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Quality Preservation and Shelf Life Extension of Broccoli Florets Using Tragacanth Gum Coating

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ABSTRACT

Broccoli (*Brassica oleracea* L. var. *italica*) as an important vegetable has a high postharvest respiration rate, so, it loses its quality rapidly. The use of edible films and coatings as protective layers to create a covering on the surface of fruits and vegetables plays a key role in maintaining the quality of this product. The present research investigated the qualitative and biochemical traits of broccoli coated with tragacanth gum (0, 0.1, 0.2, and 0.4%) and cellophane and uncoated ones (as control) weekly during three-weeks cold storage. Based on the results, coating influenced all measured traits (except flavonoid content, vitamin C and antioxidant activity) and storage time influenced all recorded traits significantly (P< 0.01). The results revealed that over the storage period, the physicochemical and biochemical parameters and visual quality of the broccoli decreased. Tragacanth gum 0.2% led to less weight loss, however, appropriate soluble solids content, and higher titratable acidity and organoleptic properties were recorded for 0.4% coated florets. Cellophane was effective in retaining some physicochemical characteristics, weight, and marketability, but it reduced phenolics. Tragacanth gum coating can be used as a biomaterial, as a substitute for synthetic cellophane film to preserve broccoli.

Keywords: Biochemical traits, Cellophane film, Edible coating, Organoleptic properties.

INTRODUCTION

Due to their high moisture content and physiological nature, fruits and vegetables keep respiration after harvest and start to gradually decay because of sustained respiration. Furthermore, after harvest, they are exposed to bacteria, fungi, and other microorganisms that intensify their decay and widely affect their taste, aroma, and appearance. This is one of the main economic challenges of agriculture (Tabatabaei *et al.*, 2016). Therefore, proper post-harvest storage of crops is an important and effective measure in ensuring their health in terms of nutritional value, preventing decay, saving costs, and preventing the producer or seller's failure. Recently, application of some technologies, such as edible coatings with antimicrobial properties, low temperature, and modified atmosphere packaging, have contributed to prolonging shelf life and enhancing the quality of fruits and vegetables during the storage period and marketing (Yu and Ren, 2013). Edible coatings are thin layers of foodstuffs that are applied to the surface of products as an alternative to protective wax coatings (Varasteh *et al.*, 2012). These coatings are characterized by preventing the release of moisture, O_2, CO_2, and ethylene and maintaining the appearance, firmness, acids, color, taste, and sugar of fruits and

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vegetables by controlling their respiration process, thereby extending their shelf-life. Edible coatings may be made of polysaccharides, proteins, lipids, or a combination of them and are applied on whole and fresh-cut fruits and vegetables (Raghav *et al.*, 2016).

Tragacanth gum (dried secretions from *Astragalus* species) is an edible coating of polysaccharide origin and a non-uniform and highly branched hydrophilic carbohydrate that produces sugars like D-galactose, D-galacturonic acid, D-xylose, L-arabinose, L-fructose, and L-rhamnose after acidic hydrolysis. Tragacanth consists of two main components – bassorin and tragacanthin. Bassorin accounts for 60-70% of the total gum and is capable of swelling and forming a gel. The properties of tragacanth gum are highly related to bassorin (Ahmadi Gavlighi, 2012). A study on red pepper, revealed that tragacanth and *Aloe vera* gel coatings exhibited better performance and delayed changes in color and firmness. It was also stated that samples coated with tragacanth gum lost their moisture more slowly than the uncoated samples (Mohebbi *et al.*, 2012).

Broccoli (*Brassica oleracea* L. var. *italica*) is an important vegetable from the family Brassicaceae that is medicinally valuable due to its high content of minerals, organic matter, and vitamins. Polyphenols of broccoli, which have high antioxidant activity, can be very strong scavengers of oxygen free radicals (Koh *et al.*, 2009; Lemoine *et al.*, 2010). Since broccoli loses its quality rapidly after harvest due to a high respiration rate, its post-harvest respiration should be controlled by suitable technologies and methods in order to supply it to the market in good quality. Therefore, this study aimed to evaluate the effect of tragacanth gum-based edible coating on the physicochemical and biochemical properties of broccoli florets during cold storage.

MATERIALS AND METHODS

Plant Materials and Experimental Design

To explore the impact of tragacanth gum-based edible coating and storage time on quality and biochemical characteristics of broccoli (*Brassica oleracea* L. var. 'Italica'), a factorial experiment was conducted on the basis of a completely randomized design with six coating treatments and four storage times, in three replications. The study was carried out at the Horticulture Sciences Laboratory, Gorgan University of Agriculture Sciences and Natural Resources, Iran, during 2017-2018. First, green uniform inflorescences of broccoli were harvested fresh from a commercial farm and were immediately transferred to the laboratory to avoid the loss of moisture and quality. Then, the samples that were intact, non-infested, and uniform in size, color, and texture were selected. Tragacanth gum powder (Food Grade) was procured by Giah Essence Phytopharm Co., Gorgan, Iran. To prepare tragacanth gum coating solutions at 0.1, 0.2, and 0.4% (w/v), 0.1, 0.2 and 0.4 g of tragacanth gum powder was dissolved in 50 mL distilled water. The solutions were stirred over low heat (40°C) for 60 minutes on a magnetic stirrer/hot plate. After cooling down to 20°C, glycerol monostearate (1.0%) (Sigma) was added as a plasticizer and the solution was made to 100 mL final volume using distilled water. Broccoli florets were dipped in each concentration of tragacanth gum coating solution (0, 0.1, 0.2, and 0.4%) for 3 minutes and the coating solution was applied uniformly on the whole surface. Some untreated samples were also covered by cellophane. The uncoated samples were considered as control. Then, the samples were stored at 4±1ºC and 90±5 relative humidity and their physicochemical and biochemical traits were recorded weekly for 21 days.

Assessed Traits

The weight loss percentage of broccoli was measured by Equation (1) as follows:

Weight loss percentage= [(weight on day 0–Weight on day x)/Weight on day 0]×100 (1)

Where, x= after 7, 14, and 21 days.

Soluble Solid Content (SSC) was measured with a digital refractometer and expressed in percent. Titratable Acidity (TA) percent was determined with 0.1N NaOH in the presence of phenolphthalein reagent based on citric acid. The flavor index was calculated as the ratio of SSC to TA. Vitamin C content of the plant samples was calculated by the titration method with the 2,6-dichloroindophenol reagent in mg per 100 g sample weight (Varasteh *et al.*, 2017). To determine total phenol, flavonoid, and antioxidant activity, methanol extract of the plant was used at a 1:10 ratio (1 g plant+10 mL 80% methanol). Total phenol was determined by the Folin-Ciocalteu reagent in mg Gallic Acid Equivalent (GAE) per g Fresh Weight (FW). The absorbance of the samples was recorded at 765 nm (Slinkard and Singleton, 1977). Flavonoid content was estimated by the chloride aluminum method in mg Quercetin Equivalent (QE) per g FW. The absorbance was recorded at 415 nm (Chang *et al.*, 2002). To assess antioxidant capacity, DPPH free radicals inhibition percent was measured by reading absorbance of samples at 517 nm and then, calculating Equation (2) (Boudet, 2007).

Free radicals inhibition percent= [(Ac-As)/Ac]×100 (2)

Where, As= Absorbance of the sample; Ac= absorbance of the control.

The organoleptic properties of the broccoli, e. g. color (yellow to green), aroma (strong off flavor to normal), texture (very soft to crisp), and overall marketability were assessed by 10 panelists on a scale from 1, for the least quality, to 5, for the highest quality. Then, the 12-point hedonic sensory tests were performed and the results were checked based on the overall selectivity (Ghazizadeh and Razeghi, 1998).

Statistical Analysis

The obtained data were subjected to two-way Analysis Of Variance (ANOVA) using SAS software version 9.2. The Least Significant Difference (LSD) values were calculated for mean comparisons.

RESULTS AND DISCUSSION

Weight Loss Percentage

Postharvest weight variation of fruits and vegetables is mainly related to water loss during metabolic processes including respiration and transpiration. These processes both are influenced by storage conditions (Abebe *et al.*, 2017). Indeed, weight loss reflects how produce is managed and maintained. Moisture loss can result in wrinkling and shriveling and, finally, the decline of marketability. However, approaches like packaging can contribute to retaining the internal moisture of produce and hinder its weight loss (Ashournezhad and Ghasemnezhad, 2012). Likewise, edible films and coatings can create an inhibitory layer that is semi-permeable to gases and water vapor and reduce respiration, enzymatic browning, and water loss, thereby extending the shelf life of freshly cut products (Raghav *et al.*, 2016). The weight loss percentage was increased significantly by storage time for all treatments. In our study, the highest weight loss (44%) was related to the uncoated samples (control) on day 21 of the storage, but it was not significantly different from that of the 0% gum-treated samples on day 21 (42%). The use of cellophane and 0.2 and 0.4% tragacanth gum influenced broccoli weight retention positively, differing from the uncoated treatment significantly (Figure 1). Various studies have reported that coatings and packages help retain water content significantly versus uncoated samples. It was reported about the effectiveness of edible coatings that tragacanth gum-coated peppers lost 16.15% of their moisture, whereas the weight loss in the uncoated samples was 26.80% (Mohebbi *et al.*, 2012). These results are consistent with our findings.

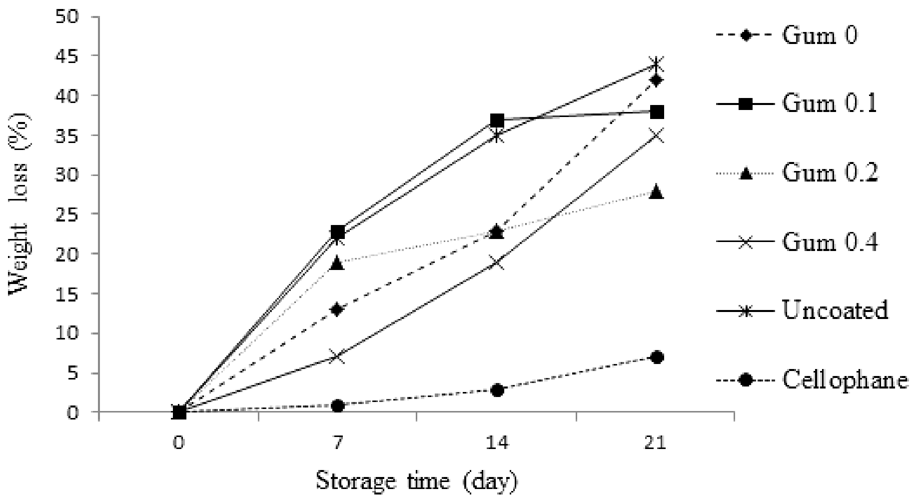

Figure 1. Effect of tragacanth gum coating (%) on broccoli florets weight loss (%) stored for 21 days at 4˚C.

Soluble Solids Content (SSC)

SSC is an important qualitative feature that should be considered with regard to consumer acceptance. SSC decline is related to the reduction of carbohydrates and pectins, partial hydrolysis of proteins, and the decomposition of glycosides to its subunits and their consumption during respiration (Athmaselvi *et al.*, 2013). As is evident in Table 1, the highest SSC (3%) was observed in the samples of day 0. As the storage time extended, the treatments exhibited a descending trend of SSC. The lowest SSC was 1% for the control samples on day 21. Coatings create a good semi-permeable conditions on produce and change its internal atmosphere, thereby reducing respiration and decomposition by oxygen molecules. The decline of respiration reduces the synthesis and consumption of metabolites and, consequently, increases SSC (Yaman and Bayoindirli, 2002; Varasteh *et al.*, 2017). Over time, the SSC of cucumbers decreased, but the use of chitosan and lemongrass-based edible coatings increased SSC versus the uncoated samples (Omoba and Onyekwere, 2016). According to Hassanpour (2015), aloe vera coating was more effective in maintaining SSC because lower permeability resulted in lower respiration rate and influenced the metabolism of raspberries during the storage. Ali *et al*. (2010) reported that the use of 15% gum arabic retarded SSC variation versus the uncoated fruits, which is similar to our findings.

Titratable Acidity (TA)

TA is used as an indicator of maturity in the form of acid reduction during crop maturation. Organic acids sharply decline after harvest. This reduction during the maturing or postharvest period is related to the involvement of acids in respiration and their conversion to sugars (Takahashi and Kakehi, 2010). The lowest titratable acidity was 0.12%, observed on the first day of the experiment. The acidity of the broccoli was increased over storage time and the samples treated with tragacanth gum and cellophane covering exhibited more titratable acidity compared to the uncoated samples. It seems the amount of dry matter in the fresh weight of the product increase due to water loss during storage, which is probably the reason for the increase in some substances during

Table 1. Mean comparison of physicochemical and biochemical properties of broccoli under the influence of coating and storage time.[a]

Coating	Storage time	SSC (%)	TA (%)	Flavor index	Vitamin C (mg 100 g^{-1} FW)	Antioxidant activity (%)
Uncoated (Control)	0	3 a	0.12 c	25.71 a	126.67 ab	80 ab
	7	2.1 c	0.35 a	6.14 c-e	150 a	72 b-e
	14	1.5 d-f	0.23 b	6.43 cd	100 cd	62 c-f
	21	1 g	0.23 b	4.29 hi	60 f	61 c-f
Gum (0) (Water)	0	3 a	0.12 c	25.71 a	126.67 ab	80 ab
	7	2.4 bc	0.35 a	6.86 c	150 a	95 a
	14	1.5 d-f	0.23 b	6.43 cd	70 ef	53 f
	21	1.7 d	0.35 a	4.86 e-i	53 f	35 g
Gum (0.1%)	0	3 a	0.12 c	25.71 a	126.67 ab	80 ab
	7	1.5 d-f	0.27 b	5.71 c-g	143.33 ab	75 bc
	14	1.5 d-f	0.23 b	6.43 cd	53.33 f	65 b-f
	21	1.4 d-f	0.35 a	4 i	63.33 f	58 d-f
Gum (0.2%)	0	3 a	0.12 c	25.71 a	126.67 ab	80 ab
	7	2.5 b	0.23 b	10.71 b	120 bc	58 c-f
	14	1.4 d-f	0.23 b	6 c-f	100 cd	74 b-d
	21	1.3 e-g	0.23 b	5.57 c-h	65 f	67 b-f
Gum (0.4%)	0	3 a	0.12 c	25.71 a	126.67 ab	80 ab
	7	2.3 bc	0.23 b	9.86 b	100 cd	57 ef
	14	1.5 d-f	0.23 b	6.43 cd	100 cd	73 b-e
	21	1.6 de	0.35 a	4.57 g-i	60 f	58 d-f
Cellophane film	0	3 a	0.12 c	25.71 a	126.67 ab	80 ab
	7	2.4 bc	0.39 a	6.29 cd	93.33 de	69 b-e
	14	1.2 fg	0.23 b	5.14 d-i	133.33 ab	60 c-f
	21	1.5 d-f	0.35 a	4.64 f-i	60 f	69 b-e

[a] Means in the column with the same letter are not significantly different ($P \leq 0.05$).

this period. In addition, probably, by modifying internal atmosphere, coating caused decrease in usage of sugars and organic acids due to reduction of respiration and metabolism. It is reported that 25-µm cast polypropylene and 25-µm biaxially oriented polypropylene films resulted in the accumulation of TA in button mushrooms (Aminzadeh *et al.*, 2014). Hassanpour (2015) reported that the aloe vera gel coating was effective in preserving the TA of raspberries during storage time.

Flavor Index (SSC/TA)

Flavor index, i.e. the ratio of sugars to acids (SSC/TA), determines taste and flavor. The preservation of flavor and taste is related to the control of water loss and the reduction of respiration, which are influenced by pre-harvest and post-harvest factors. As a result, consumption of stored substances, e.g. organic acids, is inhibited and the nutritional quality of the produce is kept at an optimal level (Robert, 2005). The flavor index decreased over storage time and the highest flavor index (25.71) was observed in all treatments at the beginning of the experiment (Table 1). Gum coatings and cellophane caused lower flavor index changes during storage. The use of edible coatings and packaging films around the produce hinders moisture evaporation and the shriveling of the produce by creating a saturated atmosphere. Since these coatings are impermeable to O_2 and CO_2 molecules, they create a modified atmosphere around the produce (fruits and vegetables) and this reduces respiration and delays aging and softening (Raghav *et al.*, 2016).

Ascorbic Acid (Vitamin C)

Ascorbic acid is of crucial importance for nutritional value, but it is very susceptible to decomposition by oxidation (Shivashankara *et al.*, 2004). The amount of ascorbic acid decreases or increases over storage time depending on storage conditions and treatments. The ascorbic acid content decreased over the storage period in all packaging and storage treatments, but the rate of decline was lower in the packaged samples than in the control (Oke *et al.*, 2012). Over storage time, vitamin C content decreased, but the samples coated with cellophane performed better in vitamin C preservation from day 7 on (Table 1). The ascorbic acid content of loquat fruit decreased at the end of the storage time, but cellophane film inhibited its sharp decline. This may be related to lower rates of respiration and ethylene synthesis during storage (Ashournezhad and Ghasemnezhad, 2012). In our study, Tragacanth gum at a rate of 0.2 and 0.4% also gave an optimal result for vitamin C preservation. Similarly, it was reported that ascorbic acid decreased during storage, but aloe vera gel coating retarded the decline of ascorbic acid of pineapples (Adetunji *et al.*, 2012). Ali *et al*. (2010) reported that gum arabic has antioxidant activities so that it increases antioxidant capacity and prevents the decline of vitamin C. Phenolic compounds present in the tragacanth gum exuded from the plant are responsible for its effective free radical scavenging, and antioxidant and antibacterial activities (Ghasemi Pirbalouti and Imaniyan-Fard, 2016).

ANTIOXIDANT ACTIVITY

Antioxidants are involved in scavenging Reactive Oxygen Species (ROS) produced during aging, so, their level goes down on the first days of storage, but ROS synthesis in vegetables exposed to different biotic stresses and those stored exceeds the antioxidant capacity of cells and this injures the cells and reduces antioxidant compounds. It has been reported that phenolic compounds are a key factor effective in antioxidant activity (Lemoine *et al.*, 2010). In this research, the samples had 80% antioxidant activity on the first day, but it declined over time. Although the samples treated with 0% gum exhibited an increased antioxidant activity (95%) on day 7, this parameter started to decrease from the next day so that the lowest antioxidant activity (35%) was recorded by the samples treated with 0% gum on day 21. The samples coated with gum (0.1, 0.2%, and 0.4%) and cellophane showed a decrease in their antioxidant activity, but this decline happened at a slower rate (Table 1). The antioxidant capacity of loquat increased slightly at the beginning of the storage period, but then decreased until the end of storage. However, the antioxidant capacity was significantly higher in the fruits coated with cellophane than in the control. This coating preserved antioxidant compounds and prevented loquats' loss of nutritional value during storage (Ashournezhad and Ghasemnezhad, 2012). Researchers studied the antioxidant capacity of mangos before and after the storage period and found that their antioxidant capacity did not change for 20 days in the storage, but then, it started to decline (Shivashankara *et al.*, 2004).

Total Phenol Content

As depicted in Figure 2-A, the highest total phenol content was 0.567 mg g^{-1} FW observed in the samples treated with 0.4% Tragacanth gum, and the lowest was 0.432 mg g^{-1} FW related to the cellophane. Phenolic compounds play a key role in the shelf life of horticultural produce as they make products resistant to different postharvest quality-reducing factors and edible coatings application increases phenolic compounds (Abebe *et al.*, 2017). The total phenol content increased during storage and the highest was observed on day

21 (0.646 mg g^{-1} FW) (Figure 2-B). It is reported that total phenol increased in coated lettuce leaves during storage by the post-harvest accumulation of phenol content due to crashing, water loss, and leaf tissue breaking (Rivera *et al.*, 2006). These results support our findings.

Total Flavonoid Content

Flavonoids are important secondary metabolites that play a significant role in reducing oxidative stress due to their antioxidant activity. Flavonols, flavones, flavanone, and anthocyanins are primary flavonoids in fruits and vegetables (Ignat *et al.*, 2011). Flavonoid content increased until day 14, after which it started to decline and the minimum amount was 0.237 mg g^{-1} FW observed on day 0 (Figure 3). Over storage time, the flavonoid content of grapes decreased, but the samples treated with 130 and 140 mg chitosan preserved flavonoids so that their flavonoid content was higher than the control (Ahmed *et al.*, 2018). It has been reported that tomatoes coated with carnauba edible coating exhibited longer shelf life and higher flavonoid content (Dávila-Aviña *et al.*, 2014). Strawberries coated with 2% chitosan had more flavonoids than the control (Petriccione *et al.*, 2015).

Organoleptic Properties Evaluation

The best appearance in terms of the color index was observed in the broccoli heads coated with cellophane (score 5) followed by those coated with 0.4% gum (score 4.6). The samples treated with 0.1% gum were scored the lowest (score 2) in color quality (Figure 4). Color is an essential appearance parameter that is influenced by chemical, biochemical, microbiological, and physical changes that happen during development and maturing and after harvest. Plastic covering retards color changes due to a combined impact on increasing moisture and changing atmospheric composition. Color change may be associated with chlorophyll degradation when chlorophyll pigments are bleached by radiation and oxygen. Enzymatic destruction of chlorophyll may also happen (Pathare *et al.*, 2013).

Assessment of broccoli aroma showed that the aroma score was the highest (4.6) in the control followed by those coated with cellophane and 0.4% gum (4.4). The lowest score was 2.8 related to 0.1% gum (Figure 4). Flavor and aroma are two important marketability features that make the product look attractive to customers. Fruits and

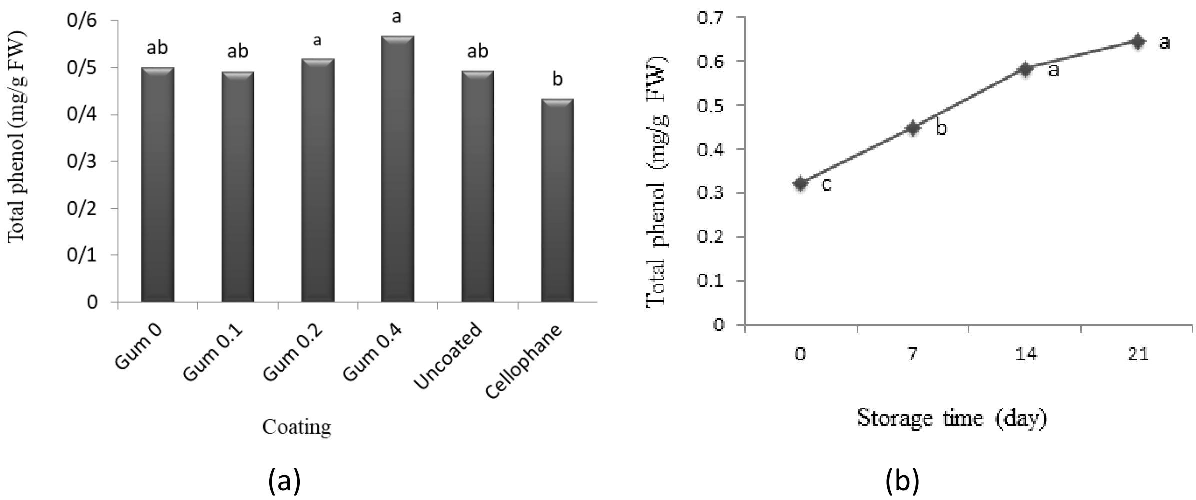

Figure 2. Effect of tragacanth gum coating (%) (A) and storage time (B) on total phenol of broccoli florets stored for 21 days at 4˚C.

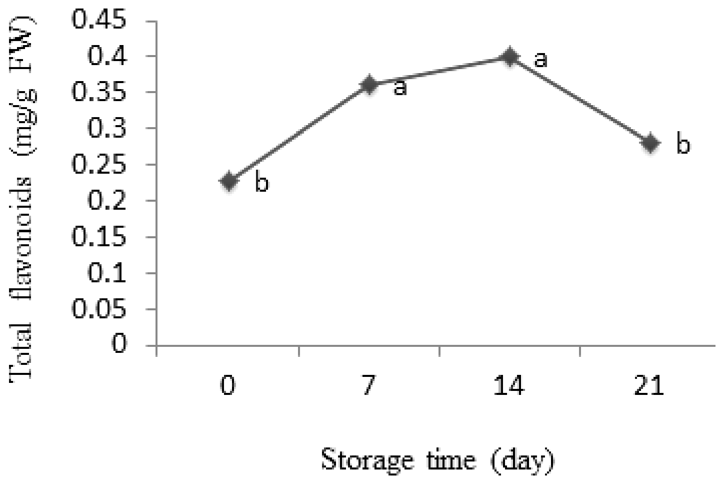

Figure 3. Effect of storage time on total flavonoids of broccoli florets stored for 21 days at 4˚C.

vegetables partially lose their aroma and flavor during long-term storage. By considering product metabolism and using various storage methods, chemical reactions that cause undesirable changes in aroma and flavor can be retarded in long-term storage or can be decelerated. The use of coatings and packages is also a key factor in protecting fruits and vegetables. Coating highly perishable agricultural products is a conventional way that reduces the rate of degradation of qualitative features such as texture firmness, aroma, flavor, and sensory characteristics and the rate of microbial growth by reducing their loss of moisture and respiration (Bifani *et al.*, 2007).

According to Figure 4, the samples coated with cellophane scored the best (5) in firmness followed by those treated with 0.4% gum (3.2). Firmness is a key factor determining the shelf life and marketability of fresh produce. Compared to the control, firmness of fruits coated with polymer was maintained better during cold storage, and it declined more gradually. The higher firmness of the coated samples may be related to the inhibitory activity of the coating substances that prevent water loss, thereby increasing water content and turgidity of the fruit tissue. Also, coatings

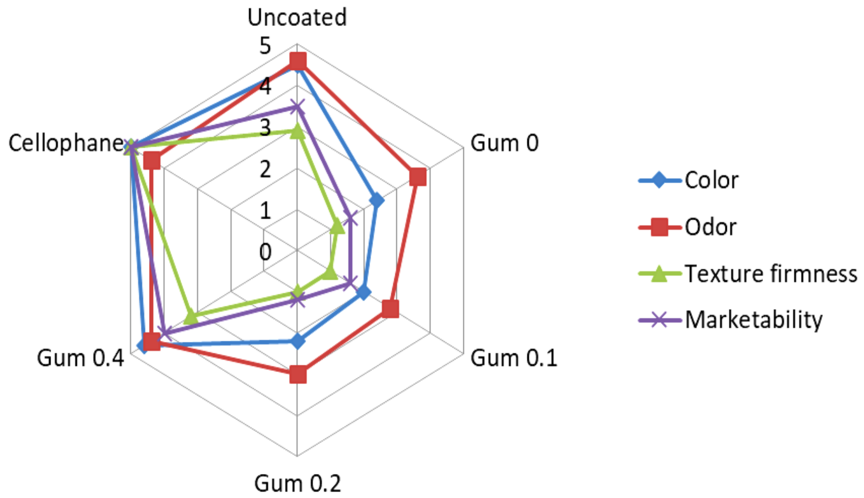

Figure 4. Organoleptic properties of tragacanth gum coated (%) broccoli florets stored for 21 days at 4˚C.

can reduce the activity of cell-wall-degrading enzymes that are responsible for tissue softening (No *et al.*, 2007). Better preservation of firmness has been reported for cherries and nectarines coated with aloe vera gel. Also, coating of peppers with Tragacanth gum contributed to controlling moisture loss from the fruit tissue and preserving its firmness versus the control (Mohebbi *et al.*, 2012).

The samples coated with cellophane scored the best (5) in general appearance quality and marketability. The next rank was for those coated with 0.4% gum (4). Appearance is a qualitative factor that can be assessed by sensory tests. Storage of fruits and vegetables with packaging coatings and films helps their quality retention and increases their shelf life, which results in a decrease in the rate of chemical reactions and the growth of pathogenic microorganisms (Ozturk *et al.*, 2016).

Jafari *et al*. (2018) stated that trehalose and *Artemisia sieberi* essential oil edible coatings improved some sensory and visual features of tomatoes including color, aroma, texture, and flavor, while they did not adversely affect the general acceptance, such that, 10 days after storage, the coated samples showed more optimal firmness, appearance, and marketability. These findings are similar to our results.

CONCLUSIONS

In conclusion, the results revealed the physicochemical traits and sensory features of broccoli florets affected by tragacanth gum-based edible coating and cellophane over a 21-day storage period. Although the uncoated treatments showed an increase in some traits, they were less marketable than the other treatments due to high weight loss, and shriveling. Among different rates of tragacanth gum, 0.2 and 0.4% outperformed the others.

Tragacanth gum at 0.2% led to less weight loss, though appropriate soluble solids content, titratable acidity, color, texture, aroma, and marketability, and higher content of antioxidants such as phenolic compounds were recorded for 0.4% coated florets.

The conventional cellophane coating of the broccoli florets preserved some physicochemical parameters, visual quality, weight, and their marketability, but the amount of antioxidant biochemical compounds, e.g., the invaluable compounds of phenols, did not increase acceptably and even decreased in some cases. In addition to the postharvest preservative treatments (e.g., coating films), the factor of storage time is also very effective for product quality. In this experiment, physicochemical and biochemical parameters and visual quality of the broccoli decreased over time. Although some traits, like TA and total phenol content, increased over time, the storage of broccoli for 7-14 days performed better in retaining internal traits and marketability. However, the effect of storage time on the other quality parameters needs to be assessed. Overall, tragacanth gum coating can be used as a biomaterial to substitute synthetic cellophane film to preserve broccoli.

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نگهداری کیفیت و افزایش ماندگاری گلچه‌های کلم بروکلی با استفاده از پوشش صمغ کتیرا

ف. وارسته، و س. زمانی

چکیده

کلم بروکلی (*Brassica oleracea* L. var. *italica*) به عنوان یک سبزی مهم دارای میزان تنفس پس از برداشت بالایی است، بنابراین پس از برداشت به سرعت کیفیت خود را از دست می‌دهد. استفاده از فیلم‌ها و پوشش‌های خوراکی به عنوان لایه‌های محافظ با ایجاد پوششی روی سطح میوه‌ها و سبزی‌ها نقش موثری در حفظ کیفیت این محصولات دارد. در پژوهش حاضر صفات کیفی و بیوشیمیایی کلم بروکلی پوشش داده شده با صمغ کتیرا (0 ، ۰/۱، ۰/۲ و ۰/۴ درصد) و سلفون و بدون پوشش (به عنوان شاهد) به صورت هفتگی در طی سه هفته نگهداری در سردخانه مورد بررسی قرار گرفت. بر اساس نتایج، پوشش بر تمام صفات اندازه‌گیری شده (به جز محتوای فلاونوئید، ویتامین ث و فعالیت آنتی اکسیدانی) و مدت زمان نگهداری بر تمام صفات ثبت شده به‌طور معنی‌داری (P<۰/۰۱) تأثیر داشت. نتایج نشان داد که طی دوره نگهداری، پارامترهای فیزیکوشیمیایی و بیوشیمیایی و کیفیت بصری کلم بروکلی کاهش یافت. صمغ کتیرا ۰/۲ درصد، منجر به کاهش وزن کمتر شد، اما محتوای مواد جامد محلول، اسیدیته قابل تیتر، خواص حسی و بازارپسندی مناسب در گلچه‌های پوشش داده شده با صمغ ۰/۴ درصد ثبت شد. سلفون در حفظ برخی از خصوصیات فیزیکوشیمیایی، وزن و بازارپسندی موثر بود، اما باعث کاهش مواد فنلی شد. پوشش صمغ کتیرا می‌تواند به عنوان ماده‌ای زیستی، به عنوان جایگزینی برای فیلم سنتزی سلفون برای نگهداری کلم بروکلی مورد استفاده قرار گیرد.