EFFECT OF CARBOXYMETHYL CELLULOSE WITH EDIBLE COATING TREATMENTS ON QUALITY AND STORABILITY OF FRESH-CUT GREEN BEAN PODS DURING COLD STORAGE.

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Abstract
Green beans (*Phaseolus vulgaris* L.) cv. Paulista pods were harvested and treated for carboxymethyl cellulose with gum arabic 5% for 5 minutes, carboxymethyl cellulose with calcium chloride 0.5% for 5 minutes, carboxymethyl cellulose with ascorbic acid 5% for 5 minutes, carboxymethyl cellulose for 5 minutes and tap water for 5 minutes which served as control. fresh cut green pods wrapped with polypropylene bags and stored under 5°C, 85-90% relative humidity for twenty days , then studying the effect of previous treatments on physical and chemical characters of fresh- cut green bean pods under cold storage conditions .Results showed that the treatment treated for carboxymethyl cellulose with gum arabic 5% reduced pods weight loss , decay score and maintained pods general appearance, firmness , total soluble solids, total chlorophyll content and led to a decrease in total phenolic compound and microbial count followed by carboxymethyl cellulose with calcium chloride 0.5% compared with another treatments up to 20 days of storage.

Keywords: Green beans, Carboxymethyl cellulose, Gum arabic Calcium chloride.

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1. Introduction:

Green beans (*Phaseolus vulgaris* L.) are considered one of the most important leguminous crops in Egypt for local consumption and exportation. In addition, it is rich in vitamins, minerals, and carotene. It is a source of vitamin B, macro-and micro elements (Al-Sanabani *et al.,* 2016), also are climacteric type of respiration pattern; therefore, changes in the flavor, texture and appearance are limiting factors of the quality of pods (Kasim and Kasim, 2015). Generally green beans harvested at a physiologically immature stage. The most rapid of growth at the time of harvest and green beans exhibit comparatively higher respiration, even when held at low temperatures, cutting of green bean also accelerates respiration rate more than in whole beans. Therefore, fresh-cut of green beans highly decrease in quality. In order to prevent the loss of quality of fresh-cut vegetables, several treatment methods are being practiced reduce the changes that occur after harvesting. Postharvest treatments for fresh produce seek to reduce physiological processes of senescence and maturation, inhibit development of physiological disorders, and minimize the risk of pathogens growth and contamination. In addition to basic postharvest technology for temperature management, an array of others has been developed, including various physical (irradiation, heat and edible coatings); chemical (anti-browning, antioxidants and antimicrobials); and gaseous treatments. Edible coating is used to inhibit oxygen, migration of moisture, aromas, Carbone dioxide and lipids and to improve the mechanical integrity or handling characteristics of fruits (Röjas-Graü *et al.,* 2011). Carboxymethyl cellulose (CMC) one of the most used and widely common polysaccharides in the food, agriculture, and other industries and has been safety used as a food additive and is approved by the FDA and EFSA (Shebis *et al.,* 2022). Carboxymethyl cellulose prepared by a reaction of cellulose with sodium hydroxide and chloroacetic acids (Biswal and Singh, 2004). In addition, carboxymethyl cellulose can be produced from agricultural waste such as papaya (Rachtanapun *et al.,* 2007), Mimosa pigra (Rachtanapun and Rattanapanone, 2011), durian (Rachtanapun *et al.,* 2011), and pomelo peel. Many research have applied carboxymethyl cellulose for extend shelf-life and storage period of fresh produce such as peach and pear (Togˇrul and Arslan, 2004), avocado (Maftoonazad and Ramaswamy, 2005), mango (Rachtanapun *et al.,* 2008), cucumber (Adetunji et al., 2013), Rambutan (Kasinee *et al.,* 2017) and Strawberry (Shebis *et al.,* 2022). The produced, novel Carboxymethyl cellulose were applied alone and in combination with edable coating, gum arabic, calcium chlorid, and ascorbic acid, known to protect fruits and vegetables. Gum arabic, which is used as an edible coating to preserve the quality of fruits, is a substance that contains a large number of important polysaccharides used in agricultural processing due to its ease of formation in the form of a film, and the unique emulsifying and encapsulating properties that received the highest safety ratings by a joint research between the World Health Organization and the Food Organization Agriculture and Food Additives Committee (Anderson and Eastwood, 1989; Motlagh *et al.,* 2006). When used as an edible coating material, gum arabic also acted on some important consequences of delaying signs of ripeness during storage of apples in storage under cryogenic conditions (El-Anany *et al.,* 2009; Huang *et al.,* 2021). Calcium is as one of important element for application postharvest for several Fresh to stop the causes that lead to the occurrence of many factors of post-harvest deterioration and thus to improve the storage conditions of field crops. It also supports many physiological and biological functions within the cell wall, organs, and chromosomes, increasing enzyme activation and Ca-phytohormone interactions. Calcium has other positive effects, most notably in vegetables, so it can extend storage life by reducing respiration rate, delaying signs of ripeness, increasing durability and vitamin C content, and reducing the appearance of storage decay (Naveena and Immanule 2017 and Gemeda, 2021). Ascorbic acid is a antioxidant molecule (Shalata and Neumann 2001) which contributes to the detoxification of reactive oxygen spices (ROS) and therefore the usage of ascorbic acid is associated with delayed senescence and resistance plants to oxidative stress (Bilgin 2021). This research aimed to study the effects of Carboxymethyl cellulose alone or in combination with edable coating on pod quality of fresh-cut green bean under cold storage conditions.

2. Materials and Methods:

Green bean (*Phaseolus vulgaris* L.) cv. Paulista pods were obtained, from private farm at El Behira governorate during the two successive seasons of 2022 and 2023 respectively. Green pods were harvested at commercial maturity (i.e., bright green, tender fleshy and with small green immature seeds) at the 11th and 16th of January during the two successive seasons. The precooling process was carried out and then green pods were transferred to the laboratory in Horticulture Research Institute, Giza governorate. Pods without any visual defects were washed with tap water to eliminate soil residues, Pods were cut from both ends, using a sharp stainless steel knife.

Pods of the same length and completely free from damage or visual defects. The pods were distributed into five groups for the following treatments

1. Dipping in the solution of Carboxymethyl Cellulose + gum Arabic 5% for 5 minutes (CMC+ Gum Arabic).
2. Dipping in the solution of Carboxymethyl Cellulose + calcium chloride 0.5% for 5 minutes (CMC+ CaCl2).
3. Dipping in the solution of Carboxymethyl Cellulose + Ascorbic acid 5% for 5 minutes (CMC+ Ascorbic acid).
4. Dipping in the solution of Carboxymethyl Cellulose for 5 minutes (CMC).
5. Dipping in tap water for 5 minutes which served as control.

Carboxymethyl Cellulose, were prepared by the water hyacinth plants. Washed, dried, and ground. The dried powder was then extracted with 1 % (w/v) sodium hydroxide (NaOH) solution at the ratio of cellulose to solvent being 1: 30 (w/v) at 90 °C for 3 h. The mixture was filtered, washed with water until neutral and dried at 80 °C. The dried cellulose was passed through 100 mesh sieves and kept in the polyethylene bags. Fifteen grams of prepared cellulose was mixed with 450 ml of isopropanol, and 50 ml of 30 % NaOH solution in a beaker for 30 min. Then, 18 g of chloroacetic acid was added into the mixture and stirred for 1.5 h. The mixture was covered with aluminium foil and placed in an oven at 55 °C for 3.5 h. The obtained solid was neutralized with 90 % acetic acid, filtered, washed 5 times with ethanol and 1 time with methanol. The final product CMC wh was obtained after drying at ambient temperature (Kasinee *et al.,* 2017).

Gum arabic solutions were prepared by dissolving 5 and 10 g of powder gum arabic in 100 mL purified water. The solutions were stirred with low heat (40 °C) for 60 min on a magnetic stirrer/hot plate (Model: HTS-1003), then filtered to remove any undissolved impurities using a vacuum flask. After cooling to 20 °C, glycerol monostearate (1.0%) (Sigma) was added as a plasticizer to improve the strength and flexibility of the coating solutions. The pH of the solutions was adjusted to 5.6 with1 N NaOH (Ali *et al.,* 2010).

Each treatment consists of 200 g of fresh cut green pods wrapped with polypropylene bags and stored under 5°C, 85-90% relative humidity. Samples were taken at random from the three replicates for each treatment. The treatments were examined immediately after harvest and every four days intervals for the following parameter and stored for 20 days.

2.1. Weight loss percentage: it was estimated according to the following equation: Weight loss% = [(Initial weight - weight of fruits at sampling date)/Initial weight of fruits] x 100.

2.2. Decay: it was determined as score system of 1= none, 2= slight, 3= moderate, 4= moderately severe, 5= severe. This depends on decay percentage on pods (Watada and Morris, 1996; Jimenez *et al.*, 1998).

2.3. General appearance: it was determined as score system of excellent> 9, good> 7 to 8.9, fair> 5 to 6.9, poor> 3 to 4.9, and unassailable> 2.9. The scale depends on morphological defects such as shriveling, fresh appearance, color change of pods and decay. Pods rating (5) or below considered unmarketable (Watada and Morris, 1996; Jimenez *et al*., 1998).

2.4. Firmness: the average firmness of the fruits was measured in kg/cm^2 by digital force Gauge model FGV 50 A, Shimpo Instrument Co, Japan, with total capacity of 20 kg/cm^2 and resolution of 0.01kg/cm^2 using cone pointed head.

2.5. Total soluble solids percentage (T.S.S.): was determined as a composite juice sample by digital refractometer of model Abbe Leica according to (A.O.A.C., 1990).

2.6. Total chlorophyll: was determined as described in (Shehata *et al.,* 2018). In brief, 0.5 g of fresh sample were homogenized with 5 mL dimethyl formamide and kept in the dark in the refrigerator for 48 h. The absorbance was then measured at 470, 647 and 663 nm with a spectrophotometer (model UV-2401 PC, International Equipment Trading LTD. (IET), Milano, Italia).

2.7. Total phenolic compound: was calculated by using the Folin–Ciocalteu reagent with some alteration by using gallic acid as a standard curve

(El-Mogy *et al.,* 2020). Five grams of the sample was diluted using 5 mL of methanol (80%). The solution was blended with 2.5 mL of Folin–Ciocalteu (10-fold with distilled water) and added to 2.5 mL of distilled water. Afterwards, 2 mL of aqueous sodium carbonate solution (7.5%, w/v) was added after incubation for 5 min. The final solution was mixed and incubated in the dark at room temperature for 1 h. The absorption was assessed at 765 nm using the spectrophotometer, and the results were expressed as milligrams of gallic acid equivalent (GAE) per 100 mg of fresh fruit weight.

2.8. Microbiological analysis: each sample was prepared by homogenizing 10 gm of sliced green bean with 100 ml sterile 0.1 peptone water for 2 min. Dilution by 0.1 pepton water was made as needed in Plate Count Agar (PCA) and incubated for 24 hr at 37 °C for the determination of meso-sphilic aerobic microorganisms. Viable counts were determined by counting the number of colonies and reported as colony forming units per gram, CFU/g (Anese and Nicoli, 1997).

All data were subjected to statistical analysis according to the procedures reported by Snedecor and Cochran (1982) and means were compared by Duncan's multiple range tests (1955).

3. Results and discussions:

3.1. Weight loss percentage:

Data in Table (1) indicate increase in weight loss till the end of storage period, where the maximum loss was occurred. The results showed that the weight loss of green bean pods increased significantly and steadily as the storage period increased in the pods collected during the two growing seasons. This phenomenon may be explained by the loss of moisture inside the pods through transpiration and the loss of part of the dry matter content as a result of tissue respiration during storage. These results are consistent with (Zhu *et al*., 2008, Abdullah *et al.,* 2018a and El-Mogy *et al.,* 2020).

With regard to the effect coefficients, the data showed that there were significant differences between the coefficients in the percentage of weight loss during the storage period. All treatments maintained their normal weight during the storage period when compared to untreated plants. Moreover, dipping green bean pods treated for Carboxymethyl Cellulose with gum arabic 5% for 5 minutes was the most effective treatment in reducing the percentage of weight loss % followed by Carboxymethyl Cellulose with calcium chloride 0.5% for 5 minutes. The highest value of weight loss percentage was recorded for antlers with untreated control. These results were achieved in the two growing seasons and were consistent with (Shebis *et al.,* 2022) who found that fruits treated concentrations of Carboxymethyl Cellulose with some edible coating the treatments gave less weight loss when compared to the untreated fruit as a control.

Also, oligosaccharides cause as elicitors signals inducing a defense response including wound healing (Yu *et al.,* 2018), which might explain their effect on the weight loss reduction.

The effect of the interaction between both the storage period and the treatments on weight loss was significant. There was a gradual increase in weight loss in the pods in each treatment at the end of the storage period. From the above observations, the decrease in weight loss was very sharp after 20 days of storage for all treated plants.

3.2. Decay score:

The data presented in Table (1) indicate that the treatment has an effect on the degree of decomposition of green bean pods during the storage period. The data show that the decomposition began at a lower rate and increased with the lengthening of the storage period in both seasons. The explanation for this phenomenon may be that it occurred as a result of the continuous biochemical changes that occurred in the centuries (Shebis *et al.,* 2022).

For treatments used were recorded lowest decay score in comparison to control. Moreover, green beans pods treated for Carboxymethyl Cellulose with gum arabic 5% for 5 minutes or Carboxymethyl Cellulose with calcium chloride 0.5% for 5 minutes were the most effective treatments in reducing the decay. The highest value of decay score was recorded with untreated treatment (control).

Calcium chloride and gum arabic and using to delaying, slowing ripening fruit and maintaining quality during the storage period. These results are in agreement with (Abdullah *et al.,* 2018b)

As for the interaction between the treatments and the storage period, the data indicated that the untreated fruits began to appear decay after only 4 days of storage and many symptoms of decay were observed at the end of the storage period, while no decay was observed in the pods treated with the used materials (Carboxymethyl Cellulose with gum Arabic) till 16 days in both season.

3.3. General appearance score:

By looking at the data in Table No. (1), the effect of post-harvest treatments on the general appearance (grade) of green bean pods during storage is clear. The results indicated a significant decrease in the general appearance of green bean pods with an extended storage period in both seasons. The decrease of general appearance during the storage period and reaches its maximum depression at 20 days after storage. Similar results were reported by (Kasim and Kasim, 2015 and Abdullah *et al.*, 2018a) on fresh-cut green bean.

In view of the effect of post-harvest treatments, the data showed clear significant differences between the treated and untreated fruits (control). Green bean pods treated with all treatments recorded clear significant differences. However, green bean pods treated with carboxymethyl cellulose with gum arabic 5% were the most effective treatments to preserve the general shape of the fruits, followed by carboxymethyl cellulose with calcium chloride 0.5%, while the untreated control recorded the least effective treatment. These results were recorded in the two seasons.

The effect of gum arabic and calcium chloride on maintaining the general appearance might be referred to its ability on decreasing fruit water loss (Abdullah *et al.*, 2018b). As for the interaction between the storage period and post-harvest treatments, the data indicated that the pods dipped in a solution of carboxymethyl cellulose with gum arabic did not have any changes in their appearance until 16 days of storage of the fruits. On the other hand, untreated pods had the poorest data for pod appearance at the end of the storage period (20 days). These results were consistent in both seasons.

3.4. Firmness:

The data in Table (2) shows the effect of the hardness of green bean pods with post-harvest treatments during storage. Examining the data showed that there is a negative effect on a significant decrease in the hardness of green bean pods by increasing the storage period in the two seasons. The decrease in hardiness during storage may be due to the activity of physiological processes within the plant, including the metabolism process, which may increase the activity of fungi. Similar results were obtained by Kassem and Kassem (2015).

For the effect of postharvest treatments, data showed that all postharvest treatments had a significant effect on pod firmness as compared with untreated control during storage. However, green bean pods treated for carboxymethyl Cellulose with gum arabic 5% gave the highest value of pod firmness during storage followed by carboxymethyl Cellulose with calcium chloride 0.5%. The lowest value of pod firmness was obtained from untreated control. These results were achieved in the two seasons and were in agreement with (Shebis *et al.*, 2022)

Table (1): Effect of carboxymethyl cellulose with edible coating treatments on weight loss %, decay and general appearance of green beans during cold storage.

Treatments	Days after storage	First season						Second season					
		Weight loss %		Decay		General appearance		Weight loss %		Decay		General appearance	
Control	0			1.00	g	9.00	a			1.00	f	9.00	a
	4	1.45	q	1.33	fg	8.33	ab	1.07	t	1.33	ef	8.33	ab
	8	1.95	n	2.00	de	7.00	cd	1.54	o	1.67	de	7.00	cd
	12	3.17	g	2.33	cd	6.33	d	2.94	h	2.00	cd	6.33	de
	16	3.95	c	3.00	ab	5.00	e	3.54	c	2.67	ab	5.00	f
	20	4.65	a	3.33	a	4.33	e	4.34	a	3.00	a	3.00	g
CMC+ Gum Arabic	0			1.00	g	9.00	a			1.00	f	9.00	a
	4	0.93	w	1.00	g	9.00	a	0.75	w	1.00	f	9.00	a
	8	1.25	t	1.00	g	9.00	a	1.15	s	1.00	f	9.00	a
	12	2.16	m	1.00	g	9.00	a	1.94	n	1.00	f	9.00	a
	16	2.84	i	1.00	g	8.33	ab	2.65	j	1.00	f	8.33	ab
	20	3.34	f	1.33	fg	7.67	bc	3.04	g	1.33	ef	7.67	bc
CMC+ CaCl2	0			1.00	g	9.00	a			1.00	f	9.00	a
	4	1.11	v	1.00	g	9.00	a	0.82	v	1.00	f	9.00	a
	8	1.38	r	1.00	g	9.00	a	1.28	r	1.00	f	9.00	a
	12	2.35	l	1.00	g	9.00	a	2.23	m	1.00	f	9.00	a

	16	3.13	h	1.33	fg	7.00	cd	2.83	i	1.33	ef	7.00	cd
	20	3.63	d	2.00	de	5.00	e	3.23	e	1.67	de	5.67	ef
CMC	**0**			1.00	g	9.00	a			1.00	f	9.00	a
	4	1.33	s	1.00	g	9.00	a	0.83	v	1.00	f	9.00	a
	8	1.67	o	1.00	g	9.00	a	1.43	p	1.00	f	9.00	a
	12	2.76	j	1.33	fg	8.33	ab	2.55	k	1.00	f	9.00	a
	16	3.65	d	2.00	de	6.33	d	3.13	f	1.67	de	6.33	de
	20	4.07	b	2.67	bc	4.33	e	3.61	b	2.33	bc	3.67	g
CMC+ Ascorbic acid	**0**			1.00	g	9.00	a			1.00	f	9.00	a
	4	1.19	u	1.00	g	9.00	a	0.88	u	1.00	f	9.00	a
	8	1.56	p	1.00	g	9.00	a	1.33	q	1.00	f	9.00	a
	12	2.55	k	1.00	g	9.00	a	2.41	l	1.67	de	7.00	cd
	16	3.44	e	1.67	ef	6.33	d	2.94	h	1.67	de	6.33	de
	20	3.94	c	2.00	de	5.00	e	3.44	d	2.00	cd	5.00	f
Control		3.03	A	2.17	A	6.67	C	2.69	A	1.94	A	6.44	D
CMC+ Gum Arabic		2.10	E	1.06	D	8.67	A	1.91	E	1.06	D	8.67	A
CMC+ CaCl2		2.32	D	1.22	CD	8.00	B	2.08	D	1.17	CD	8.11	B
CMC		2.70	B	1.50	B	7.67	B	2.31	B	1.33	BC	7.67	C
CMC+ Ascorbic acid		2.53	C	1.28	C	7.89	B	2.20	C	1.39	B	7.56	C
	0			1.00	D	9.00	A			1.00	D	9.00	A
	4	1.20	E	1.07	D	8.87	A	0.87	E	1.07	D	8.87	A
	8	1.56	D	1.20	CD	8.60	AB	1.35	D	1.13	CD	8.60	A
	12	2.60	C	1.33	C	8.33	B	2.42	C	1.33	C	8.07	B
	16	3.40	B	1.80	B	6.60	C	3.02	B	1.67	B	6.60	C
	20	3.93	A	2.27	A	5.27	D	3.53	A	2.07	A	5.00	D

Values followed by the same letter (s) are not significantly different at 5 %

The effect of the interaction between the storage period and post-harvest treatments had a significant effect on the hardness of pods in both seasons. The pods from all the treated treatments over the storage period were much better than the untreated ones (control).

3.5. Total soluble solids percentage:

The data in Table (2) shows the effect of green bean pods using post-harvest treatments on total soluble solids as a percentage during storage. The data indicated that there was a decrease in the total dissolved solids of green bean pods in the case of prolonging the storage period until the end of the storage period in both seasons, and these results are similar (Abdullah *et al.,* 2018a).

Regarding the effect of post-harvest treatments, the data showed the extent to which there was a difference in the percentage of total soluble solids between the treated and untreated bean fruits during the storage period. Green bean pods treated with carboxymethyl cellulose with gum arabic recorded the highest percentage of dissolved solids, followed by carboxymethyl cellulose with calcium chloride. Pods from all treatments during the storage period were higher in T.S.S. of those untreated (control) fruits. Moreover, the pods treated with carboxymethyl cellulose with gum arabic during the storage period had slightly higher T.S.S. compared with other treatments during the storage period.

3.6. Chlorophyll content:

Data in Table (2) show the effect of postharvest treatments on Chlorophyll content of green bean pods during storage. Data presented that progressive and significant decrease happened in chlorophyll content. Generally, green bean pods became yellowish green in the end of the storage period. This decrement in content of chlorophyll could be attributed to the destruction by turn of chloroplasts to chromoplasts and chlorophyllase activity. These results were true in both seasons and were in agreement with Abed El-Hakim (2017) on Fresh–Cut Green Bean Pods**.**

Regarding the effect of postharvest treatments, it is clear from the results that pods treated for carboxymethyl Cellulose with gum arabic significantly reduced chlorophyll degradation of green bean pods compared with other treatments, in both seasons. In general untreated green bean pods (control) contained the lowest value in chlorophyll contents. These results were in agreement with the findings of Shebis *et al.* (2022).

The effect of the interaction between storage period and post-harvest treatments on pods was a significant reading of chlorophyll in all planting seasons. However, pods treated with carboxymethyl cellulose and gum arabic had the highest chlorophyll content during cold storage. On the other hand, untreated (control) fruits recorded the lowest value of chlorophyll content during cold storage.

3.7. Total phenolic compound:

The data presented in Table (3) show the effect of total phenolic compounds content of green bean pods as a result of post-harvest treatments on storage. The data indicated a decrease in the total phenolic compound of green bean pods when the storage period was extended until the end of the storage period in the two study seasons. These results are similar to (Abdul Hakim, 2017).

Concerning the effect of postharvest treatments, data indicated that there were significant differences between all treatments and clear observed that all treatments maintained phenolic compounds during storage period with little changes in their contents, especially for treated carboxymethyl Cellulose with gum arabic which show the lowest decreasing rates followed by carboxymethyl Cellulose with calcium chloride compared with untreated green bean pods which had a significantly greater decrease. These results may be due to coating materials gum arabic and calcium chlorid, which may form a protective barrier on the pods surface and reduce the oxygen supply for enzymatic oxidation of phenols. The same results were in agreement with (Macheix *et al.*, 1990; Feng *et al.*, 2015)

By studying the effect of interaction between all post-harvest treatments and storage period on pods was significant for total phenolic compound in both seasons. However, pods treated for carboxymethyl cellulose with gum arabic was the most effective in maintaining total phenolic compound during coldstorage. On the other hand, untreated (control) recorded lowest value of total phenolic compound during cold storage.

3.8. Microbial analysis:

As shown in Table (3), results indicate that there was a linear relation between the microbial load and storage period, where it was found that the increase in storage period was accompanied by an increase in microbial load these results are similar with (Abdullah *et al.*, 2018a).

Regarding the effect of postharvest treatments, it is clear from the results that the most effective antimicrobial treatment which diminish the microbial load was treated green pods for carboxymethyl Cellulose with gum arabic followed by carboxymethyl Cellulose with calcium chloride compared with untreated green bean pods. Same result was obtained by (Shebis et al., 2022) who found that treated green bean pods with oligo

Table (2): Effect of carboxymethyl cellulose with edible coating treatments on firmness (kg/cm^2), total soluble solids % and total chlorophell of green beans during cold storage.

Treatments	Days after storage	First season			Second season		
		Firmness (kg/cm^2)	Total soluble solids %	Total chlorophell	Firmness (kg/cm^2)	Total soluble solids %	Total chlorophell
Control	0	2.66 a	6.40 a	26.31 a	2.57 a	6.00 a	25.66 a
	4	2.24 g	6.20 bcd	25.31 h	1.78 fgh	6.00 a	24.72 f
	8	1.73 m	6.27 abc	25.05 k	1.62 hi	5.87 bc	24.03 l
	12	1.44 p	6.07 def	24.63 o	1.22 lm	5.73 de	23.74 n
	16	1.03 t	5.87 ghi	23.82 u	0.88 no	5.47 h	23.13 r
	20	0.73 u	5.73 i	23.24 v	0.92 n	5.47 h	22.54 t
CMC+ Gum Arabic	0	2.66 a	6.40 a	26.31 a	2.57 a	6.00 a	25.66 a
	4	2.53 b	6.27 abc	25.91 b	2.36 b	6.00 a	25.30 b
	8	2.36 d	6.33 ab	25.60 e	2.11 cd	5.93 ab	25.01 d
	12	2.13 h	6.20 bcd	25.24 j	1.86 efg	5.80 cd	24.61 g
	16	1.80 l	6.00 efg	24.81 n	1.61 hi	5.67 ef	24.22 j
	20	1.42 pq	5.80 hi	24.36 r	1.27 kl	5.60 fg	23.83 m
CMC+ CaCl2	0	2.66 a	6.40 a	26.31 a	2.57 a	6.00 a	25.66 a
	4	2.41 c	6.27 abc	25.78 c	2.30 b	6.00 a	25.11 c
	8	2.23 g	6.27 abc	25.36 g	2.02 de	5.87 bc	24.72 f
	12	1.93 j	6.07 def	25.02 l	1.70 gh	5.80 cd	24.23 j
	16	1.64 n	6.00 efg	24.54 p	1.41 jk	5.60 fg	23.82 m

	20	1.22	s	5.73	i	24.02	t	1.05	mn	5.47	h	23.52	p
CMC	**0**	2.66	a	6.40	a	26.31	a	2.57	a	6.00	a	25.66	a
	4	2.30	f	6.20	bcd	25.60	e	2.25	bc	6.00	a	24.93	e
	8	1.91	jk	6.13	cde	25.28	i	1.81	fg	5.87	bc	24.44	h
	12	1.61	o	6.07	def	24.91	m	1.51	ij	5.67	ef	24.14	k
	16	1.28	r	5.87	ghi	24.17	s	1.13	lm	5.53	gh	23.56	o
	20	1.90	k	5.73	i	23.81	u	0.73	o	5.47	h	23.05	s
CMC+ Ascorbic acid	**0**	2.66	a	6.40	a	26.31	a	2.57	a	6.00	a	25.66	a
	4	2.33	e	6.27	abc	25.71	d	2.27	bc	6.00	a	25.11	c
	8	2.04	i	6.20	bcd	25.41	f	1.92	ef	5.87	bc	24.74	f
	12	1.73	m	6.07	def	25.02	l	1.62	hi	5.67	ef	24.30	i
	16	1.40	q	5.93	fgh	24.50	q	1.29	kl	5.60	fg	23.84	m
	20	1.02	t	5.73	i	24.02	t	0.88	no	5.53	gh	23.27	q
Control		1.64	E	6.09	B	24.73	D	1.50	E	5.76	B	23.97	E
CMC+ Gum Arabic		2.15	A	6.17	A	25.37	A	1.96	A	5.83	A	24.77	A
CMC+ CaCl2		2.02	B	6.12	AB	25.17	B	1.84	B	5.79	AB	24.51	B
CMC		1.94	C	6.07	B	25.01	C	1.67	D	5.76	B	24.30	D
CMC+ Ascorbic acid		1.86	D	6.10	B	25.16	B	1.76	C	5.78	B	24.49	C
	0	2.66	A	6.40	A	26.31	A	2.57	A	6.00	A	25.66	A
	4	2.36	B	6.24	B	25.66	B	2.19	B	6.00	A	25.04	B
	8	2.06	C	6.24	B	25.34	C	1.90	C	5.88	B	24.59	C
	12	1.77	D	6.09	C	24.97	D	1.58	D	5.73	C	24.20	D
	16	1.43	E	5.93	D	24.37	E	1.26	E	5.57	D	23.72	E
	20	1.26	F	5.75	E	23.89	F	0.97	F	5.51	E	23.24	F

Values followed by the same letter (s) are not significantly different at 5 %

Table (3): Effect of carboxymethyl cellulose with edible coating treatments on total phenolic (mg/100 g) and microbial analysis of green beans during cold storage.

Treatments	**Days after storage**	**First season**				**Second season**			
		Total phenolic mg/100 g		**Microbial analysis**		**Total phenolic mg/100 g**		**Microbial analysis**	
Control	**0**	153.13	a	0.33	w	151.19	a	0.31	l
	4	148.34	e	1.34	s	144.52	f	1.26	ijk
	8	140.65	j	2.54	k	137.41	j	2.55	ef
	12	134.23	m	3.32	f	127.72	r	3.84	bc
	16	126.03	r	4.14	c	118.54	w	3.93	b
	20	119.12	s	4.95	a	101.35	x	6.76	a
CMC+ Gum Arabic	**0**	153.13	a	0.33	w	151.19	a	0.31	l
	4	151.11	b	0.93	v	148.84	b	0.85	k
	8	147.51	f	1.54	r	145.02	e	1.45	hij
	12	142.83	h	1.95	o	138.17	i	1.95	gh
	16	137.92	k	2.75	i	132.72	m	2.54	ef
	20	132.52	n	3.23	g	129.12	p	3.03	de
CMC+ CaCl2	**0**	153.13	a	0.33	w	151.19	a	0.31	l
	4	150.91	bc	1.04	u	147.02	c	0.95	jk
	8	147.50	f	1.75	q	143.18	g	1.75	ghi
	12	141.52	i	2.23	m	135.15	k	2.24	fg
	16	136.52	l	2.96	h	130.43	o	2.82	e
	20	130.71	p	3.85	d	126.73	s	3.35	cd
CMC	**0**	153.13	a	0.33	w	151.19	a	0.31	l
	4	149.85	d	1.08	t	146.42	d	1.11	jk
	8	143.13	h	2.13	n	141.72	h	2.17	fg
	12	138.03	k	2.63	j	131.84	n	2.85	de
	16	131.35	o	3.53	e	125.62	t	3.36	cd
	20	127.63	q	4.43	b	121.23	v	4.03	b

CMC+ Ascorbic acid	**0**	153.13	a	0.33	w	151.19	a	0.31	l
	4	150.63	c	1.09	t	147.03	c	1.01	jk
	8	145.32	g	1.92	p	143.33	g	1.93	gh
	12	140.42	j	2.45	l	133.24	l	2.55	ef
	16	134.12	m	3.34	f	128.14	q	3.05	de
	20	130.55	p	4.17	c	124.52	u	3.75	bc
Control		136.91	E	2.77	A	130.12	E	3.11	A
CMC+ Gum Arabic		144.17	A	1.79	E	140.84	A	1.69	D
CMC+ CaCl2		143.38	B	2.03	D	138.95	B	1.90	CD
CMC		140.52	D	2.36	B	136.34	D	2.31	B
CMC+ Ascorbic acid		142.36	C	2.21	C	137.91	C	2.10	BC
	0	153.13	A	0.33	F	151.19	A	0.31	F
	4	150.17	B	1.10	E	146.77	B	1.04	E
	8	144.82	C	1.98	D	142.13	C	1.97	D
	12	139.41	D	2.52	C	133.22	D	2.69	C
	16	133.19	E	3.34	B	127.09	E	3.14	B
	20	128.10	F	4.12	A	120.59	F	4.18	A

Values followed by the same letter (s) are not significantly different at 5 %

carboxymethyl Cellulose decrease the total bacterial counts.

Concerning the interaction among different treatments and storage period, there was a significant difference between them, where it was noticed that all treatments affected the microbial load and decrease it until the first 4 days compared with untreated pods especially green pods treated for carboxymethyl Cellulose with gum arabic. Then after this storage period a remarkable increase in microbial load was observed.

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