Impact of different sumac additives on the free fatty acids, myoglobin content, and sensory evaluation of beef burger

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Abstract

The quality of meat and meat products is of high importance for producers and consumers, usually determined by low levels of physical, chemical, and microbial changes. The meat industry has turned to the possibility of using natural additives in packaging and storage to maintain the quality and acceptability of the product for the longest possible storage period. Sumac is rich in bioactive compounds which exhibit strong antioxidant and antimicrobial properties. Therefore, this study aimed to evaluate the potential of sumac additive to improve beef burgers quality and the possibility of increasing product stability in terms of oxidation resistance and extended shelf life. Beef burgers were prepared with different additives and concentrations of sumac powder or extract (0.5%, 1%, and 1.5%) for storage periods of 1, 15, 30, and 45 days at $^{-}18$°C. The results showed that treating burgers with sumac extract or powder reduced the early oxidation index (FFA) which recorded low levels even after 45 days of treatment, with the lowest value being 0.876 MDA/Kg in the 1% sumac powder burger treatment and the highest value being 1.84 MDA/Kg in the 0.5% sumac powder treatment compared to the control, which recorded 1.35 MDA/Kg. Myoglobin, as a color change indicator, remained significantly higher in the 0.5% sumac powder and 1% sumac extract treatments, recording 4.166 and 4.336 mg/g, respectively, compared to the control, which recorded 2.983 mg/g. Furthermore, sensory evaluation results showed that burgers treated with sumac extract or powder, especially the 1% extract or 0.5% powder treatments, consistently achieved higher sensory evaluation values than the other treatments and the untreated control.

Keywords: Sumac, Free fatty acid, Burger quality, shelf life

Introduction

It goes without saying that the value of meat comes from its high-quality and quantitative content of proteins, fats, and some vitamins and minerals. Its nutritional value is linked to its high content of these components. Therefore, the quality of meat and meat products is the most important factor for producers and consumers, and is associated with low levels of physical, chemical, and microbial changes (8, 27). This includes product quality in terms of nutritional value and the extent to which the product is resistant to storage while ensuring maximum preservation of quality (11). Burgers, as a popular food, are constantly exposed to high levels of oxidation and microbial contamination, especially under conditions of inaccurate storage (9). The nature of good burger manufacturing is also linked to the burger's high-quality fat content, which in turn is susceptible to oxidation and rapid fat rancidity, which negatively impacts the quality of processed meat and negatively impacts consumer acceptance of the product (4). Generally, the meat and meat product preservation industry is associated with the use of preservatives, most of which are synthetic, that are relied upon to delay or prevent chemical, microbial, and qualitative changes, thus extending storage periods. Recently, the meat industry has turned to natural alternatives for meat preservation, using edible gelatin packaging or treating the product with plant preparations or plant extracts, particularly those that add an acceptable flavor without compromising product acceptability (26).

Sumac (*Rhus coriaria*) is a spice widely used in Middle Eastern and Mediterranean cuisines, characterized by its pungent, citrus-like flavor and attractive red color (16). In addition to its culinary appeal, sumac is rich in bioactive compounds, including polyphenols, flavonoids, and organic acids, which enhance its potent antioxidant and antimicrobial properties (24). Sumac contains a wide range of chemical components, including a 0.02% volatile oil, phenolic compounds, aldehydes, and terpenoid compounds, which also contain 11% cisphenic acid (29). Its phytochemical components (flavonoids, flavones, and anthocyanins) have led to significant health benefits (17). The sumac plant (Rhus coriaria) is a rich and valuable food source of important nutrients, including unsaturated fatty acids, vitamins, and minerals (21). These properties make sumac a promising natural additive for improving food quality and extending shelf life. In meat products, oxidation and microbial spoilage are major concerns that affect freshness and safety. Adding sumac to meat-based foods, such as beef burgers, may help slow lipid oxidation, reduce microbial growth, and improve overall sensory properties (6). With increasing consumer demand for natural preservatives, exploring the potential role of sumac in food preservation becomes essential. Therefore, this study aimed to evaluate the potential of adding sumac to improve the quality of beef burgers and the effect of adding sumac at different concentrations on product stability in terms of oxidation resistance and extended shelf life.

Materials and methods

Preparation of the Aqueous Sumac Extract

Dried sumac fruits were obtained from the local market and used for processing with the aqueous extract or sumac powder. Depending on the treatment, a method was followed. To prepare the aqueous extract, 10 g of dry sumac powder was placed in a 100 ml glass beaker with 20 ml of boiling distilled water. The mixture was then blended in a food processor for 15 minutes and the solution was left to stand for 30 minutes. The extract was then filtered through cheesecloth, and the filtrate was transferred to a centrifuge at 3000 rpm for 10 minutes to obtain a clear plant extract. The extract was stored at -20°C until use (14).

Preparation of the Beef burger

Minced beef, pelvic fat, and kidney fat were purchased from local markets. The meat and fat were mixed with 1% Karbal spice (an Iraqi variety). The burger ingredients were mixed with a ratio of 70% beef, 30% beef fat, and 1.5% sodium chloride and blended for 5 minutes in a Havant meat mixer. A 62 ± 1 g burger with a diameter of 9 cm was formed using a manual press. Burger treatments, in addition to the untreated control (T1), included burger mix treated with 0.5% (T2) ,1% aqueous sumac extract (T3), and 0.5%, 1%, or 1.5% sumac powder (T4, T5, T6), respectively. The samples were frozen at -18°C, and study measurements were taken after storage periods (1, 15, 30, and 45 days).

Determination of free fatty acids (FFA):

After each of the different storage periods (15, 30, and 45 days), free fatty acids (FFA) were determined in the burger samples. FFA was determined by weighing 28 grams of fat extracted from the meat samples. 50 ml of 95% ethyl alcohol and several drops of phenolphthalein were added to the mixture. The mixture was sieved with 0.1 N sodium hydroxide solution until a light pink color appeared (19). The percentage of free fatty acids in the product was estimated as follows:

$$FAA = \frac{\text{No. of NaOH ml} * Normality * 0.0282}{Sample\ weight\ g} X100$$

Myoglobin Mb concentration determination:

The myoglobin (Mb) concentration was measured in burger samples for the same storage periods (30). The test was conducted by taking 10 g of meat from each treatment and homogenizing it with 90 ml of distilled water using a homogenizer. 10 g of the mixture was then added to 15 ml of distilled water and homogenized using a homogenizer. The homogenized mixture was then filtered through No.1 filter paper. The optical absorbance of the filtrate was read at a wavelength of 525, and the myoglobin concentration was calculated:

$$Mb = \frac{\text{Absorbance} * 2.4}{Sample\ weight\ g * 0.452}$$

Where:
0.452: Absorbance coefficient at (525 nm)
2.4: Dilution factor.

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After the end of the storage period (day 45) scheduled for the experiment, sensory evaluation of the burgers produced for the different sumac treatments was conducted. Product quality was assessed by 10 trained consumer experts. All burger samples for all treatments were fully cooked in an ungreased frying pan. The frying pans used for each treatment were cleaned after cooking. After cooking, the burgers were cut into 10 samples to ensure sensory evaluation consistency and presented to the experts. A 10-minute waiting period was adopted between each sample, with water provided for oral hygiene after each test. Guidelines were explained to the panel members to ensure consistency of evaluation. The final score for each rated attribute was obtained by averaging the scores recorded by the panel members (7). The evaluation form was completed by all panel members based on the studied characteristics for each sample on an eight-point scale, from 0 for very poor to 8 for very good:

Tenderness was assessed and scored as 1= Too firm to 8- Very tender, Flavor as 1 point for undermined to 8=very strong. Juiciness based on mouthfeel and moisture level of the sample as 1=very dry to 8= very good juiciness). Texture as1= Very soft to 5=Very rough. and the Overall acceptance was rated from 1= dislike extremely to 8=like extremely (23).

Experimental Design and Statistical Analysis:

The experimental units were distributed in a factorial experiment (4*6) using a completely randomized design (CRD) with five replicates. The results were analyzed using computing SAS software (SAS, 2012). The means were compared to FOR determine the significant differences between the parameters using Duncan's (1955) multinomial test ($P \leq 0.05$) (13).

Mathematical Model: $Yijk = \mu + Ti + Pj + TP(ij) + eijk$

Results and discussion

Effect of sumac additives on burger's content of Free Fatty Acids (FFA%)

The results (Table1) showed an interaction effect the different sumac treatments and cold-storing periods on the FFA content in beef burgers. A significant increase ($P<0.01$) was observed in burger's FFA content of the control treatment (without additions) at the fourth period (45-day post treatment), which recorded the highest FFA value of 1.35MDA. There were also varying differences between treatments for different storage

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Table1. Effect of sumac additives on burger's content of Free Fatty Acids (FFA%) at different storage periods

Treatments	FFA %				Average
Sumac additives	Day 1	Day 15	Day 30	Day 45	
Control	0.239± 0.046i	0.846± 0.023g	1.170± 0.030b	1.35± 0.014a	0.903A
Extract 0.5%	0.212± 0.026i	0.696± 0.017h	0.840± 0.030g	1.084± 0.030c	0.708B
Extract 1%	0.198± 0.023i	0.670± 0.010h	0.853± 0.025g	1.026± 0.012cd	0.687BC
Powder 0.5%	0.201± 0.023i	0.654± 0.006h	0.896± 0.012fg	0.990± 0.005de	0.685B
Powder 1%	0.187± 0.027i	0.634± 0.018h	0.926± 0.008efg	0.876± 0.017fg	0.656C
Powder 1.5%	0.189± 0.046i	0.659± 0.030h	0.953± 0.008def	0.960± 0.030def	0.690BC
Average	0.20472D	0.69344C	0.94006B	1.04906A	

Values (± standard error) are means of five replications, means followed by different letter(s) among all interaction treatments, within average row, or average column are significantly different according Duncan's multiple range tests (P<0.05)

periods. The results indicated that significant differences among sumac percentages. The untreated burger recorded the highest average of FFA (0.903 MDA/Kg), with a significant difference (P<0.01) from most treatments, especially compared to the 1% sumac powder, which recorded the lowest value (0.656 MDA/Kg). It was observed that all beef burger treatments with sumac powder or extract led to a significant reduction in FFA levels, regardless of the storage period, compared to the untreated control. In general, the FFA content was lowest during the initial storage

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period, then began to increase as the storage period progressed, reaching its highest level after 45 days of storage, regardless of the type of treatment. It was noted that the recorded FFA content in the product was within the acceptable limits specified by the Iraqi standard specifications (18), which should not exceed 1.5 MDA/Kg.

The low FFA levels in sumac-treated bulgur are likely due to the sumac fruit high content of phenolic, which acts as powerful antioxidants and has a reducing power to inhibit free radicals (25).

A logical increase in FFA content was also observed as the storage period progressed, particularly in the control treatment. This confirms the presence of high levels of lypolytic enzymes such as lipase and phospholipase, which lead to the release of FFA (20). This decomposition is accompanied by the production of an unacceptable odor that is reflected in the deterioration of flavor, causing a decrease in the nutritional value of meat and meat products with increased storage period (22). On the other hand, the reason for the low percentage of FFA in the addition treatments is due to the sumac plant containing active compounds that act as antioxidants, thus reducing the damage resulting from oxidation in these treatments (3, 5).

Effect of sumac treatments on burger's content of Myoglobin Mb (mg/g)

The results in Table (2) indicate that the myoglobin content of burgers varies depending on the type of treatment (sumac extract or powder) and the storage period after treatment. A significant increase ($P<0.01$) in myoglobin concentration (7.3433) was observed in burgers treated with 1% sumac extract (T3) after 15 days of storage compared to treatment T1 (without addition), which recorded the lowest myoglobin concentration (2.983) in the fourth storage period. There were also varying differences between treatments and different storage periods. In general, burger treatments with sumac extract or powder maintained significantly higher myoglobin levels than the untreated control, regardless of the storage period (Table 2). On the other hand, it was also found that the myoglobin value gradually decreased with the progress of the storage period until it reached its lowest concentration in the fourth period, 45 days after treatment. The bright color of beef burgers during the early stages is attributed to the presence of the pigment oxymyoglobin (OxyMb) on the meat surface (12, 15). Freezing meat storage resulted in a change in the bright color to a dark red or brown, which is attributed to a lack of oxygen, and consequently stimulated the formation of the pigment metmyoglobin (MetMb) on the meat surface (10).

Table2. Effect of sumac additives on burger's content of Free Fatty Acids (FFA%) at different storage periods

Treatments Sumac additives	Mb mg/g meat				Average
	Day 1	Day 15	Day 30	Day 45	
Control	5.743± 0.023bcd	4.355± 0.146ef	4.983± 0.627cdef	2.983± 0.063g	4.516C
Extract 0.5%	5.782± 0.060bcd	6.643± 0.404ab	4.000± .0.399fg	3.930± 0.640fg	5.0892B
Extract 1%	6.096± .0.379abc	7.343± 0.066a	5.996± 0.056bcd	4.336± 0.728ef	5.9433A
Powder 0.5%	6.120± 0.177abc	5.573± 0.454bcde	4.766± 0.305def	4.166± 0.194fg	5.1566B
Powder 1%	6.590± 0.040ab	5.653± 0.296bcd	4.990± 0.434cdef	3.980± 0.100fg	5.3033B
Powder 1.5%	6.370± 0.015ab	6.510± 0.070ab	4.998± 0.628cdef	5.760± 0.899bcd	5.9095A
Average	6.1172A	6.0131A	4.9557B	4.1928C	

Values (± standard error) are means of five replications, means followed by different letter(s) among all interaction treatments, within average row, and within average column are significantly different according Duncan's multiple range tases ($P \leq 0.05$)

Effect of sumac additives on burger's quality as measured by sensory evaluation

Regarding the effect of sumac additive treatments on burger quality indicators after 18 days of refrigerated storage, the sensory evaluation results (Table 3) indicate higher scores for flavor in the burger treated with 0.5% sumac powder or 1% sumac extract, which recorded 8.000 and 7.666, respectively, with a significant difference compared to the control treatment score of 4.666. The same treatments for sumac powder and extract achieved the highest scores in burger tenderness evaluation (8.00 and 7.66, respectively), which differed significantly from most other treatments and also from the control treatment, as the last recorded a value of 5.333. The sensory assessment based on juiciness also recorded the highest scores in the burger treated with 0.5% sumac powder (8.00), with differences from the other treatments that recorded lower values for this indicator.

The effect of treatments on the burger texture index was also observed (Table 3), as the lowest texture score was 3.000 recorded in the burger treated with 0.5% sumac extract, which did not differ from the control treatment, while the burger treatment with 0.5% sumac powder also recorded the highest texture score (5.00) among all treatments, followed by the 1% sumac extract treatment (4.00), while the rest of the treatments recorded lower texture values, equal to or less than the control. Table (3) also shows the effect of treatments on the overall acceptability scores, which were consistent with the treatments that recorded the highest points in the sensory evaluation indicators. It was found that the highest value ($p<0.0$) for the overall acceptability scores were in the burger treatments with 0.5% sumac powder and the treatment with 1% sumac extract, which recorded scores of 5.00 and 4.00, respectively. However, it was also noted that the general acceptance rate decreased in the sumac powder treatments at higher concentrations of 1% and 1.5%, which recorded points that did not differ from the control treatment.

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Table3. Effect of different sumac additives on burger's quality (sensory evaluation) 18 days of cold-storage

Treatments Sumac additives	Flavor	Tenderness	Juiciness	Texture	General acceptance
Control	4.666± 0.333d	5.333± 0.333d	3.6667± 0.333e	3.6667± 0.333bc	6.6667± 0.333b
Extract 0.5%	5.666± 0.333bc	7.000± 0b	7.0000± 0bc	3.0000± 0d	7.0000± 0b
Extract 1%	7.666± 0.333a	7.333± 0.333b	7.3333± 0.333ab	4.0000± 0b	7.0000± 0b
Powder 0.5%	8.000± 0a	8.0000± 0a	8.0000± 0a	5.0000± 0a	8.0000± 0b
Powder 1%	6.333± 0.333b	7.0000± 0b	6.3333± 0.333c	3.0000± 0d	6.0000± 0c
Powder 1.5%	5.333± 0.333cd	6.0000± 0c	5.0000± 0d	3.3333± 0.333cd	6.0000± 0c

Values (± standard error) are means of five replications, means followed by different letter(s) within a column are significantly different according Duncan's multiple range tases ($P \leq 0.05$)

A higher flavor scoring was observed in sumac-treated burgers, attributed to the sumac's acidic content, which contributes to a desirable flavor for consumers (16). Meanwhile, the control treatment showed a significant decrease in flavor, likely due to the loss of volatile substances responsible for the unacceptable meat flavor, as well as protein and fat decomposition, producing fatty acids and nitrogenous bases during storage, causing unacceptable meat flavors and odors (5, 20). The tenderness index also increased in sumac-added treatments, indicating higher moisture and

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juiciness, or increased solubility of myofibril proteins (28). The lower tenderness index in the control treatment was generally attributed to the increased cooking loss of fat and juiciness, which leads to shrinkage and decreased tenderness (5). Therefore, adding sumac improved the juiciness of the product by increasing the moisture content of the product and the water-holding capacity of the meat (1).

The increase in sensory evaluation indices in burgers with sumac additions indicates that sumac contributed to preserving meat quality and reducing oxidative damage, protein degradation, and microbial degradation, among other factors. This led to improved sensory attributes of the product, including flavor, tenderness, texture, and juiciness, thereby improving overall meat acceptance (2).

Conclusion

Findings of this study showed that treating burgers with sumac extract or powder reduced the early oxidation index (FFA) to obviously low levels even after 45 days of cold-storage compared to untreated burger. Sumac treated burger also maintained higher myoglobin levels indication low change in product color especially when using 0.5% sumac powder or 1% sumac extract. Moreover, findings of the sensory evaluation revealed that burgers treated with sumac extract or powder recorded higher scores for texture, juiciness, flavor, tenderness and general acceptance compared to the untreated burger meat.

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