PRESERVING THE POSTHARVEST QUALITY OF THOMPSON SEEDLESS GRAPE BY USING PROPOLIS AND ALOE VERA GEL COATING

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ABSTRACT

This study was aimed to save Thompson Seedless grapes and quality has been preserved through cold storage using an edible covering made from propolis and aloe vera gel. Thompson grapes have high value economically, but after they are picked, their shelf life is reduced due to a rapid decline in quality. Based on the rapid weight loss, low carotene content, softening, and frequent berry degradation, uncoated berries exhibited a rapid deterioration at 5°C and 85–90% relative humidity (RH). On the contrary, the above criteria relating to post-harvest quality losses were greatly delayed in those berries treated with propolis and aloe vera gel and may extend the storability up to 30 days at 5°C. Interestingly, weight loss, berries cracking, and decaying which greatly increased in uncoated berries throughout storage—were reduced by this edible coating. According to the author's knowledge, propolis has never been used as an edible coating on grapes, which would be a novel and intriguing way for it to be used commercially and a substitute for the usage of chemical treatments during postharvest.

Keywords: edible covering, cold storage, berry quality, berry cracking.

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الحفاظ على جودة ما بعد الحصاد لعنب ثومسن عديم البذور باستخدام طلاء البروبوليس وهلام الألوفيرا

علي محي الدين عمر الجباري
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الكلية التقنية للعلوم التطبيقية – جامعة السليمانية التقنية

المستخلص

تم الحفاظ على سلامة وجودة عنب طومسون عديم بذور من خلال التخزين البارد باستخدام غطاء صالح للأكل مصنوع من البروبوليس وهلام الألوفيرا. يتمتع عنب طومسون بقيمة اقتصادية عالية، ولكن بعد قطفه تقل مدة صلاحيته بسبب الانخفاض السريع في الجودة. استنادًا إلى فقدان الوزن السريع وانخفاض محتوى الكاروتين والتليين وتدهور التوت أظهر الحبات غير المطلي تدهورًا سريعًا عند 5 درجات مئوية ورطوبة نسبية 85–90٪. على العكس من ذلك، فإن الصفات المذكورة أعلاه المتعلقة بفقدان جودة ما بعد الحصاد قد تأخرت كثيرًا في الحبات المعاملة بالبروبوليس وهلام الألوفيرا، وقد تمتد قابلية التخزين إلى 30 يومًا عند 5 درجات مئوية. ومن المثير للاهتمام، أن فقدان الوزن وتشقق الحبات وتلفه والذي زاد بشكل كبير في الحبات غير المغطى أثناء التخزين ولكن تم تقليله بواسطة هذا الطلاء الصالح للأكل. وفقًا لمعرفة المؤلف، لم يتم استخدام البروبوليس مطلقًا كطلاء صالح للأكل على العنب، وهو ما سيكون طريقة جديدة ومثيرة للاهتمام لاستخدامه تجاريًا وبديلاً لاستخدام المعاملات الكيميائية أثناء مرحلة ما بعد الحصاد.

الكلمات المفتاحية: غلاف صالح للأكل، التخزين البارد، جودة الحبات، تشقق الحبات.

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INTRODUCTION

Table grapes (*Vitis Vinifera* L.) have many problems throughout storage and retailing. The deficiencies of its quality are related to color changes, accelerated softening, rachis browning, berry decay, and weight loss (14, 16), which leads to a decrease in its shelf life. Edible coatings work as barriers to oxygen and moisture during postharvest processes, and in addition, they delay food deterioration and improve its safety owing to their biocide naturally active or antimicrobial compounds incorporation (15). Packaging waste reduction is another advantage of the edible coatings use which could be due to their being biodegradable, and the new products development. Several studies have indicated that edible coatings produced from different compounds are used mainly to prevent weight loss and preserve fruit quality such as milk proteins (23, 27), seed oils (5), and oils and chitosan (4). Researchers have recently studied aloe vera gel used for coating fruits. They found that the aloe vera makes a modified atmosphere of internal gases that decreases weight loss. The using of edible coatings enhances the appearance of food and preservation since they are friendly to the environment. The aloe vera application extends the shelf life and delays changes in variables associated with the quality deterioration of sweet cherries (22, 24). Natural aloe vera gel could stop firmness loss, control respiration rate, retard oxidative browning, manage development and maturation, and reduce microbial proliferation in fruits like nectarine, making them useful as edible fruit coatings (1), and table grapes (38). Aloe vera plant extract has also been applied to the different fruits after harvest. In recent years, it has been applied as an edible covering for strawberries, lowering TSS, raising ascorbic acid content, and total phenolic content, and enhancing antioxidant activity compared to uncoated fruits (34). One of the other major problems for table grapes is berry cracking. Grape splitting can also happen while the fruit is in storage, which manifests as small, surface splits. These symptoms, which we refer to as hairline, are more prevalent in cultivars of immature green fruit taken from over-cropped vines but have no clear pattern of distribution. The hairline is not influenced by the pace of cold or by humid storage conditions (40). This investigation aimed to investigate the impact of Aloe vera and Propolis coating to enhance Thomson Seedless grape postharvest quality attributes and reduce the berries cracking during different periods of cold storage.

MATERIALS AND METHODS

Sampling and treating

Thompson Seedless grapes (*Vitis Vinifera* L.) were picked manually from a private orchard in Tapa Kura, Halabja, Iraq. In the lab, clusters were chosen based on color, size, free of injuries, and healthy greenish rachises to create uniform groups. For all treatments, the clusters were submerged in the coating solutions for a minute; while, the control clusters were submerged in distillate water. Dried on a level surface at room temperature and were packed in 1 kg of polyethylene and had 8 holes with 1-centimeter diameter. After that, the polyethylene packages were stored at 5°C and 85–90% RH depending on storage durations. Investigations into seven various treatments included: Control, Propolis (0.25, 0.50, 0.75%), and Aloe vera (5, 10, 15%), which were stored for 10, 20, and 30 days as storage periods, and after each storage period the physical and chemical parameters were measured.

Aloe vera coating preparation

The leaves of aloe vera (*Aloe barbadensis*) were purchased from a market. At the laboratory, the aloe vera was washed with (1% w/v) chlorine solution. A sharp stainless-steel knife was used to isolate the gel from the outer cortex of the aloe vera leaf, and a blender was used to evenly combine the colorless hydroparenchyma. The extract was then strained to get rid of the fibrous components, and the liquid gel was collected. Before use, the gel was pasteurized at 65 °C for 30 minutes and kept at 4 °C (16). Aloe vera extracts (5, 10, and 15%) were made by diluting the gel with distilled water.

Propolis coating preparation

The propolis extracts were purchased from a market and were frozen at -20ºC. Then, 10 g of propolis was combined with 90 mL of 70% ethanol and stirred for one week to get 10% ethanol-extracted propolis. At hourly intervals,

the extract was shaken for 1 minute. After that, the mixture was filtered through Whatman 1 filter paper. Before use, the filtered solution was kept at 4 °C in the dark. To create the 0.25%, 0.50%, and 0.75% propolis extracts, the resulting solution was diluted with distilled water (instead of 70% ethanol) at the necessary ratios as described by Kahramanoğlu, et al. (19). To increase practicability and usage in practical applications, the final extracts production was carried out with distilled water.

Berries physical parameters

Fresh weight loss (%): Weights of individual samples were recorded on the first day and at the end of each storage duration as mentioned by AL-Jabary and Fadil, (7).

Berry cracking (%): Cracked berries were calculated using the equation:

Berry cracking (%) = (Cracked berries weight / Initial cluster weight) ×100

Berry decay (%): Decayed berries were calculated using the equation:

Berry decay (%) = (Decayed berries weight / Initial cluster weight) ×100

Berry firmness: A texture analyzer was used to determine the hardness of the flesh. Using a 4 mm diameter probe, the penetrating force for each berry was measured and recorded separately. 5 mm s^{-1} penetration rate. Newtons (N) were used to express the values.

Berries chemical parameters

With the use of an ATAGO refractometer**, total soluble solids (TSS)%** was calculated, as described in Alsalhy and Aljabary (9). **Titratable acidity (TA) %** was determined using the techniques outlined by Taha and Aljabary (36). **The favoring test** refers to the ratio of total soluble solids to total acidity (TSS/TA). **Carotene content (µg/kg)** was measured by using acetone 80% depending on the method Aljabary, et al., (6). **Glucose and fructose (%):** These were calculated using phenol 5% and 5 ml of concentrated sulfuric acid as the predominant sugars in the juice of European grape types. It read on the device at a wavelength of 488 nm for glucose and 490 nm for fructose, depending on the method reported by Al-bauty, (2) using the spectrophotometer (Spectrophotometer UV/Visible – Shimadzu - Japan).

Statistical analysis

Using XLSTAT software and Duncan's test at the 0.05 level (three repetitions, n=3), a completely randomized design (CRD) with two factors (treatments X storage duration) was carried out to identify statistical differences between the treatments.

RESULTS AND DISCUSSION

Berries physical parameters

Weight loss (%): All coating treatments impacted grape quality. Propolis and aloe vera coating considerably decreased grape berry weight loss when compared to the control. The grape berries coated with 0.25 and 0.75% propolis showed the least weight reduction, while the control group showed the most weight loss (Fig. 1A). Based on the differences in water vapor pressure between the fruit and the surrounding air, weight loss happens. The propolis' hydrophobic waxes and essential oils act as a barrier to the movement of gases and water vapor (3, 39) and have a wide range of antibacterial action. The thin layer of coating material surrounding the fruit, where the coating treatment methods operate as a barrier to the permeability of moisture, CO_2, O_2, and reduced respiratory rates and water loss, is what had the edible coating its beneficial effect on reducing weight loss (33). According to this study, using propolis and aloe vera reduced weight loss (35). The hygroscopic properties of aloe vera gel enable the creation of a barrier to prevent water diffusion from the fruit to the surrounding environment, which reduces fresh weight loss in coated fruit (24). This could be attributed to these materials having effective water vapor barrier qualities. A lower rate of water loss results in less weight loss when the fruit is covered in a thin layer of edible covering. The data showed that the weight loss percentage progressively and significantly increased with extending the storage durations, as expected, in the first 10 storage days, the weight loss was 2.81% and gradually raised to 7.81 % at day 30 (Fig. 1B). Numerous studies results are in harmony with our results, in the study conducted by Marf et al., (23) on fig fruit and Ali and Aljabary, (4) on pomegranate fruits, they noticed that the fresh weight loss raised with extended storage duration.

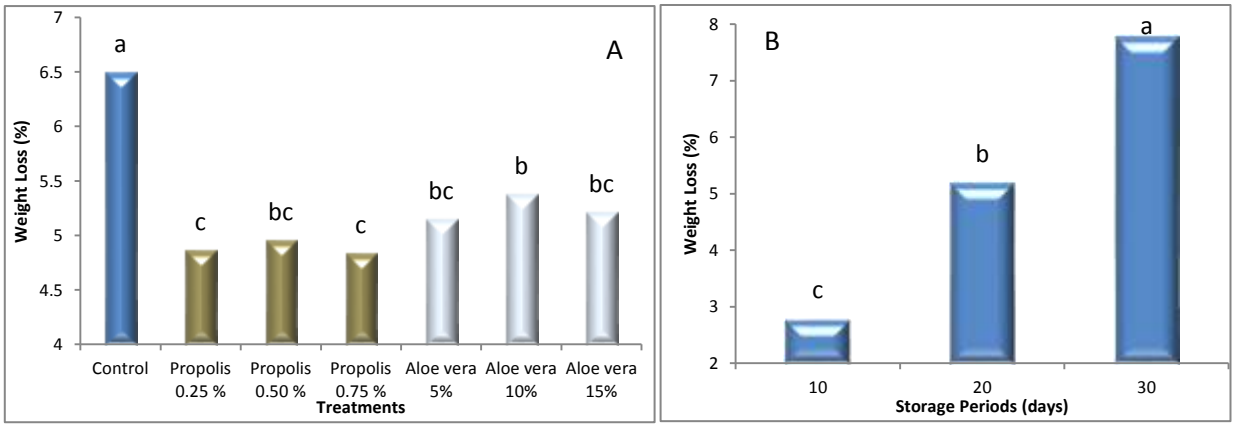

Figure 1. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on weight loss (%) of the Thompson Seedless Grape

Cracked berries (%): Berry cracking is a physiological condition in which the fruit's surface cracks, causing significant economic losses in the production of table grapes by reducing both yield and quality. Cracking typically originates from the physical failure of the cuticle or skin; it is brought on by stress on the skin. In comparison to the control treatment, all coating materials significantly minimized grape berries cracking. In grape berries coated with 0.25 and 0.50% propolis, the lowest cracked berries were observed, and the highest percentage was noticed in the control (Fig. 2A). Cracking in sweet cherry fruits has been linked to the size of micro-fractures that develop on cuticular membranes during the last stage of berry maturity (30). This could be related to the possibility of hairline cracks during storage. The reduction of berries cracking after the propolis treatments can be justified that could be given to its role in preventing the soluble of the pectic material, which prevents the deterioration of pectin by polygalacturonase (PG) and pectin methyl esterase (PME), as well as, the propolis could be utilized as an antioxidant too. Thus, propolis extract coating maintained the pectic material presented in the cell wall and the skin tissues, thus maintaining it from degradation and cracking. On the other hand, according to Tarabih and El-Metwally (37), aloe vera prevents the activity of major cell wall-degrading enzymes such as PG, cellulase, and xylanase via lowering ethylene synthesis. This prevents skin berry cracking and maintains the berries quality. Longer storage times resulted in non-significant differences in the cracked berries (Fig. 2B).

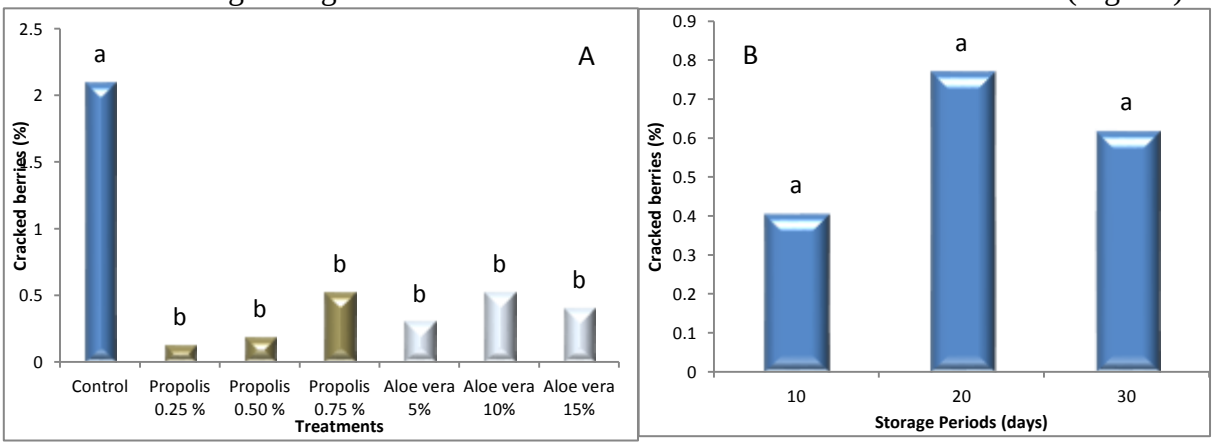

Figure 2. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on Cracked Berries (%) of the Thompson Seedless Grape

Berry Decay (%): Significant reductions of decayed berries were observed in all coating materials levels as compared to the control. Increasing the propolis or aloe vera levels gradually decreased the decayed berries, additionally, the decayed berries did not appear in coated grape berries with 0.75 % propolis (Fig. 3A). This could be due to the

great amounts of ferulic acid, cinnamic acid, and caffeic acid in propolis extracts were thought to be the cause of their potent activity of antimicrobial (13). Numerous studies have also been done on its effectiveness against pathogens that spoil food, propolis's antimicrobial efficacy has generally been attributed to one of two different mechanisms: first, direct impact on pathogens through the inhibition of some reactions of biochemical, and second increasing product resistance to pathogens through the enhancement of other biochemical reactions (25, 10, 8). Meanwhile, Treatments with aloe vera were more successful at preventing microbial deterioration while being stored. This could be a result of directly inhibiting microbial growth or activating defense responses in clusters, which helped to lessen and prevent infections from colonizing tissue. Most studies that were described in the literature concentrated on using these organic extracts to guarantee the microbiological safety of products. In addition, aloe vera-coated grapes and sweet cherries demonstrated a delayed evolution of organoleptic quality metrics and a reduction in decayed fruit, which received good marks from the sensory panelist (24), thus reducing the decay berry percentage. Decayed berries gradually increased with a prolonged storage period, whereas the decayed berries appeared after 20 days of storing (Fig. 3B). This increase could be due to grapes being non-climacteric fruits and thus should be harvested at the ripening stage so with prolonged storage period increase in the decay percentage as a result of physiological activity and wilting of berries.

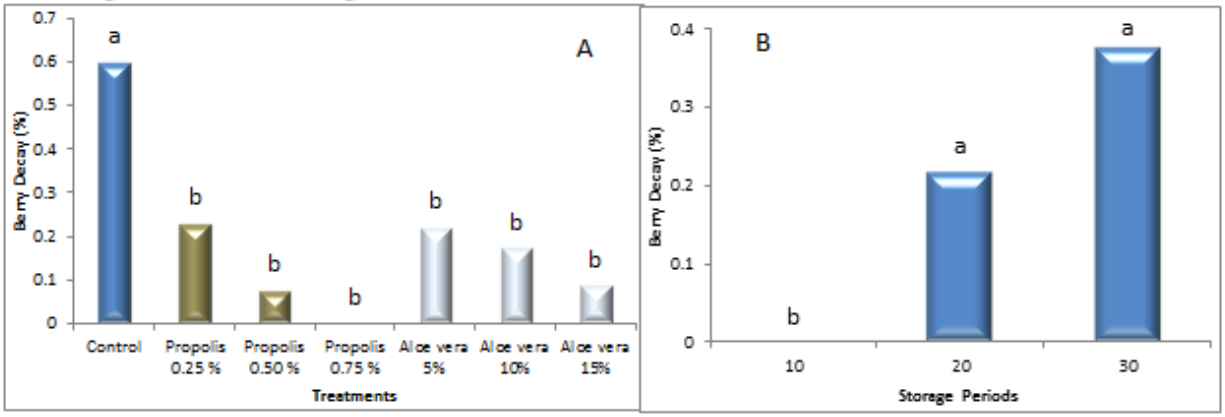

Figure 3. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on berry decay (%) of the Thompson Seedless Grape

Berry hardness (N): One of the key criteria for assessing the suitability for fresh consumption of table grapes is firmness. All treatments coating (propolis and aloe vera) preserved the hardness of the berries in comparison to the control, except berries coated with 0.50% propolis which got the lowest hardness. Because of the strong effectiveness of 0.75% propolis extract on the berries hardness maintained the significantly highest hardness among most concentrations studied, additionally, control treatment (Fig. 4A). The presence of a water-alcohol solution that could be applied to the insoluble pectic material, which prevents PME and PG (the enzymes responsible for fruit softening) from degrading pectin, could be used to explain why berries stiffen after storage following postharvest propolis treatments. The propolis extract coating improves firmness retention and supports the findings of (26) that oranges treated with 2.5% propolis and 5% propolis appeared firmer than the control during the storage period following postharvest. Moreover, this could be explained by the Aloe vera coating's capacity to prevent dehydration, which results in resistance to cell wall degradation. Moreover, Aloe vera gel-coated fruits decreased water vapor but preserved the same cell wall turgor pressure (16, 31). Aloe vera treatments could had higher hydrophobic qualities, which may account for the slightly increased hardness of the fruit after treatment. Additionally, mucilage from basil seed-infused aloe vera gel retained the apricot fruit firmness (28). According to research conducted by Valverde et al., (38), they mentioned aloe vera gel edible coating to keep Crimson Seedless table grapes safe and healthy. Compared to control grapes, aloe vera gel dramatically

reduced firmness losses through storage and shelf life. Non-significant variations were produced by longer storage durations (Fig. 4B).

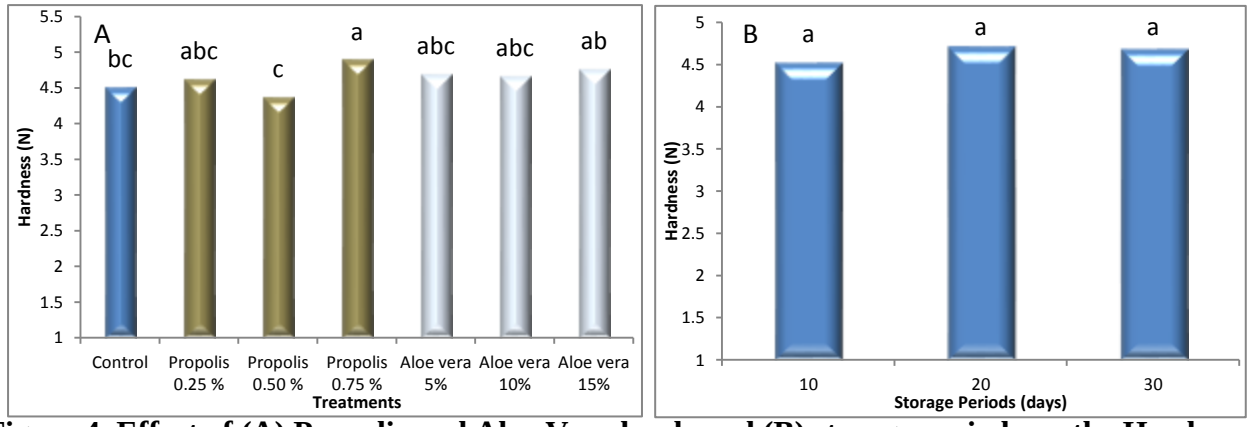

Figure 4. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on the Hardness (N) of the Thompson Seedless Grape

The results in Table (1) show that the highest percentage of weight loss, cracked berries, and decayed berries appeared in control from 10 days upto 30 days of storage, which is dramatically different compared with the other combination treatment. After 30 days of storage, some treatments (0.50 and 0.75% Propolis and 15% Aloe vera) preserved the berries from cracking and decay. On the other hand, the berries coated with 0.25% Propolis maintained significantly the greatest hardness when stored for 20 days as compared with some of the other treatments. Whilst the minimum weight loss and hardness appeared in the berries coated with 0.50% Propolis which were stored for 10 days.

Table 1. Impact of the overlap between treatments and storage periods on some physical properties of grapes

Treatments X Storage Periods		Weight loss (%)	Cracked berries (%)	Decayed berries (%)	Hardness (N)
Control	10	2.93 ^{hi}	0.39 ^{b}	0.00 ^{b}	4.79 $^{a-f}$
	20	6.05 ^{e}	2.52 ^{a}	0.51 ^{b}	4.45 $^{c-f}$
	30	10.55 ^{a}	3.42 ^{a}	1.20 ^{a}	4.32 ^{def}
Propolis 0.25 %	10	2.53 ^{hi}	0.20 ^{b}	0.00 ^{b}	4.22 ^{ef}
	20	5.32 ^{f}	0.00 ^{b}	0.15 ^{b}	5.30 ^{a}
	30	6.77 ^{d}	0.21 ^{b}	0.54 ^{b}	4.37 ^{def}
Propolis 0.50 %	10	2.42 ^{i}	0.31 ^{b}	0.00 ^{b}	4.09 ^{f}
	20	4.98 ^{fg}	0.27 ^{b}	0.23 ^{b}	4.51 $^{b-f}$
	30	7.50 ^{bc}	0.00 ^{b}	0.00 ^{b}	4.53 $^{b-f}$
Propolis 0.75 %	10	2.43 ^{i}	0.99 ^{b}	0.00 ^{b}	4.55 $^{b-f}$
	20	5.02 ^{fg}	0.61 ^{b}	0.00 ^{b}	5.02 $^{a-d}$
	30	7.09 ^{cd}	0.00 ^{b}	0.00 ^{b}	5.16 ^{ab}
Aloe vera 5 %	10	3.01 ^{hi}	0.23 ^{b}	0.00 ^{b}	4.35 ^{def}
	20	4.54 ^{g}	0.49 ^{b}	0.28 ^{b}	4.64 $^{a-f}$
	30	7.94 ^{b}	0.21 ^{b}	0.39 ^{b}	5.12 ^{abc}
Aloe vera 10 %	10	3.21 ^{h}	0.33 ^{b}	0.00 ^{b}	4.51 $^{b-f}$
	20	5.39 ^{ef}	0.75 ^{b}	0.37 ^{b}	4.82 $^{a-e}$
	30	7.57 ^{bc}	0.51 ^{b}	0.15 ^{b}	4.72 $^{a-f}$
Aloe vera 15 %	10	3.14 ^{hi}	0.44 ^{b}	0.00 ^{b}	5.26 ^{a}
	20	5.27 ^{fg}	0.80 ^{b}	0.00 ^{b}	4.39 ^{def}
	30	7.26 ^{bcd}	0.00 ^{b}	0.27 ^{b}	4.68 $^{a-f}$

*** According to Duncan's test, various letters in one column denote a statistical difference ($p \leq 0.05$) between treatments.**

Total soluble solids (TSS): The data indicated a substantial reduction in all berries coated with aloe vera extract as compared to the control fruits in the TSS content, also increasing propolis concentration significantly decreased TSS gradually. While, the maximum significant TSS value was noticed in the coated fruits with 0.25% propolis than in all treatments (Figure 5A). This reduction of TSS could be due to slowing the ethylene production within the fruit tissues (11, 21). This leads to a slowing respiration process in

the berries as a result of the coating material, where the coating works as a barrier to the gas exchange that reduces the respiratory rate (33) is what had the edible coating a beneficial impact on preserving the berry's quality. Through the storage period, the TSS dramatically increased, during the first 10 storage days the TSS was the lowest, and gradually increased at the 30 storage days. This is in harmony with the results found by (12, 23). As carbohydrates are the main component of TSS, nutritional degradation, such as the breakdown of carbohydrates into simple saccharides, could be the cause of TSS rising with storage time. Alternatively, this might be owing to water loss and transpiration.

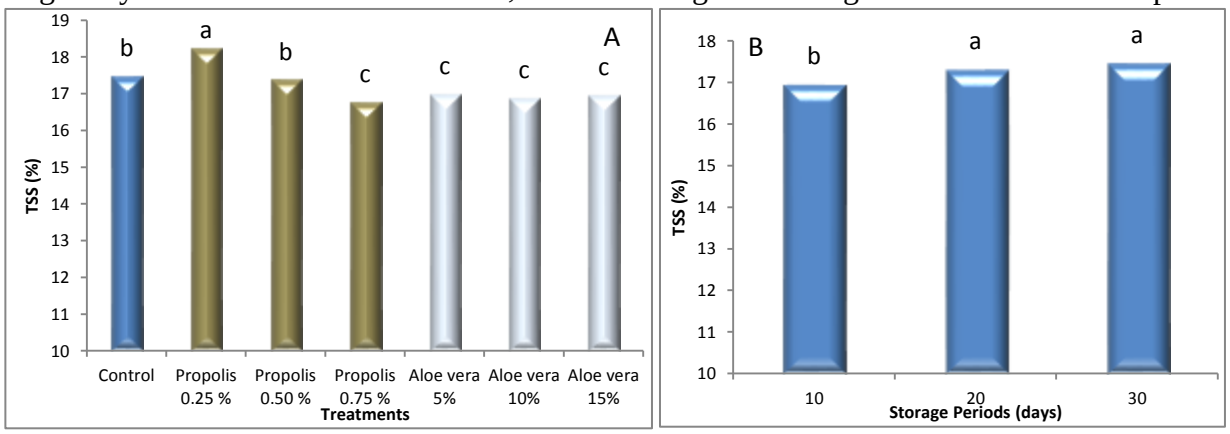

Figure 5. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on TSS (%) of the Thompson Seedless Grape

Total acidity (TA) was significantly changed in most of the coated berries than the control, except 0.25% and 15% of propolis and aloe vera, respectively (Figure 6A). This increase in acidity, which was also noticed by Pereira et al. (29), could be related to the breakdown of pectin PG and PME and the potential creation of galacturonic acid. Also, through the storage for 25 days, both the control and 2.5% propolis exhibited raise in the TA content. Mendes et al. (26) found that the impact was significantly more obvious in the postharvest control sample. The exhaustion of organic acids during respiration could be explained as the reduction of TA in the fruit (32). Aloe vera gel and basil oil can decrease the rate of respiration of the fruit by serving as a gas barrier and inhibiting oxygen intake. Tomatoes coated in chitosan and aloe vera gel also showed a similar result (20). Significant variations in TA% through the storage periods were also discovered. Whereas, gradually the TA % boosted in berries with prolonged storage (Figure 6B). Ali and Aljabary (4) also found a TA% increase in pomegranate juice coated with chitosan and oil seed at the end of storage. The variations in TA% could be caused by modifications to the fruit's nutritional composition during respiration, such as the conversion of carbohydrate molecules into organic acids or phenolic compounds and vice versa (5).

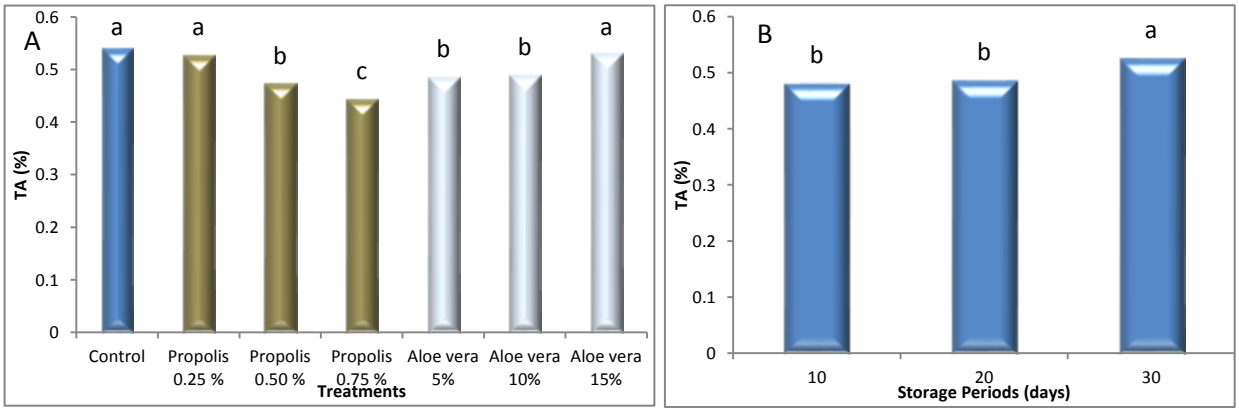

Figure 6. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on TA (%) of the Thompson Seedless Grape

The flavor index (TSS/TA): The balance of sour and sweet qualities in the fruit is determined during the fruit's ripening stage, which is indicated by variations in the TSS/TA value. All berries coated with propolis significantly incremented the TSS/TA ratio with increasing propolis concentration gradually, except the berries coated with 0.25% propolis which non-significant increases found compared with the control. While coated berries with aloe vera gel showed contrasting results, the TSS/TA ratio is minimized by increasing aloe vera levels (Fig. 11). Generally, the rise in flavor test results during storage could be caused by the higher rate of organic acids consumed than sugar during biochemical changes (physiological processes). Whereas, the TSS/TA ratio was significantly minimized in berries after 30 days of storage (Fig. 12).

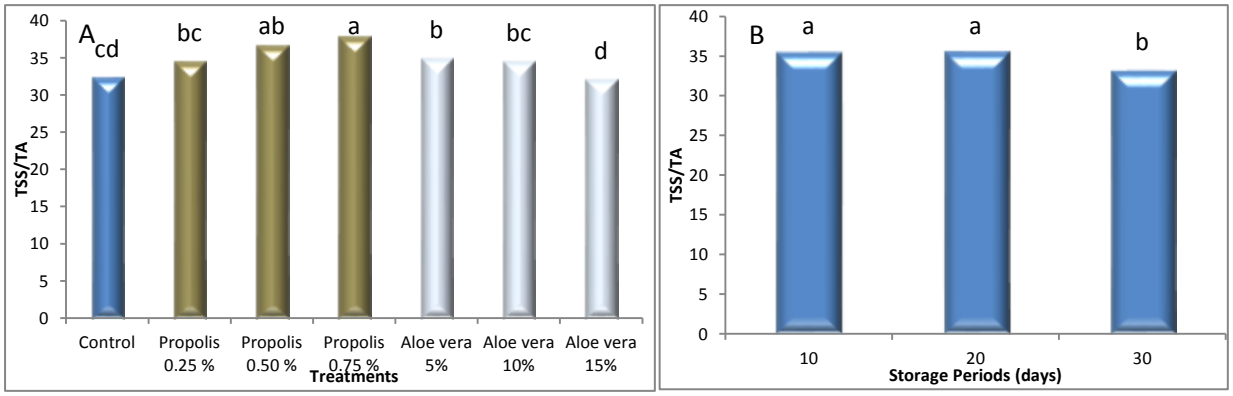

Figure 7. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on TSS/TA of the Thompson Seedless Grape

Glucose (%): Overall, in all the coated berries the glucose content was not changed significantly than the control. The highest value appeared in the coated berries with 0.50% propolis (Fig. 8A). However, glucose content changed significantly in the berries during the storage periods (Fig. 8B). Fruit juice became more concentrated and the TSS rose as a result of the change in water loss during storage periods, which raised the sugar content (Figure 1).

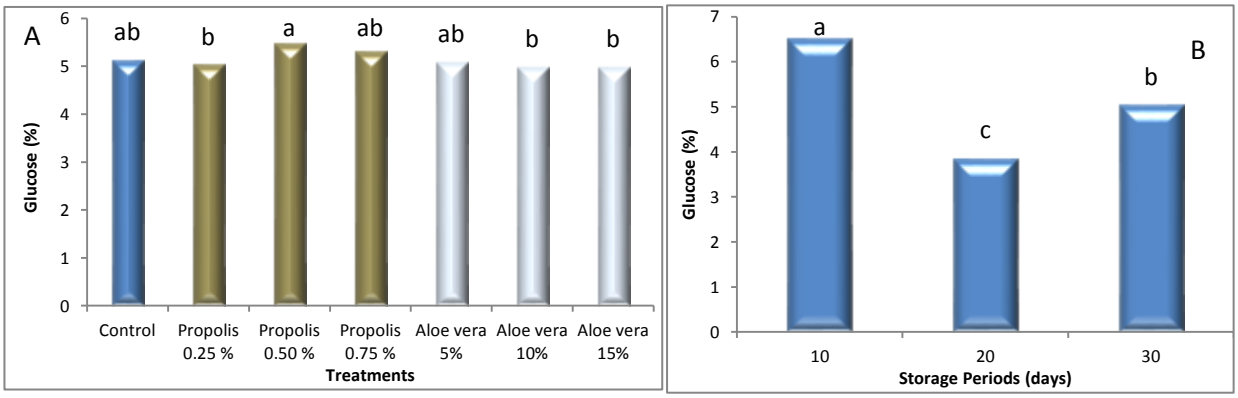

Figure 8. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on glucose (%) of the Thompson Seedless Grape

Fructose (%): The non-significant differences were found in the fructose content in the coated and uncoated berries (Fig. 9A). However, fructose content was significantly changed in the berries during the storage periods (Fig. 9B). Fruit juice became more concentrated and the TSS rose as a result of the change in water loss during storage periods, which raised the sugar content (Figure 1).

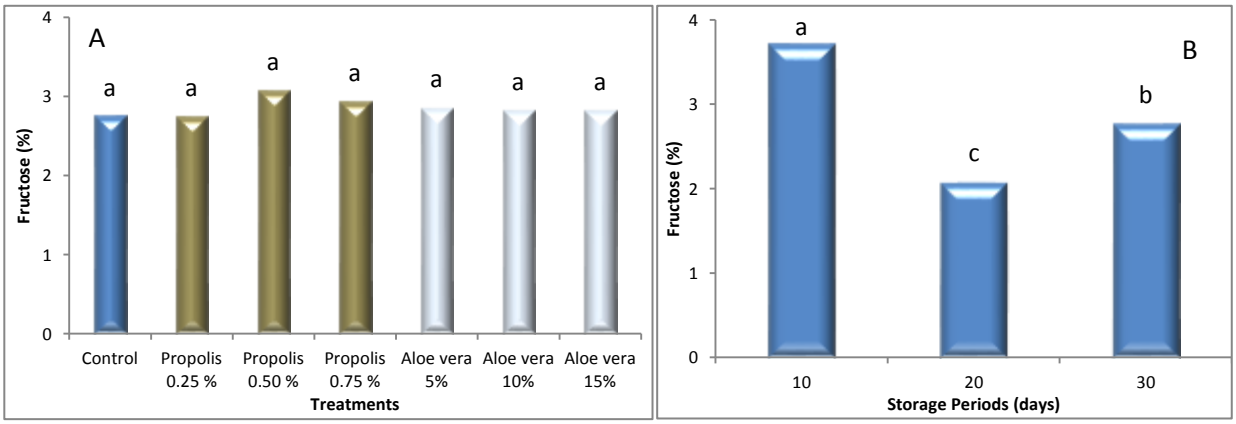

Figure 9. Effect of (A) Propolis and Aloe vera levels and (B) storage periods on fructose (%) of the Thompson Seedless Grape

Carotene content (µg/kg): Generally, all coated berries got the highest carotene content than the control. Carotene resulted in a sharp decrease with increasing Propolis and Aloe vera levels, which means the maximum content was noticed in berries treated with the minimum levels of both, which are significantly higher than the control (Fig. 10A). This result could be due to slowing or suppressing physiological processes in the berries due to the coating substance, which acts as a barrier to the gas exchange permeability, this increases in carotene could be achieved (33). Therefore, the edible coating's positive impact on berry quality preservation results from reduced carotenoid oxidation. Carotene resulted in a sharp increase from the 10 days up to the 20 days of cold storage, while showing a reduction after 30 days of the storage (Fig. 10B).

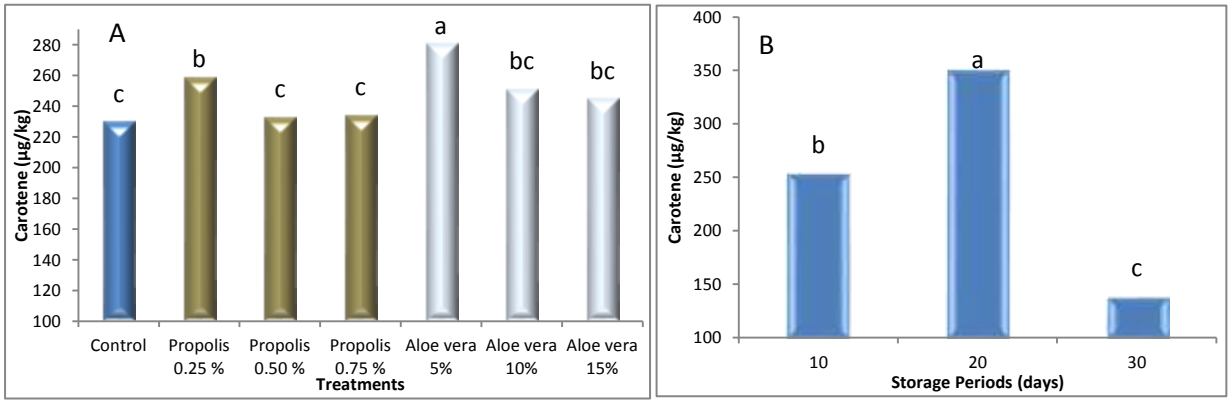

Figure 10. Effect of (A) Propolis and Aloe Vera levels and (B) storage periods on Carotene (µg/kg) of the Thompson Seedless Grape

The minimum TSS percentage was found in the control after 10 days of storage, while 30 days after storage, the maximum TSS was found in the 0.25 % propolis-treated fruits and the control treatment. Coated berries with Aloe vera 15 % show the highest TA value after 30 days of storage, on the other side, the lowest value was shown in coated berries with 0.75 % propolis which was stored for 10 days. Data of the current study exhibited that the treated fruits with 0.75 % propolis are effective in keeping the highest percentage of glucose and fructose in fruit after 10 days of storage significantly than the most other treatments (Table 2). After 30 days of storage, the minimum carotene content was noticed in coated berries with 0.75 % propolis and 10 % aloe vera after 30 days, whereas the maximum content was found in berries coated with 10 % aloe vera after 20 days.

Table 2. Impact of the overlap between treatments and storage periods on some phytochemical contents of berries juice

Treatments X Storage Periods		TSS (%)	TA (%)	TSS/TA	Glucose (%)	Fructose (%)	Carotene (µg/kg)
Control	10	16.20 ^{f}	0.525 ^{bcd}	5.95 ^{bc}	3.17 ^{bc}	31.17 ^{fg}	220.00 ^{ij}
	20	17.67 ^{b}	0.525 ^{bcd}	3.83 ^{fgh}	2.05 ^{ef}	33.78 $^{c-g}$	312.46 ^{de}
	30	18.67 ^{a}	0.575 ^{ab}	5.68 ^{cd}	3.10 ^{bc}	32.50 $^{d-g}$	159.42 ^{k}
Propolis 0.25 %	10	17.65 ^{b}	0.525 ^{bcd}	6.57 ^{ab}	3.60 ^{ab}	33.62 $^{c-g}$	248.70 ^{ghi}
	20	18.47 ^{a}	0.575 ^{ab}	3.16 ^{h}	1.73 ^{f}	32.16 ^{efg}	398.55 ^{a}
	30	18.67 ^{a}	0.488 ^{cde}	5.44 ^{cd}	2.97 ^{bc}	38.30 ^{b}	130.73 ^{kl}
Propolis 0.50 %	10	17.33 ^{bc}	0.450 ^{e}	6.90 ^{a}	3.88 ^{a}	38.75 ^{b}	286.96 ^{ef}
	20	17.47 ^{b}	0.475 ^{de}	5.52 ^{cd}	3.13 ^{bc}	36.82 ^{bcd}	277.39 ^{fg}
	30	17.43 ^{b}	0.500 ^{cde}	4.09 ^{fg}	2.27 ^{def}	34.91 $^{b-f}$	137.10 ^{kl}
Propolis 0.75 %	10	16.57 ^{def}	0.388 ^{f}	6.84 ^{a}	3.90 ^{a}	42.85 ^{a}	267.83 ^{fgh}
	20	16.30 ^{f}	0.463 ^{e}	3.65 ^{gh}	1.93 ^{ef}	35.31 $^{b-f}$	325.22 ^{cd}
	30	17.57 ^{b}	0.488 ^{cde}	5.48 ^{cd}	3.04 ^{bc}	36.05 $^{b-e}$	111.59 ^{l}
Aloe vera 5 %	10	17.47 ^{b}	0.475 ^{de}	6.55 ^{ab}	3.86 ^{a}	36.96 ^{bcd}	261.45 ^{fgh}
	20	17.13 $^{b-e}$	0.463 ^{e}	3.59 ^{gh}	1.92 ^{ef}	37.09 ^{bc}	382.61 ^{ab}
	30	16.47 ^{ef}	0.525 ^{bcd}	5.18 ^{cde}	2.84 ^{cd}	31.37 ^{fg}	200.87 ^{j}
Aloe vera 10 %	10	17.07 $^{b-e}$	0.488 ^{cde}	6.43 ^{ab}	3.83 ^{a}	35.01 $^{b-f}$	239.13 ^{hi}
	20	17.23 ^{bcd}	0.450 ^{e}	3.48 ^{gh}	1.87 ^{ef}	38.31 ^{b}	404.93 ^{a}
	30	16.43 ^{ef}	0.538 ^{abc}	5.08 ^{de}	2.84 ^{cd}	30.81 ^{fg}	111.59 ^{l}
Aloe vera 15 %	10	16.60 $^{c-f}$	0.538 ^{abc}	6.53 ^{ab}	3.96 ^{a}	30.90 ^{fg}	258.26 ^{fgh}
	20	17.10 $^{b-e}$	0.472 ^{de}	3.89 ^{fgh}	2.07 ^{ef}	36.52 $^{b-e}$	353.91 ^{bc}
	30	17.23 ^{bcd}	0.588 ^{a}	4.57 ^{ef}	2.49 ^{cde}	29.38 ^{g}	124.35 ^{kl}

***According to Duncan's test, various letters in one column denote a statistical difference ($p \leq 0.05$) between treatments.**

Conclusion

Coating with propolis or aloe vera has great potential to extend the Thompson Seedless grape storage life. Coating with propolis or aloe vera successfully delayed postharvest weight loss, reduced berries cracking and decay, and maintained quality properties such as TA, TSS, firmness, and carotene content of the fruit. Additionally, to my knowledge, this is the first study on the Thompson Seedless grape that showed that propolis coating inhibited weight loss, berries cracking, and decay incidence in berries and maintained the postharvest quality. Therefore, it can be said that grapes could be stored for a longer period using propolis and aloe vera.

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Competing Interests

There are no related interests to disclose.

Data Availability

All raw data of this study are available from the author, I would display it upon reasonable request.

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