Improvement of Shelf Life and Physicochemical Quality of Fresh–Cut Green Bean Pods (*Phaseolus vulgaris* L. cv. *Polista*) Using Edible Coatings

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Abstract: Fresh-cut fruits and vegetables offer to consumers highly nutritious, convenient and healthful commodities in case of maintaining the freshness of the non-processed products. Postharvest technologies have allowed horticultural industries to meet the global demands of local and large scale production and intercontinental distribution of fresh produce that have high nutritional and sensory quality. Thus, the aim of this study was to evaluate the physicochemical and microbiological parameters of fresh-cut green bean pods (*Phaseolus vulgaris L. cv. Polista*) stored at 4°C for 20 days with edible coatings. Edible coatings prepared with carrageenan, guar gum, potassium sorbate and citric acid were tested. The analyses carried out on the samples were: total sugars, L- ascorbic acid, weight loss, firmness, color attributes, total phenolics, total flavonoids, antioxidant activity, as well as, microbiological analysis (total viable bacteria, psychrophilic bacteria and yeast and mold counts). The results indicated that coated pods (carrageenan, guar gum, potassium sorbate and citric acid) extended and improved their shelf life quality due to minimization of the physicochemical changes. Therefore, the results indicated that the formulated edible coating has potential to extend the shelf life and maintain quality of fresh-cut green bean pods.

Keywords**: G**reen beans, carrageenan, guar gum, potassium sorbate, citric acid color attributes, firmness, weight-loss, storage, safety

INTRODUCTION

Phaseolus vulgaris, the green bean, is an herbaceous annual plant belonging to Fabaceae. Green beans are annual or multi-annual plant cultivated for its edible pods or the seeds inside them. Green beans are often sold canned or frozen. Egypt has a significant comparative advantage in the production of horticultural commodes including green bean for export, based on its geographic position and agro-climatic conditions. Egypt is the sixth largest producer in the world of green (FAO STAT, 2014), it estimated 253.100 tons.

Green beans are rich in carotene, vitamins, and minerals. It is a source of vitamin B, macro-and micro-nutrients (Al-Sanabani *et al.,* 2016). Green beans are climacteric type of respiration pattern, therefore, changes in the texture, flavor and appearance are limiting factors of the quality of minimally processed products (Kasim and Kasim, 2015).

Green beans are generally harvested at a physiologically immature stage of development. Growth is most rapid at the time of harvest and beans exhibit comparatively higher respiration rate, even when held at low temperatures, cutting of green bean also accelerates respiration rate more than in intact beans. Therefore, the quality of fresh-cut green bean decreases rapidly. In order to prevent the loss of quality of fresh-cut vegetables, several treatment methods are being practiced .In order to slow down the changes that occur after harvesting, studies on the use of edible coating in order to prolong shelf life of fruits and vegetables (Kasim and Kasim, 2015).

Vegetables have a natural waxy coating, called a cuticle, made up of fatty acid–related substances (waxes and resins) with low water permeability. This waxy layer may be removed or altered during washing (Hagenmaier and Baker, 1993a), resulting in increasing water loss and subsequent weight loss in uncoated commodities. Wax and oil coatings have been shown to retard desiccation of many vegetables. If pores, cracks, or pinholes occur in the film surface, mass transfer of water vapor through these areas may be much more rapid than dissolving and diffusion of water vapor through a film barrier (McHugh and Krochta, 1994b). Water vapor transfer through films is dependent on the environmental conditions, such as temperature and humidity, as mentioned above, and thus should be tested under conditions that are expected to be encountered by a specific product.

Optimal postharvest treatments for fresh produce seek to slow down physiological processes of senescence and maturation, reduce/inhibit development of physiological disorders, and minimize the risk of microbial growth and contamination. In addition to basic postharvest technologies for temperature management, an array of others has been developed, including various physical (heat, irradiation and edible coatings); chemical (antimicrobials, antioxidants and anti-browning); and gaseous treatments. Edible coating is used to inhibit migration of moisture, oxygen, Carbone dioxide, aromas and lipids and to improve the mechanical integrity or handling characteristics of foods (Röjao- Graü *et al*., 2011).

Edible films should have adequate mechanical strength and extensibility to maintain integrity and withstand the external strength that occurs during processing, handling and storage (Yang and Paulson, 2000). These films can be obtained from different types of materials, but the most used ones made of polysaccharides, proteins and lipids (Chang, 1995). According to Olivas and Barbosa-Canovas (2005), some polysaccharides such as carrageenan have been used

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successfully in the coverage of minimally processed fruits. Carrageenan is water-soluble galactose polymers extracted from red seaweed; it contains a linear chain of partially sulphated galactose which has ability to forming coating material forming. Carrageenan film formation includes this gelation mechanism during moderate drying, leading to a three – dimensional network formed by polysaccharides double helices and to a solid film after solvent evaporation (Karbowiak *et al*., 2006). Gums in edible-forming preparation are used for their texturizing capabilities. All gums including Guar gum are polysaccharides composed of sugars other than glucose those called galactomannans (Mahajan *et al*., 2014).

Edible coating has also been studied as potential carriers of active ingredients such as antioxidants, antimicrobial, coloring agents, probiotics, plasticizers and nutroceuticals. (Pranoto *et al*., 2005). Fresh – cut processing alters the integrity of fruits and vegetables, bringing about the negative effects as product quality such as browning, off – flavor development, texture breakdown and proliferation of microorganisms, thus reducing the shelf life of fresh- cut fruit commodities. Various techniques such as modified atmosphere, enzymes and browning inhibitors, texture stabilizers and antimicrobial dips are employed to delay these negative effects. The application of each technique has advantages and drawbacks. Edible coating offer excellent prospects for extending the shelf life of fresh cut product by reducing the deleterious effects caused by minimal processing operations (Röjao-Graü *et al*., 2011).

Fresh fruits and vegetables are highly perishable and approximately 50% fresh produce is deteriorated during harvest, handling, transportation and storage. Edible coating plays a very important role to handle this situation. Edible coatings are applied on whole and fresh–cut fruits and vegetables (Dhall, 2011; Youssef *et al*., 2015). Plasticizers are mixed in solution of edible coating for increase mechanical property. These contain low molecular weight, it is mixed with protein coating material for enhancing and change it is structural ability- water, as well as, citric acid is also natural and effective plasticizers (Sothernvit and krochla, 2005).

Thus, the aim of this study was to evaluate the physicochemical and microbiological parameters of fresh-cut green bean pods (*Phaseolus vulgaris L.cv. Polista*) stored at 4ºC for 20 days with edible coatings.

MATERIALS AND METHODS

Materials

Green bean pods (*Phaseolus vulgaris L.cv. Polista*), were obtained from a farm near Giza governorate at the immature physiological stage (green –skin color). Carrageenan and guar gum were purchased from United Co., Egypt. Citric acid and potassium sorbate were purchased from El-Nasr pharmaceutical chemicals Co., Egypt.

Methods

Preparation and application of edible coatings

Carrageenan and/or guar gum coating solutions (0.25%) were prepared according to Karbowiak *et al.* (2006) by dissolving 0.25g of carrageenan and guar gum powder in 100 ml distilled water at 70ºC for 10 min under magnetic stirring. Potassium sorbate (0.15 g) and citric acid (1g) were separately added to the above mentioned solutions to produce antimicrobial coating solutions.

Experimental design

The pods were washed, drained and divided into 10 batches as follows:

T1. Control samples without coating, antimicrobial and antioxidant agents
T2. Guar gum solutions only.
T3. Guar gum solutions containing potassium sorbate.
T4- Guar gum solutions containing potassium sorbate and citric acid.
T5- Carrageenan solutions only.
T6. Carrageenan solutions containing potassium sorbate.
T7- Carrageenan solutions containing potassium sorbate and citric acid.
T8- Carrageenan and Guar gum solutions only.
T9- Carrageenan and Guar gum solutions containing potassium sorbate.
T10- Carrageenan and Guar gum solutions containing potassium sorbate and citric acid.

Fresh green bean pods were immerged in the above mentioned coating solutions separately for 1 min and kept at room temperature to allow the coating to dry. All pods were packed in polyethylene containers and stored at 4ºC and 90% humidity degree. Green bean pods samples were withdrawn at intervals every10 days for analysis.

Analytical methods

Chemical analysis

All Samples were determined as follows: L-ascorbic acid, and sugar content were determined according to the method of AOAC (2012).

Determination of total phenolic compounds (TPC)

Total phenolic compounds (TPC) were determined by the Folin-Cicalteau method as described by (Singleton *et al*., 1999), with minor modifications. Gallic acid was used for calibration curve. Results were expressed as mg Gallic acid (GAE).

Determination of total flavonoids

Total flavonoids content was determined by using aluminum chloride calorimetric method, as described by (Chang, *et al*., 2002). The results were expressed as catechin equivalents (CE) in mg/100g of dried extract.

Determination of antioxidant activity

The antioxidant activity of free and bound phenolic extracts was measured by using 1, 1-diphenyl-2-picrylhydrazyl (DPPH) scavenging as previously described by (Hung and Morita, 2009).

Determination of total carotenoids, chlorophyll a and chlorophyll b

Total carotenoids, chlorophyll a (Chl. A) and chlorophyll b (Chl. b) were determined as described by Ranganna (1977).

Physical analysis

Texture profile analysis

Both coated and uncoated green bean pods texture was measured by a universal testing machine (Cometech, B type, Taiwan). Flat head stainless cylindrical probe of 2 mm diameter was used for penetration test. The start of penetration test was the contact of the probe and sample surface, finish – when the probe penetrated the tissues to 50% of sample height. The probe speed was 1 mm s^{-1}. (Bourne, 2002) the values are expressed Newton (N).

Weight loss

Weight loss of fresh green bean pods was determined gravimetrically using analytical balance during storage period Han *et al.* (2004) by monitoring the weight changes of pods during storage periods. Weight loss was calculated as a percentage loss of initial weight using the following equation:-

Weight loss%= [(initial pod's weight - final pod's weight) x 100] / initial pod's weight

Color measurement

To determine the color of the samples, five measurements were performed on the pod skin using a Minolta color reader CR-400 (Minolta Co. Ltd., Osaka, Japan). Lightness (L*), green to red (a*), and blue to yellow (b*) were evaluated using the Hunter scale McGuire (1992).

Microbiological analysis

Total viable bacterial count, psychrophilic bacteria, molds and yeasts were determined using the methods by American Public Health Association (2001). All the microbiological counts were carried out in three replicates. The plates were incubated at 37˚C for 48 hours (total viable bacteria), 7˚C for 5-7 days, hours (psychrophilic bacteria) and 20-25˚C for 3days (yeasts and molds). The results were expressed as (CFU/g).

Statistical analysis

The results (mean± standard deviation) were statistically analyzed by analysis of variance (ANOVA) using the statistical package (SAS) software (version 9.4) according to (Steel and Torri, 1980). To establish significant difference a significant level of P≤0. 05 was applied.

RESULTS AND DISCUSSIONS

Effect of coating materials on total sugars and L-ascorbic acid of green bean pods during cold storage

The effect of coating materials on total sugars (%, on dry weight basis.), of green bean pods during storage was shown in Fig. (1). According to the formulas consisted of carrageenan and guar gum solutions containing potassium sorbate and citric acid (T10) had best effect for maintaining the sugar content followed by (T9) compared to all treatments.

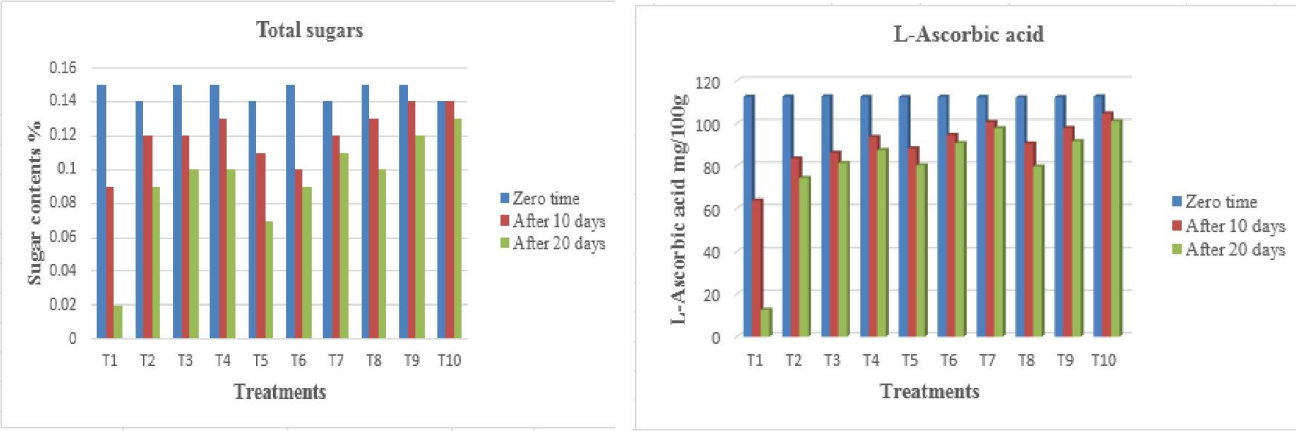

Fig. (1): Effect of coating materials on total sugars (%) and L-ascorbic acid (mg/100g, on dry weight basis.), of green bean pods during storage at 4°C.

T1: Control samples without coating, antimicrobial and antioxidant agents. **T2:** Guar gum solutions only. **T3:** Guar gum solutions containing potassium sorbate. **T4:** Guar gum solutions containing potassium sorbate and citric acid. **T5:** Carrageenan solutions only. **T6:** Carrageenan solutions containing potassium sorbate. **T7:** Carrageenan solutions containing potassium sorbate and citric acid. **T8:** Carrageenan and Guar gum solutions only. **T9:** Carrageenan and Guar gum solutions containing potassium sorbate. **T10:** Carrageenan and Guar gum solutions containing potassium sorbate and citric acid.

These results may be due to the using of different formulas of coating material which decreased the losing of sugar content by decreasing the consumption of sugar in respiration and the growth of microorganisms. These results in agreement with Wills and Gonzalez (1998), who mentioned that the decrease in sucrose content is due to its degradation, releasing fructose and glucose for respiration. Meanwhile, the effect of coating materials on L-ascorbic acid values of green bean pods during storage is shown in Fig. (1). The ascorbic acid values decreased during the storage period in all treatments of coated green bean pods. These results were observed clearly in the case of formulas containing citric acid, which considered as antioxidant agent and the using of different coating materials, maintaining the L-ascorbic acid content at the end of storage period. These findings

were in agreement with Oms-Oliu *et al.* (2008) who mentioned that although L-ascorbic acid of both coated and uncoated samples decreased throughout storage, the use of gellan-based edible coatings significantly reduced the loss of L-ascorbic acid in fresh-cut melon pieces. Keeping oxygen away delays the deteriorative oxidation reactions of L-ascorbic acid. The coating minimized the loss of ascorbic acid. From the previous results it was clear that there were a significant difference between all coated treatments and control sample specially for T10.

Effect of coating materials on phytochemical components contents and antioxidant activity of green bean pods during cold storage

Total phenols, total flavonoids and antioxidant activity of green bean pods were listed in Table (1).

Table (1): Effect of coating materials on phytochemical components contents and antioxidant activity of green bean pods during storage at 4°C (on dry weight basis)

Treatments	T. phenol mg/100 g			T. flavonoid mg/100 g			Antioxidant activity %		
	Storage, days								
	Zero Time	After 10 days	After 20 days	Zero Time	After 10 days	After 20 days	Zero time	After 10 days	After 20 days
T1	187.13^{a} ±1.73	105.22^{e} ±1.22	59.11^{g} ±1.07	24.89^{a} ±0.34	12.52e ±0.12	3.52^{f} ±0.05	14.01^{a} ±0.24	6.41^{d} ±0.10	2.23^{h} ±0.08
T2	188.00^{a} ±3.05	141.55^{d} ±2.43	142.98^{f} ±1.99	23.13^{a} ±0.36	18.33^{b} ±0.11	11.65^{cd} ±0.25	14.54^{a} ±0.18	9.65^{c} ±0.12	7.56^{f} ±0.29
T3	186.35^{a} ±1.73	183.74^{ab} ±1.52	176.85^{d} ±1.64	24.34^{a} ±0.26	15.35^{cd} ±0.22	13.54^{bc} ±0.32	14.45^{a} ±0.26	12.98^{a} ±0.25	8.01^{e} ±0.33
T4	188.12^{a} ±1.98	187.52^{a} ±2.41	181.78^{abc} ±1.79	24.61^{a} ±0.20	21.45^{a} ±0.13	16.98^{a} ±0.42	14.67^{a} ±0.37	13.88^{a} ±0.31	9.25^{c} ±0.29
T5	187.53^{a} ±2.02	182.14^{b} ±1.90	152.18^{e} ±1.51	23.11^{a} ±0.23	14.58^{d} ±0.19	8.35d^{e} ±0.11	14.06^{a} ±0.43	12.42^{ab} ±0.40	7.45^{g} ±0.34
T6	188.42^{a} ±1.75	185.24^{ab} ±1.73	181.16^{abc} ±1.33	24.82^{a} ±0.12	17.24^{bcd} ±0.15	12.47^{bc} ±0.19	14.20^{a} ±0.31	12.72^{ab} ±0.37	8.00^{e} ±0.39
T7	188.64^{a} ±1.73	187.11^{a} ±2.64	183.62^{ab} ±2.05	24.44^{a} ±0.32	22.31^{a} ±0.12	15.11^{ab} ±0.35	14.83^{a} ±0.29	13.97^{a} ±0.32	9.27^{c} ±0.52
T8	187.98^{a} ±2.01	157.45^{c} ±3.06	178.99^{cd} ±2.11	23.98^{a} ±0.33	17.56^{bc} ±0.22	10.22^{e} ±0.22	14.51^{a} ±0.20	10.45^{bc} ±0.13	9.02^{d} ±0.42
T9	187.77^{a} ±1.92	184.65^{ab} ±4.01	180.04^{bcd} ±1.88	24.17^{a} ±0.24	18.02^{bc} ±0.21	12.21^{c} ±0.28	14.11^{a} ±0.35	13.79^{a} ±0.41	9.43^{b} ±0.32
T10	188.33^{a} ±1.71	186.14^{ab} ±3.46	184.55^{a} ±1.58	24.54^{a} ±0.45	23.05^{a} ±0.23	17.62^{a} ±0.48	15.45^{a} ±0.12	14.52^{a} ±0.32	10.12^{a} ±0.28

Values are mean ±SD of three replicates**.** Different letters in each column show significant difference. All statistical analysis was performed at $P< 0.05$.

T1: Control samples without coating, antimicrobial and antioxidant agents. **T2:** Guar gum solutions only. **T3:** Guar gum solutions containing potassium sorbate. **T4:** Guar gum solutions containing potassium sorbate and citric acid. **T5:** Carrageenan solutions only. **T6:** Carrageenan solutions containing potassium sorbate. **T7:** Carrageenan solutions containing potassium sorbate and citric acid. **T8:** Carrageenan and Guar gum solutions only. **T9:** Carrageenan and Guar gum solutions containing potassium sorbate. **T10:** Carrageenan and Guar gum solutions containing potassium sorbate and citric acid.

From Table (1), it could be observed that there were significant differences between all treatments. Total phenolic compound decreased during different storage periods, and it was observed that all coated samples maintained phenolic compounds during storage periods with little changes in their contents, specially for (T4, T5, T10 and T7, respectively) which show the lowest decreasing rates reached to 0.33, 1.89, 2.03 and 2.66%, respectively, compared with uncoated green bean pods which had a significantly greater decrease reached to 68.41%. These results may be due to coating materials and incorporating with potassium sorbate and citric acid, which may form a protective barrier on the pod's surface and reduce the oxygen supply for enzymatic oxidation of phenols. The same results were recorded by (Macheix *et al*., 1990; Feng *et al*., 2015) who mentioned that the decrease in phenols might be due to breakdown of cell structure as the fruit senesce and the using of coating materials reduce the enzymatic oxidation of phenols. In the same trend, the result confirmed that total flavonoids contents and antioxidant activity were affected by using coating treatments, but, in low rate compared to the uncoated sample (T1) which had the highest decreasing ratio reached to 85.86 and 84.73%, respectively, for total flavonoids content and

antioxidant activity, which may be due to the surrounding aerobic conditions.

Effect of coating materials on photosynthesis pigment contents of green bean pods during cold storage

The contents of photosynthesis pigments chlorophylls (a and b) and total carotenoids) of green bean pods influenced by coating materials are presented in Table (2). There were significant differences (P≤0. 05) between all treatments for chlorophylls (a and b) and total carotenoid levels, the main photosynthesis pigments, were found to be the highest levels and the lowest reduction of coated green bean pods which recorded to be 10.68, 14.74 and 22.00% (T10, T7 and T4, respectively) these given results may be due to incorporating of coating materials in addition of the presence of citric acid, which maintaining photosynthesis pigments followed by the other coating treatments.

Meanwhile, the lowest levels and the highest reduction were recorded to uncoated sample (T1) during the storage periods reached to 133.90%. On the other hand, it could be notice that total carotenoid contents were minimized increasing for coating, green bean pods (T10, T7 and T4, respectively) and the other coating treatments compared with the uncoated sample (T1) which recorded highest rate of increasing during the storage periods reached to 133.90%., these given results may be due to chlorophyll degradation and conversion to carotenoids during storage period at 4°C.

These results were in good agreement with those reported by (Chang *et al.,* 2003) and (Figueriredo *et al.,* 2002), who got similar results and mentioned that the increasing of carotenoids during refrigerator storage due to chlorophyll degradation and converted it carotenoids at minimized rate.

The use of coatings considerably reduces pigment changes in pods. These changes can be due to the modified atmosphere created in the pods, with high level of CO_2 and low level of O_2 retarding the maturation processes. (Gonzalez-Aguilar *et al*., 2005, Bosquez- Malina, 2005).

Table (2): Effect of coating materials on photosynthesis pigments (Chlorophyll a, Chlorophyll b contents and total carotenoids of green bean pods during storage at 4°C (on dry weight basis)

Treatments	Chl. a mg/100 g			Chl. b mg/100 g			T. carotenoids mg/100 g		
	Storage, days								
	Zero time	After 10 days	After 20 days	Zero time	After 10 days	After 20 days	Zero time	After 10 days	After 20 days
T1	513.12 ^{a} ±4.70	204.32 ^{i} ±2.34	87.25 ^{j} ±1.02	299.26 ^{a} ±1.98	101.08 ^{h} ±1.11	57.85 ^{j} ±0.96	170.23 ^{a} ±1.78	282.41 ^{a} ±1.84	398.20 ^{a} ±2.86
T2	513.35 ^{a} ±3.34	416.12 ^{d} ±1.86	214.85 ^{h} ±1.32	299.35 ^{a} ±1.76	162.15 ^{g} ±1.23	158.55 ^{i} ±1.62	170.04 ^{a} ±1.97	223.34 ^{c} ±1.46	242.21 ^{b} ±1.35
T3	513.27 ^{a} ±4.01	315.86 ^{h} ±3.25	289.14 ^{g} ±1.67	299.21 ^{a} ±2.06	199.55 ^{e} ±1.30	173.15 ^{f} ±1.41	170.12 ^{a} ±2.21	201.82 ^{e} ±2.14	233.34 ^{c} ±2.55
T4	513.75 ^{a} ±2.74	495.18 ^{a} ±2.94	388.01 ^{c} ±1.77	299.76 ^{a} ±2.49	240.87 ^{c} ±2.48	216.24 ^{b} ±2.55	170.40 ^{a} ±1.63	191.15 ^{f} ±1.79	207.89 ^{e} ±1.61
T5	513.11 ^{a} ±3.80	354.27 ^{g} ±3.01	210.53 ^{I} ±2.00	299.19 ^{a} ±1.56	189.25 ^{f} ±1.08	191.32 ^{d} ±1.73	170.15 ^{a} ±1.45	231.25 ^{b} ±2.66	246.33 ^{b} ±1.70
T6	513.25 ^{a} ±2.99	400.83 ^{f} ±2.22	381.87 ^{d} ±2.89	299.28 ^{a} ±2.41	192.40 ^{f} ±1.56	166.45 ^{h} ±1.64	170.34 ^{a} ±2.33	212.64 ^{d} ±1.59	225.16 ^{d} ±2.23
T7	513.80 ^{a} ±3.18	462.46 ^{b} ±2.64	397.24 ^{b} ±1.55	299.80 ^{a} ±1.80	247.99 ^{b} ±2.47	210.59 ^{c} ±2.75	170.46 ^{a} ±2.67	185.61 ^{f} ±1.88	196.58 ^{f} ±1.37
T8	513.10 ^{a} ±2.11	405.55 ^{e} ±3.15	328.45 ^{f} ±1.68	299.34 ^{a} ±2.04	197.75 ^{e} ±1.64	169.65 ^{g} ±2.01	170.22 ^{a} ±1.46	199.34 ^{e} ±2.57	219.62 ^{d} ±1.71
T9	513.31 ^{a} ±3.51	435.11 ^{c} ±2.04	365.21 ^{e} ±2.14	299.15 ^{a} ±2.59	206.11 ^{d} ±1.35	179.21 ^{e} ±1.05	170.18 ^{a} ±1.81	191.98 ^{f} ±1.75	211.35 ^{e} ±1.38
T10	513.95 ^{a} ±3.00	498.24 ^{a} ±2.71	409.65 ^{a} ±1.54	299.86 ^{a} ±1.32	268.22 ^{a} ±2.66	226.13 ^{a} ±2.21	170.57 ^{a} ±1.94	179.14 ^{g} ±2.40	188.78 ^{g} ±2.10

Values are mean ±SD of three replicates**.** Different letters in each column show significant difference. All statistical analysis was performed at $P< 0.05$.

T1: Control samples without coating, antimicrobial and antioxidant agents. **T2: T1**Guar gum solutions only. **T3:** Guar gum solutions containing potassium sorbate. **T4:** Guar gum solutions containing potassium sorbate and citric acid. **T5:** Carrageenan solutions only. **T6:** Carrageenan solutions containing potassium sorbate. **T7:** Carrageenan solutions containing potassium sorbate and citric acid. **T8:** Carrageenan and Guar gum solutions only. **T9:** Carrageenan and Guar gum solutions containing potassium sorbate. **T10:** Carrageenan and Guar gum solutions containing potassium sorbate and citric acid.

Effect of edible coating on physical properties of green beans

Physical properties (color, firmness and weight loss) of the uncoated and coated green bean pods were determined to study the effect of previously mentioned edible coatings on such properties.

Effect of edible coating materials on the firmness and weight loss of green bean pods during cold storage

Losses in the texture and consequent drop in consumer acceptability are the most noticeable change occurring in fruits and vegetables during prolonged storage (Verela *et al*., 2007). The firmness of green bean pods as affected by coating materials are shown in Fig. (2). From the most effective treatment in maintaining the firmness of green bean pods was (T8, T9, and T10) the incorporation of carrageenan and guar gum solutions with or without potassium sorbate and citric acid, which provided the highest value reaching 11.71 N when compared with other treatments at the end of storage period. Meanwhile, the lowest firmness value was (2.41 N) recorded to control sample (T1).

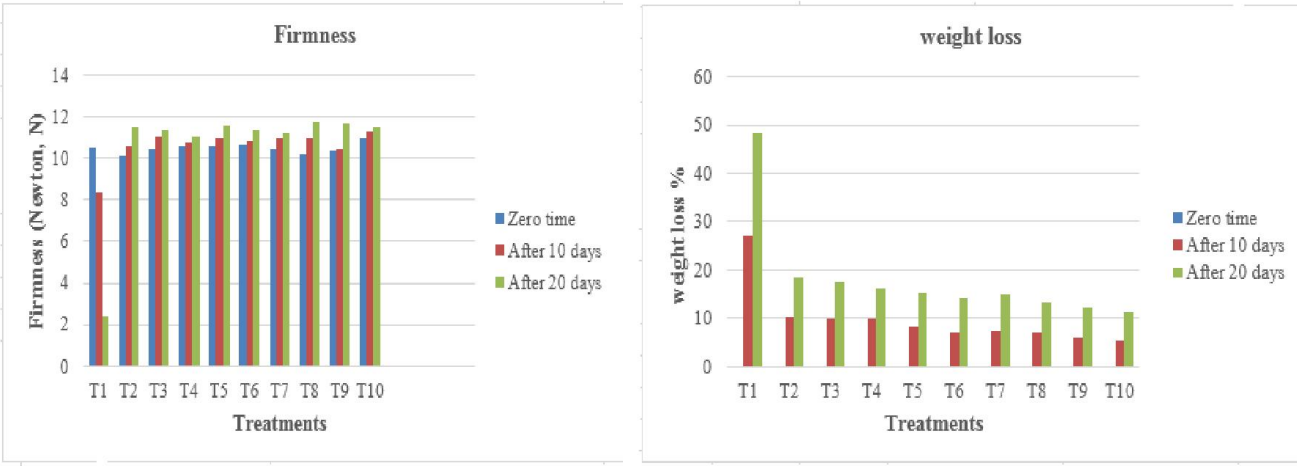

Fig. (2): Effect of coating materials on firmness (Newton, N) and weight loss (%) of green bean pods during cold storage at 4°C

T1: Control samples without coating, antimicrobial and antioxidant agents. **T2:** Guar gum solutions only. **T3:** Guar gum solutions containing potassium sorbate. **T4:** Guar gum solutions containing potassium sorbate and citric acid. **T5:** Carrageenan solutions only. **T6:** Carrageenan solutions containing potassium sorbate. **T7:** Carrageenan solutions containing potassium sorbate and citric acid. **T8:** Carrageenan and Guar gum solutions only. **T9:** Carrageenan and Guar gum solutions containing potassium sorbate. **T10:** Carrageenan and Guar gum solutions containing potassium sorbate and citric acid.

These results may be due to the using of more than coating material with the addition of potassium sorbate, which are protecting the green bean pods from rotting and keeping it in a good texture T10, indicated that coating treatments maintain firmness this phenomenon may be due to the inhibition of water loss and the activates of pectin degrading enzymes closely related to fruit softening by reducing the rat of metabolic processes during senescence (Conforti and Zinck, 2002; Zhau *et al*., 2007).

On the other hand, the effect of coating materials on weight loss of green bean pods is shown in Figure (2). Weight loss value increases constantly ($p \leq 0.05$) during the evaluation period in all treatments. However, the coated pods had lower losses when compared with uncoated samples (T1) especially, T10 samples. It could be due to using different coating materials which corresponding of retaining the fluid and delay migration of moisture from the pods and decrease the respiration rate. These results correspond to the finding of (Ali *et al.,* 2013a) who stated that vapor pressure differences between product and the surrounding storage atmosphere is the fundamental mechanism of weight loss from post-harvest fruits and vegetables. This is attributed to the reduction of open area of the solids networks, which restricted the transport of water vapor from the inside (Bàez *et al*., 2001), even though weight loss can also increase due to respiratory heat, (Xiao *et al.,* 2010) who explained that this was ascribed to the fact that edible coating on the fruit surface can retain the fluid and delay to great extend migration of moisture from the fruit to the environment and decrease the respiration rate. The reduction in weight loss is very important so fruits keep desirable to the consumer, and the use of edible coatings is an excellent tool to control the weight reduction (Silva *et al.,* 2012).

Effect of edible coating on color attributes (L*, a* and b*) of green bean pods during storage

The primary criterion that the consumers consider about a product is its appearance; color has been considered to have a key role in the choice of food. The color result is an important indication of the shelf life of fruits and vegetables. The level of skin color which is an important parameter to predict the shelf life of pods, food preference and acceptability, and may even influence taste thresholds, sweetness, perception and pleasantness.

Color is one of the main attributes, along with texture, that characterizes the freshness of most vegetables (Rico *et al*., 2007b). Color of fruit and vegetables is derived from natural pigments, many of which change as the plant proceeds through maturation and ripening. Color parameters, i.e., lightness (*L** value), redness (*a** value) and yellowness (*b** value) of uncoated and coated green bean pods were determined as presented in Fig. (3). from the results in Fig. (3). It could be noticed that using of guar gum and carrageenan as coating materials with the addition of potassium sorbate and citric acid (T10) followed by T7 and T4 reduced color deterioration of coated green bean pods during storage compared with (T1) or other formulas. It was cleared from the results presented in Table (2) that The incorporation of potassium sorbate and citric acid into guar gum and carrageenan coating influenced on the color and maintained the plant pigments such as chl. a, b which resulted in the best external color parameters and *L**, *a** values were increased, on the other hand, b* values were reduced. These results are in agreement with Narsaiah *et al.* (2015) who reported that slower color change in the coated samples could be attributed to the slow respiration rate which in turn delayed ripening and senescence.

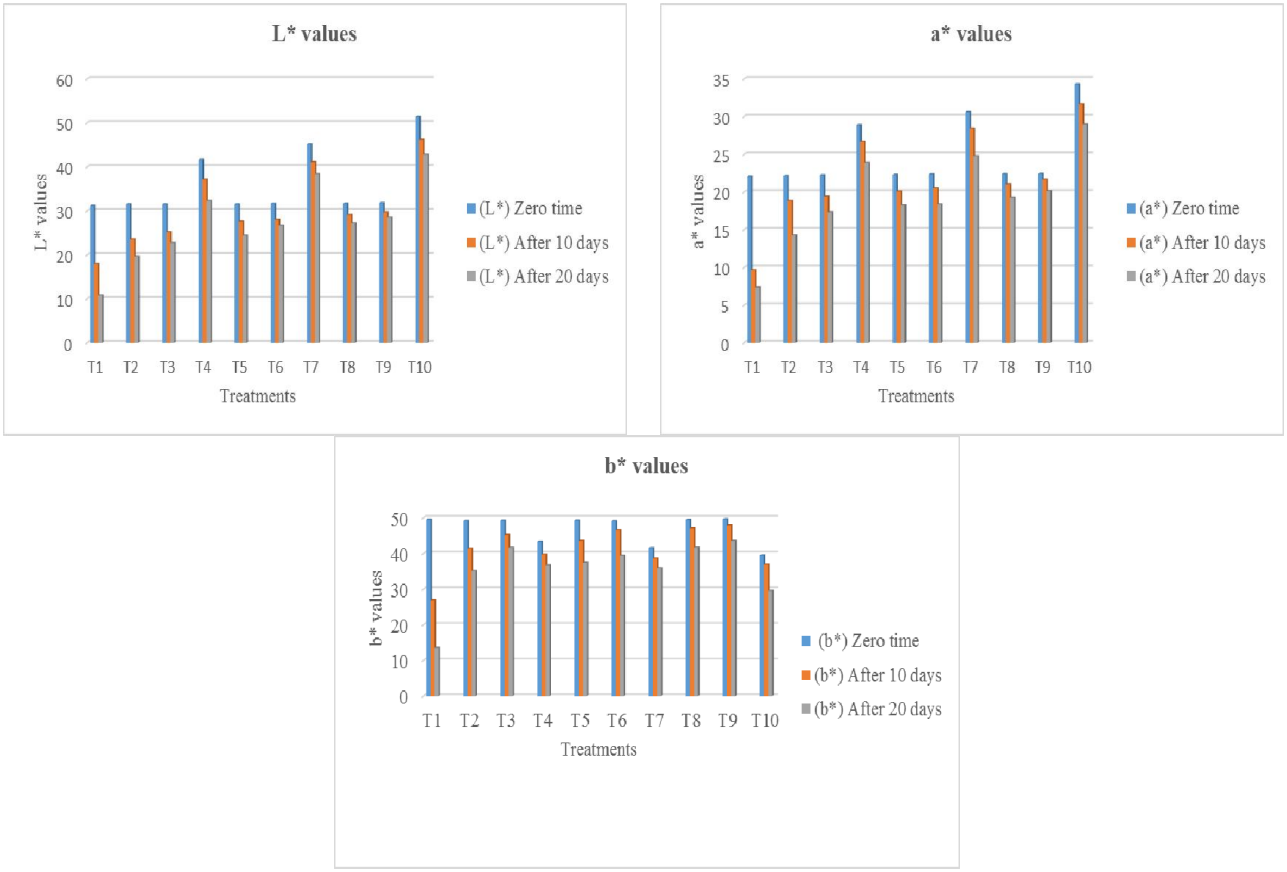

Fig. (3): Effect of coating materials on color attributes (L*, a* and b*) of green bean pods during storage at 4°C.

T1: Control samples without coating, antimicrobial and antioxidant agents. **T2:** Guar gum solutions only. **T3:** Guar gum solutions containing potassium sorbate. **T4:** Guar gum solutions containing potassium sorbate and citric acid. **T5:** Carrageenan solutions only. **T6:** Carrageenan solutions containing potassium sorbate. **T7:** Carrageenan solutions containing potassium sorbate and citric acid. **T8:** Carrageenan and Guar gum solutions only. **T9:** Carrageenan and Guar gum solutions containing potassium sorbate. **T10:** Carrageenan and Guar gum solutions containing potassium sorbate and citric acid.

Effect of coating materials on the microbial quality of green bean pods during storage

The effect of different treatments of coating materials on microbial counts (total bacterial count, yeast and mold and psychrophilic bacteria counts) of green bean pods is presented in Table (3). T10 sample were the most effective treatment in inhibiting microbial growth at the end of cold storage periods 20 days.

From the previously mentioned results in Table (3) it could be concluded that coating, green bean pods using of carrageenan and guar gum solutions with the incorporation of potassium sorbate and citric acid, prolonged its shelf life until the 20th day of storage.

These results are in agreement with those obtained by Campos *et al.* (2012) stated that edible coating provided reductions in counts of psychrophilic microorganisms on cold stored strawberry fruits and Parra *et al.* (2014) stated that potassium sorbate either alone or in wax as the carrier had the potential to be environmentally compatible, nontoxic postharvest fungicides to be used against citrus mold. As well as, the count below the maximum permissible count recommended by (CAC, 2003). Therefore, T10 can be used as a protective barrier on pods.

Table (3): Effect of coating materials on microbial counts (CFU/g) of green bean pods during cold storage at 4°C

Treatments	Total count			Yeast and mold			Psychrophilic		
	Storage, days								
	Zero Time	After 10 days	After 20 days	Zero Time	After 10 days	After 20 days	Zero Time	After 10 days	After 20 days
T1	$3.5x10^1$	$2 x10^3$	$12.2x10^4$	$3 x10^1$	$4.3x x10^2$	$12.1 x10^2$	$2.5x10^2$	$1.2 x10^3$	$9.2x10^4$
T2	$3.4 x10^2$	$3.8 x10^2$	$4.7 x10^2$	$1.3 x10^2$	$1.4 x10^2$	$2.8 x10^2$	$2.4 x10^2$	$2.7 x10^2$	$3.6 x10^2$
T3	$2.8 x10^2$	$3.3 x10^2$	$4.2 x10^2$	$1.2 x10^2$	$1.1 x10^2$	$2.3 x10^2$	$2.0 x10^2$	$2.3 x10^2$	$3.1 x10^2$
T4	$3.3 x10^2$	$3.5 x10^2$	$4.0 x10^2$	$2.1 x10^2$	$1.1 x10^2$	$1.9 x10^2$	$2.1 x10^2$	$2.5 x10^2$	$3.0 x10^2$
T5	$3.5 x10^2$	$3.4 x10^2$	$6.2 x10^2$	$1.1 x10^2$	$1.5 x10^2$	$3.6 x10^2$	$3.5 x10^2$	$2.4 x10^2$	$5.1 x10^2$
T6	$3.4 x10^2$	$3.9 x10^2$	$5.9 x10^2$	$1.2 x10^2$	$1.3 x10^2$	$3.2 x10^2$	$3.4 x10^2$	$2.9 x10^2$	$4.9 x10^2$
T7	$3.4 x10^2$	$3.8 x10^2$	$4.5 x10^2$	$1.1 x10^2$	$1.2 x10^2$	$2.3 x10^2$	$3.4 x10^2$	$2.8 x10^2$	$3.6 x10^2$
T8	$3 x10^2$	$3.6 x10^2$	$3.8 x10^2$	$1.1 x10^2$	$1.3 x10^2$	$2.4 x10^2$	$1.2 x10^2$	$2.6 x10^2$	$2.7 x10^2$
T9	$3 x10^2$	$3.3 x10^2$	$3.6 x10^2$	$1.1 x10^2$	$1.3 x10^2$	$2.0 x10^2$	$0.6 x10^2$	$2.3 x10^2$	$2.4 x10^2$
T10	$4 x10^1$	$9 x10^1$	$1.5 x10^2$	$3.1 x10^1$	$0.8 x10^2$	$1.2 x10^2$	$2 x10^1$	$7 x10^1$	$1.1 x10^2$

Values are mean of three replicates**.**

T1: Control samples without coating, antimicrobial and antioxidant agents. **T2:** Guar gum solutions only. **T3:** Guar gum solutions containing potassium sorbate. **T4:** Guar gum solutions containing potassium sorbate and citric acid. **T5:** Carrageenan solutions only. **T6:** Carrageenan solutions containing potassium sorbate. **T7:** Carrageenan solutions containing potassium sorbate and citric acid. **T8:** Carrageenan and Guar gum solutions only. **T9:** Carrageenan and Guar gum solutions containing potassium sorbate. **T10:** Carrageenan and Guar gum solutions containing potassium sorbate and citric acid.

CONCLUSION

Finally, it could be clearly concluded through this study, that, it is available, economical and successful to prolong shelf life of fresh- cut green bean pods by using of edible coatings. This would lead to maintain it is nutritional value as well as, processing a product with high quality attributes for 20 days.

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تحسين الخواص الفيزيائية والكيميائية ومدة الحفظ لقرون الفاصوليا الطازجة (صنف بوليستا) بإستخدام مواد التغطية القابلة للأكل.

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تعتبر الفاكهة والخضروات الطازجة من السلع الغذائية ذات القيمة الغذائية والصحية العالية التي تستهلك بواسطة جموع المستهلكين. وقد سمحت تكنولوجيا ما بعد الحصاد للصناعات البستانية بتلبية المتطلبات سواء للإنتاج المحلى أو العالمي بإنتاج منتجات طازجة ذات جودة تغذوية وكذلك التوزيع العابر للقارات للمنتجات الطازجة ذات الجودة التغذوية والحسية العالية. ولذلك، كان الهدف من هذه الدراسة هو تقييم الخواص الفيزيائية والكيميائية والميكروبيولوجية لقرون الفاصوليا الخضراء الطازجة (بوليستا) والمخزنة على درجة ٤°م لمدة ٢٠ يوما مع استخدام مواد التغطية القابلة للأكل. وتم تحضير مواد التغطية القابلة للأكل باستخدام الكاراجينان، صمغ الجوار، سوربات البوتاسيوم وحمض الستريك. وتم إجراء التحاليل التالية على العينة: السكريات الكلية، فيتامين ج، الفقد في الوزن، الصلابة، الخواص اللونية، الفينولات الكلية، الفلافونويدات الكلية، النشاط المضاد للأكسدة، وكذلك التحليل الميكروبيولوجي (البكتيريا الحية، البكتيريا المحبة للحرارة المنخفضة والخمائر). وأثبتت النتائج أن القرون المغلفة باستخدام (الكاراجينان، صمغ الجوار، سوربات البوتاسيوم وحامض الستريك) حدث لها إطالة لمدة الحفظ وأيضا تحسين جودتها بسبب التقليل من التغيرات الفيزيائية. لذلك، أشارت النتائج إلى أن استخدام مواد التغطية الصالحة للأكل أدى إلى إطالة مدة الحفظ والحفاظ على جودة قرون الفاصوليا الخضراء الطازجة.