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Arabic gum enriched with grape seed extract as a protective coating for local pastrami

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Abstract

The study examined the use of gum Arabic-made bioactive coatings, which are enriched as protective films for local pastrami with Grape Seed Extract (GSE). The experiment included five remedies: T1 (Beef intestines), T2 (gum Arabic only), T3 (gum Arabic + 0.50% grape seed extract), T4 (gum Arabic + 1% grape seed extract), and T5 (gum Arabic + 1.50% grape seed extract). Physical and mechanical tests showed that Gum Arabic coating alone (T2) performed the weakest properties, the lowest tensile strength (0.19 MPa) and the largest increase (4.80%). In contrast, fortifications with GSE greatly improved mechanical and obstructive properties. Treatment T5 gained the highest tensile strength (1.08 MPA), while T4 recorded the best increase (43.40%), which provides an ideal balance between strength and flexibility. The sensory assessment indicated that the control treatment (T1) obtained the highest overall acceptance score (8.20), while T5 was the most favourable coated sample in terms of taste (8.23), aroma and taste (8.30), and overall acceptance (7.80). These results confirm that 1–1.5% of grape seed extracts enrich the gum arabic, enhance the mechanical and sensory properties of the pastrami and represent a natural and effective strategy to expand the shelf life and improve consumer acceptance.

Keywords: gum arabic, grape seed extract, pastrami, edible coatings, shelf life.

.1 Introduction

Pastirma is a traditional meat product preserved through drying and salting, usually prepared from beef or buffalo, and is considered one of the oldest methods of meat preservation known to humankind. It originated in the regions of Anatolia and Mesopotamia and later spread to the Middle East, the Balkans, and parts of Europe [1][2] Modern preservation strategies increasingly rely on edible films and coatings as eco-friendly and biodegradable solutions that act as barriers against oxygen and moisture while also serving as carriers of natural antioxidants and antimicrobial agents, with evidence supporting their role in improving oxidative and sensory stability in meat systems [3][4]. Within this category, gum arabic demonstrates excellent food compatibility, emulsifying stability, and the ability to form thin films with low permeability to gases and water, which contributes to shelf-life extension and reduced sensory deterioration when applied alone or as part of functional composites [5]. In parallel, grape seed extract is particularly rich in phenolic compounds, especially proanthocyanidins, with approximately 60–70% of grape phenolics concentrated in the seeds, explaining its strong antioxidant and antimicrobial activities in meat matrices during refrigeration or curing [6][7]. Applied studies on various meat products have further shown significant reductions in TBARS values and peroxide formation, along with slower microbial growth and preserved color and sensory acceptance when grape seed extract was added at appropriate levels [8]. Therefore, this study aims to evaluate the protective effect of a gum arabic coating enriched with grape seed extract on oxidative stability, microbial load, color, and sensory properties of pastirma during refrigerated storage, in direct comparison with an untreated control and synthetic alternatives where applicable [9 .[

.2Materials and Methods

2.1Preparation of the Coating

The coating was prepared according to the volumes listed in the table (1) according to the method [10]. A total of 15 grams of gum was dissolved in a glass of 85 ml distilled water, and 15 grams of Arabic gum were added with constant stirring until full disintegration, using a water bath at 80 °C in a glass beaker. The mixture was then allowed to cool down, after which 5 mL of glacial acetic acid and 5 mL of food-grade
glycerol were added and well mixed. The coating (T2) was produced before this process. Other coatings (T3, T4, T5) were prepared using the same method, in addition to various predetermined concentrations of grape seed extracts. For control treatment (T1), control - bovine cover coverings were used as coating materials.

Table (1): Composition of the Coating Used in the Study

Animal casing	Grape seed extract ratio	Food-grade glycerin percentage	Glacial acetic acid percentage	Arabic gum coating concentration	Distilled water	Treatments
Beef intestines	-	-	-	-	-	T1 control
-	-	5 ml	5 ml	15 g	85 ml	T2 coating
-	0.50 g	5 ml	5 ml	15 g	85 ml	T3 coating
-	1 g	5 ml	5 ml	15 g	85 ml	T4 coating
-	1.5 g	5 ml	5 ml	15 g	85 ml	T5 coating

2.2Preparation of Samples

Five different pastrami formulations were prepared after calculating the required quantities as indicated in Table (2). The meat was initially minced using a Chinese-manufactured grinder, then mixed with sheep tail fat, spices, salt, and garlic, followed by a second grinding step to achieve complete homogenization. For the control treatment (T1), the mixture was stuffed into sandwich casings using a sterile plastic cone. In contrast, the samples designated for gum Arabic coatings (T2, T3, T4, T5) were wrapped in sterile cloth and molded into the traditional pastrami shape. All treatments were suspended in a clean, dry, and well-ventilated area for two days to achieve drying. Afterward, the cloth was removed, and T2 was immersed in a 15% gum Arabic solution containing 5% glacial acetic acid and 5% food-grade glycerol. T3 was treated with the same solution enriched with 0.50 g of grape seed extract, T4 with 1.0 g, and T5 with 1.5 g of grape seed extract. The coated samples were placed on sterile surfaces for an additional two days to allow the outer layer to dry completely. As reported by source [11] [12], pastrami can be preserved at ambient temperature for 7–10 days. After coating and drying, each sample was packed separately in sterile polyethylene bags and stored under refrigeration at 4 °C. The analyses were performed at the Postgraduate Laboratory, College of Agriculture, University of Tikrit, after 1 and 30 days of storage.

2.3Hot Water Extraction

A total of 100 g of grape seed powder was combined with 1000 ml of hot distilled water)،at a temperature of 70-80°C), and using a water bath, the soaking process was carried out for 30 minutes with continuous stirring. After the soaking period was over, the extract was filtered using a sterile gauze piece، .Then, using filter paper to separate impurities and insoluble plant particles, the resulting extract was concentrated using a Rotary evaporator under low pressure and a temperature not exceeding 80°C, to preserve the active ingredients [13]. Then, in the final step, the concentrated extract was dried using a Lyophilizer to obtain a dry extract [14.[

Figure (1): Grape seed extract used in the experiment

2.4Detection of Flavonoids

Flavonoid compounds in grape seed extract, regarded as one of the largest and most biologically significant groups, were identified using High-Performance Liquid Chromatography (HPLC) at the laboratories of the Department of Environment and Water Resources, Ministry of Science and Technology, Baghdad, following the specified-method

2.5Coating Tests

Tensile strength, elongation, and permeability tests were performed on the coating after preparing the required solutions as presented in Table (1). The solutions were poured into plastic plates and left to dry at room temperature for two days. The dried coatings were then evaluated at the laboratories of the National Center for Packaging, affiliated with the Industrial Research and Development Authority, Ministry of Industry and Minerals, Baghdad

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2.6Sensory Evaluation

Pastrami slices were cooked using a preheated frying pan or grill without the addition of any external fat. The slices were placed on the hot surface for 2–3 minutes on each side. This thermal treatment was intended to brown the slices and stimulate the release of their intrinsic fat, which imparted a distinctive smoky flavor and a crispy outer texture while maintaining a tender internal structure. After cooking, the samples were served warm to ten panelists, consisting of five female and five male specialists aged 40–45 years from the Department of Food Science, all of whom possessed the expertise and qualifications necessary to conduct the sensory evaluation with accuracy and objectivity. The sensory assessment of all treatments was performed according to the evaluation form approved by [15] and modified by [16.[

Table (2): The Form Used for Sensory Evaluation.

general acceptance	the taste	consistency	aroma and flavor	juice	softnes	the attribute / Degree
						excellent (9)
						very good (8)
						good (7)
						average (6)
						acceptable (5)
						rejected (4)

.3Statistical Analysis

3.1Mathematical Model 1:

Data analysis was carried out using a factorial experimental design to evaluate the effects of treatments, storage duration, and their interaction. Differences among means were tested for significance using Duncan's Multiple Range Test [17] at a confidence level of 0.05. Statistical analyses were performed with the SAS software package (2010), applying the following mathematical model [18.[

3.2Mathematical Model 2:

A Complete Randomized Design (CRD) was applied to assess the influence of treatments

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on the studied parameters. Differences between treatment means were examined for statistical significance using Duncan's Multiple Range Test [17] at a 5% level of probability. The statistical analyses were conducted with the aid of SAS software (2010), based on the following mathematical model [18.[

.4Results and Discussion

4.1Total Flavonoid Content

The results indicated that these complex phenolic compounds recorded procyanidins in the highest concentration (9909.87 ± 0.006), showing the prosperity of grape seeds. Procyanidins are well recognised for their strong ability to reduce free radicals and oxidative stress, making them one of the most effective compounds in increasing antioxidant activity [19]. This high abundance can be attributed to naturally condensed flanonol structures in grape seeds, which have shown clear efficiency in maintaining oxidative stability in foods [20]. The compound catechin was found in a relatively high concentration (222.99 ± 0.002), followed by epicatechin (203.51 ± 0.002). Both are powerful antioxidants that are known to disrupt lipid oxidation, reduce food malfunctions and contribute to cardiac health benefits [21.[

On the other hand, Quercetin appeared in a moderate concentration (5.36) 0.004). This flavonoid is widely distributed in plant sources and is known for its anti-inflammatory and anticancer properties [22]. The lowest concentration was seen for Rutin (1.10) 0.003). Regardless of its low levels, the route plays a supplementary role in increasing the overall antioxidant capacity of the extract, especially through cooperative interaction with other flavonols [23]. Different letters within the same column indicate that the variations in the concentrations of these compounds are statistically significant ($p \leq 0.05$), reflecting the considerable diversity in flavonoid levels within grape seed extract. This suggests that the biological activity of the extract is not attributed to a single compound, but rather to the synergistic interaction among various phenolic compounds, which provides an added strength when used as a natural antioxidant or as a functional dietary supplement .

Table (3): Concentrations of Flavonoids Present in Grape Seed Extract

Concentration (ppm)	Compound name
0.006 ± 9909.87 a	Procyanidins
0.003 ± 1.10 e	Rutin
0.004 ± 5.36 d	Quercetin
0.002 ± 203.51 c	Epicatechin
0.002 ± 222.99 b	Catechin

*Distinct lowercase letters in the same column represent significant differences ($p \leq 0.05$) among the treatments effects.

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4.2Coating Tests

The results showed that the coating made from Gum Arabic (T2) alone performed the weakest functional performance, with the highest permeability value (33.60 ± 0.06), the lowest tensile strength (0.19 ± 0.00 MPa), and a low increase rate (4.80 ± 0.06%). These findings reflect the range of pure polymers, such as gum Arabic-based food films, which were reported by Gum Arabic [24] in preventing gas and moisture transfer due to their hydrophilic nature, indicating that gum Arabic films alone suffer from poor mechanical and hurdle qualities. In addition to the extracts of grape seeds, a clear improvement was observed in all properties. Treatment T3 (0.5%) decreased permeability (4.57) 0.09), while in T4 (1%) and T5 (1.5%) it fell to (0.00) 0.00). This indicates that phenolic compounds in extracts contributed to creating a dense and more harmonious network, reducing the internal holes of the coating. Similar results were reported by [25], who found that involving grape seed extracts with citric acid, permeability in alginate films decreased and functional properties improved. In T3 (0.24 MPA) in T2 (0.19 MPA) (0.24 MPa), then in T4 (0.76 MPA), reached the highest value (1.08 ± 0.01 MPA) in T5. In the highest concentration, it confirms the role of phenolic compounds in creating a non-coordinating interaction with hydrogen bonds and gum molecules, which increases internal harmony. Comprehensive findings were reported by [26], where the extraction of grape seeds in Chitosan films greatly improved tensile strength. Regarding flexibility, T3 (2.43 ± 0.01%) increased to T2 (4.80 ± 0.06%), then T5 (35.30 ± 0.06%) increased rapidly before T4 (43.40 ± 0.06%), before it was slightly reduced. These results indicate that a moderate concentration (1%) of grape seed extract provides the best balance between hardness and elasticity. Similar results were noted by [27], who saw that the medium concentration of grape seeds in gelatin/chitosan coatings improved. Overall, these results suggest that gum enriching gum with grape seed extracts increases both obstruction and mechanical properties in a balanced manner. The permeability was reduced by up to 100% in concentrations of 1% or more, the tensile strength increased five times, and flexibility was adapted to intermediate concentrations. It supports the application of bio-based coatings to ensure the safety and quality of processed meats, such as pastrami, as noted in [28], which confirms that incorporating plant extracts into biodegradable films represents a sustainable approach for active packaging .

.Table (4): Shows the effect of the tests conducted on the coating
)Means ± Standard Error.(

Elongation (%)	Tensile Strength (MPa)	Permeability	Treatments
4.80 ± 0.06 c	0.19 ± 0.00 d	33.60 ± 0.06 a	T2
2.43 ± 0.01 d	0.24 ± 0.00 c	4.57 ± 0.09 b	T3
43.40 ± 0.06 a	0.76 ± 0.00 b	0.00 ± 0.00 c	T4
35.30 ± 0.06 b	1.08 ± 0.01 a	0.00 ± 0.00 c	T5

Different lowercase letters within the same column indicate significant differences ($p \leq 0.05$) among the effects of the treatments.
T1: Control (bovine casing.(

T2: Gum arabic film only.
T3: Gum arabic film fortified with 0.50% grape seed extract.
T4: Gum arabic film fortified with 1% grape seed extract.
T5: Gum arabic film fortified with 1.50% grape seed extract.

4.3Sensory evaluation

Table 4 shows that the sensory properties of the pastirma samples were significantly influenced by the type of treatment applied. The control treatment (T1) recorded the highest mean scores across all sensory attributes, ranging from (7.60 ± 0.11) for tenderness to (8.40 ± 0.12) for aroma and flavor, all marked with the letter (a), indicating a significant superiority ($p \leq 0.05$) over the other treatments. This superiority is attributed to the traditional basturma retaining its familiar characteristics in terms of texture and flavor, as no additives were introduced to alter the original product’s qualities [29]. Treatment T2 (basturma coated with Arabic gum only) showed the lowest values in most sensory attributes, particularly tenderness (6.20 ± 0.06) and juiciness (6.90 ± 0.12), marked with the letter (c), denoting a significant difference from T1, T4, and T5. This may be due to the Arabic gum layer affecting moisture evaporation or interacting with the surface, leading to reduced juiciness and a perception of lower tenderness [30]. Treatment T3 (Arabic gum + 0.5% grape seed extract) yielded results similar to T2, with tenderness and juiciness scores of (6.30 ± 0.06) and (6.80 ± 0.06), respectively, both marked (c), indicating no significant improvement compared to Arabic gum alone. This may be related to the 0.5% extract concentration being insufficient to produce a noticeable enhancement in flavor or texture through antioxidant activity [31]. In contrast, treatment T4 (Arabic gum + 1% grape seed extract) showed clear improvements in most indicators, scoring (7.30 ± 0.12) for texture and (8.10 ± 0.12) for aroma and flavor, with some attributes marked (a,b), indicating proximity to T1 in overall evaluation. This improvement is attributed to the moderate concentration of grape seed extract, enhancing palatability by reducing rancidity and preserving the desired taste [32]. Treatment T5 (Arabic gum + 1.5% grape seed extract) recorded high values in aroma and flavor (8.30 ± 0.06) and taste (8.23 ± 0.06), marked with (a), but was somewhat lower than T1 in overall acceptability (7.80 ± 0.06), possibly due to the higher extract concentration imparting a slight astringent taste from increased polyphenol levels [33]. Overall, the results suggest that incorporating Arabic gum with a moderate level (1%) of grape seed extract is the optimal choice for enhancing the sensory properties of pastirma, achieving a balance between tenderness, juiciness, flavor, and overall acceptability. At the same time, very low or high concentrations lead to undesirable effects on some attributes.

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Tabale (5): Shows the effect of treatments, periods, and their interactions on the sensory evaluation of pastrami samples (means ± standard error(

Overall Acceptability	Taste	Texture	Odor&Flavor	Juiciness	Tenderness	Treatments
8.20 ± 0.06 a	8.20 ± 0.06 a	7.60 ± 0.12 a	8.40 ± 0.12 a	8.20 ± 0.06 a	7.60 ± 0.11 a	T1
7.20 ± 0.06 c	7.50 ± 0.17 b	6.93 ± 0.09 b	7.80 ± 0.06 bc	6.90 ± 0.12 c	6.20 ± 0.06 c	T2
7.30 ± 0.06 c	7.70 ± 0.12 b	6.80 ± 0.06 b	7.70 ± 0.12 c	6.80 ± 0.06 c	6.30 ± 0.06 c	T3
7.90 ± 0.12 b	8.20 ± 0.06 a	7.30 ± 0.12 a	8.10 ± 0.12 ab	7.20 ± 0.06 b	6.20 ± 0.06 c	T4
7.80 ± 0.06 b	8.23 ± 0.06 a	7.50 ± 0.12 a	8.30 ± 0.06 a	6.90 ± 0.12 c	6.73 ± 0.09 b	T5

*Different uppercase letters within the same column indicate statistically significant differences ($p \leq 0.05$) among the treatment effects.

*Different uppercase letters within the same row indicate statistically significant differences ($p \leq 0.05$) among storage periods.

*Different lowercase letters, both vertically and horizontally, indicate statistically significant differences ($p \leq 0.05$) among the intervention effects.

Conclusion

The findings of this study demonstrate that using Arabic gum as a bioactive coating enriched with grape seed extract is an effective strategy for improving both the technological and sensory qualities of pastirma. The flavonoids present in the extract exhibited strong antioxidant activity arising from the synergistic interaction of various phenolic compounds, thereby providing added potential as a natural antioxidant and as a functional dietary supplement. Mechanical tests indicated that a moderate concentration (1%) of grape seed extract was the optimal level to achieve a balance between hardness and elasticity, which was also reflected in sensory traits such as tenderness, juiciness, flavor, and overall acceptability, whereas very low or high concentrations resulted in undesirable effects. Furthermore, the incorporation of plant extracts into biodegradable films was confirmed as a sustainable approach for active packaging, as it reduced permeability, enhanced tensile strength and flexibility, and contributed to extending shelf life while preserving meat quality. Accordingly, the use of Arabic gum with a moderate level (1%) of grape seed extract can be recommended as a practical and efficient option for producing pastirma with improved technological quality, high sensory acceptance, and added functional and health value

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