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Improvement of Safety and Quality of Minced Meat Using Pomegranate and Guar Gum Extracts

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Abstract

DEVELOPMENT of meat additives is a continuous effort aims to maximize safety and acceptability of meat products. So, herbals as "green foods" are commonly used as natural agents for food preservation. Therefore, the current study aimed to evaluate the beneficial effect of pomegranate peel (PPE) and guar gum (GG) aqueous extracts on the overall quality and shelf-life of minced meat. PPE and GG extracts were primarily analyzed for their phenolic compounds, followed by their addition with concentrations of 1% and 3% for PPE, 0.3 and 0.5% for GG, and a mix of them (PG) (1% PPE + 0.3% GG) separately on five groups of minced meat; moreover, control group was accounted. Treated groups were examined for their overall quality along twelve days of refrigeration. Results revealed significant ($P \leq 0.05$) overall improvement in the treated groups, especially in the treated group with mixed PPE and GG extracts, which showed acceptability up to the 12th day of storage. Furthermore, enhanced moisture content (%) and declined cooking loss (%) were recorded in the treated groups. Moreover, pH, total volatile nitrogen (TVN) and thiobarbituric acid (TBA) showed significant stability findings representing the powerful antioxidant effects of the used additives. In addition, the treated groups showed significant retardation in the microbial growth in comparing with the control untreated group. So, it can be concluded that PPE and GG extracts can be recommended to be used as minced meat additives for extending shelf life and increasing minced meat safety, productivity and palatability for human consumption.

Keywords: Acceptability, Herbal extender, Natural additives, Phenolic compounds, Shelf-life.

Introduction

Meat and meat products are one of the primary sources of high biologically valuable protein. Additionally, because they contain highly bioavailable vitamins like A, B12, and folic acid as well as micronutrients such as iron, magnesium, potassium, selenium, and sodium, they have a high affinity for accelerated microbial growth and oxidation processes that occur during muscle changes during the processing and storage of meat, increasing vulnerability to degradation [1, 2].

Many factors impact consumer preference, but the most significant ones are the colour, flavour, texture, and overall acceptability of meat products. The reduction in size and cooking output of processed meat products are major challenges for manufacturers due to the breakdown of meat protein. Furthermore, they affect the product's size, uncomfortable-looking packaging, and economic function [3].

The great water-holding capacity of gums and gelatinization can resolve such processing problems. Apart from that, guar gum's outstanding ability to bind water is assumed to be the main food additive function that positively affects the texture of meat products [4]. Regarded as a versatile polymer for the food sector, guar gum is mostly composed of poly-galactomannan, which is produced from the endosperm of various bean plant seeds. Because of its ability to provide exceptionally high viscosities in aqueous solutions even at low concentrations, it is widely used in a variety of food processing applications as an emulsifier, foam stabilizer, and thickening agent. Furthermore, guar gum is a high molecular weight polysaccharide that occurs naturally. It is classified as E412 on the European list of additives and is used in many different applications in the food industry, agricultural, and other sectors [5].

Furthermore, using natural antioxidants is thought to be a good way to delay or reduce lipid oxidation

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and lower the amount of dangerous oxidation products produced in meat products, increasing the shelf-stability of food items **[6].** Thus, there has recently been an increase in interest in the polyphenols with antioxidant properties found in pomegranate peel. The pomegranate, or *Punicagranatum* L., is a traditional fruit that has been farmed around the world and in the Mediterranean area. Its usage has long been associated with certain health benefits. Recent in vitro and in vivo studies have consistently documented its beneficial physiological effects, which include its anti-oxidative that suppress lipid and protein oxidation and avoid colour degradation of the meat products, antibacterial through its polyphenolic content's direct action on the bacterial cell, and anti-inflammatory properties [7].

Because minced meat has more exposed surface area and is more vulnerable to environmental changes that can accelerate the growth of some proteolytic and lipolytic foodborne microorganisms and even food pathogens, it usually has a shorter shelf life in the refrigerator and is more prone to microbial alterations than non-minced meat in refrigeration storage [8].

Foodborne bacteria that thrive inside food items can cause physical, chemical, and sensory changes that lead to food degradation. These microorganisms digest certain dietary ingredients and create metabolic byproducts as they grow. Eating such contaminated food can cause a variable range of illnesses, from full-body infections to moderate-to-severe food poisoning [9].

Sodium nitrite, butylated hydroxytoluene (BHT), and butylated hydroxy anisole (BHA) are a few examples of common synthetic and chemical food additives used in minced meat products to enhance their sensory quality and lengthen their shelf life. Research has repeatedly demonstrated that these additives pose significant long-term health risks. Therefore, as a source of novel macromolecules with useful qualities, their usage as food additives needs to be declined or replaced by natural and safe substitutes with powerful antioxidant and antimicrobial effects [6, 10]. So, and following that trend of the food industry's demands for antioxidants and antimicrobials from natural sources, the present investigation studied the add-on effect of guar gum and pomegranate peel powder's extracts on the shelf life of refrigerated minced meat.

Material and Methods

Collection of minced meat samples

A total of eighteen kg of fresh raw meat cuts (beef) were purchased from retail butcher's markets located in Benha city, Qalubiya Governorate, Egypt; followed by mincing in the laboratory for more hygiene. The samples were mixed, placed in a sterile plastic bag and refrigerated in 4±1^{O}C to be examined as rapid as possible.

Experimental design

The used additives

Preparation of pomegranate peel extract (PPE) according to Hama et al. [11].

In a sealed bottle, 50 g of dried pomegranate peel powder and 500 ml of hot, distilled water were combined to create an aqueous extract. Whitman No. 1 filter paper was used to filter the extract, which was made by continuously shaking the mixture for 24 hours at room temperature. The extract was collected using another bottle. After the filtrates were concentrated using a Soxhlet apparatus, the extract was dried, placed in sealed vials, and stored at 4°C.

Guar gum (GG)

Commercial ready-to-use lyophilized guar gum powder (GG) was obtained from AVI CHEM. LAB., India (CAS: 9000-30-0).

Analysis of phenolic compounds of the used extracts

In the chromatographic unit of the National Research Center (NRC), HPLC analysis was carried out using an Agilent 1260 series. Zorbax Eclipse Plus C8 column (4.6 mm x 250 mm i.d., 5 μm) was used for the separation. Water (A) and 0.05% trifluoroacetic acid in acetonitrile (B) were combined to form the mobile phase, which was flowing at a rate of 0.9 ml/min. The following was the sequential linear gradient programming for the mobile phase: 82% A for 0 min; 82% A for 0–1 min; 75% A for 1–11 min; 60% A for 11–18 min; 82% A for 18–22 min; and 82% A for 22–24 min. At 280 nm, the multi-wavelength detector was seen. For every sample solution, there was one injection volume of five microliters. At 40 °C, the column temperature was kept constant. Utilizing the Folin-Ciocalteu (FC) phenol reagent in accordance with **Sarkis et al. [12],** the total phenolic contents (TPC) of the extract from various sample materials were measured and represented as gallic acid equivalent (GAE).

Preparation of samples

The collected minced meat samples were mixed well in a sterile condition, and divided into six equal primary groups (1000 g/group) as follow: Control group (G1), minced beef + PPE (1%) (G2), minced beef + PPE (3%) (G3), minced beef + GG (0.3%) (G4), minced beef + GG (0.5%) (G5) and minced beef + GG (0.3%) + PPE (1%) (PG-G6). Each group was divided into five secondary groups; where, they were furtherly subgrouped separately for physico-chemical and bacteriological subgroups for each day of examination. Control and treated groups were refrigerated at 4±1^{O}C. Physical, chemical and bacteriological analyses were performed at day zero

(within 30 minutes after treatment), 3rd, 6th, 9thand 12th day of cold storage.

Concentrations of the used additives was planned according to Hama et al. [11] and El-Shinawy and Abdelmonem [13] for PPE and GG, respectively. Where, the trial was repeated in triplicates.

Samples were subjected to the following examinations:

Physical examinations

Sensory quality of the examined groups (colour, odour, texture and overall scores) was assessed following Mörlein [14], in scores (1 to 5), where ≤1- represented the worst, while 5- represented the excellent mark, were recorded. In addition, moisture content and cooking loss were determined according to EOS 63-3 [15] and Murphy and Zerby [16], respectively.

Chemical analyses

pH, total volatile nitrogen (TVN), and thiobarbituric acid (TBA) values were conducted according to EOS 63-11 [17] using a calibrated pH meter (Adwa, AD1200) dipped in 50g of minced meat sample, EOS: 63-9 [18] in which ten grams of minced meat sample was mixed with magnesium oxide and Dist. water and place to boiler for distilling vapor in mixture of boric acid and methyl red reagent; which will furtherly neutralized by sulphoric acid 0.1N. % for TVN = Sulphoric acid (ml) needed to neutralize the end product - Sulphoric acid (ml) needed to neutralize the control test x 14 (mg/100 g of meat); and EOS 63-10 [19] through mixing of ten grams of well-minced meat distilled water + hydroaluric acid 4N, followed by heating of the flask containing the mixture to distill about 50 ml of the distillate; from which, 5 ml were mixed with thiobarbituric acid reagent and was kept in a boiling water bath for 35 minutes. Optical density of the end product was measured at wavelength 538; where, TBA = Light absorption x 7.8 (mg malonaldhyde/kg), respectively.

Bacteriological examinations

After preparation of serial dilution for each sample according to ISO 6887-2 [20], samples were subjected to the bacteriological estimation pre- and post-treatment of total bacterial count (TBC), psychrotrophs, Enterobacteriaceae, coliform, *E. coli* and *S. aureus* counts according to ISO 4833-1 [21], ISO 17410 [22], ISO 21528-2 [23], ISO 4832 [24], ISO 16649-2 [25], and ISO 6888-1 [26], respectively. Moreover, detection of Salmonella species and *Listeria monocytogenes* was conducted according to ISO 6579 [27], and ISO 11290 [28], respectively.

Statistical analyses

Statistical analyses were run in triplicate and results were reported as mean values and standard Error (Mean ± SE). Using of Statistical Packaging for the Social Science (SPSS) Ver. 27. A *P*-value less than 0.05 ($P \leq 0.05$) was considered statistically significant.

Results

Referring to the recorded results in Table (1), gallic acid and Kaempferol were the most detected phenolic compounds in PPE and GG extracts, respectively; whereas, other compounds were determined in lower concentrations. In addition, catechin, pyrocatechol and rutin were not detected in both extracts. Significant differences ($P \leq 0.05$) were determined between the examined extracts revealing PPE of higher phenolic compounds; which was confirmed through the total phenolic compounds (TPC) that was significantly higher in PPE than GG.

In Table (2), the used additives showed a significant ($P \leq 0.05$) improvement in the sensory quality of the treated samples in comparing with the control untreated group; where the overall sensory score was the highest in the PG mixed group (2.9) revealing it acceptable after 12 days of storage. In addition, Table (3) revealed that addition of PPE and GG had a significant ($P \leq 0.05$) improvement of the moisture content (%) with declined cooking loss (%) properties of the treated samples. Correlation between moisture content and cooking loss revealed that the higher moisture content, the lower cooking loss leaving juicy and palatable meat piece. The combination group showed the highest moisture content, with lower cooking loss, followed by GG 5%, GG 3%, PPE 1% and PPE 3%, respectively.

Chemical analyses of the treated groups **(**Table, 4) showed significant ($P \leq 0.05$) amelioration in the pH, TVN and TBA parameters of the treated samples in relation to the control untreated sample; where they still fit for human consumption until the 9th day of refrigeration; moreover, PG treated group still fit up to the 12th day, while the control group exceeded the permissible limits before the 9th day of refrigeration. In details, the initial pH mean value was 5.81, 5.76, 5.72, 5.78, 5.75 and 5.7 for the control and PPE (1% and 3%), GG (0.3 and 0.5%) and mixed PG groups, respectively; which gradually increased to 6.9 for the control group at the 9th day of storage indicating its spoilage, while it was still within acceptable limits in the treated groups up to the 12th day of storage. Moreover, the initial TBA mean value (mg malonaldehyde/Kg) was the same (0.59) for the control and treated groups; which gradually increased to 0.98 for the control group at the 9th day of storage indicating its spoilage, while it was still within acceptable limits in the treated group with both PPE and GG up to the 12th day of storage; whereas, the other treated samples exceeded the acceptable limit (> 0.9). Furthermore, the initial TVN mean value (mg/100g) was the same (15.7) for the

control and treated groups; which gradually increased to 21.1 for the control group at the 9th day of storage indicating its spoilage, while it was still within acceptable limits in the treated group with both PPE and GG up to the 12th day of storage; whereas, the other treated samples exceeded the acceptable limit (> 20).

Regarding with the bacteriological analyses, TBC, Enterobacteriaceae, coliform, *E. coli*, *S. aureus* and psychrotrophs were detected in the mean counts of 4.5, 2.1, 1.6, 1.2, 2.1 and 2.3 $\log_{10}$ CFU/g which was considered as initial bacterial loads, respectively; whereas, Salmonella species and *L. monocytogenes* were not detected in the examined samples. Addition of PPE and GG of different concentrations had a significant ($P \leq 0.05$) antibacterial effect appeared as a retardation in the bacteriological growth in the treated groups in relation to the control untreated groups, where the average of reduction ranged from 1.2 log to 3.1 log based on the type of bacteria and the concentration of the additive (Fig. 1-6). It is worthy noted that the bacterial counts showed significant reductions in the 3rd and 6th day of storage, after which it showed gradual increase along the rest days of storage; which was dose and time dependent.

Discussion

At the retail counter, ground beef is the most popular beef product to be purchased. However, its shorter shelf life than non-minced beef product means that the merchant loses out on sales and puts the consumers' health at danger [29].

In addition to microbiological contamination of meat and meat products with bacteria and fungus during production and packaging, contamination of meat products can also occur during raw material preparation, handling, processing, and storage. While some research on microbial contamination have focused on carcasses, others have indicated that food handlers and utensil surfaces can function as a conduit for the spread of infections, leading to an increase in total bacterial and coliform counts [30].

Domínguez et al. [31] have found that severe changes in taste, texture, and colour, which determine meat freshness and consumer acceptability, are linked to lipid oxidation and protein breakdown during cold storage of minced beef. Many factors, including the interaction of microbial lipolytic and proteolytic enzymes with the intrinsic activity of autolytic enzymes, were implicated in the quality deterioration of meat and meat products that were kept in cold storage [32]. Additionally, mincing of raw meats causes the cell matrix to produce prooxidants, which increases the oxidation of myoglobin and lipids. Therefore, antioxidants added to meat can aid in their preservation as they have an ability to prevent or reduce the oxidative damage of a tissue indirectly by improving natural defence of cell and/or directly by scavenging free radicals [33].

Meat preservation primarily aims to postpone microbiological deterioration and chemical reactions, prevent the meat from losing its qualities, and minimize flavour and texture changes [34].

Natural antioxidants, especially those derived from plants, have been shown to have greater application potential for improving the acceptability, palatability, stability, and lengthening the shelf life of meat products by consumers. This is in line with the growing awareness of the use of natural food additives with preservative characteristics as a safer alternative to synthetic preservatives [35].

Both edible and inedible plants frequently contain polyphenolic chemicals. Flavonoids and phenolic acids, two types of polyphenols that are commonly found in phenolic compounds, may be found in fruits, vegetables, whole grains, and other plants. Each polyphenol has many identified constituents. These plants and plant-derived products include a class of highly hydroxylated phenolic chemicals that have the ability of dysfunction the microbial metabolism and cell wall selectivity [36].

Pomegranate, on the other hand, is well-known for its anti-inflammatory, anticancer and antioxidant properties because of its phytochemical constituents, which primarily include hydrolysable ellagitannins, anthocyanins and other polyphenols. The peel, which makes up around 50% of the entire fresh fruit, contains the highest concentration of these substances (exocarp and mesocarp). According to Salim et al. [37], these bioactive phytochemicals have a wide range of antimicrobial effects on fungi, Gram-positive and Gram-negative bacteria through bacterial membrane damage and inhibit virulence factors like enzymes and toxins and suppress the formation of bacterial biofilms [38].

On the other hand, due to its phenolic chemicals, the annual legume plant known as guar is a significant supplier of guar gum, which has several industrial and therapeutic uses. As a result, eating guar and its byproducts has been linked to a lower chance of developing some cancers and other chronic illnesses. Polyphenols, also known as phenolic chemicals, act as antioxidants through a combination of metal chelation and free radical scavenging processes [39].

Referring to the recorded results, gallic acid and Kaempferol were the most detected compounds in PPE and GG extracts, respectively; which came in line with the reported findings of Wang et al. [40] and Sharma et al. [39], respectively.

One of the most significant plant polyphenols with several health-promoting benefits is kaempferol, along with gallic acid. Numerous investigations have demonstrated that they prevent bacterial growth by

changing the shape of the membrane, bacterial metabolism, and the biofilm formation [41, 42].

When comparing the sensory quality of the treated samples to the untreated control group, the application of PPE (1% and 3%), GG (0.3 and 0.5%), and a combination of PPE (1%) and GG (0.3%) showed a significant ($P \leq 0.05$) improvements in the overall acceptability of the treated samples. This improvement may be attributed to the known antimicrobial and antioxidant effects of pomegranate peel extract, which contains flavanols, anthocyanins, phenolic and organic acids [43], and the noteworthy gelling quality of the GG, which aids in enhancing the texture and adhesion of the minced meat; which came in line with Tahmouzi et al. [44] who noted that adding the gum to the meat after dissolving its solubility in cold water and swelling preserves its sensory qualities and guards against microbial contamination, giving the meat higher sensory scores and longer shelf life.

In addition to making the minced meat look appetizing, PPE and GG significantly ($P \leq 0.05$) increased the moisture content (%) and decreased cooking loss (%) of the treated minced meat. The latter was higher in the PG group, which may be related to guar gum's capacity to form a colloid structure with a strong water retention power [13]. Additionally, the pH values increased during refrigeration storage to varying degrees in various treated groups based on the type and concentration of the treatment. These increases were caused by endogenous enzymes, bacterial metabolites (like hydrogen sulfides and organic sulfides), and other volatile organic compounds like amines [9]. However, in the present study, the initial pH of the control increased from 5.81 to 6.9 by the end of storage, while slower increase of the pH in the treated samples was detected, especially in the mixed PG group, which may be referred to the bioactive, antimicrobial and antioxidant effect of the used extracts [45]. Moreover, during the storage period the pH value maintained at a safe level.

Meat is perishable, and during storage, endogenous enzymes and microorganisms cause changes in its chemical composition. Total volatile nitrogen (TVN) is frequently employed as a biomarker for the breakdown of amines and proteins [46]. Furthermore, thiobarbituric acid (TBA) is a good measure of rancidity, especially in meat [47].

Regarding with the current obtained results of TVN and TBA values, significant ($P \leq 0.05$) improvement in the keeping quality of the treated minced meat samples represented by significant retardation in the rising curve of TVN and TBA values; which may be referred to the antioxidant and antimicrobial properties of the used extracts. These findings came in line with the recorded results of Alexandraki et al. [48] and Ghimire et al. [49] who recorded significant elongation in the shelf life of the treated meat samples with guar gum and pomegranate peel extracts with significant inhibition of protein decomposition and lipid oxidation revealing lower TVN and TBA values than the untreated samples.

The juice, peels, and seeds of the pomegranate fruit have all been linked to possible antibacterial properties [50]. Pomegranate peel extracts have recently been shown to have stronger antibacterial and antioxidant properties; as a result, they may be recommended as a natural, safe substitute for synthetic antimicrobial agents (Rosas-Burgos et al. [51]); and by looking at how it affected Gram-positive and Gram-negative foodborne bacteria, the findings showed that different concentrations of its extracts might cause variable microbial susceptibilities, which may be liked with the high levels of pomegranate peel's phenolic contents [52].

Referring to the antibacterial effect of the currently used additives, addition of pomegranate peel extract and guar gum showed a promising antibacterial effect represented by significant reduction in the bacterial counts (CFU/g) along six days of storage followed by gradual increase and retardation in the microbial multiplication in comparison with the control untreated group; which may be attributed to the bioactive compounds in PPE and guar gum, such as organic acids and polyphenols, which seem to be maximized in combination with guar gum through catching the water molecules forming a colloid structure revealing deprivation of the bacterial cell though decreasing the water activity (aW) in the meat product [53]. The obtained results came in agreement with those recorded by Ahmad et al. [54]; Das et al. [55] and Eldahrawy et al. [56] who recorded a significant reduction in the microbial count with elongation in the shelf life of the treated meat with PPE, which may have attributed to the pH reduction - caused by organic acids (citric, tartaric, malic, succinic, etc.), the primary factor that affected the survival and growth of microorganisms. Furthermore, the selective inhibition of microbial ATP synthase brought on by polyphenol activity is a likely explanation for microbial cell death, which happens when germs are deprived of cellular energy. Furthermore, it has been claimed that the pomegranate fruit's byproducts, or residues, (seeds, pomace, and peel), include bioactive substances such phenolic and polyphenolic compounds, dietary fibres, complex polysaccharides, minerals, and vitamins. These substances, which are derived from pomegranate byproducts, can be utilized as functional components or food additives to maximize the antioxidant and antibacterial properties, or they can be employed to replace protein and fat in a variety of muscle-building food items. Besides, these natural additives are reported to improve the quality,

safety, and extend the shelf life of different types of food products, including meat and meat products.

Guar gum's distinctive ability to retain a lot of water leads to a high viscosity, which is what makes it stick to hydrophilic surfaces. These characteristics make GG useful in many different sectors, including the food processing industry [57]. In line with Lima et al. [58] and Alexandraki et al. [48], who concluded that adding guar gum as a polysaccharide, hydrophilic substance with herbal extract of antimicrobial and antioxidant characters maximizes its action and makes it a more potent preservative agent through formation of polysaccharide conjugate, the current study's mixture of pomegranate extract (1%) and guar gum (0.3%) showed more inhibitory effect on the microbial growth with higher keeping quality [59].

Recorded variations between different authors may be attributed to variation in the way of extraction, concentration of the used substances, way of application and storage conditions.

On the other hand, absence of Salmonella species and *L. monocytogenes* in the examined minced meat samples came in contrary with the recorded results of El Gendy et al. [60] and Uludag et al.[61] who detected Salmonella species and *L. monocytogenes* in samples collected from Egypt and Turkey, with the incidence of 28% and 21%, respectively; while, Khyralla [62] reported negative detection of *L. monocytogenes* in the examined samples collected from Alexandria governorate, Egypt; which may be referred to variation in the location of collection and the applied hygienic measures during preparation and storage of meat products.

Conclusion

After all these results, PPE and GG have been shown to be a promising food preservative, that have an enhancement effect on the sensory, physicochemical and microbiological quality of minced meat in the refrigerator storage, especially in pomegranate peel-guar gum extracts combination.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

TABLE 1. Major phenolic compounds determined in pomegranate peels and guar extracts (µg/g), and TPC (mg GAE/g)

	PPE	GG
Gallic acid (GA)	37381.31	16.70
Chlorogenic acid (CGA)	11225.73	17.60
Ellagic acid	1493.16	ND
Syringic acid	831.60	ND
Coffeic acid (CA)	454.66	17.00
Kaempferol (KP)	106.36	28.90
Ferulic acid (FA)	38.16	16.50
Rosmarinic acid	33.70	ND
Catechin	ND	ND
Pyro catechol	ND	ND
Rutin	ND	ND
TPC	2.74475e4	79.23

TPC: Total Phenolic Compounds, PPE: Pomegranate Peels Extract, GG: Gur Gum, ND: not detected.

TABLE 2. Sensory profile of untreated and treated minced beef samples in cold storage (4±1^{O}C).

Groups	Tested parameter	C	PPE 1%	PPE 3%	GG 0.3%	GG 0.5%	PG
Zero day	Color	4.6±0.16	4.6±0.16	4.6±0.16	4.6±0.16	4.6±0.16	4.6±0.16
	Odor	4.5±0.3	4.5±0.3	4.5±0.3	4.5±0.3	4.5±0.3	4.5±0.3
	Texture	4.7±0.4	4.7±0.4	4.5±0.4	4.8±0.4	4.7±0.4	4.8±0.4
	Overall	4.6±0.1^{a}	4.6±0.1^{a}	4.5±0.03 ^{a}	4.6±0.1^{a}	4.6±0.1^{a}	4.6±0.1^{a}
3nd day	Color	3.5±0.23	3.8±0.14	4.3±0.1	4.0±0.1	4.2±0.1	4.4±0.1
	odor	3.7±0.16	4.0±0.12	4.2±0.2	4.1±0.3	4.3±0.3	4.5±0.3
	Texture	3.8±0.2	3.9 ±0.3	4.0±0.3	4.0±0.2	4.3±0.4	4.5±0.4

Groups	Tested parameter	C	PPE 1%	PPE 3%	GG 0.3%	GG 0.5%	PG
	Overall	3.7±0.1^{c}	3.9±0.1^{b}	4.2±0.1^{a}	4.0±0.03^{a}	4.3±0.03^{a}	4.5±0.03^{a}
6th day	Color	2.9±0.12	3.2±0.11	3.7±0.1	3.5±0.2	3.8±0.1	4.0±0.1
	odor	2.9±0.23	3.4±0.2	3.8±0.2	3.6±0.5	4.0±0.3	4.1±0.4
	Texture	2.3±0.18	3.1±0.3	3.6±0.3	3.4±0.3	4.0±0.2	3.8±0.2
	Overall	2.7±0.2^{c}	3.2±0.1^{b}	3.7±0.1^{b}	3.5±0.1^{a}	3.9±0.1^{a}	4.0±0.1^{a}
9th day	Color	1.0±0.01	2.7±0.20	3.2±0.1	2.8±0.3	3.0±0.2	3.7±0.2
	odor	1.1±0.2	2.5±0.2	3.0±0.3	2.4±0.2	2.8±0.3	3.5±0.3
	Texture	1.0±0.05	2.4±0.3	2.8±0.3	3.0±0.16	3.5±0.2	3.5±0.2
	Overall	1.0±0.03^{c}	2.5±0.1^{b}	3.0±0.1^{b}	2.7±0.2^{b}	3.1±0.2^{ab}	3.6±0.1^{a}
12th day	Color	<1	1.8±0.20	2.0±0.1	1.5±0.3	1.8±0.2	2.8±0.2
	odor	<1	1.5±0.2	1.8±0.3	1.0±0.2	1.5±0.3	3.0±0.3
	Texture	<1	1.1±0.3	1.5±0.3	1.8±0.16	2.1±0.2	3.0±0.2
	Overall	<1	1.5±0.2^{c}	1.8±0.1^{b}	1.4±0.2^{c}	1.8±0.2^{b}	2.9±0.1^{a}

The values represent Mean ± SE of three experiments.
Means within the same row (abcd) followed by different superscript letters are significantly different ($P \leq 0.05$).
4.0-5.0 very good 3.1-3.9 good 2.1-3.0 Acceptable 1.1-2.0 Unacceptable 0.0-1.0 spoiled

TABLE 3. Effect of the used additives on moisture content (%) and cooking loss (%) in the treated samples during refrigerator storage (Means ± SE).

T	Moisture %					Cooking loss %				
	Zero	3rd	6th	9th	12th	Zero	3rd	6th	9th	12th
C	69.3±0.1^{a,}	68.1±0.1^{b,}	60.1±0.2^{c,}	54.4±0.2^{d,}	48±0.5^{e,}	25.4±0.1^{eA}	29.5±0.1^{dA}	34.5±0.2^{cA}	40.1±0.3^{bA}	46.0±0.3^{aA}
PPE 1%	69.1±0.1^{a,}	68.5±0.1^{b,}	62.5±0.2^{c,}	58.1±0.2^{d,}	52.2±0.3^{e,}	25.5±0.1^{eA}	28.7±0.1^{dB}	32.2±0.2^{cB}	38.5±0.1^{bB}	41.8±0.2^{aB}
PPE 3%	69.1±0.1^{a,}	68.3±0.1^{b,}	62.1±0.2^{c,}	57.4±0.2^{d,}	50.0±0.3^{e,}	25.6±0.1^{eA}	28.5±0.1^{dB}	31.7±0.1^{cC}	37.2±0.1^{bC}	44.2±0.1^{aC}
GG 0.3%	69.2±0.1^{a,}	68.7±0.1^{b,}	63.7±0.1^{c,}	60.0±0.2^{d,}	55.2±0.2^{e,}	25.1±0.1^{eA}	27.7±0.1^{dC}	30.3±0.1^{cD}	34.3±0.2^{bD}	39.1±0.2^{aD}
GG0.5%	69.2±0.1^{a,}	68.7±0.1^{b,}	64.4±0.1^{c,}	62.4±0.2^{d,}	58.0±0.2^{e,}	25.3±0.1^{eA}	27.4±0.1^{dD}	30.6±0.1^{cDE}	33.7±0.2^{bE}	36.2±0.1^{aE}
PG	69.3±0.1^{a,}	68.9±0.1^{b,}	65.3±0.1^{c,}	63.0±0.1^{d,}	56.3±0.2^{e,}	25.5±0.1^{eA}	27.2±0.1^{dD}	30.0±0.1^{cE}	32.5±0.1^{bF}	37.7±0.1^{aF}

Means within the same row (abcd) followed by different superscript letters are significantly different ($P \leq 0.05$).
Means within the same column (ABCD) followed by different superscript letters are significantly different ($P \leq 0.05$).

TABLE 4. Effect of different concentration of pomegranate peel (PPE) and guar gum (GG) extracts on TVN and TBA of minced meat during refrigerator storage (Means ± SE).

T	pH					TBA (mg malonaldehyde/Kg)					TVN (mg/100g)				
	Zero	3rd	6th	9th	12th	Zero	3rd	6th	9th	12th	Zero	3rd	6th	9th	12th
C	5.81±0.1^{dA}	6.0±0.1^{cA}	6.5±0.1^{bA}	6.9±0.1^{aA}	S.	0.59±0.1^{dA}	0.76±0.1^{cA}	0.84±0.1^{bA}	0.98±0.1^{aA}	S.	15.7±0.1^{dA}	16.7±0.1^{cA}	18.1 9±0.2^{bA}	21.1±0.2^{aA}	S.
PPE 1%	5.76±0.1^{dA}	5.61±0.1^{cC}	5.86±0.1^{cBC}	6.1±0.1^{cC}	6.8±0.2^{cC}	0.59±0.1^{dA}	0.64±0.1^{cB}	0.72±0.1^{bB}	0.80±0.1^{aB}	>0.9	15.7±0.1^{dA}	15.9±0.1^{cC}	16.3±0.2^{b} D	18.2±0.2^{aC}	>20
PPE 3%	5.72±0.1^{Dd}	5.56±0.1^{dD}	5.61±0.1^{dD}	5.9±0.2^{dD}	6.5±0.2^{cC}	0.59±0.1^{dA}	0.57±0.1^{cC}	0.67±0.1^{bC}	0.74±0.1^{aD}	>0.9	15.7±0.1^{dA}	15.8±0.1^{cC}	16.1±0.1^{b} E	17.3±0.1^{aE}	>20
GG 0.3%	5.78±0.1^{Ba}	5.64±0.1^{bC}	5.84±0.1^{bC}	6.10±0.1^{bC}	6.6±0.1^{cC}	0.59±0.1^{dA}	0.63±0.1^{cB}	0.68±0.1^{bC}	0.78±0.1^{aC}	>0.9	15.7±0.1^{dA}	16.1±0.1^{cB}	17.3±0.1^{b} B	18.5±0.2^{aB}	>20
GG0.5%	5.75±0.1^{Ea}	5.72±0.1^{eB}	5.91±0.1^{eB}	6.23±0.1^{eB}	6.5±0.1^{cC}	0.59±0.1^{dA}	0.61±0.1^{cB}	0.66±0.1^{bC}	0.72±0.1^{aD}	>0.9	15.7±0.1^{dA}	16.0±0.1^{cB}	17.2±0.1^{b} B	18.7±0.2^{aB}	>20
PG	5.70±0.1^{bA}	5.68±0.1^{bB}	5.9±0.1^{bB}	6.1±0.1^{bC}	6.4±0.2^{cC}	0.59±0.1^{eA}	0.60±0.1^{dB}	0.64±0.1^{cC}	0.70±0.1^{bE}	0.87±0.2^{a}	15.7±0.1^{eA}	15.8±0.1^{dC}	16.5±0.1^{c} D	17.9±0.1^{bD}	18.6±0.2^{a}

Means within the same row (abcd) followed by different superscript letters are significantly different ($P \leq 0.05$).
Means within the same column (ABCD) followed by different superscript letters are significantly different ($P \leq 0.05$).

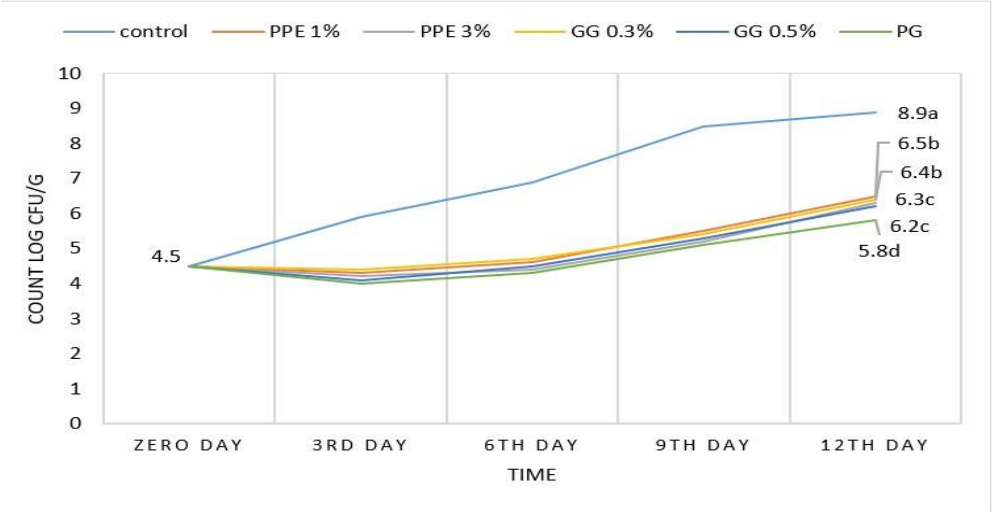

Fig. 1. Average values of *TBC* (log_{10} CFU/g) in minced beef groups at cold storage (4±1^{O}C).
Means within the same row (abcd) followed by different superscript letters are highly significantly different ($p \leq 0.05$).

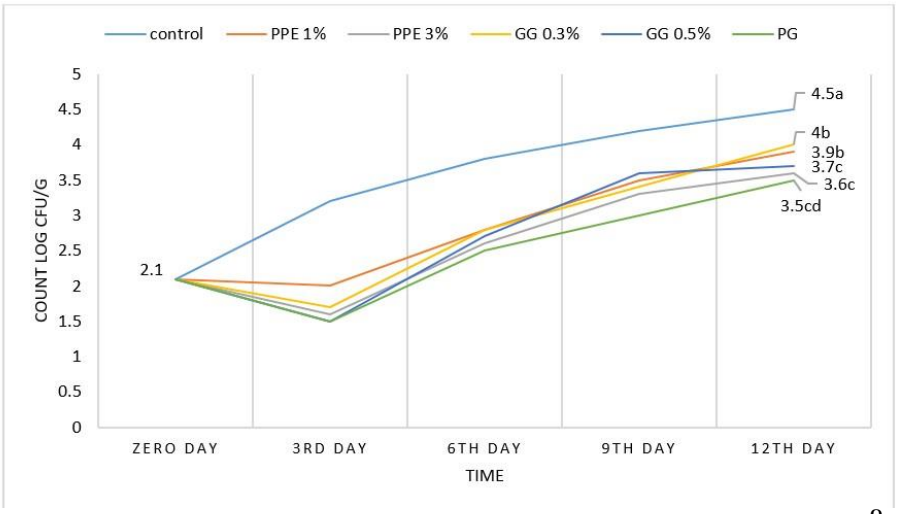

Fig. 2. Average values of *Enterobacteriaceae* (log_{10} CFU/g) in minced beef groups at cold storage (4±1^{O}C).
Means within the same row (abcd) followed by different superscript letters are highly significantly different ($p \leq 0.05$).

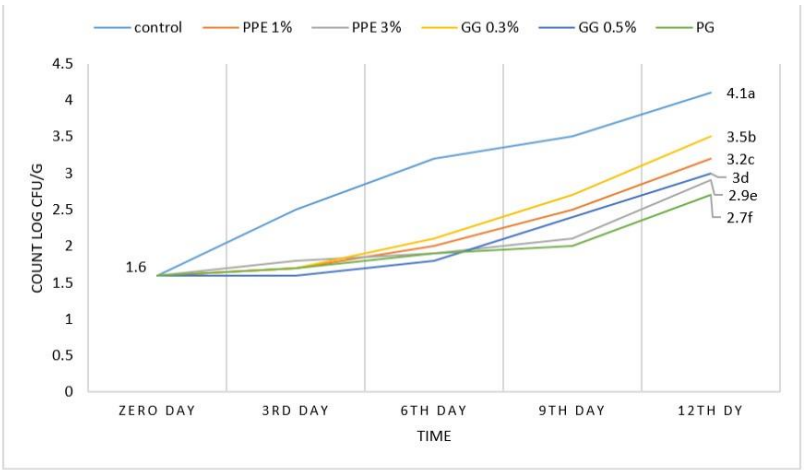

Fig. 3. Average values of *coliform* (log_{10} CFU/g) in minced beef groups at cold storage (4±1^{O}C).
Means within the same row (abcd) followed by different superscript letters are highly significantly different ($p \leq 0.05$).

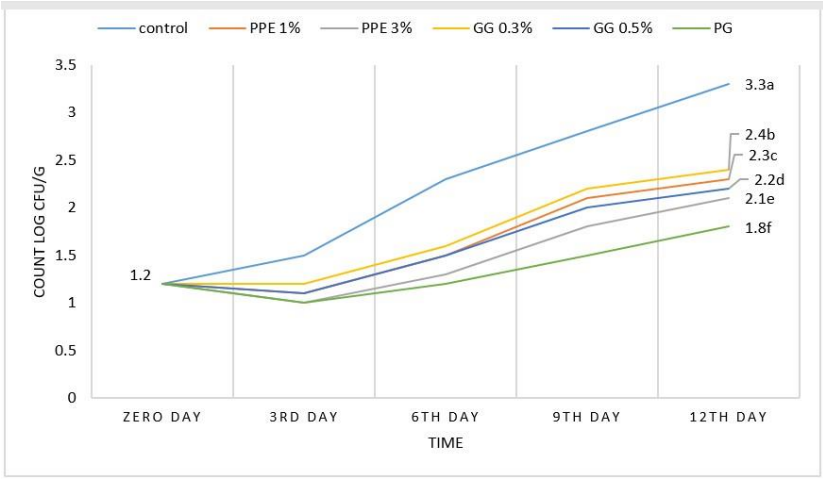

Fig. 4. Average values of *E. coli* (log_{10} CFU/g) in minced beef groups at cold storage (4±1^{O}C).
Means within the same row (abcd) followed by different superscript letters are highly significantly different ($p \leq 0.05$).

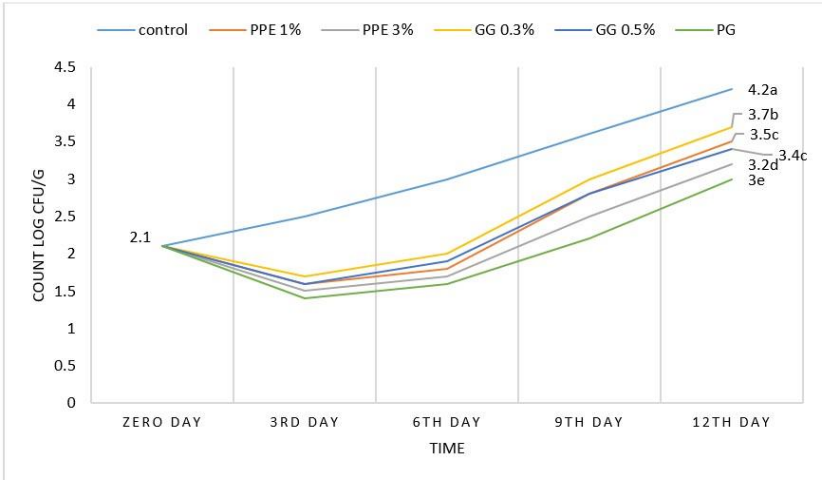

Fig. 5. Average values of *S. aureus* (log_{10} CFU/g) in minced beef groups at cold storage (4±1^{O}C).

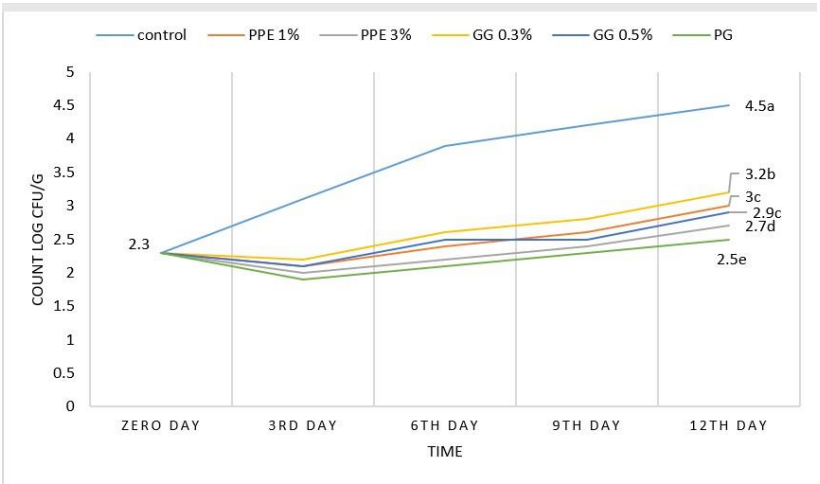

Fig. 6. Average values of psychrotrophs (log_{10} CFU/g) in minced beef groups at cold storage (4±1^{O}C).
Means within the same row (abcd) followed by different superscript letters are highly significantly different ($p \leq 0.05$).

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تحسين الحالة الصحية للحم المفروم باستخدام مستخلص قشر الرمان وصمغ الغار

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الملخص

إن تطوير إضافات اللحوم هو جهد متواصل يهدف إلى تحقيق أقصى قدر من السلامة والقابلية لمنتجات اللحوم. لذلك، تُستخدم مستخلصات الأعشاب بشكل شائع كعوامل طبيعية لحفظ الأغذية. ولذلك، تهدف الدراسة الحالية إلى تقييم التأثير المفيد للمستخلص المائي لقشر الرمان (PPE) وصمغ الغار (GG) على الجودة الشاملة والعمر الافتراضي للحوم المفرومة. تم تحليل مستخلصات قشر الرمان وصمغ الغار لمحتوياتها من المركبات الفينولية، ثم تم إضافة مستخلص قشر الرمان بتركيزات ١% و٣%، بينما تمت إضافة صمغ الغار بتركز٠,٣ و٠,٥%، وخليط منهما بنسبة ١% و٠,٣% لمستخلص قشر الرمان وصمغ الغار على التوالي بشكل منفصل على خمس مجموعات من اللحم المفروم؛ علاوة على ذلك، تم حساب المجموعة الضابطة. تم فحص المجموعات المعالجة للتأكد من جودتها الشاملة طوال اثني عشر يومًا من التبريد. كشفت النتائج عن تحسن عام ملحوظ ($P \geq 0.05$) في المجموعات المعالجة، وخاصة في المجموعة المعالجة بخليط مستخلصات قشر الرمان وصمغ الغار، والتي أظهرت قابلية حتى اليوم الثاني عشر من التخزين. علاوة على ذلك، تم تحسين نسب الرطوبة مع انخفاض نسبة الفقد عند الطهي في المجموعات المعالجة. علاوة على ذلك، أظهر الرقم الهيدروجيني والنيتروجين الكلي المتطاير (TVN) وحمض الثيوباربتيوريك (TBA) نتائج ثبات كبيرة تمثل التأثيرات القوية المضادة للأكسدة للمواد المضافة المستخدمة. بالإضافة إلى ذلك، أظهرت المجموعات المعاملة تأخراً ملحوظاً في النمو الميكروبي مقارنة بالمجموعة الضابطة غير المعاملة. لذلك، يمكن الاستنتاج أنه يمكن التوصية باستخدام مستخلصات قشر الرمان وصمغ الغار كإضافات للحم المفروم لإطالة العمر الافتراضي وزيادة سلامة اللحوم المفرومة وإنتاجيتها واستساغتها للاستهلاك الآدمي.

الكلمات الدالة: القابلية، مواد مالئة عشبية، إضافات طبيعية، المركبات الفينولية، مدة الصلاحية.