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Shelf Life and Quality Traits of The Breast Meat of Local Kurdish Roosters Fed a Diet Supplemented with Powdered Sumac Seeds

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Abstract

This study evaluated the impact of adding powdered sumac seed powder (SSP) as an antimicrobial and antioxidant on the microbiological activity, oxidative stability, and breast meat quality characteristics of local Kurdish rooster during postmortem aging. A total of 108 local Kurdish roosters aged 20 weeks were divided into 4 groups (n=27) of three replicates each. The first groups received the basal diets without supplements (control treatment) while the other three had, 0.5, 0.75, and 1.0% SSP added to their feed. At 26 weeks the roosters were slaughtered for meat quality measurements. The findings shows that the breast meat of the roosters fed diets with SSP had the lowest values for pH, TBARS, drip loss, cooking loss, total aerobic count, coliform bacteria, and *pseudomonas* bacteria compared to the control. Additionally, adding 1.0% SSP improved water holding capacity with the highest rate reached at one day of storage. However, the values for all the above parameters increased gradually with higher postmortem refrigerated storage periods. The lightness (L*) and redness (a*) color parameters increased while yellowness (b*) decreased with SSP addition especially at 0.75% SSP. In conclusion, adding SSP to the rooster diets can enhance the physical attributes and reduce oxidative

stability and microbial activity during postmortem aging.

Keywords: Microbial spoilage, Oxidative stability, Postmortem aging, Rooster, Sumac.

مدة الحفظ وخصائص جودة لحم صدر الديك الكردي المحلي المغذاة على علف مكمل بمسحوق بذور السماق (Rhuscoriaria L.)

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الخلاصة

استهدفت هذه الدراسة إلى تقييم تأثير استهلاك مسحوق بذور السماق في العلف كمضاد للمايكروبات ومضاد للأكسدة على النشاط المايكروبي، الثبات التأكسدي وصفات جودة لحم الصدر للديك الكردي المحلي خلال التعتيق. تم تقسيم 108 ديكة كردية محلية بعمر 20 أسبوع إلى 4 مجموعات (27 ديكة لكل مجموعة) باستخدام ثلاث مكررات لكل مجموعة. تلقت المجموعة الأولى العليقة الأساسية بدون مسحوق بذور السماق (معاملة المقارنة)، في حين تم تغذية المجموعات الإضافية بـ 0.5، 0.75، و1.0% من مسحوق بذور السماق. عند عمر 26 أسبوعًا، تم ذبح الديكة لقياس جودة اللحم. أظهرت نتائج البحث أن الديك الذي تم تغذيته بكميات مختلفة من مسحوق بذور السماق كان له أقل قيم للأس الهيدروجيني، قيمة حامض الثايوباربيتوريك، السائل الناضح أثناء التبريد، فقدان الماء أثناء الطبخ والعدد الكلي للبكتيريا الهوائية والقولونية والبكتيريا من نوع سودوموناس (*Pseudomonas Sp.*) عند تغذيته على علف مكمل بنسبة 0.75٪ و1.0% مسحوق بذور السماق على التوالي مقارنة بالمجموعة الأولى. بالإضافة إلى ذلك، أدى إضافة 1.0% من مسحوق بذور السماق إلى تحسين القدرة على الاحتفاظ بالماء والوصول إلى أعلى معدل في يوم واحد من التخزين. ومع ذلك، فإن قيمة جميع الصفات المذكورة أعلاه زادت تدريجيا مع زيادة فترة الخزن. تحسنت قيم قياسات اللون، بما في ذلك الخفة (L*)، الاحمرار (a*) بينما الاصفرار (b*) انخفضت مع إضافة مسحوق بذور السماق إلى علف الديكة، خاصة عند استكماله بـ 0.75% مسحوق بذور السماق أثناء التخزين. في الإستنتاج، فإن إضافة مسحوق بذور السماق إلى العلف يمكن أن يحفز الصفات الفيزيائية ويقلل من الثبات التأكسدي والنشاط المايكروبي خلال التعتيق.

كلمات مفتاحية: الفساد المايكروبي، الثبات التأكسدي، خلال التعتيق، الديكة، السماق.

Introduction

The nutritional value of chicken feed greatly influences the consumption of chicken meat (25). Commercial broiler feed often includes biologically active additives, while primary poultry diets typically consist of cereals such as wheat and corn. Lately, biologically active additives, such as sumac, cloves, turmeric, thyme, and anise, have garnered much attention as feed supplements for a variety of uses in the chicken production industry (2). According to (17), feed additives are classes of non-nutritive products that are added to diets in order to increase the efficiency of animal production through improved intake, digestive microorganism, production characteristics, meat quality, vitality, and health condition. The goal of poultry feeding is to maximize the gains in live weight within a short period of time while consuming a minimum quantity of feed.

Sumac (*Rhuscoriaria* L.) is widely cultivated in Asian countries for use in traditional medicine (36). Organic acids found in sucuk fruits include malic, citric, and tartaric acids as well as hydrolyzable tannins, flavanols, phenolic acids, and antioxidants (30). Meat and meat products are an excellent source of protein but are vulnerable to lipid oxidation and many pathogens, which carry the risk for human health (16). The oxidation of lipids is a restricting factor affecting the physiochemical quality and shelf life of meat. Researchers have identified it as a significant factor in non-microbial meat deterioration, particularly in pro-oxidative situations like storage in refrigerators.

Meat and its products are subject to various effects such as microbial and chemical interactions, moisture changes, and oxidation, especially during storage in the refrigerator (31). Sumac contains phenolic substances that scavenge the hydroxyl radical and superoxide anion, as well as prevent lipid peroxidation (25). In addition, sumac seed is efficient against gram negative and gram positive bacteria through it work better against the latter positive (1). It is probable that the elevated percentage of α-pinene (86.95%) in whole essential oils is linked to its antibacterial properties.

In addition to dry matter (88.7%), crude protein (4.3%), crude ash (4%), and crude fat (19.2%), the sumac seed also contains 95.4, 310.4, and 110.3 mg/g ascorbic acid, total phenolics, and flavonoids, respectively (37). Sumac is a herbal plant with numerous uses, such as being a growth promoter improving carcass characteristics, and having antimicrobial and antioxidants. However, the effect of supplementing powdered sumac seed in feeds on the physical and microbial quality of carcasses during storage have not been studied. This study thus evaluated the effects SSP-supplemented diets on the shelf life and quality of rooster meat during postmortem aging.

Materials and Methods

Experimental birds and design: A total of 108 20-week-old Kurdish roosters of approximately similar live weights (1250 g) were sorted into 4 groups, each birds divided into three replications of nine. The birds in all the treatments were fed a basal diet with 20% crude protein and 3150 k/cal (Table 1). Fresh sumac seed from a local market were ground into a fine powder and combined into the basic diet at four

levels (0 – control, 0.5, 0.75, and 1.0%). Feed and water were supplied adlibitum over the experimental period, till the roosters were 24 weeks of age.

Table 1: Nutritional content of the experimental diet.

Component	g(kg^{-1}) diet
Wheat	305
Corn	350
Oil	25
Soya bean meal	275
Lysine	1.5
Methionine	4.5
Monocalcium Phosphate	15
Limestone	16
T- Salt	3.0
Antitoxin	2.0
Coccidiostat	0.5
Enzyme	0.5
Premix	2.0
Total	1000

Note: Metabolisable Energy = 3150 kcal / kg Crud Protein= 20%.

Nine roosters from each treatment were randomly selected, weighted and slaughtered in accordance with Islamic principles. This involved severing the neck and removing the veins in the jugular and the carotid arteries without detaching the head. Immediately after slaughter the rooster carcasses were transported to the laboratory and cooled at 4°C for 7 days to determine meat quality, microbial activity, and lipid oxidation.

Oxidative stability of the rooster breast meat: Some adjustments were made in examining the oxidative stability of the meat. Lipid oxidation as 2-thiobarbituric acid reactive compounds (TBARS) was measured according to (7), with some minor changes. About 5 grams of minced samples homogenized for two minutes using 50 milliliters distilled water and 1.25 milliliters 4N HCl. Then, boiled 2.5 milliliters each of the distillate and a TBA reagent comprising a 0.375% thiobarbituric and 15% trichloroacetic acid mixture were boiled for —35 minutes in a water bath. After cooling for 10 minutes under flowing tap water, the absorption was measured at 538nm and compared to a blank. To determine the TBARS values, the value of the optical density was multiplied by 7.843. The oxidation products were measured using malondialdehyde (MDA) equivalents, or MDA mg per kg of meat.

Physical analyses of the breast meat: The breast muscles (pectoral major) were divided into two sections to determine the meat quality characteristics. The first portion was vacuum-packed, labeled and kept at 4 °C to measuring drip loss while the second was used to measure pH, water holding capacity, cooking loss, color parameters, and microbial activity.

Determining pH of the breast meat: A portable pH meter (Hanna® instruments, Woonsocket, USA) was used to measure the pH of the meat on the breast muscle after 24 hours of postmortem. Following calibration with two pH 4.0 and 7.0 buffers supplied with a glass electrode 0.5 g minced meat was mixed with a 10 ml centrifuge

tube according to (40). The glass electrode was then installed and a stable reading was awaited.

Drip loss of the breast meat (%): Meat samples were taken from the breast muscle (pectoral major) and weighed within 45 minutes of postmortem. To quantify drip loss, each weighted steak was suspended in an inflated polythene bag (ensuring the samples did not touch the sides of the bag) for one day at 4 °C. After a day, the samples were removed, gently dried, and weighed. The weight lost due to drip loss was calculated based on the method described by (19), As follows:

Drip loss (%) = [(weight of fresh sample (g) - sample weight (g) / weight of fresh sample (g)] × 100

Cooking loss in the breast meat (%): The procedure described by (8) was utilized to determine cooking loss. Plastic vacuum-sealed bags were used to cook samples in a water bath (HAAKE ® instruments, Woonsocket, USA) at 80ºC for 30 minutes. The samples were then cooled for 30 minutes at room temperature to remove any residual moisture. They were weighed before and after being subjected to thermal (heat) treatment. The loss during cooking is represented as the weight loss ratio to initial weight using the equation:

Cooking loss of sample % = [weight before cooking (g) - weight after cooking (g)] / weight before cooking (g) ×100

Water holding capacity of the breast meat (%): The ability of protein to hold water was established based on (10). About 1g of the meat samples was wrapped in absorbent cotton and placed in a centrifuge tube (Hettich, Zentrifugen, Germany). The tubes were placed in a centrifuge separator and rotated at 3000g for ten minutes at 4°C (380R, Rotina, Germany), after which each of the samples were weighed. The water-holding capacity (WHC) of the sample was estimated as the proportion of the weight of the sample after centrifugation to the initial sample weight using the following formula:

Water holding capacity (%) = sample weight after centrifugation (g)/ sample weight before centrifugation (g) × 100

Determination of the breast meat color: Meat color values were determined using Color Flex spectrophotometers according to the International Commission on Illumination Lab values (CIE) lab values of lightness (L*), redness (a*), and yellowness (b*) utilizing a 10^{o} standard observer, D56 illumination, and reflectance at a particular emission wave length (400–700 nm). Before use, the instrument was calibrated against a standard white and black plate. The breast samples were processed to achieve a thickness of approximately 12 mm (5), allowed to bloom for thirty minutes, and positioned with their bloomed side toward the bottom of the color flex cup. The values for the three attributes were averaged based on ten measurements for each treatment.

Microbiological analysis: One gram of aseptically-drawn meat from the roosters was placed in a test tube containing 9 milliliters of distilled water at 1, 3, 5, and 7-day postmortem periods. The surface of a dry medium was sprayed with 0.1 ml samples of serial dilutions of minced meat homogenates (1:10 diluent and distilled water) in order to measure the microbial counts. Total aerobic counts (TAC) were made using duplicate ten-fold dilutions dispersed on standard procedures agar plates. In addition, *pseudomonas spp*. counts were made after two-days incubation at 25 °C and on

Pseudomonas isolation agar after three-days incubation at 32 °C, according to the method of (15). The coliform bacteria were plated on MacConkey agar medium (LAB) and the inoculation plates kept at 37 °C for 48 hours. According to the guidelines provided by the American Public Health Association, the number of dark red colonies was counted following incubation (6). The increasing counts in the number of bacteria were transformed to log10 values.

Statistical analysis: The results obtained were submitted to one-way analysis of variance (ANOVA) in the general linear model with the Statistical Analysis System package (SAS) version 9.1 software (34). The parametric repeated measures ANOVA tests were used to compare the levels of TBARS, microbiological, and physical characteristics on days 1 and 7 postmortem. The interaction between treatment groups and sample periods was calculated but was not statistically significant. Duncan's test was carried out to determine the differences among means at a p value of 0.05.

Results and Discussion

The formation of secondary products of oxidation, including esters, ketones, and aldehydes, may lead raw meat to become rapidly rancid (40). Malondialdehyde is a major secondary oxidation product used to measure lipid oxidation during storage of meat and meat products. (22) declared that the meat manufacturing industry is significantly influenced by lipid oxidation. Due to the easy oxidation of polyunsaturated fatty acid esters by molecular oxygen, poultry meat with a high content of unsaturated fatty acids is particularly susceptible to oxidation of lipid during storage. The mean oxidative stability values of the meat of the roosters fed diets with different amounts of SSP are shown in Table 2.

There was a significant difference ($P \leq 0.05$) in the lipid oxidation value of the meat samples in all the treatments during the extended postmortem period and higher average MDA values in their breast muscle at day 7 in the control. Conversely, the values for the group fed 0.5 % with SSP were significantly lower than the control group except at 1 and 5 days of storage. The sumac fruit has considerable antioxidant properties because of the presence of these phenolic substances, particularly gallic acid (4).

As noted in several studies, SSP may decrease lipid oxidation by preventing the development of free radicals as they contain polyphenols that have both antioxidant properties and can increase meat shelf life. Because the rooster meat samples include compounds that have inhibitory effects on the creation of free radicals, it thus contributes to lessening the progression of the process of oxidation and preserving the samples from oxidative damage. The findings of this study are consistent with (33) who observed that meat samples of Japanese quail supplemented with *L. serriola* leaves had significantly lower TBARS values compared to those in the control group as well as with (3), who noted that the supplementation of *cyperus rotundus* tuber and vitamin E powder to chicken feed have a significant role in decreasing the oxidation of fat during storage.

Table 2: Malondialdehyde (mg/kg^{-1} meat) content of breast meat in local Kurdish rooster fed- diets supplemented with different levels of SSP during postmortem aging.

Storage times (days)	SSP treatments			
	Control (0%)	0.5 %	0.75 %	1.0 %
1	0.77 ± 0.02 $^{a\,C}$	0.71 ± 0.02 $^{ab\,C}$	0.65 ± 0.02 $^{bc\,C}$	0.59 ± 0.01 $^{c\,C}$
3	0.87 ± 0.02 $^{a\,B}$	0.79 ± 0.01 $^{b\,C}$	0.70 ± 0.01 $^{c\,C}$	0.64 ± 0.01 $^{d\,C}$
5	0.99 ± 0.05 $^{a\,B}$	0.90 ± 0.04 $^{ab\,B}$	0.80 ± 0.02 $^{bc\,B}$	0.73 ± 0.01 $^{c\,B}$
7	1.33 ± 0.06 $^{a\,A}$	1.16 ± 0.05 $^{b\,A}$	1.04 ± 0.03 $^{bc\,A}$	0.95 ± 0.02 $^{c\,A}$

*$^{a,\,d}$ Mean ±SE significant differences ($p<0.05$) are indicated by different superscripts in the same row (treatment).

*^{A,D} Mean±SE significant differences ($p<0.05$) indicated by different superscripts in the same column (storage).

Table 3 shows the pH values in the breast meat of the roosters fed diets containing different amounts of SSP after 7days of chilled storage. Significant reductions at $p<0.05$were recorded in the values of the treated samples compared to the T1 control. SSP amounts have a major impact on the ability of the phenol compounds in binding the protein molecules and preventing pH values from rising. Alternatively, extending storage periods had a significant ($P<0.05$) effect on pH values. Although higher compared to the control treatment, extending postmortem aging periods from 1 to 7 days led to a significant ($P<0.05$) increase in pH values. This may be due to the prolonged storage affecting the proteins and then isolating amine groups that affect the ability of meat to retain water (29).

In addition, the results show that the meat samples treated with SSP have higher water holding capacity (WHC) for all treatment levels during cold storage as compared to the control. This may be because the SSP contains phenolic compounds that may have a rolein preventing lipid oxidation, and reducing protein oxidation leads to improved WHC. These findings are consistent with (18) who noted a significant rise in the ability of chick meat to hold water, especially in the T2 and T3 groups supplemented with 1 g and 2 g of sumac fruit powder/kg feed, respectively. A considerable ($P<0.05$) decline was observed in the WHC of all the meat samples at 7-days cold storage compared to the untreated group. These results agree with (12) who found that pH values decreased with higher citrus waste supplementation in the feed compared to the control treatment at that storage period.

In relation to drip loss, the ability of the flesh to discharge a watery solution in the absence of external force is an essential indicator of high-quality meat (14). The findings displayed in Table 3 reveal that the rooster breast meat samples in a group fed SSP had lower significant ($P<0.05$) drip loss during chilling storage periods, except at 3 days where it declined insignificantly. For prolonged storage of 5 and 7 days, SSP-supplemented diets significantly reduced drip loss of the meat samples compared to the control. These results agree with (40) who observed that drip loss decreased when the diet was supplemented with 0.5% SSP. This reduction may be attributed to the effect of the SSP which enhances the ability of meat to hold water. Also, the amount of drip loss increases proportionally at a significant ($P<0.05$) rate with higher postmortem aging duration compared to untreated samples.

Finally, cooking loss refers to the reduction in weight of meat during the cooking process (23). The results presented in Table 3 indicate that cooking loss values of breast meat samples rose considerably (P≤0.05) with extending storage duration of postmortem aging excluding 1 and 3 days when treated with 0.5% compared with that of the control treatment and reached a high percentage of 24.78 at 7 days of storage in the untreated sample (control treatment) this is may be due to increasing protein oxidation and its effect on protein oxidation and cause the increasing drip loss and ability to hold water. However, the percentage of cooking loss declined insignificantly in groups of roosters that were fed a diet treated with 0.5% sumac seed powder, excluding 1% SSP that increased significantly at 1 day of refrigerator storage. Whereas during extending storage periods 3, 5, and 7 days, the amount of cooking loss decreased significantly with increasing the level of sumac seed powder in the local rooster diet, this result in agreement with the finding of (18) who find a significant improvement in cooking loss of broiler chicks after adding 1 and 2 grams of sumac seed to 1 kg of broiler chick feed.

Table 3: Physical properties of breast meat in local Kurdish rooster fed-diets supplemented with different levels of SSP during postmortem aging.

Parameter	Storage time (days)	SSP treatments			
		Control (0%)	0.5 %	0.75 %	1.0 %
pH	1	5.88 ± 0.01 $^{a D}$	5.75 ± 0.01 $^{b D}$	5.69 ± 0.01 $^{c C}$	5.71 ± 0.01 $^{c D}$
	3	5.94 ± 0.01 $^{a C}$	5.79 ± 0.01 $^{b C}$	5.77 ± 0.01 $^{b B}$	5.78 ± 0.02 $^{b C}$
	5	5.99 ± 0.01 $^{a B}$	5.87 ± 0.01 $^{b B}$	5.81 ± 0.01$^{c B}$	5.83 ± 0.01 $^{c B}$
	7	6.37 ± 0.01 $^{a A}$	6.30 ± 0.01 $^{b A}$	6.26 ± 0.01 $^{c A}$	6.29 ± 0.01 $^{bc A}$
Water holding capacity %	1	78.73 ± 0.61 $^{c A}$	80.64 ± 0.12 $^{b A}$	82.78 ± 0.53$^{a A}$	82.97 ± 0.52 $^{a A}$
	3	76.15 ± 0.29 $^{c B}$	78.12 ± 0.21 $^{b B}$	79.49 ± 0.31$^{a B}$	80.41 ± 0.37 $^{a B}$
	5	73.28 ± 0.29 $^{c C}$	75.07 ± 0.13 $^{b C}$	76.61 ± 0.34$^{a C}$	77.01 ± 0.51 $^{a C}$
	7	70.06 ± 0.08 $^{c D}$	71.92 ± 0.11 $^{b D}$	74.03 ± 0.27$^{a D}$	74.44 ± 0.32 $^{a D}$
Drip loss %	1	3.86± 0.01$^{a C}$	3.77 ± 0.01$^{ab D}$	3.68 ± 0.03 $^{b D}$	3.48 ± 0.05 $^{c D}$
	3	3.98± 0.03 $^{a C}$	3.97 ± 0.03 $^{a C}$	3.86 ± 0.02 $^{a C}$	3.65 ± 0.03$^{a C}$
	5	4.83 ± 0.07 $^{a B}$	4.21 ± 0.02 $^{b B}$	4.04 ± 0.03 $^{c B}$	3.88 ± 0.03$^{d B}$
	7	5.38 ± 0.08 $^{a A}$	5.34 ± 0.02 $^{b A}$	4.95 ± 0.02 $^{c A}$	4.21 ± 0.06 $^{d A}$
Cooking loss %	1	16.91 ± 0.09 $^{a D}$	16.62 ± 0.13 $^{ab D}$	16.13 ± 0.1$^{bc I}$	15.7 ± 0.29$^{c C}$
	3	18.52 ± 0.34 $^{a C}$	17.70 ± 0.25 $^{ab C}$	17.25 ± 0.31$^{bc C}$	16.48 ± 0.31$^{c C}$
	5	22.07 ± 0.31 $^{a B}$	20.37 ± 0.27 $^{b B}$	19.90 ± 0.14$^{b B}$	19.55 ± 0.23$^{b B}$
	7	24.78 ± 0.24 $^{a A}$	23.26 ± 0.32 $^{b A}$	22.52 ± 0.28$^{b A}$	21.26 ± 0.55$^{c A}$

*^{a,d}Mean ±S.E significant differences (p<0.05) are indicated by different superscripts in the same row (treatment).

*^{A,D}Mean ±S.E significant differences (p<0.05) are indicated by different superscripts in the same column (storage).

Meat color is an essential characteristic of high-quality meat and the first aspect that consumers consider when buying meat. Table 4 shows that samples of local Kurdish rooster breast during extended postmortem aging of 1, 3, 5, and 7 days had lower significant (P≤0.05) lightness (L*). It is probable that lower water retention leads to a drop in surface light reflection (20). L* increased significantly in the experimental diet which included 0.75% SSP compared to the control treatment. This might be due to the

low ultimate pH of the samples which has a negative effect on L*(negatively correlated) (23). The pale appearance of meat is believed to be due to its low ultimate pH (28). The experimental diet with SSP played a role in reducing pH as well as increasing the water holding capacity of the meat samples.

However, the redness (a*) values of the meat samples declined significantly during refrigerator storage from 1 to 7 days, reaching lowest value of 7.61 at 7 days in the control treatment. The primary cause of the darkening (discoloration) of the meat is the accumulation of metmyoglobin (MetMb) on its surface during preservation (9). Moreover, the breast meat samples supplemented with dietary SSP had higher a* values compared to the untreated group, with favorable values obtained in the 0.75% SSP supplemented diet at 1 day of storage. This could be due to the SSP's ability to maintain myoglobin from oxidation as it contains antioxidant compounds such as polyphenols and flavonoids that prevent the myoglobin from being converted to metmyoglobin.

The attribute of yellowness (b*) increased significantly ($P \leq 0.05$) during postmortem aging except for the groups fed the SSP supplemented diet at 3 days storage compared to the control treatment. The main reason for the increase with prolonged postmortem aging might be due to myoglobin oxidation and conversion to metmyoglobin, producing the brown color in the samples and the oxidation of the unsaturated (meat lipid) fatty acids. It could also be due to the production of additional free radicals that oxidize the ferrous (Fe2+) in oxy-myoglobin to the ferric form (Fe3+) in metmyoglobin (26). On the other hand, the breast samples of the birds fed a diet supplemented with different levels of SSP had significant ($P \leq 0.05$) lower values of b* compared to the control untreated group. This may be due to the ability of the powdered sumac seeds to maintain myoglobin from oxidation as they contain antioxidant compounds such as polyphenols and flavonoids that prevent myoglobin from being converted to metmyoglobin, or it might be due to the decline of lipid oxidation.

Table 4: Color parameters of breast meat in local Kurdish rooster-fed diets supplemented with different levels of SSP during postmortem aging.

Parameter	Storage time (days)	Treatments			
		Control (0%)	0.5 %	0.75 %	1.0 %
Lightness L*	1	56.66 ± 0.80$^{b\,A}$	60.65 ±0.74$^{a\,A}$	62.12 ±0.12$^{a\,A}$	61.92 ±0.05$^{a\,A}$
	3	54.44 ± 0.68$^{c\,A}$	56.81 ±0.64$^{b\,B}$	59.07 ± 0.6$^{a\,B}$	58.46±0.42$^{ab\,B}$
	5	51.84 ± 0.52$^{c\,B}$	54.30 ±0.47$^{b\,C}$	56.60 ±0.35$^{a\,C}$	56.14 ±0.46$^{a\,C}$
	7	48.78 ± 0.91$^{c\,C}$	52.06± 0.54^{bD}	54.25 ±0.15$^{a\,D}$	53.60±0.23$^{ab\,D}$
Redness a*	1	8.59 ± 0.13$^{b\,A}$	8.87 ± 0.01$^{a\,A}$	9.02 ± 0.08$^{a\,A}$	8.89 ± 0.02$^{a\,A}$
	3	8.27 ± 0.03$^{b\,B}$	8.80 ± 0.05$^{a\,A}$	8.85 ± 0.03$^{a\,B}$	8.80 ± 0.01$^{a\,B}$
	5	7.94 ± 0.04$^{c\,C}$	8.49 ± 0.03$^{b\,B}$	8.71 ± 0.03$^{a\,B}$	8.74 ± 0.03$^{a\,B}$
	7	7.61 ± 0.10$^{c\,D}$	8.14 ± 0.03$^{b\,C}$	8.38 ± 0.02$^{a\,C}$	8.34 ± 0.03$^{a\,C}$
Yellowness b*	1	5.43 ± 0.09$^{a\,D}$	5.35 ± 0.08$^{ab\,D}$	5.14 ± 0.03$^{bc\,D}$	5.01 ± 0.01$^{c\,C}$
	3	7.58 ± 0.08$^{a\,C}$	7.33 ± 0.08$^{a\,C}$	7.10 ± 0.09$^{a\,C}$	6.98 ± 0.02$^{a\,B}$
	5	8.63 ± 0.12$^{a\,B}$	7.92 ± 0.02$^{b\,B}$	7.63 ± 0.01$^{c\,B}$	7.45 ± 0.03$^{c\,B}$
	7	10.96 ±0.04$^{a\ A}$	10.71 ±0.10$^{b\,A}$	10.37 ±0.04$^{c\,A}$	9.91 ± 0.03$^{d\,A}$

*^{a,d}Mean ±S.E significant differences ($p<0.05$) are indicated by different superscripts in the same row (treatment)

*A,D Mean ±S.E significant differences (p<0.05) are indicated by different superscripts in the same column (storage).

Fresh poultry meat has a short shelf life in a refrigerator; therefore, microbiological deterioration is an important issue (11). According to (32), fresh poultry should contain no more than 6-7 log10 cfu/g of total microorganisms for safe consumption. Table 5 shows that the untreated group of local Kurdish roosters fed a basal diet had significant increases in total aerobic bacterial, coliform, and *pseudomonas* counts during postmortem aging that reached the highest value of 5.36, 2.86, and 4.25 log10 cfu/g, respectively at 7 days storage. Whereas the treated group with a diet of 1.0% SSP experienced a considerably (P≤0.05) gradual decreases in bacterial count during postmortem aging, excluding at 1 day of storage, compared to the untreated group.

These findings are in line with (27) who noted that total bacterial count increased during prolonged storage periods. In contrast, broiler chickens fed diets containing different additive levels had the lowest total bacterial counts. In addition our result is in agreement with (13), who found that there was a significant decline in the total bacterial count for the rosemary leaf treatment at 0.5% over a period of 14 days. At extended storage periods, coliform bacterial counts increased significantly (P≤0.05) at 5 and 7 days and marginally at 1 and 3 days compared to the untreated group. Moreover, considerable (P≤0.05) increments in count were seen during prolonged refrigerator storage compared to the control treatment. The number of *pseudomonas* bacteria declined significantly in the groups fed diets supplemented with 0.75 and 1.0% SSP, reaching the lowest value of 2.30 log10 cfu/gin the 1.0% SSP group compared to the control.

These outcomes are consistent with (35) who found significant decreases in coliform count with higher levels of SSP in Japanese quail diets. According to the results obtained, there was a significant increase in all bacteria form counts with extended storage periods, especially at 5 and 7 days due likely to the increase in pH values during refrigerator storage. In contrast, the SSP-supplemented diet had a positive effect on reducing bacterial growth during postmortem aging (refrigerator storage) because of its strong antibacterial effect.

Table 5: Changes in the microbiological count of breast meat in local Kurdish roosters-fed diets supplemented with different levels of SSP during postmortem aging.

Parameter	Storage time (days)	Treatments			
		Control (0%)	0.5 %	0.75 %	1.0 %
Total aerobic count (Log10 CFU/g)	1	4.07 ± 0.09 $^{a\,D}$	3.98 ± 0.07$^{a\,D}$	3.87 ± 0.04$^{a\,D}$	3.73 ± 0.48 $^{a\,AB}$
	3	4.51 ± 0.08 $^{a\,C}$	4.32 ± 0.02 $^{b\,C}$	4.09 ± 0.03 $^{c\,C}$	3.90 ± 0.05 $^{d\,B}$
	5	4.91 ± 0.04$^{a\,B}$	4.79 ± 0.04 $^{a\,B}$	4.60 ± 0.05 $^{b\,B}$	4.30±0.03$^{c\,AB}$
	7	5.36 ± 0.05$^{a\,A}$	5.27 ± 0.03 $^{a\,A}$	5.05 ± 0.02 $^{b\,A}$	4.91 ± 0.01$^{c\,A}$
Coliform Count (Log10 CFU/g)	1	1.89 ± 0.02$^{a\,C}$	1.82 ± 0.02$^{b\,C}$	1.74 ± 0.03 $^{c\,C}$	1.69 ± 0.02$^{c\,C}$
	3	1.94 ± 0.01 $^{a\,C}$	1.88 ± 0.01$^{b\,C}$	1.80 ± 0.01$^{c\,C}$	1.74 ± 0.01 $^{d\,C}$
	5	2.47 ± 0.08 $^{a\,B}$	2.31 ± 0.07 $^{a\,B}$	2.09 ± 0.05 $^{b\,B}$	1.99 ± 0.02$^{b\,B}$
	7	2.86 ± 0.05 $^{a\,A}$	2.72 ± 0.04 $^{b\,A}$	2.54 ± 0.03 $^{c\,A}$	2.26 ± 0.03$^{d\,A}$
Pseudomonas spp. (Log10 CFU/g)	1	2.67 ± 0.05 $^{a\,D}$	2.56 ± 0.08 $^{a\,D}$	2.37 ± 0.03 $^{b\,D}$	2.30 ± 0.03 $^{b\,D}$
	3	2.99 ± 0.08 $^{a\,C}$	2.88 ± 0.05$^{ab\,C}$	2.73 ± 0.05$^{bc\,C}$	2.57 ± 0.04$^{c\,C}$
	5	3.85 ± 0.08 $^{a\,B}$	3.69 ± 0.06 $^{a\,B}$	3.38 ± 0.05 $^{b\,B}$	3.18 ± 0.09 $^{b\,B}$
	7	4.25 ± 0.07 $^{a\,A}$	4.01 ± 0.04 $^{b\,A}$	3.8 ± 0.04 $^{c\,A}$	3.67 ± 0.05 $^{c\,A}$

^{*a,d} Mean ±SE significant differences ($p<0.05$) are indicated by different superscripts in the same row (treatment).

^{*A,D} Mean ±SE significant differences ($p<0.05$) are indicated by different superscripts in the same column (storage).

Conclusions

As shown in this study, incorporating sumac seed powder into the diets of the roosters improved the physical properties of their breast meat, reduced cooking and drip loss, and increased their water holding capacity. It also increased their shelf life by reducing lipid oxidation and the number of microorganisms as well as prevented the color of meat from degrading during postmortem aging.

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The authors declare no conflict of interest.

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