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Impact of fruit peels extract on the shelf-life of minced beef

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ABSTRACT

Fourteen kilograms of minced meat were divided into 4 groups (about 3.5 Kg for each group). All samples were examined to study the effect of the addition of 1% fruit peel extracts (banana, orange, and pomegranate) on the extension of the shelf life of such food article. Reduction of APC after 6 days in samples treated with banana, orange, and pomegranate peel reached 83.9 %, 91.6 %, and 95.4%, respectively and reduction of articles coliform reached 75.8%, 90.3 %, and 93% while *S. aureus* count reduced by 77.5%, 89%, and 96.5 %, respectively. Fruit peels decreased pH values compared with the control sample during storage at 4˚C for 10 days. pH values of samples treated with banana peel decreased from 5.63 to 5.61 at zero time and from 6.71 to 5.84 on the 6th day and orange peel decreased to 5.58 and to 5.70 while pomegranate to 5.56 and to 5.67 at zero time and on the 6th day of storage, respectively. TVB-N values of samples treated with banana decreased from 1.97 to 1.89 at zero time and from 29.58 to 9.83 on the 6th day and orange peel decreased to 1.84 and to 7.90 while pomegranate to 1.81 and to 6.88 at zero time and on the 6th day. TBA values of samples treated with banana peel decreased from 1.22 to 0.25 on the 6th day but orange peel decreased to 0.02 and to 0.19 and with pomegranate to 0.02 and to 0.14 at zero time and on the 6th day of storage, respectively. In general, the incorporation of banana, orange, and pomegranate peel powder into minced meat as natural preservatives improved color, odor, appearance, consistency, and overall acceptability and extended their shelf life during storage.

Introduction

Meat and meat products are the most palatable and desirable foods for human beings, as they are important sources of animal protein, fat, essential amino acids, minerals, and vitamins (Zafar *et al*., 2016). On the other hand, they are considered as ideal culture medium for the growth of organisms because of the high moisture, the high percentage of nitrogenous compounds, and minerals, some fermentable carbohydrates, and favorable pH for most microorganisms resulting in their spoilage, economic losses, foodborne infections in human (Komba *et al*., 2012).

Meat products were subjected to various degrees of contamination through meat processing. So, a concentrated effort should be made to maintain sanitary conditions in processing, preparation, and handling (Shaltout *et al*., 2014).

Natural and synthetic food-additives, of the antioxidant effect, have been commonly used in the meat industry to inhibit the development of oxidative reactions and extend the shelf-life of meat products (Cunha *et al*., 2018).

Plants have antibacterial, antioxidant, and anti-inflammatory activity (Ficker *et al*., 2003). The natural antioxidants found in plants have gained interest for their role in preventing the auto-oxidation of fats, oils, and fat-containing food products (Reddy *et al*., 2005) So, consumers prefer using natural food additives in various products to delay the oxidative degradation of lipids, improve quality and nutritional value of foods and replace synthetic preservatives (Aminzare *et al*., 2019).

Banana peel is rich in proteins, potassium, essential amino acids, and unsaturated fatty acids and contains high phenolic content which possesses antimicrobial activity (Morais *et al*., 2015) Banana peel extract is considered as good antibacterial agent against different types of bacteria (Mokbel and Hashinaga, 2005).

The meat market is demanding natural antioxidants, free of synthetic additives and able to diminish the oxidation processes in high-fat meat and meat products, and discuss how to extend the shelf life of meat products by the successful use of pomegranate peel extracts containing phenolic as natural preservative agent can improve stored meat products quality, namely instrumental color retaining, limitation of microflora growth, retardation of lipid and protein oxidation (Slim *et al*., 2019).

Punica granatum Linn. (Pomegranate) is a member of the family Punicaceae. This plant is found all over India. Pomegranate peel contains tannins, flavonoids, polyphenols, and some anthocyanins as delphinidins, cyanidins, etc (Abdollahzadeh *et al*., 2011; Choi *et al*., 2011; Singh *et al*., 2014). This antimicrobial activity was related to the phenolic compounds that involve precipitation of membrane proteins of microorganisms resulting in microbial cell lysis (Rosas-Burgos *et al*., 2017). Therefore, this study was carried out to evaluate the effect of the addition of fruit peel powder (Banana, Orange, and Pomegranate peel) on bacteriological quality and extending the shelf-life of minced meat.

Materials and methods

Collection and Preparation of samples

A total of 14 kilograms of minced meat were purchased from the butcher shop in Shibin Elkom City, Menoufia governorate, Egypt. The collected samples were kept in sterile plastic bags and preserved in an ice box then transferred to the Laboratory. All minced meat samples were examined to study the effect of the addition of fruit peel extracts on the extension of the shelf life of such food subjects.

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The samples were divided into 4 groups about 3.5 Kg for each group and each group was represented by 35 samples 100g for each. The first group was prepared as a control (Untreated group) and the other 3 groups were treated with 1% banana peel extract, 1% orange peel extract, and 1% Pomegranate peel extract, respectively.

Treatment of samples with fruit peel extracts (Barbosa et al., 2009)

Each treated sample was dipped for 15 min in the dipping emulsion solution (1 g of pure fruit peel to a final volume of 100 ml of sterile distilled water) and then drained well for 5 min on a sterile stainless wire mesh screen. The control group was dipped in sterile distilled water. The previously treated minced meat samples were labeled and each single sample was separately packaged in polyethylene bags. The experiment was conducted for 10 days of chilling storage at 2°C. All tested samples of such groups either control or treated were subjected to bacteriological, chemical and sensory assessment at zero time (within 2 hours after treatment) and then periodically every 2 days until decomposition appeared in each group (zero, 2, 4, 6, 8 and 10 days). The scheme was replicated 3 times.

Bacteriological examination

Preparation of samples (ISO 6887-1, 2013)

Under complete aseptic conditions, 25 grams of the sample were weighed and transferred into a sterile homogenizer flask containing 225 ml of sterile peptone water (0.1%). The content of the flask was homogenized for 3 minutes at 14000 rpm and then allowed to stand for 5 minutes at room temperature. One ml of the homogenate was transferred into a separate tube containing 9 ml of sterile peptone water (0.1%) from which tenfold serial dilutions were prepared. The prepared meat samples were subjected to the following examinations:

Aerobic Plate Count "APC" (ISO 4833-1, 2003)

One ml from each of the previously prepared dilutions was transferred into two separate sterile Petri dishes to which approximately 15 ml of sterile melted and tempered plate count agar (45°C) were added. After thorough mixing, the inoculated plates were allowed to solidify before being incubated at 37°C for 24 hours. The Aerobic Plate Count (APC) per gram was calculated on plates containing 30-300 colonies and each count was recorded separately.
APC = average number of duplicate plates x dilution factor cfu/g.

Coliform count "MPN/g"(FDA, 2002)

One ml from each decimal dilution was inoculated into 3 fermentation tubes containing 5 ml of Lauryl Sulphate Tryptose (LST) broth and inverter Durham's tubes. The inoculated and control tube and plates were incubated at 37°C for 24 hours. The positive tubes showing gas production were recorded. Further, a loopful from each positive tube was transferred into another fermentation tube containing Brilliant Green Bile Lactose Broth (2%). The inoculated and the positive tubes showing gas production were recorded. According to MPN tables for the 3 tube dilutions, the results were recorded as the presumptive MPN of coliforms/g.

Determination of *S. aureus* count (FDA, 2001)

The procedures recommended by using a Baired Parker agar medium were done. One ml from each of the previously prepared serial dilutions was spread over the Baired Parker agar plate using a sterile bent glass spreader. The plates were retained in an upright position until the inoculums were absorbed by agar for about 10 min, or placed in upright in the incubator for about one hour. The inoculated and control plates were inverted and incubated at 37°C for 48 hours. After which they were examined for colony character. The developed colonies (shiny black colonies) were enumerated as presumptive *S. aureus* count/g was calculated.

Chemical examination

Determination of pH (Pearson, 2006)

In a blender, approximately 10 g of the sample was blended in 10 ml of neutralized distilled water. The homogenate was left at room temperature for 10 minutes with continuous shaking. The pH value was determined by using an electrical pH meter (Bye model 6020, USA).

Determination of Total Volatile Nitrogen "TVN" (ES: 63-9/ 2006)

In a clean distillation flask, 10 g of the sample was added to 300 ml of distilled water and thoroughly mixed by inserting a polytron probe. Then, an antifoaming agent and 2g of Magnesium Oxide were added. To 500ml receiving flask, 25 ml of 2% boric acid and a few drops of the indicator were added. The receiving flask was installed such that the receiver tube dipped below the boric acid solution. The distillation flask was heated within 10 minutes till boiling which continued for 25 minutes then distilling for 25 minutes. Then titration of TVN received in boric acid by H_2So_4 n 0.1 was recorded. Accordingly, TVA was calculated from the following formula:
TVN/l00g = (mls H_2So_4 n 0.1 for sample – ml H_2So_4 n 0.1 for Blank) x 14

Determination of Thiobarbituric Acid Number "TBA" (ES: 63-10/2006)

The test depends on the determination of malonaldehyde (MDA) as an end product of lipid peroxidation. The extent of oxidative rancidity is normally reported as TBA number or values and expressed as milligrams of malonaldehyde equivalents per kilogram of the samples. When oxidative destruction of unsaturated fatty acids of meat occurs, free melanoaldhyde is produced forming the TBA-melanoaldhyde complex. When melanoaldhyde is produced, it can be measured as an indicator of lipid oxidation and food quality. Actually, 10 g of prepared meat sample was transferred to a distillation flask and mixed with 50 ml of distilled water, then (2.5 ml hydrochloric acid diluted in 47.5 water) was added. Then, small pieces of antifoaming agents were added. The distillation flask was heated for distillation of 50 ml within 10 minutes from the beginning of boiling. Accordingly, 5 ml of a distilled solution was put in a tube with a cover, then 5 ml of prepared thiobarbituric acid (prepared by dissolving 0.2883 Thiobarbituric acid in trichloroacetic acid 90 % and was completed to 100 ml). The tube was covered and put in the water bath and boiled for 35 minutes, then cooled by water for 10 minutes. Then the absorbance of the sample was measured using a Spectrophotometer (UNICAM969AA Spectronic, USA) under wavelength 538.

TBA value= absorbance of sample x 7.8 (malonaldehyde (mg) /Kg)

Sensory evaluation (Fik and Fik, 2007)

Sensory properties of control and treated minced meat during refrigerated storage were evaluated by a 6-member panel appropriately trained and tested in sensory sensitivity. Training sessions were concluded when individual scores did not vary by more than 1 unit from the mean score and the panelists were familiar with the evaluation system. Representative samples from stored meat were randomly selected and served on porcelain plates in the laboratory (open area). Panel members were asked to evaluate the freshness grade using a 5-point scale attribute being scored from 1 to 5 points depending on specifications of sensory quality. The following properties were evaluated: color, odor, appearance, and consistency. The overall sensory quality scores 5, 4, 3, 2, and 1 cor-

responded to the beef mince qualities evaluated as very good, good, acceptable, unacceptable, and bad, respectively.

Results

In Table 1, during the cold storage period it is obvious that the APC of control samples prepared without fruit peels powder was remarkably increased progressively over the storage time from ($6.1x10^3 \pm 0.4x10^3$) at zero time and reached $1.8x10^6 \pm 0.3x106$ after 6 days of cold storage. Reduction in APC of minced meat samples treated with banana peel 1% reached 83.9% while samples treated with orange peel 1% reached 91.6% and sample treated with pomegranate peels 1% showed the highest reduction percent after 6 days of the experiment at 95.4% (Fig. 1).

Result in Table 2 indicated that coliform count for the control sample prepared without fruit peels powder was increased progressively over time during storage from ($1.8x10^3 \pm 0.2x10^3$) at zero time to ($9.1x10^4 \pm 1.5x10^4$) at 6 days of cold storage. Other samples treated with banana, orange, and pomegranate peel showed a reduction percent in coliform count reaching 75.8%, 90.3 %, and 93%, respectively after 6 days of cold storage (Fig. 2).

Table 3 indicated that the treatment with banana, orange, and pomegranate peel inhibited *S. aureus* count significantly in comparison with a control group which showed spoilage signs on the 6th day of cold storage and *S. aureus* decrease in the samples treated with banana, orange, and pomegranate peel with reduction percent 77.5%, 89%, 96.5 %, respectively indicating higher reduction % with sample treated with pomegranate peel (Fig. 3).

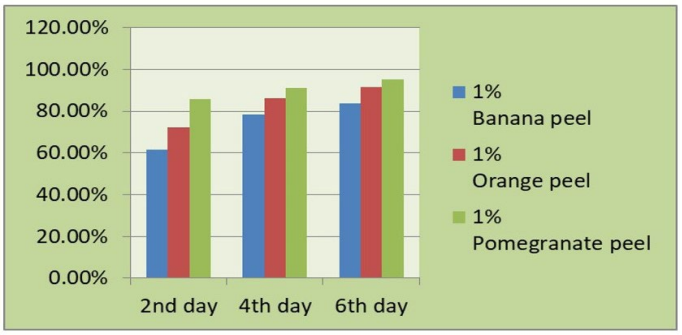

Fig. 1. Reduction % of APC (cfu/g) at minced meat samples treated with fruit peels.

In Table 4 it is obvious that fruit peels decrease pH values compared with the control sample during storage at 4˚C for 10 days. The pH values of samples treated with banana peel decreased from 5.63 to 5.61 at zero time and from 6.71 to 5.84 on the 6th day and samples treated with orange peel decreased to 5.58 at zero time and to 5.70 on the 6th day, while the progressive reduction in samples treated with PP to 5.56 at zero time and to 5.67 on the 6th day of storage indicating significantly different at ($P<0.05$) in pH values (Fig. 4).

Table 1. Effect of fruit peels on APC (cfu/g) for extending the shelf life of minced meat samples at 4˚C (n=3).

Treatment / Storage time	Control	Banana peel (1%)		Orange peel (1%)		Pomegranate peel (1%)	
		Count	R %	Count	R %	Count	R %*
Zero time	$6.1\times10^3\pm0.4\times10^3$	$6.1\times10^3\pm0.4\times10^3$	-----	$6.1\times10^3\pm0.4\times10^3$	-----	$6.0\times10^3\pm0.4\times10^3$	------
2nd day	$1.4\times10^5\pm0.2\times10^{5a}$	$5.4\times10^4\pm0.3\times10^{4b}$	61.4	$3.9\times10^4\pm0.2\times10^{4c}$	72.1	$2.0\times10^4\ 0.1\times10^{4\,d}$	85.7
4th day	$5.5\times10^5\pm0.4\times10^{5a}$	$1.2\times10^5\pm0.1\times10^{5b}$	78.2	$7.6\times10^4\pm0.5\times10^{4c}$	86.2	$4.8\times10^4\pm0.3\times10^{4d}$	91.3
6th day	$1.8\times10^6\pm0.3\times10^{6a}$	$2.9\times10^5\pm0.2\times10^{5b}$	83.9	$1.5\times10^5\pm0.1\times10^{5c}$	91.6	$8.2\times10^4\pm1.1\times10^{4c}$	95.4
8th day	S	$6.5\times10^5\pm0.4\times10^{5a}$	-----	$5.3\times10^5\pm0.4\times10^{5b}$	-----	$1.4\times10^5\pm0.1\times10^{5c}$	------
10th day	S	$8.9\times10^5\pm1.1\times10^{5a}$	-----	$6.6\times10^5\pm0.5\times10^{5b}$	-----	$3.5\times10^5\pm0.2\times10^{5c}$	------

R %*: Reduction %; S: Spoiled.
*Mean values with different superscripts in the same rows are significantly different at ($P<0.05$). EOS (2005) established that APC should not exceed 106/g.

Table 2. Effect of fruit peels on coliforms (cfu/g) for extending the shelf life of minced meat samples at 4˚C (n=3).

Treatment / Storage time	Control	Banana peel (1%)		Orange peel (1%)		Pomegranate peel (1%)	
		Count	R %	Count	R %	Count	R %*
Zero time	$1.8\times10^3\pm0.2\times10^3$	$1.8\times10^3\pm 0.2\times10^3$	------	$1.8\times10^3\pm0.2\times10^3$	------	$1.8\times10^3\pm 0.2\times10^3$	------
2nd day	$3.3\times10^4\pm0.2\times10^{a}$	$7.5\times10^3\pm 0.4\times10^{3\,b}$	77.3	$5.2\times10^3\pm0.3\times10^{c}$	84.2	$3.0\times10^3\pm 0.2\times10^{3\,d}$	90.9
4th day	$5.7\times10^4\pm0.4\times10^{a}$	$1.2\times10^4\pm 0.1\times10^{4\,b}$	78.9	$7.4\times10^3\pm0.6\times10^{c}$	87	$5.9\times10^3\pm 0.5\times10^{3\,d}$	89.6
6th day	$9.1\times10^4\pm1.5\times10^{a}$	$2.2\times10^4\pm 0.1\times10^{4\,b}$	75.8	$8.8\times10^3\pm0.9\times10^{c}$	90.3	$6.3\times10^3\pm 0.5\times10^{3\,d}$	93
8th day	S	$3.7\times10^4\pm 0.3\times10^{4\,a}$	------	$1.0\times10^4\pm0.1\times10^{b}$	------	$7.4\times10^3\pm 0.6\times10^{3\,c}$	------
10th day	S	$5.2\times10^4\pm 0.6\times10^{4\,a}$	------	$1.9\times10^4\pm0.1\times10^{b}$	------	$9.1\times10^4\pm 0.8\times10^{4\,c}$	------

*Mean values with different superscripts in the same rows are significantly different at ($P<0.05$).

Table 3. Effect of fruit peels on *S. aureus* count (cfu/g) for extending the shelf life of minced meat samples at 4˚C (n=3).

Treatment / Storage time	Control	Banana peel (1%)		Orange peel (1%)		Pomegranate peel (1%)	
		Count	R %	Count	R %	Count	R %*
Zero time	$4.3\times10^2\pm0.2\times10^2$	$4.3\times10^2\pm0.2\times10^2$	------	$4.3\times10^2\pm0.2\times10^2$	------	$4.2\times10^2\pm0.2\times10^2$	------
2nd day	$3.9\times10^3\pm0.3\times10^{3\,a}$	$1.4\times10^3\pm0.1\times10^{3\,b}$	64.1	$1.1\times10^3\pm0.1\times10^{3\,b}$	71.8	$8.0\times10^2\pm0.6\times10^{2\,b}$	79.5
4th day	$8.7\times10^3\pm0.7\times10^{3\,a}$	$3.5\times10^3\pm0.4\times10^{3\,b}$	59.8	$1.9\times10^3\pm0.1\times10^{3\,b}$	78.2	$9.0\times10^2\pm0.7\times10^{2\,b}$	89.7
6th day	$2.9\times10^4\pm0.3\times10^{4\,a}$	$6.5\times10^3\pm0.5\times10^{3\,b}$	77.5	$3.2\times10^3\pm0.4\times10^{2\,b}$	89	$1.0\times10^3\pm0.1\times10^{3\,b}$	96.5
8th day	S	$8.1\times10^3\pm0.5\times10^{3\,a}$	------	$5.0\times10^3\pm0.4\times10^{3\,a}$	------	$2.4\times10^3\pm0.2\times10^{2\,a}$	------
10th day	S	$1.0\times10^4\pm0.1\times10^{4\,a}$	------	$7.3\times10^3\pm0.6\times10^{3\,a}$	------	$3.6\times10^3\pm0.4\times10^{3\,a}$	------

*Mean values with different superscripts in the same rows are significantly different at ($P<0.05$). EOS (2005) established that *S. aureus* count should not exceed 102/g.

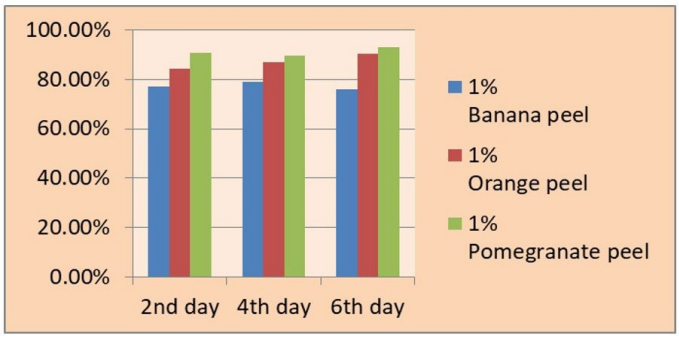

Fig. 2. Reduction % of coliforms (cfu/g) at minced meat samples treated with fruit peels.

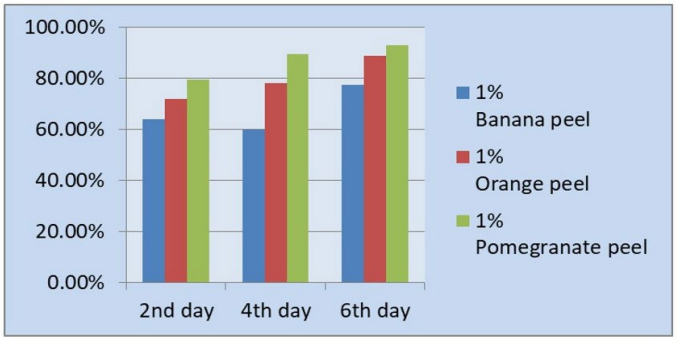

Fig. 3. Reduction % of *S. aureus* count (cfu/g) at minced meat samples treated with fruit peels.

Data in Table 4 indicated that TVB-N decreased compared with the control sample during storage at 4˚C for 10 days. The TVB-N of samples treated with banana peel decreased from 1.97 to 1.89 at zero time and from 29.58 to 9.83 on the 6th day and in samples treated with orange peel decreased to 1.84 at the zero time and to 7.90 on the 6th day while progressive reduction in samples treated with PP to 1.81 at zero time and to 6.88 on the 6th day of storage indicating significantly different at (P<0.05) in TVB-N values (Fig. 5).

Table 4. Effect of fruit peels on chemical profile for extending the shelf life of minced meat samples at 4˚C (n=3).

Treatment Storage time	Control	Banana peel (1%)	Orange peel (1%)	Pomegranate peel (1%)
pH				
Zero time	5.63± 0.01	5.61± 0.01	5.58± 0.01	5.56± 0.01
2nd day	5.92± 0.03[a]	5.67± 0.01[b]	5.63± 0.01[b]	5.59± 0.01[b]
4th day	6.15± 0.03[a]	5.74± 0.01[b]	5.69± 0.01[b]	5.66± 0.01[b]
6th day	6.71± 0.04[a]	5.84± 0.02[b]	5.70± 0.01[c]	5.67± 0.01[c]
8th day	S	6.07± 0.02[a]	5.85± 0.02[b]	5.81± 0.01[b]
10th day	S	6.46± 0.04[a]	6.19± 0.04[b]	6.14± 0.03[b]
TVB-N				
Zero time	1.97± 0.15	1.89± 0.14	1.84± 0.14	1.81± 0.13
2nd day	11.82± 0.27[a]	5.03± 0.16[b]	3.35± 0.13[c]	3.07± 0.11[c]
4th day	15.18± 0.40[a]	6.41± 0.18[b]	4.74± 0.15[c]	4.36± 0.12[c]
6th day	29.58± 1.04[a]	9.83± 0.31[b]	7.90± 0.24[c]	6.88± 0.19[d]
8th day	S	13.62± 0.38[a]	10.44± 0.36[b]	9.27± 0.31[c]
10th day	S	20.19± 0.62[a]	15.98± 0.49[b]	13.53± 0.42[c]
TBA				
Zero time	0.03± 0.01	0.03± 0.01	0.02± 0.01	0.02± 0.01
2nd day	0.37± 0.04[a]	0.10± 0.01[b]	0.06± 0.01[b]	0.04± 0.01[b]
4th day	0.54± 0.04[a]	0.17± 0.01[b]	0.13± 0.01[b]	0.10± 0.01[b]
6th day	1.22± 0.08[a]	0.25± 0.02[b]	0.19± 0.01[b]	0.14± 0.01[b]
8th day	S	0.53± 0.03[a]	0.37± 0.02[b]	0.29± 0.02[b]
10th day	S	0.90± 0.04[a]	0.71± 0.03[b]	0.55± 0.04[b]

*Mean values with different superscripts in the same rows are significantly different at (P<0.05).

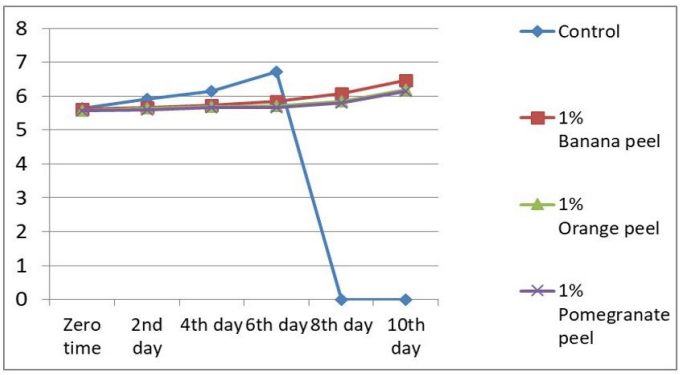

Fig. 4. Effect of fruit peels on pH values for extending the shelf life of minced meat samples at 4˚C.

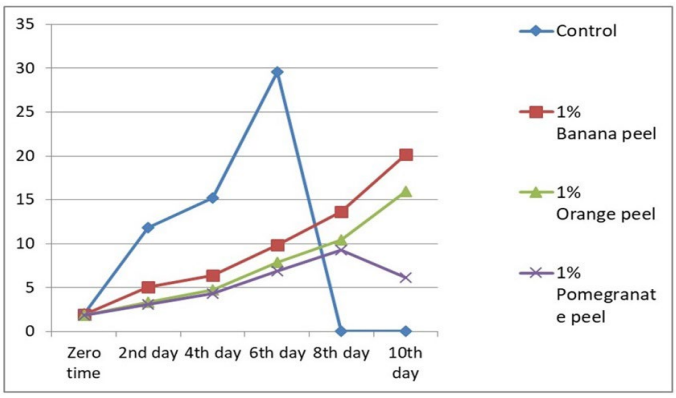

Fig. 5. Effect of fruit peels on TVB-N (mg/100g) for extending the shelf life of minced meat samples at 4˚C.

Data in Table 4 indicated that TBA decreased compared with the control sample during storage at 4˚C for 10 days. TBA values of samples treated with banana peel decreased from 1.22 to 0.25 on the 6th day and in samples treated with orange peel decreased from 0.03 to 0.02 at zero time and to 0.19 on the 6th day while the progressive reduction in samples treated with PP to 0.02 at zero time and 0.14 on the 6th day of storage indicating significantly different at (P<0.05) in TBA values.

Table 5 indicated that the treatment with BP, OP, and PP extended the acceptable sensory characters significantly when compared with a control group which showed spoilage signs on the 8th day of cold storage. PP 1% showed the highest scores up to banana and orange peel. So, the incorporation of fruit peel extract into minced meat as a natural preservative improved color, odor, appearance, consistency, and overall acceptability and extended their shelf life during storage.

Discussion

Aerobic plate count has been used to assess sanitary quality and safety inspection of meat which is used as an indicator of bacterial population on a sample (APHA, 2001).

The similarity of the results is recorded in Table 1 with Kanatt *et al.* (2010) and Al-zoreky (2009).

Coliform is used as a hygiene indicator for organisms. The coliform group of bacteria includes all the aerobic and facultative anaerobic, gram-negative, and non-sporulating bacilli that produce acid and gas during the utilization of lactose. The observed results in Table 2 agree with El-Nashi *et al.* (2015) and Agourram *et al.* (2013) who mentioned the inhibition effect of pomegranate powder against gram-positive and gram-negative bacteria over time during cold storage.

The phenolic compound of fruit peel extract exhibits an antimicrobial effect by decreasing the pH value of microbial cells through the ionization of acid molecules decreasing the water content and altering bacterial growth (Abdel-Naeem *et al.*, 2022). The results in Table 3 indicated that treatment with banana, orange, and pomegranate peel inhibited *S. aureus* compared with a control sample.

Table 4 shows that fruit peels decreased pH value compared with the control sample of minced meat during storage at 4˚C for 10 days. There

Table 5. Sensory characteristic scores of treated minced meat stored at 4ºC (n=3).

Trait / Storage time	Color -5	Odor -5	Appearance -5	Consistency -5	Overall -5	Grade
Control						
Zero time	4.9	4.8	4.9	4.9	4.9	Very good
2nd day	3.8	3.4	3.6	3.8	3.6	Acceptable
4th day	3	2.6	3	2.8	2.8	Unacceptable
6th day	1.8	1.6	1.6	1.4	1.6	Bad
8th day	S	S	S	S	S	Spoiled
10th day	S	S	S	S	S	Spoiled
1% banana peel						
Zero time	4.9	4.8	4.9	4.9	4.9	Very good
2nd day	4.6	4.4	4.2	4.6	4.5	Good
4th day	4.4	4	4.2	4	4.2	Good
6th day	4.2	4	3.8	3.8	4.1	Good
8th day	3.8	3.6	3.6	3.6	3.7	Acceptable
10th day	3.4	3.2	3.4	3	3.3	Acceptable
1% orange peel						
Zero time	4.9	5	5	4.9	4.9	Very good
2nd day	4.8	4.8	4.6	4.6	4.7	Very good
4th day	4.4	4.6	4.4	4.2	4.4	Good
6th day	4	4	3.8	4.2	4	Good
8th day	3.8	3.8	3.6	3.8	3.8	Acceptable
10th day	3.4	3.6	3.2	3.2	3.4	Acceptable
1% Pomegranate peel						
Zero time	4.9	5	5	4.9	4.9	Very good
2nd day	4.8	4.8	4.8	4.8	4.8	Very good
4th day	4.8	4.6	4.6	4.8	4.7	Very good
6th day	4.6	4.6	4.4	4.8	4.6	Very good
8th day	4.4	4.4	4.2	4.4	4.4	Good
10th day	4	3.8	3.6	4	3.8	Acceptable

4.5- 5: Very good; 4-4.5: Good; 3-4: Acceptable; 2-3: Unacceptable; 1-2: Bad; S: Spoiled.

are significant differences at (P<0.05) in pH values. The decrease in pH values is usually due to lactic acid formation and glycogen breakdown. These results agree with Devatkal *et al*. (2010) and Qin *et al*. (2013).

TVB-N decreased in samples treated with fruit peels compared with the control sample. There are significant differences at (P<0.05) in TVB-N values. Break-down of nitrogenous substances by microbial activity leads to an increase of TVB-N (Madkour *et al*., 2000 and Gibriel *et al*., 2007) have similar results that were obtained in Table 4. By addition of pomegranate peel powder lead to the inhibition of microorganism and the prevention of protein breakdown resulting in volatile nitrogen compounds. The antimicrobial mechanisms of phenolic compounds involve reaction of phenolics with microbial cell membrane proteins and/or protein sulfhydryl groups that yield bacterial death due to membrane protein precipitation and inhibition of enzymes such as glycosyltransferases (Naz *et al*., 2007).

TBA value (expressed as mg malonaldehyde /kg) of the sample treated with fruit peels decreased compared with the control group. Progressive reduction in samples treated with pomegranate. Pomegranate peel extract's strong phenolic content may be the cause. Abu-Amsha *et al*., (1996) noted that there are direct correlation between total phenolic content and antioxidant activity. According to Kim *et al.* (2013), fruit peel extracts reduced the levels of TBA in minced meat when compared to untreated samples. The current study's findings in Table 4 agree with Reddy *et al.* (2013). There are significant differences at (P<0.05) in TBA values. Greene and Cumuze (1982) said that TBA value may be taken as a good chemical parameter for quality assurance and measuring the extent of the secondary oxidant of edible lipids.

From the previous results, it can be found that TBA values of minced meat treated with pomegranate peel exhibited their beneficial effect on the deterioration reactions that happened in sample lipids during storage. The inhibitory effect of pomegranate peel on lipid oxidation might be related to its phenolic content and other biochemical compounds. Pomegranate peels inhibit lipid oxidation by blocking radical chain reactions in the oxidation process (Jia *et al*., 2012).

Sensory attributes such as appearance and color, texture, juiciness, and flavor are

considered critical subsets to judge their quality and acceptability, influencing

the consumers' preference and willingness to purchase food products (Madane *et al*., 2020; Das *et al*., 2020). The obtained results in Table 5 agree with those recorded by (Ibrahim *et al*., 2018).

The information given by the achieved results proved that treatment of minced meat by the addition of pomegranate peel powder inhibited the bacterial count, Coliform count, and *S. aureus* count and could reduce pH, TVB-N, and TBA in the examined samples and extended the shelf-life of refrigerated treated minced meat. It can be concluded that pomegranate peel powder has the potential to be used in food as flavoring and natural preservative to control food spoilage and improve the quality of minced meat.

Conclusion

Pomegranate peel powder 1% exhibited a natural preservative in producing good quality minced meat. pH, TVB-N, and TBA as quality criteria are evaluated during storage at (4˚C) for 10 days and have been found to be affected by the addition of pomegranate peel powder (1%). Microbiological quality criteria (APC, Coliform, and *S. aureus* count) of examined samples have been discussed and evaluated during storage at 4˚C for 10 days and were decreased in the pomegranate-treated sample. So, pomegranate peel powder exhibits antimicrobial and antioxidant activity (APC, Coliform, and *S. aureus* count) and could reduce pH, TVB-N, and TBA in the examined samples of minced meat.

Conflict of interest

The authors declare that they have no conflict of interest.

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