concentrations. Canbay and Bardakci (2011) claim that this fatty acid profile is representative of the typical pattern observed in sheep flesh. The fatty acid composition

Table 5: Sensory panel scores of mutton meat samples as affected by treatments and cooking methods.

Item	Moist cooking			Dry cooking			SEM
	Control	Ginger	Mint	Control	Ginger	Mint	
Color	5.7[b]	7.3[a]	5.7[b]	5.6[b]	7.0[a]	5.0[b]	0.75
Flavor	5.0[c]	7.7[a]	6.3[b]	5.7[c]	7.7[a]	5.9[c]	0.86
Juiciness	6.7[c]	8.0[a]	7.0[b]	5.3[d]	7.5[ab]	5.6[d]	0.61
Tenderness	6.7[b]	8.0[a]	7.7[a]	5.3[c]	7.7[a]	6.3[b]	0.53
Overall	5.9[c]	7.6[a]	6.7[b]	5.7[c]	7.5[a]	6.2[b]	0.45

Differences between means with different superscripts exceed the estimate of the least significant difference at a 5% critical value. Comparisons were made on an individual trait level and are not applicable down rows.

Table 6: Instrumental color parameters of raw and cooked marinated mutton meat samples.

	Raw			Moist cooking			Dry cooking			SEM
	Control	Ginger	Mint	Control	Ginger	Mint	Control	Ginger	Mint	
L*	40.0[c]	39.7[c]	37.3[d]	47.9[b]	48.7[b]	55.6[a]	48.8[b]	53.3[a]	48.3[b]	4.43
a*	13.3[b]	17.5[a]	15.1[c]	5.0[f]	6.6[e]	5.1[f]	8.0[d]	8.2[d]	6.9[e]	1.31
b*	4.4[c]	3.9[c]	2.1[d]	7.6[b]	7.2[b]	8.4[a]	7.9[b]	8.8[a]	7.6[b]	1.15

Differences between means with different superscripts exceed the estimate of the least significant difference at a 5% critical value. Comparisons were made on an individual trait level and are not applicable down rows. ***L*: lightness a*: redness. b*: yellowness***

Table 7: Fatty acid profile including heptadecanoic acid as an indicator for branched-chain fatty acids of raw and cooked marinated mutton meat samples.

	Raw			Moist cooking			Dry cooking			
	Control	Ginger	Mint	Control	Ginger	Mint	Control	Ginger	Mint	SEM
SFA	47.4[c]	43.4[e]	43.6[e]	49.0[a]	45.1[d]	47.5[c]	48.6[b]	45.4[d]	47.7[c]	4.64
MUFA	45.9[d]	49.6[b]	50.3[a]	43.9[f]	45.0[de]	45.3[d]	44.6[e]	45.9[d]	46.4[c]	5.29
PUFA	4.7[e]	6.4[b]	6.1[b]	5.1[d]	6.9[a]	5.4[d]	4.3[e]	5.7[c]	5.4[d]	0.98
TUFA	50.6[c]	56.0[a]	56.4[a]	49.0[d]	50.9[c]	51.9[b]	48.9[d]	51.6[b]	51.4[b]	6.45
TFA	14.0[a]	12.0[c]	11.5[d]	12.1[c]	11.7[d]	11.2[d]	13.0[b]	12.4[c]	11.9[bc]	2.47
C17:0	3.5[a]	2.5[b]	2.9[b]	3.1[a]	2.5[b]	2.8[b]	3.0[a]	2.6[b]	2.8[b]	0.55

Differences between means with different superscripts exceed the estimate of the least significant difference at a 5% critical value. Comparisons were made on an individual trait level and are not applicable down rows.

also revealed that the addition of the marinade significantly reduced (P <0.05) the SFA and increased the MUFA, PUFA, and TUFA. However, there was no obvious difference between the samples that had been treated with either *Zingiber officinale* or *Mentha piperitae folium extracts*. The results obtained by Mancini et al. (2017) recorded that the application of ginger powder to pork patties significantly increased the level of PUFAs. Regardless of the thermal processing technique, the fatty acid content of marinated mutton changed considerably (P <0.05) during cooking. Dry heat marginally enhanced SFA and MUFA levels while lowering PUFA, TUFA, and TFA levels in both treated meat groups as compared to the control group. The *Zingiber officinale* and *Mentha piperitae folium-treated* groups were similar to one another. When compared to the control group utilizing the moist cooking method, the SFA value in both the *Zingiber officinale* or *Mentha piperitae folium*-treated groups exhibited significantly higher (P <0.05) MUFA and TUFA values. The provided data also indicated that adding both extracts to the marinade greatly reduced the TFA levels. Additionally, cooking extracts-treated mutton caused a further decrease in TFA concentration, especially with moist heat. Therefore, meat should be cooked at low temperatures with the addition of antioxidants because cooking meat at high temperatures increases the risk of TFA production (Suleman et al., 2020).

The lipid composition and fatty acid oxidation have a significant effect on the flavor of the meat. Aldehydes, ketones, and alcohol are examples of low molecular weight substances that can serve as odorants or Maillard reaction substrates (Bravo-Lamas et al., 2018). Meat is especially prone to oxidative alterations because it contains significant amounts of USFAs, particularly PUFAs. Mutton has higher lipid oxidation potentials than beef because it contains more USFAs (Suleman et al., 2020). Branch-chain fatty acids (BCFA), particularly 4-methyloctanoic (MOA) and 4-methylnonanoic (MNA) acids, which are members of the SFA group, have been identified as the primary components of the «mutton flavor» of cooked sheep flesh, especially from older animals. The presence of such a group of fatty acids generally makes the meat less appealing to consumers. Heptadecanoic acid (C17:0 FA), which is present in sheep fat, increases with animal age according to (Oriani et al., 2005). The favorable association between 4-methyloctanoic (MOA) and 4-methylnonanoic (MNA) and C17:0 FA, as shown by Watkins and Frank (2019), suggests that this FA may be used as a marker for these two BCFAs and the «mutton" flavor». Table (7) illustrated the correlation between heptadecanoic acid (C17:0 FA) and the addition of plant extracts, which resulted in a significant ($P<0.05$) reduction in heptadecanoic acid in comparison to the control. However, there were no discernible variations between the *Zingiber officinale* or *Mentha piperitae folium*.

CONCLUSION

According to the data, the addition of both *Zingiber officinale* and *Mentha piperitae folium* crude water extracts enhanced the sensory qualities of old-age mutton meat by giving it flavor and taste, while also having a noticeable antioxidant effect (preventing lipid peroxidation) and a noticeable reduction in BCFA, as shown by a decline in heptadecanoic acid (C17:0 FA). Additionally, the addition of *Mentha piperitae folium* before moist cooking assisted in lowering unwanted TFA and improving the health impact of mutton meat, and the inclusion of *Zingiber officinale* and *Mentha piperitae folium* water extracts could have a significant financial impact because it could lower losses attributable to spoiling and also enable mutton to be used for processing various processed meat products.

ACKNOWLEDGEMENTS

This study was financially supported from Faculty of Veterinary Medicine, Cairo University, Cairo, Egypt.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

NOVELTY STATEMENT

The main goal of this study is to overcome the unacceptable mutton sensory quality specially flavor by using natural plant extracts for the first time. All the findings of this paper are therefore novel.

AUTHORS CONTRIBUTION

All authors contributed equally to the manuscript.

REFERENCES

Abdeldaiem MH, Hoda GMA, Ali GM (2014). Tenderization of camel meat by using fresh ginger (*Zingiber officinale*) extract. FSQM. 23: 25-38.

Alvarado C, Sams A (2003). Injection marination strategies for remediation of pale, exudative broiler breast meat. Poult. Sci. 82(8): 1332-1336. https://doi.org/10.1093/ps/82.8.1332

AMSA "American Meat Science Association" (2016). Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. Chicago, IL, USA: American Meat Science Association.

Baker IA, Alkass JE, Saleh HH (2013). Reduction of oxidative rancidity and microbial activities of the karadi lamb patties in freezing storage using natural antioxidant extracts of rosemary and ginger. Int. J. Agric. Res. 2(1): 31-42. https://doi.org/10.24102/ijafr.v2i1.142

Brand-Williams W, Cuvelier M, Berset C (1995). Use of a free radical method to evaluate antioxidant activity. LWT - Food Sci. Technol. 28(1): 25-30. https://doi.org/10.1016/s0023-6438(95)80008-5

Bravo-Lamas L, Barron LJ, Farmer L, Aldai N (2018). Fatty acid composition of intramuscular fat and odour-active compounds of lamb commercialized in northern Spain. Meat Sci. 139: 231-238. https://doi.org/10.1016/j.meatsci.2018.02.006

Bursal E, Gülçin İ (2011). Polyphenol contents and in vitro antioxidant activities of lyophilized aqueous extract of kiwifruit (Actinidia deliciosa). Food Res. Int. 44:1482-1489. https://doi.org/10.1016/j.foodres.2011.03.031.

Canbay HS, Bardakci B (2011). Determination of fatty acid, C, H, N and trace element composition in grape seed by GC/MS, FTIR, elemental analyzer and ICP/OES. Süleyman Demirel Üniversitesi Fen Edebiyat Fakültesi Fen Dergisi. 6(2):140-148.

Echegaray N, Domínguez R, Cadavez VAP, Bermúdez R, Purriños L, Gonzales-Barron U, Hoffman E, Lorenzo JM (2021). Influence of the Production System (Intensive vs. Extensive) at Farm Level on Proximate Composition and Volatile Compounds of Portuguese Lamb Meat. Foods. 10(7): 1450. https://doi.org/10.3390/foods10071450

FAO "Food and Agriculture Organization" (2021). FAOSTAT. FAO Statistics Division. Accessed 19 August 2021. https://www.fao.org/documents/card/en/c/cb4476en.

Folch J, Lees M, Sloane Stanley GH (1957). A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem. 226(1): 497-509.

Garg V, Mendiratta SK (2006). Studies on tenderization and preparation of enrobed pork chunks in microwave oven. Meat Sci. 74(4): 718-726. https://doi.org/10.1016/j.meatsci.2006.06.003

Hinkle JB (2010). Acid marination for tenderness enhancement of beef bottom round. Theses Dissertat. Anim. Sci. 12.

Hsieh PYH, Ofori JA (2007). Innovations in food technology for health. Asia Pacific J. Clin. Nutr. 16 (S1): 65-73.

International Union Of Pure and Applied Chemistry "IUPAC" (1987). Standard Methods For the Analysis Of Oils, Fats and Derivatives, prepared by C. Paquot and A. Hautfenne, 7th revised and enlarged ed., Oxford: Blackwell Scientific Publications, 163-169.

ISO. (2007). Sensory Analysis-General Guidance for the Design of Test Rooms. Ref. no. ISO 8589:2007(E). Geneva, Switzerland: International standard. 8589.

Jongen WME, Meulenbery MTG (2005). Innovation in Agriculture Food Systems Product Quality and Consumer Acceptance, 1sted., Academic Publishers, Wageningen.

Kaewthong P, Wattanachant C, Wattanachant S (2020). Improving the quality of barbecued culled-dairy-goat meat by marination with plant juices and sodium bicarbonate. J. Food Sci. Technol. 58(1): 333-342. https://doi.org/10.1007/s13197-020-04546-8

Kandeepan G, Anjaneyulu A, Kondaiah N, Mendiratta S, Lakshmanan V. (2009). Effect of age and gender on the processing characteristics of buffalo meat. Meat Sci. 83(1):10-14. https://doi.org/10.1016/j.meatsci.2009.03.003

Lombard R, Lanier T. (2011) Marinade Composition and Vacuum Effects on Liquid Uptake and Retention in Tumbled Fish Portions. J. Aquat. Food Prod. Technol. 20(2):117-128. https://doi.org/10.1080/10498850.2010.549605

Mancini S, Paci G, Fratini F, Torracca B, Nuvoloni R, Dal Bosco A, Roscini V, Preziuso G (2017). Improving pork burgers quality using Zingiber officinale Roscoe powder (ginger). Meat Sci. 129: 161-168. https://doi.org/10.1016/j.meatsci.2017.03.004.

Moeini R, Zamindar N, Aarabi Najvani F (2022). The effect of marination by using ginger extract and citric acid on physicochemical characteristics of camel meat. Food Sci. Technol. Int. 0(0): 1-12. https://doi.org/10.1177/10820132221136590.

Mohammadabadi T (2019). The Effect Supplementation of Squaw Mint Herb on Oxidant Stability and Microbial Count of Quail Meat at Different Times of Storage in the Freezer. EC Nutrition. 14: 928-934.

Munekata P, Nieto G, PateiroM, Lorenzo J (2020). Phenolic Compounds Obtained from Olea europaea By-Products and Their Use to Improve the Quality and Shelf Life of Meat and Meat Products—A Review. Antioxidants. 9(11): 1061. https://doi.org/10.3390/antiox9111061

Nafi A, Foo HL, Jamilah B, Ghazali HM (2013). Properties of proteolytic enzyme from ginger (*Zingiber officinale* Roscoe). IFRJ. 20(1): 363-368.

Oboh G, Akinyemi AJ, Ademiluyi AO (2012). Antioxidant and inhibitory effect of red ginger (*Zingiber officinale* var. rubra) and white ginger (*Zingiber officinale* Roscoe) on fe2+ induced lipid peroxidation in rat brain in vitro. Exp. Toxicol.Pathol. 64(1-2): 31-36. https://doi.org/10.1016/j.etp.2010.06.002

Oriani G, Maiorano G, Filetti F, Di Cesare C, Manchisi A, Salvatori G (2005). Effect of age on fatty acid composition of Italian Merino suckling lambs. Meat Sci. 71(3): 557-562. https://doi.org/10.1016/j.meatsci.2005.04.040

Pawar V, Mule B, Machewad G (2007). Effect of marination with ginger rhizome extract on properties of raw and cooked chevon. J. Muscle Food. 18(4): 349-369. https://doi.org/10.1111/j.1745-4573.2007.00091.x

Saranya S, Santhi D, Kalaikannan A (2016). Ginger as a tenderizing agent for tough meats: A review. J. Livest. Sci. 7:54-61.

Sarkis JR, Michel I, Tessaro IC, Marczak LDF (2014). Optimization of phenolics extraction from sesame seed cake. Sep. Puri. Technol. 122: 506-514. https://doi.org/10.1016/j.seppur.2013.11.036

Shackelford SD, Wheeler TL, Koohmaraie M (2004). Evaluation of sampling, cookery, and shear force protocols for objective evaluation of lamb longissimus tenderness1. J. Anim. Sci. 82 :802-807. https://doi.org/10.1093/ansci/82.3.80

Shin H, Choi Y, Kim H, Ryu Y, Lee S, Kim B (2008). Tenderization and fragmentation of myofibrillar proteins in bovine longissimus dorsi muscle using proteolytic extract from Sarcodon aspratus. LWT - Food Sci. Technol. 41: 1389-1395. https://doi.org/10.1016/j.lwt.2007.08.019

Singh A, Lal UR, Mukhtar HM, Singh PS, Shah G, Dhawan RK (2015). Phytochemical profile of sugarcane and its potential health aspects. Pharmacognosy reviews. 9(17): 45. https://doi.org/10.4103/0973-7847.156340.

Suleman R, Wang Z, Aadil RM, Hui T, Hopkins DL, Zhang D (2020). Effect of cooking on the nutritive quality, sensory properties and safety of lamb meat: Current challenges and future prospects. Meat Sci. 167:108-172. https://doi.org/10.1016/j.meatsci.2020.108172

Wangensteen H, Samuelsen AB, Malterud KE (2004). Antioxidant activity in extracts from coriander. Food Chem. 88: 293-297. https://doi.org/10.1016/j.foodchem.2004.01.047

Watkins PJ, Frank D (2019). Heptadecanoic acid as an indicator of BCFA content in sheep fat. Meat Sci. 151: 33-35. https://doi.org/10.1016/j.meatsci.2019.01.005

Watkins PJ, Frank D, Singh TK, Young OA, Warner RD (2013). Sheep meat flavor and the effect of different feeding systems: a review. J. Agri. Food Chem. 61: 3561-579. https://doi.org/10.1021/jf303768e

Yarmand M, Homayouni A (2009). Effect of microwave cooking on the microstructure and quality of meat in goat and lamb. Food Chem. 112(4): 782-785. https://doi.org/10.1016/j.foodchem.2008.06.

Yusop SM, O'Sullivan MG, Kerry JF, Kerry JP (2010). Effect of marinating time and low pH on marinade performance and sensory acceptability of poultry meat. Meat Sci. 85:657-663. https://doi.org/10.1016/j.meatsci.2010.03.020