



Effect of Tragacanth Gum and Polyethylene Packaging on Postharvest Storage of "Canino" Apricot Fruits

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ABSTRACT

This study was carried out during two successive seasons (2023 and 2024) to examine the effectiveness of tragacanth gum (TCG) and polyethylene packaging in improving the postharvest quality during cold storage and shelf life periods of "Canino" Apricot fruits. Different concentrations of TCG (0.75% and 1.5%) and their combination with polyethylene bags were evaluated for their ability to reduce weight loss, decay, chilling injury, and respiration rate while maintaining firmness, total soluble solids, total acidity, vitamin C, and total phenols during cold storage at 0 ± 1 °C and 90–95% R.H. and shelf life at (25 ± 2 °C and $65\pm5\%$ R.H.). Fruit's chemical and physical characteristics were assessed every seven days. The results revealed that the TCG (1.5%)+polyethylene treatment significantly outperformed other treatments in preserving fruit quality and extending cold storage and shelf life. The TCG-formed edible coating was most effective in reducing respiration rate, weight loss, and decay, while also preserving maximum firmness, total phenols, and shelf life. Whereas, untreated fruits and polyethylene packaging treatment alone, maintained higher total soluble solids, vitamin C content, and lower total acidity. These findings highlight the potential of TCG-based coatings, particularly when combined with polyethylene, as sustainable and effective alternatives for extending the cold storage and shelf life periods of "Canino" Apricot fruits.

Keywords : Tragacanth Gum - Polyethylene Packaging – Apricot - Cold Storage - Chilling Injury.

INTRODUCTION

In the temperate regions of the world, Apricots (*Prunus armeniaca*, L., Family Rosaceae) are one of the most significant fruit crops. One of the most significant cultivars cultivated on recently reclaimed soil in Egypt is the Apricot "Canino". The primary elements reducing postharvest life of Apricot fruits are excessive softening and highly perishable led to rapid deterioration and short shelf life in markets which limits its commercial potential (Abd El Wahab, 2015). In order to improve their postharvest life and quality, various natural products must be used for postharvest treatments. This can help link fruit physiology to ripening and senescence and keep high-quality Apricot fruits in markets or in storage for a specific amount of time. The control of fungal rot is essential to maximize the storage potential of Apricot fruits. Despite the fact that chemical disinfection might lessen rotting, most people are now worried about pesticide and fungicide chemical residues in the environment. Therefore, there is a

need for alternatives to pharmaceutical disease control. Given that of the residual levels that pose major health risks, there has been a recent global push to decrease the use of chemical treatments on fruit.

In other studies, Shakir et al. (2022) reported that, edible coatings based on natural gums have been widely applied for an extension in the postharvest of horticultural fresh produce. Polysaccharides made of sugars other than glucose make up natural gums, a type of hydrocolloid that is readily available, affordable, biodegradable, odorless, and non-toxic. Saha et al. (2017) also, illustrated that, gums are known as hydrocolloids since they are water-soluble. The anionic polysaccharide known as tragacanth gum (TCG), or katira, is secreted by many *Astragalus* plant species (Nazarzadeh Zare et al., 2019). TCG exhibits exclusive biological and chemical features, including non-toxicity, biocompatibility, environment friendliness, and stability across a wide pH



range (Nasiri et al., 2017), and It is mostly found in Asiatic and Iranian mountainous and semi-desert environments (Hemmati and Ghaemy, 2016). Moreover, Kurt et al. (2016) reported that, for many years, the American and European Scientific Committees on Food have accepted TCG as an addition, and it is widely utilized worldwide as a thickener, stabilizer, emulsifier, fat substitute, and binding agent in food and pharmaceutical systems, and it is widely utilized worldwide as a thickener, stabilizer, emulsifier, fat substitute, and binding agent in food and pharmaceutical systems. The application of TCG to apricot and mango, also, maintained a higher number of biochemical attributes and antioxidants and lowered oxidative stress by reducing ROS production and suppressing the activities of softening enzymes (Ali et al., 2022).

MATERIALS AND METHODS

Plant material:

The study used ten-year-old Apricot trees (*Prunus armeniaca*, L.) that were cultivated on a private farm in El-Kattatba, Menofya Governorate, over the two seasons of 2023 and 2024. Trees were planted at 5x5 meters budded on local Apricot in sandy soil under drip irrigation system and received the common cultural practices. The experiment's fifty-four trees were chosen to be as uniform and healthy as feasible. In addition to the control, five treatments were examined. There were three replicates of each treatment, each with three trees. In this study, a complete randomized design (CRD) was used.

Preparation Tragacanth Gum Edible Coating:

Different tragacanth gum (TCG; Sigma-Aldrich, St. Louis, MO, USA) concentrations, such as 0.75% and 1.5% w/v, were prepared by adding TCG powder to deionized water and homogenizing the solutions on a magnetic stirrer for 2 h at 70°C. According to Ali et al. (2020), the solutions were then incubated for 24 h at 4°C to hydrate the hydrocolloid gum. Each coating solution was then mixed for ten

Additionally, packaging material is important for drawing in customers and extending the shelf life of certain fruits. In order to affect the metabolism of the packed produce, it is frequently preferable to create an environment around the fruit that is low in oxygen and/or high in carbon dioxide. This can reduce respiratory activity, postpone softening, ripening, and senescence, as well as lower the incidence of physiological disorders and pathogenic infestations (Jena et al., 2017). However, Bhatia et al. (2013) discovered that, due to its affordability and ease of use, packaging film appears to be a perfect solution for preserving minimally processed fruits, given the growing desire for natural and fresh products free of dangerous chemicals. Examining the impact of polyethylene packaging and tragacanth gum (TCG) on the postharvest storage of "Canino" Apricot fruits was the aim of this study.

minutes at 3000 rpm. Following a final ultra-sonication (37 kHz; Elmer, Germany) to degas the solution, it was left at ambient temperature for one hour. The final formulation of edible coating was prepared by adding Tween 20 (0.1%, v/v) as a surfactant and glycerol (1%, v/v) as a plasticizer to the solutions.

Apricot fruit harvest:

Apricot cv. "Canino" fruits were picked at maturity stage (yellowish green) according to Dragovic-Uzelac et al. (2007) during the 2 week of June in both experimental seasons. Fruits were cleaned with 0.01% sodium hypochlorite water solution for 2 min and completely air dried at room temperature, sorted, graded and the defective fruits including wounded and other disorders were excluded.

Apricot fruits were randomly selected and divided into six equal groups. These groups and subjected to the following treatments; T₁: Control (water only), T₂: TGG (0.75%), T₃: TGG (1.5%), T₄: TGG (0.75%)+polyethylene packaging, T₅: TGG (1.5%)+polyethylene packaging and T₆: polyethylene packaging, every solution with 0.05% (v/v) Tween-80. Fruits were air



dried at room temperature for 30 minutes after being submerged in treatments for 2 minutes.

Storage conditions:

Treated fruits in T₁, T₂ and T₃ were quickly and carefully placed in cartoon boxes (30 x 40 x 20 cm), while, T₄, T₅ and T₆ were packaged in a 150 micron-thick, low-density polyethylene (LDPE) film that had 54 holes that were 2 mm in diameter. Each treatment was carried out three times, the purpose of the first box was to measure decay, the second was to measure weight loss, and the third was to measure fruit quality parameters every week for four weeks at various sampling times, namely 7, 14, 21, and 28 days of cold storage. Each box contained 2 kg was replicated three times, and the experiment was repeated twice (2023 and 2024 seasons). Samples of all treatments were stored at 0±1 °C and 90-95% RH.

Quality assessments of fruit:

Determination of physical and chemical properties:

During cold storage, fruit samples from every experimental treatment underwent a number of quality assessments.

Fruit weight loss (%):

It equals the amount of water loss through evaporation and transpiration plus the amount of dry matter lost by respiration. The fruits were weighed in order to determine it. At the end of the cold storage period, the fruits were weighed, and the following formula was used to determine their weight loss: (Average loss in fruit weight/Average fruit weight at the beginning of storage) × 100.

Fruit decay (%):

All disordered fruits caused by rot, fungus, bacteria, and pathogens were included in the percentage of disordered fruits, and the defects were computed as follows: (Number of fruit decay/Number of fruit at the beginning of storage) × 100.

Fruit chilling injury (%):

One of the indicators of Apricot fruit CI that was visually inspected and given different scales was browning of the flesh. These scales included the following: As stated by Ezzat et al. (2017), there are four types of browning: (0) no browning of the

flesh; (1) browning covering less than 25% of the surface area; (2) browning covering more than 25% but less than 50% of the surface area; (3) browning covering more than 50% but less than 75% of the surface area; and (4) browning spanning more than 75% of the surface area. The formula (Number of detected fruit/Total studied fruit number) × 100 was used to calculate the chilling incidence. Fruit with a chilling scale of 2 or above was deemed defective.

Fruit Firmness (lb/in²):

It was measured on the two opposite sides of Apricot fruit samples by using a hand Magness Taylor pressure tester (lb/in²).

Total soluble solids (%):

To create freshly made juice, individual Apricot fruits were mashed in an electric juice extractor. Soluble solids content was measured using Digital refractometer (PR-32, Atago Palette, Atago. Co. Ltd., Japan) and expressed as percentage.

Total acidity (%):

Using phenolphthalein as an indicator, 5-ml of juice was titrated with 0.1N sodium hydroxide to determine the total acidity (represented as malic acid percentage) (A.O.A.C., 2000).

Vitamin C (mg/100 g. F.W.):

The 2, 5-6 dichlorophenol indophenols method, as described by A.O.A.C. (2000), was used to measure it.

Total phenols (mg/g. F.W.):

The amount of phenols as mg per g fresh weight was determined using the folin-ciocalteu calorimetric method (Swain and Hillis, 1959) at a wave length of 725 nm and a standard curve from p-hydroxyl benzoic acid.

Respiration rate (ml CO₂ /kg/h):

Each treatment's individual fruits were weighed and stored at room temperature (23 °C ± 1) in 2-liter jars. A rubber septum and a cap were used to seal the jars for three hours. Using a syringe, headspace air samples were extracted from the septum and introduced into a Servomex Institution Model 1450C (Food Pack Gas Analyzer) to determine the amount of carbon dioxide and oxygen present. The respiration rate was determined using ml CO₂/kg/h on the



day of harvest and for the duration of the 28-day cold storage period (Lurie and Pesis, 1992).

Marketing life:

Following a 28-day storage period, 10 fruits from each replicate treatment were stored at room temperature for five days, simulating market conditions, at $25\pm 2^{\circ}\text{C}$ and $65\pm 5\%$ relative humidity. Quality measurements were made, and the fruits' physiochemical properties were assessed.

Statistical analysis:

Data of study were subjected to the analysis of variance test (ANOVA) as complete randomized design (CRD). Where the first factor was for six treatments mentioned before, the second factor was for storage period. The least significant differences (LSD) at the 5% level of probability were calculated using a computer program Costat according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Fruit weight loss:

The results in **Table (1)** show that there was an increase in the percentage of weight loss with increasing the storage period, as the highest percentage of weight loss was after 28 days of storage in all treatments and untreated fruits in both seasons. All treatments also showed a significant superiority in reducing the percentage weight loss compared to untreated fruits in both seasons. The TGG (1.5)+polyethylene treatment also achieved the lowest percentage of fruit loss with significant differences from the other treatments, followed by the TGG (0.75)+polyethylene treatment in both seasons. As for the interaction between storage periods and treatments, it was clear that the lowest percentage of weight loss

was after 7 days of storage with the TGG (1.5)+polyethylene treatment in both seasons, and on the contrary, the highest percentage of weight loss was after 28 days of storage with the untreated fruits in both seasons. According to research done on persimmon fruits by Saleem et al. (2022), TCG significantly reduces weight loss during the fruit's storage time. In conclusion, fruits coated with 1% TCG showed the minimum change (8%), while uncoated persimmon fruits showed the maximum weight loss (10%) on 20th day compared to the first period of storage. Losing money is comparable to losing less weight. Weight loss in fruit is mostly caused by water transpiration and respiration, although storage conditions also have an impact (Nasiri et al., 2017).

Table (1). Effect of tragacanth gum and polyethylene packaging on weight loss percentage of "Canino" Apricot fruits under cold storage at $0\pm 1^{\circ}\text{C}$ and 90-95% R.H. in 2023 and 2024 seasons.

Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
Season 2023						
Control	0.00	2.86	3.73	9.17	12.93	5.74
polyethylene	0.00	1.72	2.32	5.34	8.84	3.64
TGG (0.75)	0.00	2.36	3.59	5.75	10.80	4.50
TGG (1.5)	0.00	1.81	2.43	5.67	10.35	4.05
TGG(0.75)+polyethylene	0.00	1.65	2.27	5.28	8.48	3.54
TGG(1.5)+polyethylene	0.00	1.60	2.16	5.02	8.03	3.36
Means	0.00	2.00	2.75	6.03	9.91	
LSD at 0.05	(T): 0.17		(D): 0.15	(T×D): 0.39		
Season 2024						
Control	0.00	3.30	4.71	10.25	13.47	6.34
polyethylene	0.00	2.55	3.58	7.34	12.45	5.18
TGG (0.75)	0.00	2.76	4.50	7.37	13.18	5.56
TGG (1.5)	0.00	2.65	4.27	7.18	12.90	5.40
TGG(0.75)+polyethylene	0.00	2.82	3.51	7.21	12.81	5.27
TGG(1.5)+polyethylene	0.00	2.48	3.05	6.09	10.02	4.33
Means	0.00	2.76	3.94	7.57	12.47	
LSD at 0.05	(T): 0.16		(D): 0.14	(T×D): 0.35		
T: Treatments	D: Storage Periods (Days)		T×D: Interaction			



The edible coating's semi-permeable barrier, which limits the flow of O₂, CO₂, water, and solutes between the coated fruit and its surroundings, may be the cause of the notable decrease in weight loss observed in TCG-coated fruits (Ali et al., 2020). Our results are consistent with research on persimmon (Saleem et al., 2020) who found that applying edible coatings made of natural gum decreased weight loss.

The basic mechanism behind weight loss is exsiccation, which normally depends upon the gradient of water pressure between the produce (fruits and/or vegetables) tissues as well as storage temperature and surrounding atmosphere (Nasiri et al., 2017). The loss in weight generally leads to visible symptoms of wrinkling or wilting of fruit surface, eventually resulting in a significant economic loss (Bico et al., 2009). The weight loss of the tragacanth gum coated group was considerably reduced because the creation of a semi-permeable barrier between the fruits and the storage environment probably stopped water loss from the fruits' protection (Ali et al., 2020).

Furthermore, these findings are consistent with those of Mohsen (2011), who discovered that polyethylene packaging achieved the least amount of weight loss for peach and apricot fruits while they were kept in cold storage.

Fruit decay:

The results in **Table (2)** showed that there was an increase in the percentage of fruits decay with increasing storage periods in all treated and untreated fruits in both seasons. The appearance of fruit decay began after a week of storage and the percentage reached its highest rate after 28 days of cold storage in both seasons. According to the results, the untreated fruits had the highest percentage of decaying fruit. In both seasons, all treatments produced noticeably lower percentages of decomposing fruit than the untreated fruits, with the TGG (1.5)+polyethylene treatment having the highest percentage, followed by the TGG (0.75)+polyethylene treatment. Coatings based on polysaccharides have been shown to possess antibacterial qualities. Applying coatings based on polysaccharides improves protection against pathogenic organisms and inhibits disease (Yao et al., 2015).

Table (2). Effect of tragacanth gum and polyethylene packaging on decay percentage of "Canino" Apricot fruits under cold storage at 0±1°C and 90-95% R.H. in 2023 and 2024 seasons.

Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
	Season 2023					
Control	0.00	0.42	0.71	1.42	2.69	1.05
polyethylene	0.00	0.00	0.00	0.21	0.38	0.12
TGG (0.75)	0.00	0.00	0.00	0.42	1.00	0.28
TGG (1.5)	0.00	0.00	0.00	0.24	0.55	0.16
TGG(0.75)+polyethylene	0.00	0.00	0.00	0.16	0.29	0.09
TGG(1.5)+polyethylene	0.00	0.00	0.00	0.11	0.20	0.06
Means	0.00	0.07	0.12	0.43	0.85	
LSD at 0.05	(T): 0.10		(D): 0.09	(T×D): 0.22		
Season 2024						
Control	0.00	0.64	1.03	1.72	3.38	1.35
polyethylene	0.00	0.00	0.11	0.41	0.65	0.23
TGG (0.75)	0.00	0.00	0.35	0.85	1.45	0.53
TGG (1.5)	0.00	0.00	0.22	0.67	0.98	0.37
TGG(0.75)+polyethylene	0.00	0.00	0.00	0.31	0.57	0.17
TGG(1.5)+polyethylene	0.00	0.00	0.00	0.25	0.49	0.15
Means	0.00	0.11	0.28	0.70	1.25	
LSD at 0.05	(T): 0.11		(D): 0.10	(T×D): 0.25		
T: Treatments D: Storage Periods (Days) T×D: Interaction						



In agreement with our results are those obtained by Saleem et al. (2022) worked on Persimmon fruits and they reported that, TCG applications significantly inhibited the decay incidence in coated persimmon fruits up to the 8th day, compared with uncoated fruits. In the horticulture industry, senescence and decay are the main reasons for postharvest losses. Because the edible covering delays senescence and preserves cellular integrity, it significantly reduces microbial attacks on covered fruits. Our findings are in agreement with those of Ali et al. (2020), who discovered that applying TCG to apricot fruits decreased microbial infestation.

Chilling injury:

The results in **Table (3)** showed that the chilling injury of the fruits significantly increased with increasing storage period, as it reached its highest values at the end of the storage period in control followed by other treatments. Furthermore, data in **Table (3)**, also indicated that, the highest percentage of chilling injury was in the untreated fruits in both seasons, while the TGG (1.5)+polyethylene treatment achieved the lowest percentage of cold damage significantly compared with other

treatments, followed by the TGG (1.50) treatment in both seasons.

Concerning the effect of the interaction between the treatments and storage period, the results revealed that the lowest values of the chilling injury of the fruits were obtained at the time of harvest and during cold storage in fruits treated with TGG (1.50) + polyethylene and TGG (1.50), while the highest values of the chilling injury in the fruits were recorded at 28 days, especially in untreated fruits (control) in both seasons. PAL, the main enzyme in the phenylpropanoid pathway, catalyzes the conversion of phenylalanine to trans-cinnamic acid, which substantially lessens chilling injury (Siboza et al., 2014). According to González-Aguilar et al. (2010), certain edible coatings help tropical fruits accumulate secondary metabolites such phenolics, flavonoids, and anthocyanin, which are crucial for boosting antioxidant activity. Additionally, EL-Oraby et al. (2014) studied EL-Amar Apricot fruits and found that the fruits' physiological abnormalities manifested as brown pitting and shriveling. The percentage of physiological anomalies was highest in control fruits and lowest in fruits packed in polyethylene bags.

Table (3). Effect of tragacanth gum and polyethylene packaging on chilling injury percentage of "Canino" Apricot fruits under cold storage at 0±1°C and 90-95% R.H. in 2023 and 2024 seasons.

50-55% R.H. in 2023 and 2024 seasons.						
Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
Season 2023						
Control	0.00	5.32	19.06	30.12	39.78	18.90
polyethylene	0.00	4.53	10.37	16.32	22.25	10.47
TGG (0.75)	0.00	2.94	5.74	6.50	7.73	4.42
TGG (1.5)	0.00	2.17	3.12	3.97	4.95	2.69
TGG(0.75)+polyethylene	0.00	2.32	5.08	5.82	6.95	3.91
TGG(1.5)+polyethylene	0.00	1.92	2.93	3.24	4.35	2.39
Means	0.00	3.17	7.54	10.73	14.21	
LSD at 0.05	(T): 0.09		(D): 0.08	(T×D): 0.20		
Season 2024						
Control	0.00	5.60	18.87	29.97	40.07	18.86
polyethylene	0.00	4.44	10.35	15.77	21.80	10.69
TGG (0.75)	0.00	2.75	5.39	6.35	7.62	4.58
TGG (1.5)	0.00	2.11	2.99	3.70	4.65	2.84
TGG(0.75)+polyethylene	0.00	2.27	4.93	5.53	6.83	4.03
TGG(1.5)+polyethylene	0.00	1.86	2.69	3.09	4.30	2.49
Means	0.00	3.20	7.72	10.99	14.34	
LSD at 0.05	(T): 0.26		(D): 0.24	(T×D): 0.58		
T: Treatments D: Storage Periods (Days) T×D: Interaction						



Fruit firmness:

Fruit firmness has a significant impact on consumers' acceptance of the product as a whole. When the cell wall's composition and mechanical strength are altered, the fruit loses firmness as it ripens on the tree or is harvested later. The synthesis of ethylene increases the activity of hydrolyzing enzymes in the climacteric fruit's cell wall (Valero and Serrano, 2010). The data presented in **Table (4)** indicate that the firmness of the fruits decreased significantly with increasing storage period, as it reached its lowest values at the end of the storage period in all treatments and the control, and all treatments recorded a significantly higher firmness than the control fruits; In both seasons, the TGG (1.5)+polyethylene treatment showed significant superiority in preserving fruit firmness compared to all treatments, and this was in both seasons. It should be noted that all treatments had an effect in maintaining the firmness of the

fruits, as the lowest firmness value was obtained for the untreated fruits at the end of the storage period (28 days). Fruit softening can take place by way of two possible mechanisms. The first is related to the decomposition of polymeric carbohydrates that occurs during ripening and that cause weakening of the cell walls. During the early stages, the texture makes the fruit tastier and, finally, fruit softening will occur due to the breakdown of plant structures (Wills et al., 2007), reduction in turgidity of the cells due to water vapor transmission is another mechanism that leads to loss of fruit firmness (Garcia and Barret, 2002). An increase in gum tragacanth concentration allowed for the formation of a thick coating on the apricot fruit surface, which could reduce moisture loss until the gum tragacanth coating dried on its own. This result is consistent with their findings.

Table (4). Effect of tragacanth gum and polyethylene packaging on firmness (lb/in²) of "Canino" Apricot fruits under cold storage at 0±1°C and 90-95% R.H. in 2023 and 2024 seasons.

Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
	Season 2023					
Control	7.64	6.69	6.04	5.00	4.14	5.90
polyethylene	7.64	7.24	6.52	5.55	4.75	6.34
TGG (0.75)	7.64	6.72	6.29	5.17	4.35	6.03
TGG (1.5)	7.64	6.84	6.46	5.39	4.54	6.17
TGG(0.75)+polyethylene	7.64	7.31	6.64	5.65	4.83	6.41
TGG(1.5)+polyethylene	7.64	7.41	6.71	5.78	5.09	6.52
Means	7.64	7.03	6.44	5.42	4.62	
LSD at 0.05	(T): 0.08		(D): 0.07		(T×D): 0.18	
Season 2024						
Control	7.34	6.37	5.80	4.90	4.35	5.75
polyethylene	7.34	7.07	6.35	5.35	4.48	6.12
TGG (0.75)	7.34	6.52	6.14	4.87	4.12	5.79
TGG (1.5)	7.34	6.75	6.34	5.16	4.37	5.99
TGG(0.75)+polyethylene	7.34	7.12	6.56	5.58	4.64	6.25
TGG(1.5)+polyethylene	7.34	7.35	6.79	6.02	5.62	6.62
Means	7.34	6.86	6.33	5.31	4.59	
LSD at 0.05	(T): 0.07		(D): 0.06		(T×D): 0.16	
T: Treatments D: Storage Periods (Days) T×D: Interaction						

EL-Oraby et al. (2014) studied the effect of different methods of modified atmosphere on keeping quality of EL-

Amar Apricot fruits and they indicate that fruit firmness decreased significantly in control and other treatments during storage



period. On the average fruits packed in polyethylene bags recorded more firmness in comparison with control in the first season. This may be due to that polyethylene can reduce respiration rate and minimize fruit moisture loss. In their study of persimmon fruits, Saleem et al. (2022) found that the application of TCG had a substantial impact on fruit firmness, with TCG-coated persimmon fruits exhibiting higher fruit firmness than uncoated fruits. Loss of firmness is associated with changes in the structure of the cell wall. According to Xue et al. (2020), the collapse of the cell wall accelerates damage to fruit tissue by rupturing the cell membrane, destroying the physical structure within the cells, and allowing the contents to leak out. Limited O₂ availability and elevated CO₂ levels brought on by TCG coating application in coated persimmons may lower the activity of enzymes that break down cell walls and guarantee greater fruit firmness (Nasiri et al., 2018); this was also noted in the current investigation.

Total soluble solids:

The percentage of total soluble solids showed a direct increase proportional to the progress in the storage period (**Table 5**), regardless of the treatments. In both seasons, the untreated fruits were recorded the highest average percentage of total soluble solids, compared to all other treatments, while the lowest average percentage was obtained with fruits treated with TGG (1.5) and TGG (1.5)+polyethylene treatments. The data also indicated that the lowest percentage of total soluble solids was recorded at harvest time and prolonging storage periods in fruits treated with TGG (1.5)+polyethylene treatment in the both seasons. On the contrary, the highest percentage of total soluble solids was obtained at the end of the 28-day storage period, especially with the untreated fruits (control) in both

seasons. The concentration of total soluble solids increases due to rapid ripening and subsequent senescence because both these factors promptly lead to the conversion of starch into sugars (Anjum et al., 2020). Furthermore, a higher concentration of total soluble solids is the outcome of the increased mass loss. So, tragacanth gum coating probably delayed fruit ripening and senescence that in turn resulted in a markedly suppressed increase in total soluble solids in the coated apricot fruits (Ali et al., 2020). Furthermore, EL-Oraby et al. (2014) worked on EL-Amar Apricot fruits and they reported that, there was gradually and significantly increase in TSS% during cold storage in control and other treatments in two seasons. There were not many variations between the treatments in terms of total soluble solids.

In their study of persimmon fruits, Saleem et al. (2022) found that during the storage period, TSS significantly rose in uncoated fruits (from 13% to 22%). However, when compared to uncoated fruits, the application of TCG coating dramatically reduced the accumulation of TSS in coated persimmon fruits. TSS has a significant role in determining whether or not consumers will accept harvested fruits (Kumar et al., 2021). The hydrolysis of polysaccharides inside the cell wall is the cause of the steady rise in TSS as storage time increases (Khaliq et al., 2020). Higher TSS accumulation in harvested fruits is the result of starch being converted to sugars due to increased respiration rate and water loss (Dong and Wang, 2018). TCG has a significant effect on fruit ripening, which is probably why coated fruits in our study displayed a slow accumulation of TSS (Ali et al., 2020). Edible coatings change the internal physiology of the fruit by creating a semipermeable barrier over its surface that limits respiration rate, sugar transformation, moisture loss, and other metabolic activities (Kumar et al., 2021).



Table (5). Effect of tragacanth gum and polyethylene packaging on total soluble solids percentage of "Canino" Apricot fruits under cold storage at $0\pm1^{\circ}\text{C}$ and 90-95% R.H. in 2023 and 2024 seasons.

Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
Season 2023						
Control	11.50	14.35	15.05	15.27	16.27	14.49
polyethylene	11.50	13.70	13.80	13.92	15.12	13.61
TGG (0.75)	11.50	13.40	13.53	13.72	14.67	13.36
TGG (1.5)	11.50	13.28	13.30	13.54	14.55	13.23
TGG(0.75)+polyethylene	11.50	13.35	13.42	13.62	14.50	13.28
TGG(1.5)+polyethylene	11.50	13.19	13.23	13.41	13.95	13.05
Means	11.50	13.54	13.72	13.91	14.84	
LSD at 0.05	(T): 0.19		(D): 0.18	(T×D): 0.44		
Season 2024						
Control	11.54	14.13	14.95	15.24	15.97	14.37
polyethylene	11.54	12.87	13.92	14.48	14.55	13.47
TGG (0.75)	11.54	13.41	13.65	13.93	14.27	13.60
TGG (1.5)	11.54	13.21	13.29	13.85	14.25	13.22
TGG(0.75)+polyethylene	11.54	12.38	13.59	14.05	14.19	13.15
TGG(1.5)+polyethylene	11.54	12.71	13.12	13.63	14.07	13.01
Means	11.54	13.11	13.75	14.19	14.55	
LSD at 0.05	(T): 0.15		(D): 0.14	(T×D): 0.34		
T: Treatments D: Storage Periods (Days) T×D: Interaction						

Total acidity:

The data **Table (6)** shows that the acidity percentage decreased as the storage period was prolonged. As for the treatments, the highest averages of acidity were obtained in both seasons with the fruits treated with TGG (0.75)+polyethylene and TGG (1.5)+polyethylene, and the differences were big enough to be significant with control in first and second season.

On the other hand, untreated fruits (control) had the lowest acidity. By examining the effect of the interaction between the treatments and storage period data, the results revealed that the highest values of the total acidity content of the fruits were obtained at the time of harvest and during cold storage in fruits treated with TGG (0.75)+polyethylene and TGG (1.5)+polyethylene, while the lowest values of the acidity content in the fruits were recorded at 28 days, especially in untreated fruits (control) in both seasons. Reduction of the amount of total acidity during post-harvest storage of fleshy fruits is usual, which is mainly due to the decomposition of organic acids of the respiration

metabolism (Gol et al., 2013). According to Nourozi et al. (2020) and Anjum et al. (2020), coating treatment creates an effective film on the surface of a treated commodity, slows down metabolic activities, reduces organic acid oxidation reactions, and preserves higher titratable acidity over a longer period of time during postharvest. Moreover, EL-Oraby et al. (2014) worked on EL-Amar Apricot fruits and they reported that, there was gradually and significantly decrease in acidity percentage during storage in all treatments and control. These findings are supported by research conducted on persimmon fruits by Saleem et al. (2022), who found that TCG treatments maintained noticeably increased TA. However, on the twentieth day, the TA of the 1% TCG-treated persimmon fruits was 1.62 times higher than that of the uncoated fruits. According to Ebrahimi et al. (2020), TA is associated with the amount of organic acids in fruits, which are crucial for fruit quality. Additionally, organic acids are ingested during fruit ripening, when the tricarboxylic acid (TCA) cycle oxidizes organic acids (Batista-Silva et al., 2018).



Table (6). Effect of tragacanth gum and polyethylene packaging on total acidity percentage of "Canino" Apricot fruits under cold storage at $0\pm1^{\circ}\text{C}$ and 90-95% R.H. in 2023 and 2024 seasons.

Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
Season 2023						
Control	2.36	1.58	1.48	1.25	1.13	1.56
polyethylene	2.36	1.81	1.62	1.50	1.32	1.72
TGG (0.75)	2.36	1.76	1.57	1.39	1.29	1.67
TGG (1.5)	2.36	1.89	1.74	1.56	1.24	1.76
TGG(0.75)+polyethylene	2.36	2.10	1.73	1.56	1.38	1.83
TGG(1.5)+polyethylene	2.36	2.27	1.82	1.68	1.49	1.92
Means	2.36	1.90	1.66	1.49	1.31	
LSD at 0.05	(T): 0.05		(D): 0.04	(T×D): 0.09		
Season 2024						
Control	2.20	1.49	1.38	1.25	1.08	1.48
polyethylene	2.20	1.66	1.54	1.34	1.25	1.60
TGG (0.75)	2.20	1.69	1.58	1.39	1.29	1.63
TGG (1.5)	2.20	1.75	1.59	1.47	1.34	1.67
TGG(0.75)+polyethylene	2.20	1.77	1.64	1.52	1.40	1.70
TGG(1.5)+polyethylene	2.20	1.80	1.72	1.58	1.49	1.76
Means	2.20	1.69	1.57	1.42	1.31	
LSD at 0.05	(T): 0.04		(D): 0.03	(T×D): 0.10		
T: Treatments D: Storage Periods (Days) T×D: Interaction						

Vitamin C:

Ascorbic acid is an essential antioxidant of non-enzymatic nature. Ascorbic acid is prone to auto-oxidative degradation in the presence of oxygen (Owusu et al., 1988). The obtained results indicated that with the end of the storage periods, the content of vitamin C decreased in all paint treatments in both seasons as shown in **Table (7)**. In the second season, it was shown that the untreated fruits had the largest decrease in vitamin C concentration. On the contrary, the lowest decreases in vitamin C contents were in fruits treated with TGG (1.5), TGG (0.75)+polyethylene and TGG (1.5)+polyethylene treatments in the first season and second seasons. As for the interaction between treatments and storage periods, the results showed that the highest values of vitamin C were founded in fruits at the time of harvest and during cold storage in untreated fruits treated, while the lowest values of vitamin C were founded in fruits after 28 from cold storage, especially in fruits treated with TGG (1.5), TGG (0.75)+polyethylene and TGG (1.5)+polyethylene treatments in both

seasons. Ishaq et al. (2009) suggest that the oxidation of dehydrate ascorbic acid to diketogulonolactone acid may be the cause of the ascorbic acid decline during storage.

Ascorbic acid is a potent antioxidant that dissolves in water and reduces oxidative stress brought on by ROS. Ascorbic acid is reduced with storage time due to the ripening and senescence of harvested fruits (Nasiri et al., 2017). Ascorbic acid concentration is adversely affected by oxygen availability to respiring fruit tissues (Ebrahimi et al., 2020). Ascorbic acid retention in TCG-coated fruits is most likely caused by the TCG coating's restriction of the oxygen supply, which lowers the respiration rate and keeps ascorbic acid levels higher (Nasiri et al., 2018). Furthermore, 1% TCG-coated apricot fruits had more ascorbic acid than uncoated apricot fruits, according to (Ali et al., 2020). The active anti-oxidative defensive mechanism that prevents ascorbic acid loss is most likely the cause of the high levels of ascorbic acid in coated fruit (Dong and Wang, 2018).



Table (7). Effect of tragacanth gum and polyethylene packaging on vitamin C (mg/100 g. F.W.) of "Canino" Apricot fruits under cold storage at $0\pm1^{\circ}\text{C}$ and 90-95% R.H. in 2023 and 2024 seasons.

Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
Season 2023						
Control	15.66	14.72	12.67	11.20	8.35	12.52
polyethylene	15.66	14.42	12.26	10.14	7.92	12.08
TGG (0.75)	15.66	14.14	11.70	9.69	7.72	11.78
TGG (1.5)	15.66	13.59	11.32	9.52	7.48	11.51
TGG(0.75)+polyethylene	15.66	13.99	11.43	9.64	7.60	11.51
TGG(1.5)+polyethylene	15.66	13.30	10.20	9.11	7.41	11.14
Means	15.66	14.03	11.59	9.88	7.75	
LSD at 0.05	(T): 0.22		(D): 0.20	(T×D): 0.49		
Season 2024						
Control	15.41	14.35	11.35	10.41	9.35	12.17
polyethylene	15.41	13.92	10.90	9.55	8.38	11.63
TGG (0.75)	15.41	13.63	10.76	9.19	7.38	11.27
TGG (1.5)	15.41	13.56	10.68	9.13	7.15	11.18
TGG(0.75)+polyethylene	15.41	13.23	10.12	9.16	7.24	11.05
TGG(1.5)+polyethylene	15.41	13.41	10.51	8.95	7.01	11.03
Means	15.41	13.68	10.72	9.40	7.75	
LSD at 0.05	(T): 0.12		(D): 0.11	(T×D): 0.26		
T: Treatments D: Storage Periods (Days) T×D: Interaction						

Total phenols:

The data in the **Table (8)** shows that the total phenols content of fruits decreased as the storage period was prolonged. As for the treatments, the highest averages of total phenols were obtained in the TGG (1.5)+polyethylene treatment, followed by the TGG (0.75)+polyethylene treatment in the first season, while in the second season, the highest averages of phenols were in the TGG (0.75)+polyethylene treatment, followed by the treatment TGG (1.5), while the lowest percentage of phenols was in the untreated fruits in both seasons. By examining the effect of the interaction between treatments and storage period, the results revealed that the highest values for the fruits' content of total phenols were obtained at harvest time in all treated and untreated fruits in both seasons, while the lowest values for the fruits content of total phenols were at 28 days of storage, especially with untreated fruits in both seasons. The increased phenolic in the tragacanth gum coated fruits may be attributed to continuous biosynthesis (Ali et al., 2019) as well as decreased oxidation, as phenolic compounds are vulnerable to

oxidative reduction while being stored (Ali et al., 2019). In their study of persimmon fruits, Saleem et al. (2022) found that TPC significantly decreased with storage time for all treatments. However, TPC significantly reduces oxidative cell damage by scavenging the ROS in fruits (Kumar et al., 2021). TPC in harvested fruits degrades as a result of oxidative damage brought on by prolonged storage (Saleem et al., 2020). Additionally, senescence results in the breakdown of cell wall elements, which lowers TPC in harvested fruits, according to Etemadipoor et al. (2020). The use of edible coatings on fruit surfaces is essential for TPC preservation because they create a modified atmosphere around the fruit surface and stop TPC from respiring and oxidizing by inhibiting polyphenol oxidase activity (Dong and Wang, 2018). A higher amount of TPC in TCG-coated persimmon fruits might be due to the barrier effect of plant-based gums which reduced the enzyme-based oxidation of TPC (Ali et al., 2020). Apricot (Ali et al., 2021), and guava (Anjum et al., 2020) are among the fruits covered with natural gums that have been found to have higher TPC.



Table (8). Effect of tragacanth gum and polyethylene packaging on total phenols (mg/g. F.W.) of "Canino" Apricot fruits under cold storage at 0±1°C and 90-95% R.H. in 2023 and 2024 seasons.

Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
	Season 2023					
Control	0.491	0.435	0.391	0.368	0.322	0.401
polyethylene	0.491	0.441	0.400	0.373	0.330	0.407
TGG (0.75)	0.491	0.456	0.410	0.382	0.339	0.416
TGG (1.5)	0.491	0.462	0.422	0.389	0.345	0.422
TGG(0.75)+polyethylene	0.491	0.471	0.432	0.404	0.351	0.430
TGG(1.5)+polyethylene	0.491	0.478	0.442	0.420	0.362	0.439
Means	0.491	0.457	0.416	0.389	0.341	
LSD at 0.05	(T): 0.004		(D): 0.003	(T×D): 0.009		
Season 2024						
Control	0.466	0.427	0.346	0.327	0.302	0.375
polyethylene	0.466	0.435	0.353	0.345	0.326	0.387
TGG (0.75)	0.466	0.443	0.365	0.351	0.335	0.394
TGG (1.5)	0.466	0.452	0.372	0.368	0.347	0.404
TGG(0.75)+polyethylene	0.466	0.459	0.382	0.377	0.358	0.411
TGG(1.5)+polyethylene	0.466	0.464	0.399	0.387	0.366	0.402
Means	0.466	0.443	0.368	0.358	0.341	
LSD at 0.05	(T): 0.013		(D): 0.012	(T×D): 0.009		
T: Treatments D: Storage Periods (Days) T×D: Interaction						

Respiration rate:

It is clear from the data in **Table (9)** that there is a relative increase in the respiration rate of the treated and untreated fruits with an increase in the storage period. All treatments succeeded in maintaining significantly low respiration rate compared to the untreated fruits in both seasons, and the lowest average respiration rate achieved by fruits treated with TGG (1.5)+polyethylene, followed by treatment with TGG (0.75)+polyethylene in both seasons, and regarding to the interaction between storage periods and treatments, with the exception of the respiration rate at harvest (before cold storage), the results indicate that the lowest respiration rate was at 7 days with TGG (1.5)+polyethylene treatment in both seasons, while the highest respiration rate was at 28 days of storage, especially with untreated fruits in both seasons. Increases in respiration rate and ethylene production are indicators of climacteric fruit ripening. Our results are in harmony with those obtained by Khaliq et al. (2015) who reported that, by controlling the expression of genes involved in carotenoid biosynthesis, chlorophyll

degradation, and starch hydrolysis to simple sugars, ethylene controls the ripening of fruit. In general, a coating's barrier lessens the interchange of gases, including oxygen, between the fruits and their surroundings (Shakir et al., 2022).

Fruits coated with plant-based gums may have poor respiration rates and ethylene production because of decreased gas exchange between the fruits and their surroundings, which limits the amount of oxygen available for respiration (Khaliq et al., 2015). Furthermore, coated fruits such sweet cherries (Dong et al., 2018) and persimmons (Saleem et al., 2020) exhibit significantly reduced respiration and ethylene generation when coated with coatings made from plant-based gums. Results by EL-Oraby et al. (2014), who studied EL-Amar Apricot fruits, concur with these findings. They found that during both the cold storage and marketing seasons, the control fruits had the maximum respiration rate. The respiration rate reflects the role of low temperature and postharvest treatments in reducing deterioration of fruits. The decline of fruit quality was accelerated by excessive



respiration at high temperatures and control fruits. These findings demonstrated how crucial cold temperatures are for lowering respiration rates, preventing fruit

degeneration, and extending fruit life. These results were close to those obtained by Mashraky et al. (2009).

Table (9). Effect of tragacanth gum and polyethylene packaging on respiration rate (ml CO₂/kg/h) of "Canino" Apricot fruits under cold storage at 0±1°C and 90-95% R.H. in 2023 and 2024 seasons.

Treatments	Storage Periods (Days)					Means
	0	7	14	21	28	
	Season 2023					
Control	28.42	3.10	3.55	3.83	4.25	8.63
polyethylene	28.42	2.27	2.85	3.28	3.65	8.09
TGG (0.75)	28.42	2.83	3.18	3.58	3.88	8.38
TGG (1.5)	28.42	2.68	2.89	3.48	3.79	8.25
TGG(0.75)+polyethylene	28.42	2.17	2.69	3.13	3.41	7.96
TGG(1.5)+polyethylene	28.42	2.01	2.45	2.87	3.12	7.77
Means	28.42	2.51	2.93	3.36	3.68	
LSD at 0.05	(T): 0.24		(D): 0.22	(T×D): 0.76		
Season 2024						
Control	30.08	3.45	3.66	3.98	4.23	9.08
polyethylene	30.08	2.43	3.02	3.34	3.83	8.54
TGG (0.75)	30.08	2.97	3.35	3.81	4.02	8.85
TGG (1.5)	30.08	2.81	3.24	3.47	3.87	8.70
TGG(0.75)+polyethylene	30.08	2.26	2.88	3.25	3.55	8.40
TGG(1.5)+polyethylene	30.08	2.21	2.52	3.02	3.28	8.22
Means	30.08	2.68	3.11	3.48	3.80	
LSD at 0.05	(T): 0.10		(D): 0.09	(T×D): 0.22		
T: Treatments D: Storage Periods (Days) T×D: Interaction						

Marketing life:

The results in **Tables (10 and 11)** show the effect of treatments on the quality characteristics of Apricot fruits stored at a temperature of 25± 2°C as marketing life. The results shows that all treatments are significantly superior in preserving the various quality characteristics compared to untreated fruits in both seasons, where the TGG (1.5), TGG (0.75)+polyethylene and TGG (1.5)+polyethylene treatments achieved, the lowest percentage of decayed fruits, weight loss, chilling injury, total soluble solids, vitamin C and respiration rate, while the same treatments achieved the highest percentage of firmness, total acidity and total phenols characteristics in both seasons.

The shelf life is an important indicator of postharvest quality of fresh produce such as fruits. Applying an edible coating suppresses deterioration, and desiccation, thus delays senescence, which subsequently conserves better-eating quality. In our instance, tragacanth gum greatly increased the coated apricots' shelf life, most likely as a result of higher sensory quality, decreased decay rate, and suppressed desiccation as compared to the control fruits (Ali et al., 2020). EL-Oraby et al. (2014) conducted a study on EL-Amar Apricot fruits and found that the fruits exhibited brown pitting and shriveling as signs of physiological disorders. After four days at room temperature, the physiological disorder values were 2%, 30%, 20%, and 70%.



Table (10). Effect of tragacanth gum and polyethylene packaging on weight loss, decay, chilling injury, firmness, and respiration rate of "Canino" Apricot fruits at ambient conditions ($25\pm 2^{\circ}\text{C}$ and $65\pm 5\%$ R.H.) in 2023 and 2024 seasons.

Treatments	Weight Loss		Decay		Chilling Injury		Firmness		Respiration Rate	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Control	14.18	15.08	4.08	4.69	6.10	6.61	3.75	3.80	4.73	4.43
polyethylene	9.04	13.07	0.78	1.10	2.31	2.54	4.46	4.26	3.78	3.94
TGG (0.75)	11.23	13.93	1.42	2.17	2.68	2.93	4.18	3.93	4.02	4.13
TGG (1.5)	10.56	13.26	1.08	1.93	2.48	2.67	4.26	4.16	3.85	4.00
TGG(0.75)+polyethylene	8.95	13.01	0.59	0.93	2.23	2.36	4.52	4.51	3.62	3.71
TGG(1.5)+polyethylene	8.71	13.01	0.46	0.78	2.13	2.19	4.72	4.93	3.38	3.37
LSD at 0.05	0.38	0.25	0.23	0.22	0.59	0.19	0.12	0.22	0.19	0.13

Table (11). Effect of tragacanth gum and polyethylene packaging on TSS, total acidity, vitamin C, and total phenols of "Canino" Apricot fruits at ambient conditions ($25\pm 2^{\circ}\text{C}$ and $65\pm 5\%$ R.H.) in 2023 and 2024 seasons.

Treatments	Total Soluble Solids		Total Acidity		Vitamin C		Total Phenols	
	2023	2024	2023	2024	2023	2024	2023	2024
Control	15.59	15.37	1.09	0.85	7.81	8.58	0.282	0.271
polyethylene	15.11	14.72	1.33	1.38	7.39	7.34	0.307	0.311
TGG (0.75)	14.81	14.57	1.21	1.25	7.29	7.13	0.317	0.310
TGG (1.5)	14.70	14.52	1.28	1.30	7.16	7.02	0.327	0.321
TGG(0.75)+polyethylene	14.75	14.48	1.19	1.20	7.18	7.07	0.329	0.331
TGG(1.5)+polyethylene	14.62	14.35	1.33	1.38	7.01	6.93	0.342	0.355
LSD at 0.05	0.13	0.10	0.03	0.04	0.12	0.15	0.007	0.005

CONCLUSION

In conclusion, the results of this study demonstrate that the application of TGG (1.5), TGG (0.75) + polyethylene and TGG (1.5) + polyethylene significantly improves the quality during cold storage and shelf life of Apricot fruits compared to untreated fruits. When compared to the control, all treated fruits exhibited reduced weight loss, fruit decay, chilling injury, total soluble solids, vitamin C, and respiration rate over the course of storage, while, the same treatments recorded the highest percentage of firmness, total acidity, and total phenols. This reduction in studying characteristics

and the preservation of important nutritional components suggest that the edible coating created by TGG (1.5), TGG (0.75) + polyethylene and TGG (1.5) + polyethylene serves as an effective barrier, delaying ripening and senescence, thus prolonging the shelf life and improving the overall postharvest quality of apricots. Therefore, TGG-based coatings, particularly in combination with polyethylene, are a promising solution for extending the storage life and maintaining the quality of "Canino" apricot fruits.

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الملخص العربي

تأثير صمغ القتاد وعبوات البولي إيثيلين على تخزين ثمار المشمش "كانينو" بعد الحصاد

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تم إجراء هذه الدراسة خلال موسمين متتاليين (٢٠٢٣، ٢٠٢٤) لتقييم فعالية صمغ القتاد وعبوات البولي إيثيلين في تحسين جودة ثمار المشمش "كانينو" بعد الحصاد وإطالة فترة صلاحيتها. تم اختبار تركيزين من صمغ القتاد (٠,٧٥٪، ١,٥٪)، بالإضافة إلى دمجها مع عبوات البولي إيثيلين، لتقليل الفاقد في الوزن، والتلف، وأضرار البرودة، ومعدل التنفس، مع الحفاظ على الصلابة، والمواد الصلبة الذائبة الكلية، والحموضة الكلية، وفيتامين (ج)، والفينولات الكلية أثناء التخزين المبرد عند درجة حرارة صفر ± ١ درجة مئوية ورطوبة نسبية ٩٠-٩٥٪، وكذلك فترة الصلاحية عند ٢ ± ٢٥ درجة مئوية ورطوبة نسبية ٦٥ ± ٥٪.

فُيِّت الخواص الفيزيائية والكيميائية للثمار كل سبعة أيام. أظهرت النتائج أن معاملة صمغ القتاد بتركيز ١,٥٪ مع عبوات البولي إيثيلين كانت الأكثر فعالية مقارنة بالمعاملات الأخرى في الحفاظ على جودة الثمار وإطالة فترة صلاحيتها حتى ٢٨ يومًا. وكان الطلاء الصالح للأكل المكون من صمغ القتاد الأكثر فعالية في تقليل نسبة الفاقد في الوزن ونسبة التلف وأضرار البرودة ومعدل التنفس، مع الحفاظ على أعلى مستويات الصلابة والفينولات الكلية وإطالة فترة التخزين المبرد وفترة الصلاحية.

في المقابل، أظهرت الثمار الغير معاملة والمعاملة بعبوات البولي إيثيلين فقط نسبة أعلى من المواد الصلبة الذائبة الكلية، ومحتوى فيتامين (ج)، ونسبة أقل من الحموضة الكلية. تؤكد هذه النتائج الإمكانيات الواعدة لاستخدام طلاءات صمغ القتاد، خاصة عند دمجها مع التعبئة بالبولي إيثيلين، كبديل مستدام وفعال لإطالة فترة التخزين المبرد وفترة الصلاحية لثمار المشمش "كانينو".