Zagazig J. Agric. Res., Vol. 47 No. (6) 2020 1439-1461

Plant Production Science

Available online at http://zjar.journals.ekb.eg
http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

EFFECT OF SOME POSTHARVEST TREATMENTS ON QUALITY OF FRESH FULL AND CUT SNAP BEAN PODS DURING COLD STORAGE

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Received: 16/09/2020 ; Accepted: 26/10/2020

ABSTRACT: Great economic losses to harvested vegetable fruits are raised by postharvest chilling injury during transportation and storage, which can be safety controlled by some polysaccharide materials as chitosan. The effect of different dipping treatments *viz*; control (tap water for 5 min.) and chitosan at 0.5 and 1% for 5 min. as well as nano chitosan at 25 and 50 ppm for 5 min. on quality of full and cutting pods of snap bean (*Phaseolus vulgaris* L.) cv. Paulista during cold storage. So, two experiments were conducted at Agric. Res. Farm, El-Kassasien Hort. Res. Station, Ismalia Governorate, and Handling Lab., Hort. Dept., Fac. Agric., Zagazig University, Egypt during the two autumn consecutive seasons of 2016/ 2017 and 2017/2018. Pods weight loss (%), general appearance score, total chlorophyll content (SPAD unit), firmness (g/cm^2), total soluble solids (TSS as Brix°), crude fiber (%), total microbial count (log 10 CFU/g), polyphenol oxidase activity (unit/g as fresh weight), total phenol content (mg/g as fresh weight) and crude protein (%) of snap bean pods were evaluated at 0, 4, 8, 12 and 16 days of storage at 4°C and 90% relative humidity. The obtained results referred to that the dipping full pods in the solutions of chitosan at 1% or nano chitosan at 50 and/or 25 ppm presented more effective preservative effect on decreasing weight loss percentage, total soluble solids, crude fiber, total microbial count and polyphenol oxidase activity and maintained pod quality and gave pods with good appearance, total chlorophyll, firmness and total phenolic after 12 days of storage at 4ºC and 90% relative humidity than other treatments or control during different cold storage periods.

Key words: Snap bean, cutting method, chitosan, cold storage, postharvest, general appearance.

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) is considered one of the important vegetable crops cultivated in Egypt for local market and it has a great importance for exportation. Such importance comes from the fact that legumes are inexpensive and very rich in protein content, minerals, amino acids, and vitamins which are essential for human nutrition (**Kerlous, 1997; Abdel-Hakim *et al*., 2012**). Cutting of green bean accelerates respiration rate more than in intact beans. Therefore, the quality of fresh-cut green bean decreases rapidly due to exposure of inner flesh to environment, thus they have much shorter shelf life 3 days at 5°C (**Kasim and Kasim, 2015**).

It is necessary to use some polysaccharide (such chitosan) as postharvest treatments in conjunction with low temperature to extend storage ability of fresh-cut snap bean pods. However, In accordance with chitosan use on vegetable post-harvest, the respiration rate and weight loss rate are inhibited, and higher firmness is continued (**Youwei and Yinzhe, 2013**). Also, chitosan treatment kept fruit texture and decreased decay incidence through all the storage periods. Thus, chitosan at 0.5 or 1% are appropriated treatments for lessening weight loss, polyphenol oxidase activity and maintaining quality of green bean at 4ºC and 85-90 RH% (**El-Sayed *et al*., 2019**). In addition, nano-materials are a favorable technology in

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many fields including agriculture (**Dimetry and Hany, 2016**). Also, **Nguyen and Nguyen (2020)** reported that coating strawberry with 0.2% and 0.4% nano chitosan kept the aggregate quality index of the fruit up to 21 days. The treatments decreased weight loss, hold firmness and titratable acidity significantly inhibited polyphenol oxidase activity of the stored fruit.

Therefore, the objective of this work was to extend the storage period and maintaining quality of fresh full or cut pods of snap bean during cold storage at 4°C and 90% RH by dipping in chitosan and nano chitosan solutions.

MATERIALS AND METHODS

This experiment was carried out during the autumn seasons of 2016/2017 and 2017/2018 at the Agriculture Research Farm, El-Kassasien Hort. Res. Station, Ismalia Governorate, Egypt, and Handling Lab., Hort. Dept., Fac. Agric., Zagazig University, Egypt, to study the effect of some postharvest treatments on the quality of fresh cut and full green pods of snap bean during cold storage (*Phaseolus vulgaris* L.) Cv Paulista during cold storage. The experimental soil was sandy in texture with 82.3 and 81.6% sand, 1.7 and 1.6% silt, 16.0 and 16.8% clay, 8.4 and 8.2pH, 0.3 and 0. 8 % organic matter, 40 and 43 ppm N, 66 and 68 ppm P and 42 and 44 ppm K in the 1st and 2nd seasons, respectively.

Seeds of snap bean were obtained from Hort. Res. Inst., Agric. Res. Center, Egypt, and sown on October 19th and 18th in 2016 and 2017, respectively on one side of dripper's lines (two seeds /hill) at 10 cm apart. At 15 days after sowing, plants were thinned leaving one plant/ hill.

All plots received equal amounts of compost at a rate of $10m^3$/faddan during soil preparation, the other recommended agricultural practices for commercial snap bean production, *i.e.*, irrigation, fertilization and weed control were followed.

This experiment was conducted to study the effect of cutting method and some postharvest treatments on keeping quality of snap bean green pods during cold storage at 4°C and 90% relative humidity (RH). In this experiment, mature green pods from the field, were harvested at suitable maturity stage for marketing on 15th December and transported soon to the Handling Lab., Hort. Dept., Fac. Agric., Zagazig Univ., Egypt, and kept overnight at 4 °C and 90% relative humidity (RH). Healthy green pods were selected in this experiment. All cutting utensils used (knife, cutting board) were washed with soap and tap water and rinsed with 1000 ppm sodium hypochlorite solution prior to use.

The following morning, marketable green snap bean pods about (250g) packed in micro perforated polypropylene bags (12 × 15) cm and served represented as one replicate (with 30µ thickness) sealed hermetically. Twelve polypropylene bags were prepared for each treatment, placed in carton box (30 × 20 ×10 cm), then stored at 4°C and 90% RH for 16 days. Three polypropylene bags were randomly taken from each treatment every 4days (4, 8, 12 and 16days) for determining the postharvest measurements.

This experiment included 10 treatments, which were the combinations between two cutting method (full pods and cutting pods) and five treatments of dipping in chitosan solutions as follows:

Cutting Methods

1- Full green pods.

2- Cutting green pods (The pods were cut in two halves).

Dipping Solutions

1- Dipping in chitosan solution at 0.5% for 5 min.

2- Dipping in chitosan solution at 1% for 5 min.

3- Dipping in nano chitosan solution at 25ppm for 5 min.

4- Dipping in nano chitosan solution at 50 ppm for 5 min.

5- Control (dipping in tap water for 5 min).

These treatments were arranged in complete randomized design. Each treatment was divided into 3 replicates, uniform snap bean pods were randomly taken for each replicate.

Preparation of chitosan and nano chitosan solutions:

A- Nano chitosan crystallitc powder was synthesized by high-energy ball milling. Powder mixture was conducted in a planetary ball mill to 40 hr. using ball to powder mass ratio of (8-1) **Gad *et al.* (2016)**.

B- The chitosan solutions were prepared according to **El Ghaouth *et al.* (1991).** An amount of 5 and10 g chitosan (for 0.5 and 1%) was dispersed in 900 ml of distilled water to which 50 ml of glacial acetic acid was added to dissolve chitosan. Solutions were centrifuged to remove undissolved particles. In order to guarantee the stability of the emulsions, the pH value was adjusted to 5.6 with 1N NaOH. Tween 80 (0.l% *V/V*) was added to solutions to improve wettability of the solution during coating.

Data Recorded

Fresh weight loss (FWL%)

The snap bean pods full and cutting weighed before cold storage to obtain the initial weight, and then weighed after each period of storage **(AOAC, 2007)**. FWL (%) calculated according to the following equation: Wi- Ws/Wi × 100 Where: Wi = pod weight at initial date and Ws = pod weight at sampling date.

General appearance (GA)

General appearance was determined using score system of 9 =excellent, 7 = good, 5 = fair, 3 = poor, and 1 = unsalable. This scale depends on the morphological defects such as shriveling or decay.

Total chlorophyll:

It was measured in fresh pods by using Minolta chlorophyll meter SPAD-502 as SPAD units as reported by **Markwell *et al.* (1995)**.

Pod firmness

Pod firmness of each individual snap bean pods (full and cutting) was measured at two points of the equatorial region by Push Pull dynamometer (Model FD101). The firmness of the flesh was expressed as g/cm^2.

Total soluble solids (TSS)

It was determined by using a hand Refractometer according to the methods mentioned in **AOAC (1990).**

Crude fiber

It was determined (as dry weight basis) according to the method of **Maynard (1970)**.

Total microbiological count (bacteria and yeast)

It was determined according to **Marshall (1992)**.

Polyphenol oxidase activity (PPO)

It was determined according to the method of **Fernandes *et al*. (2011)**.

Total phenolic content

It was determined by the colorimetric modified method of **Velioglu *et al.* (1998).**

Total crude protein (%)

It was calculated by multiplying total nitrogen percentage × 6.25 as recorded by **Chapman and Pratt (1978)**.

Statistical Analysis

All data obtained were subjected to the proper statistical analysis using the MSTAT statistical software and the treatments means were compared by using the LSD at 0.05 level of probability as described by **Snedecor and Cochran (1989)**.

RESULTS AND DISCUSSION

Weight Loss Percentage

It is obvious from the results in Table 1 that, there was a considerable and consistent increase in fresh weight loss percentage of snap bean pods as the cold storage period prolonged, where the maximum values of weight loss percentage were occurred at the end of cold storage period (16days), it reached to 1.77 and 1.70% in the 1st and 2nd seasons, respectively. This continues loss in the weight during cold storage resulted from the loss of water by transpiration and dry matter by respiration **(Atta-Aly, 1998)**.

These results are in agreement with those obtained by **Shehata *et al*. (2015)** and **Gad El-Rab (2018)** on snap bean pods. Concerning the effect of cutting method, the results in Table 1 show that, there were significant differences

Table 1. Effect of some postharvest treatments on weight loss percentage of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		Weight loss (%)											
Full pods	Control (Tap water)	-	0.73	0.88	1.07	1.93	**1.15**	-	0.71	0.86	1.05	1.90	**1.13**
	Chitosan 0.5%	-	0.63	0.75	0.93	1.78	**1.02**	-	0.62	0.73	0.90	1.77	**1.00**
	Chitosan 1%	-	0.60	0.72	0.88	1.76	**0.99**	-	0.59	0.70	0.85	1.70	**0.96**
	Nano Chito. 25ppm	-	0.52	0.65	0.82	1.63	**0.90**	-	0.49	0.56	0.79	1.59	**0.86**
	Nano Chito. 50ppm	-	0.43	0.56	0.70	1.51	**0.80**	-	0.38	0.49	0.68	1.23	**0.69**
	Mean	**-**	**0.58**	**0.71**	**0.88**	**1.72**	**0.97**	**-**	**0.56**	**0.67**	**0.85**	**1.64**	**0.93**
Cutting pods	Control (Tap water)	-	0.78	0.94	1.17	2.03	**1.23**	-	0.76	0.90	1.11	2.00	**1.19**
	Chitosan 0.5%	-	0.71	0.85	1.04	1.89	**1.12**	-	0.70	0.81	1.02	1.86	**1.10**
	Chitosan 1%	-	0.69	0.82	1.01	1.85	**1.09**	-	0.67	0.77	0.99	1.83	**1.06**
	Nano Chito. 25ppm	-	0.58	0.71	0.86	1.74	**0.97**	-	0.55	0.68	0.83	1.68	**0.93**
	Nano Chito. 50ppm	-	0.51	0.60	0.76	1.60	**0.87**	-	0.43	0.52	0.73	1.48	**0.79**
	Mean	**-**	**0.65**	**0.78**	**0.97**	**1.82**	**1.06**	**-**	**0.62**	**0.74**	**0.93**	**1.77**	**1.02**
General mean		**-**	**0.62**	**0.74**	**0.92**	**1.77**	**-**	**-**	**0.59**	**0.70**	**0.89**	**1.70**	**-**
Control (Tap water)		-	0.75	0.91	1.12	1.98	**1.19**	-	0.73	0.88	1.08	1.95	**1.16**
Chitosan 0.5% (Chito.)		-	0.67	0.80	0.98	1.83	**1.07**	-	0.66	0.77	0.96	1.81	**1.05**
Chitosan 1% (Chito.)		-	0.64	0.77	0.94	1.80	**1.04**	-	0.63	0.73	0.92	1.76	**1.01**
Nano Chito. 25ppm		-	0.55	0.68	0.84	1.68	**0.94**	-	0.52	0.62	0.81	1.63	**0.90**
Nano Chito. 50ppm		-	0.47	0.58	0.73	1.55	**0.83**	-	0.40	0.50	0.71	1.35	**0.74**

LSD at 5%	Cutting method (C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	0.03	0.05	0.05	0.07	0.06	0.10	0.14
2nd season	0.03	0.05	0.04	0.07	0.06	0.09	0.13

between the two cutting methods in weight loss percentage, where cutting pods gave the maximum weight loss percentage (1.06 and 1.02%), wheres full pods recorded the minimum weight loss percentage (0.97 and 0.93%) in the 1st and 2nd seasons, respectively. The increase in weight loss percentage may be due to the increasing in the cut surface area which leads to an increase in the rate of water loss by transpiration and dry matter by respiration. As for dipping solutions, results revealed that there were significant differences among dipping treatments in weight loss percentage during storage. All dipping treatments retained their weight loss during storage as compared with control treatment. Moreover, snap bean pods dipped in nano chitosan at 50ppm and/or 25 ppm were most effective treatment in reducing the weight loss (%) followed by chitosan at 1%. On the other side the highest values of weight loss percentage were recorded by control treatment.

The lowest weight loss from chitosan treatment is due to a semipermeable film on the pod surface can be formed by chitosan, consequently modifying the internal atmosphere of the pods with limited gas exchanges due to the coating barrier, enzymatic activity and metabolism in evolving respiration can be thus affected thereby resulting in lower weight loss **(Raymond *et al*., 2012)**. These results were achieved in the two seasons of study and were in agreement with those obtained by **El-Hamahmy *et al*. (2017)** and **Gad El-Rab (2018)** on snap bean.

With regard to the interaction among cutting method, dipping solutions and storage period, it is clear from the results that, the lowest values of weight loss percentage at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50ppm which gave 1.51 and 1.23% in the first and second seasons, respectively, followed by the interaction treatment among cutting pods and dipping in nano chitosan (50ppm) at the end of storage period that gave 1.60 and 1.48% in the 1st and 2nd seasons, respectively.

General Appearance

Results in Table 2 show that, general appearance of snap bean pods declined with the prolonging of storage period in both seasons, where the minimum values were occurred at the end of storage period (16days). It reached to 2.13 and 2.27 in the 1st and 2nd seasons, respectively. The results also showed that, there were negative correlation between fresh weight loss percentage (Table 1) and general appearance of pods. The decrease of general appearance during storage period might be due to shriveling, color change and decay **(Gonzalez-Aguilar *et al.,* 1997).** Similar results were obtained by **Shehata *et al*. (2015)** and **Gad El-Rab (2018)** on snap bean pods.

With respect to the effect of cutting method, the results in Table 2 show that, there were significant differences between the two cutting methods in general appearance, where full pods gave the best general appearance (6.63 and 6.87), whereas cutting pods recorded the minimum general appearance (6.04 and 6.27) in the 1st and 2nd seasons, respectively. The decreasing in general appearance may be due to the increasing in the cut surface area which leads to an increase in the rate of water loss by transpiration and dry matter by respiration. As for dipping solutions, results revealed that, there were significant differences among dipping solutions treatments and control on general appearance during storage, Snap bean pods treated with all dipping solution treatments gave higher score of appearance as compared with control. However, snap bean pods dipped in nano chitosan at 50ppm and/or 25 ppm were the most effective treatment for maintaining general appearance, followed by chitosan at 1%. On the other side, the lowest values of general appearance were recorded by control treatment. These results were achieved in the two seasons of study and were in agreement with those reported by **Gad El-Rab (2018)** on snap bean.

Chitosan coating acts as a semipermeable barrier on the surface of fruit and vegetables against oxygen, carbon dioxide and moisture, thereby reducing respiration, water loss, respiratory activity and degradation by enzymes and microbial rot of fruits, counteracting the dehydration and shrinkage of the fruit, and ethylene production and maintaining the overall quality and prolonging the shelf life **(Velickova *et al*., 2013)**.

With regard to the interaction among cutting method, dipping solutions and storage period,

Table 2. Effect of some postharvest treatments on general appearance of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		General appearance score*											
Full pods	Control (Tap water)	9.00	7.00	6.33	3.67	1.00	**5.40**	9.00	7.67	6.33	3.67	1.00	**5.53**
	Chitosan 0.5%	9.00	8.33	7.00	4.33	1.00	**5.93**	9.00	8.33	7.33	6.33	1.00	**6.40**
	Chitosan 1%	9.00	8.33	7.00	6.33	2.33	**6.60**	9.00	9.00	7.67	6.33	3.00	**7.00**
	Nano Chito. 25 ppm	9.00	9.00	8.33	6.33	3.67	**7.27**	9.00	9.00	9.00	6.00	3.67	**7.33**
	Nano Chito. 50 ppm	9.00	9.00	9.00	7.67	5.00	**7.93**	9.00	9.00	9.00	7.67	5.67	**8.07**
	Mean	**9.00**	**8.33**	**7.53**	**5.67**	**2.60**	**6.63**	**9.00**	**8.60**	**7.87**	**6.00**	**2.87**	**6.87**
Cutting pods	Control (Tap water)	9.00	7.67	4.33	2.33	1.00	**4.87**	9.00	7.67	5.67	2.33	1.00	**5.13**
	Chitosan 0.5%	9.00	7.00	6.33	3.67	1.00	**5.40**	9.00	7.67	6.67	3.67	1.00	**5.60**
	Chitosan 1%	9.00	7.67	6.33	3.67	1.00	**5.53**	9.00	7.67	7.00	6.33	1.00	**6.20**
	Nano Chito. 25 ppm	9.00	9.00	7.67	6.33	1.00	**6.60**	9.00	9.00	7.67	6.33	1.00	**6.60**
	Nano Chito. 50 ppm	9.00	9.00	9.00	7.67	4.33	**7.80**	9.00	9.00	9.00	7.67	4.33	**7.80**
	Mean	**9.00**	**8.07**	**6.73**	**4.73**	**1.67**	**6.04**	**9.00**	**8.20**	**7.20**	**5.27**	**1.67**	**6.27**
General mean		**9.00**	**8.20**	**7.13**	**5.20**	**2.13**	**-**	**9.00**	**8.40**	**7.53**	**5.63**	**2.27**	**-**
Control (Tap water)		9.00	7.33	5.33	3.00	1.00	**5.13**	9.00	7.67	6.00	3.00	1.00	**5.33**
Chitosan 0.5% (Chito.)		9.00	7.67	6.67	4.00	1.00	**5.67**	9.00	8.00	7.00	5.00	1.00	**6.00**
Chitosan 1% (Chito.)		9.00	8.00	6.67	5.00	1.67	**6.07**	9.00	8.33	7.33	6.33	2.00	**6.60**
Nano Chito. 25ppm		9.00	9.00	8.00	6.33	2.33	**6.93**	9.00	9.00	8.33	6.17	2.33	**6.97**
Nano Chito. 50ppm		9.00	9.00	9.00	7.67	4.67	**7.87**	9.00	9.00	9.00	7.67	5.00	**7.93**

* Score: 9= Excellent, 7= Good, 5= Fair, 3= Poor, 1= unsalable

LSD at 5%	Cutting method (C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	0.13	0.20	0.20	0.28	0.28	0.45	0.63
2nd season	0.13	0.20	0.20	0.28	0.28	0.45	0.63

it is clear from the results in Table 2 that, the best general appearance at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50 ppm which gave 5.00 and 5.67 in the first and second seasons, respectively, followed by the interaction treatment among cutting pods and dipping in nano chitosan (50 ppm) at the end of storage period that gave 4.33 as average seasons. It is known that, consumers usually judge the quality of fresh-cut fruit on the basis of appearance and freshness at the time of purchase **(Kader, 2002)**.

Total Chlorophyll Content (SPAD)

Results tabulated in Table 3 indicate that, total chlorophyll content was gradually decreased as the storage time increased, where the maximum values were occurred at harvesting time (39.28 and 41.49 SPAD) in the 1st and 2nd seasons, respectively, meanwhile the minimum values were noticed at the end of storage period (26.35 and 27.35 SPAD) in the 1st and 2nd seasons, respectively. The reduction in chlorophyll content with the elapse of storage period may be due to the destruction of chlorophyll and transformation of chloroplasts to chromoplasts by chlorophyllase activity **(Hulme, 1970)**. These results were achieved in the two seasons and were in agreement with those obtained by **Shehata *et al*. (2015)** and **Gad El-Rab (2018)** on snap bean pods.

Concerning the effect of cutting method, the results in Table 3 show that, there were significant differences between two cutting methods in total chlorophyll content, where cutting pods gave the minimum values of total chlorophyll content (33.01 and 34.90 SPAD), whereas full pods recorded the maximum values of total chlorophyll content (31.99 and 34.31 SPAD) in the 1st and 2nd seasons, respectively. These results are in agreement with those obtained by **Kasim and Kasim (2015)** on fresh-cut snap bean pods.

Respecting the effect of dipping solutions results revealed that there were significant differences among dipping solutions treatments and control on total chlorophyll content during storage. Snap bean pods treated with any dipping solutions treatments gave higher value of total chlorophyll content as compared with control. However, snap bean pods dipped in nano chitosan at 50ppm and/or 25 ppm were the most effective treatment for maintaining total chlorophyll content, followed by chitosan at 1%. On the other side the lowest values of total chlorophyll content were recorded by control treatment that gave 29.31 and 32.04 SPAD in the 1st and 2nd seasons, respectively.

The reduction of chlorophyll loss of fruit during storage by using chitosan may be attributed to these materials reduced the ethylene production by fruit thus lower respiration rate resulted in lower activity of chlorophyllase and consequence reduced color change **(El-Hamahmy *et al*., 2017)**. These results were achieved in the two seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods. Also, **Chong *et al*. (2015)** found that fresh cut honeydew coated with chitosan at 2% were significantly delayed color changes during storage as compared to control.

With regard to the interaction among cutting method, dipping solutions and storage period, it is clear from the results in Table 3 that, the highest values of total chlorophyll content at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50ppm which gave 31.42 and 31.47 SPAD in the first and second seasons, respectively, followed by the interaction treatment among cutting pods and dipping in nano chitosan (50ppm) at the end of storage period that gave 31.03 and 30.58 SPAD in the 1st and 2nd seasons, respectively. In generally, this means that, there were positive correlation between total chlorophyll content and general appearance (Table 2).

Pod Firmness (g/cm^2)

The results described in Table 4 indicate that there was a significant reduction in pod firmness of snap bean by the prolongation of storage period in the two seasons**,** where the maximum values were occurred at the harvesting time (800 and 810 g/cm^2) in the 1st and 2nd seasons respectively, meanwhile the minimum values were noticed at the end of storage period (586 and 583 g/cm^2) in the 1st and 2nd seasons respectively. The decline in pod firmness may be due to the gradually breakdown of proto-pectin to lower molecular fractions which are

Table 3. Effect of some postharvest treatments on total chlorophyll content of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		Total chlorophyll content (SPAD unit)											
Full pods	Control (Tap water)	39.25	33.18	28.55	25.63	22.76	**29.87**	41.49	35.45	32.67	27.66	24.03	**32.26**
	Chitosan 0.5%	39.25	35.08	32.00	28.14	25.67	**32.03**	41.49	37.70	34.00	30.66	27.04	**34.18**
	Chitosan 1%	39.25	35.55	32.85	29.63	26.56	**32.77**	41.49	37.75	34.11	31.51	27.55	**34.48**
	Nano Chito. 25 ppm	39.25	36.48	34.58	32.17	29.73	**34.44**	41.49	38.40	36.58	34.80	28.70	**35.99**
	Nano Chito. 50 ppm	39.25	38.12	36.29	34.51	31.42	**35.92**	41.49	40.73	38.61	35.73	31.47	**37.61**
	Mean	**39.25**	**35.68**	**32.85**	**30.02**	**27.29**	**33.01**	**41.49**	**38.01**	**35.19**	**32.07**	**27.76**	**34.90**
Cutting pods	Control (Tap water)	39.25	31.48	27.34	24.37	21.33	**28.75**	41.49	35.25	32.00	27.08	23.28	**31.82**
	Chitosan 0.5%	39.25	34.34	30.68	26.62	23.00	**30.78**	41.49	37.45	33.55	29.64	26.33	**33.69**
	Chitosan 1%	39.25	34.76	31.76	27.43	24.53	**31.55**	41.49	37.55	33.85	30.09	26.51	**33.90**
	Nano Chito. 25ppm	39.25	36.00	33.79	30.86	27.43	**33.47**	41.49	37.90	34.72	33.00	28.00	**35.02**
	Nano Chito. 50ppm	39.25	37.42	35.37	34.09	31.03	**35.43**	41.49	40.43	37.48	35.52	30.58	**37.10**
	Mean	**39.25**	**34.80**	**31.79**	**28.67**	**25.46**	**31.99**	**41.49**	**37.72**	**34.32**	**31.07**	**26.94**	**34.31**
General mean		**39.28**	**35.24**	**32.32**	**29.34**	**26.35**	-	**41.49**	**37.86**	**34.76**	**31.57**	**27.35**	**-**
Control (Tap water)		39.25	32.33	27.94	25.00	22.04	**29.31**	41.49	35.35	32.33	27.37	23.65	**32.04**
Chitosan 0.5% (Chito.)		39.25	34.71	31.34	27.38	24.33	**31.40**	41.49	37.57	33.77	30.15	26.68	**33.93**
Chitosan 1% (Chito.)		39.25	35.15	32.30	28.53	25.54	**32.16**	41.49	37.65	33.98	30.80	27.03	**34.19**
Nano Chito. 25ppm		39.25	36.24	34.18	31.51	28.58	**33.95**	41.49	38.15	35.65	33.90	28.35	**35.51**
Nano Chito. 50ppm		39.25	37.77	35.83	34.30	31.22	**35.67**	41.49	40.58	38.04	35.62	31.02	**37.35**

LSD at 5%	Cutting method (C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	0.41	0.65	0.65	0.92	0.92	1.46	2.07
2nd season	0.42	0.66	0.66	0.94	0.94	1.48	2.10

Table 4. Effect of some postharvest treatments on firmness of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		Firmness (g/cm^2)											
Full pods	Control (Tap water)	800	730	710	673	539	**690**	810	736	715	677	533	**694**
	Chitosan 0.5%	800	758	742	710	577	**717**	810	760	744	716	571	**720**
	Chitosan 1%	800	763	755	726	584	**725**	810	766	758	729	583	**729**
	Nano Chito. 25ppm	800	776	769	739	610	**739**	810	794	773	746	611	**747**
	Nano Chito. 50ppm	800	788	780	753	664	**757**	810	805	788	761	657	**764**
	Mean	**800**	**763**	**751**	**720**	**595**	**726**	**810**	**772**	**755**	**726**	**591**	**731**
Cutting pods	Control (Tap water)	800	725	693	664	530	**682**	810	728	697	660	529	**685**
	Chitosan 0.5%	800	746	727	680	551	**701**	810	749	730	684	548	**704**
	Chitosan 1%	800	752	733	685	560	**706**	810	754	739	690	556	**710**
	Nano Chito. 25ppm	800	770	762	731	592	**731**	810	783	764	738	595	**738**
	Nano Chito. 50ppm	800	781	776	745	653	**751**	810	800	780	756	650	**759**
	Mean	**800**	**755**	**738**	**701**	**577**	**714**	**810**	**763**	**742**	**705**	**575**	**719**
General mean		**800**	**759**	**745**	**710**	**586**	**-**	**810**	**767**	**749**	**716**	**583**	**-**
Control		800	727	701	668	534	**686**	810	732	706	668	531	**689**
Chitosan 0.5% (Chito.)		800	752	734	695	564	**709**	810	754	737	700	559	**712**
Chitosan 1% (Chito.)		800	757	744	705	572	**716**	810	760	748	709	569	**719**
Nano Chito. 25ppm		800	773	765	735	601	**735**	810	788	768	742	603	**742**
Nano Chito. 50ppm		800	784	778	749	658	**754**	810	802	784	758	653	**762**

LSD at 5%	Cutting method (C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	3.00	5.00	5.00	7.00	7.00	11.0	16.0
2nd season	4.00	6.00	6.00	8.00	8.00	13.0	18.0

more soluble in water and this directly correlated with the rate of softening of pods **(Wills *et al.*, 1998)**. These results were achieved in the two seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

Regarding the effect of cutting method, the results in Table 4 show that there were significant differences between the two cutting methods in pod firmness, where cutting pods gave the minimum values of pod firmness (714 and 719 g/cm^2), full pods recorded the maximum values of pod firmness (726 and 731 g/cm^2), in the 1st and 2nd seasons, respectively. These results were achieved in the two seasons of study.

With respect to the effect of dipping solutions, results revealed that there were significant differences among dipping solution treatments and control on pod firmness during storage. Snap bean pods treated with all dipping solution treatments recorded higher values of pod firmness as compared with control. However, snap bean pods dipped in nano chitosan at 50ppm and/or 25 ppm were the most effective treatment for maintaining pod firmness, followed by chitosan at 1%. On the other side, the lowest values of pod firmness were recorded by control treatment that gave 686 and 689 g/cm^2 in the 1st and 2nd seasons, respectively. These results were achieved in the two seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

The faster reduction in firmness in untreated pods might also be due to the normally occurring ripening process during storage periods which mainly occurs by degradation of the middle lamella of the cell wall **(Mshraky, 2017)**.

The favorable effect of chitosan on the maintaining firmness of pods could be due to pods treated with chitosan had significantly the lower in malondialdehyde contents and relative leakage rates, as an indicator of membrane integrity than untreated control pods, and indicating maintained higher membrane integrity **(Xing *et al*., 2011)**. Also, could be due to their higher antifungal activity and be covering of the cuticle and lenticel, thereby reducing infection, respiration, and other ripening processes during storage, and preserving the maintenance of membrane integrity **(Hong *et al.*, 2012)**.

As for the interaction among cutting method, dipping solutions and storage period, it is clear from the results in Table 4 that the highest values of pod firmness at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50 ppm which gave 664 and 657 g/cm^2 in the first and second seasons, respectively followed by the interaction treatment among cutting pods and dipping in nano chitosan (50 ppm) at the end of storage period that gave 653 and 650 g/cm^2 in the 1st and 2nd seasons, respectively without significant differences between them.

Total Soluble Solids (TSS as Brix°)

The results described in Table 5 indicate that total soluble solids of snap bean pods decreased with the prolongation of storage until 16 days in the two seasons**,** where the maximum values were occurred at harvesting time (8.79 and 9.00) in the 1st and 2nd seasons, respectively, meanwhile the minimum values were noticed at the end of storage period (6.88 and 7.01) in the 1st and 2nd seasons, respectively. The reduction in TSS (%) during the end of cold storage period might owe much to the higher rate of sugar loss through respiration than water loss through transpiration (**Wills *et al.*, 1998**). These results were achieved in the two seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

With respect to the effect of cutting method, the results in Table 5 show that there were significant differences between two cutting methods in total soluble solids, where full pods gave the maximum total soluble solids (7.80and 7.97), whereas cutting pods recorded the minimum total soluble solids (7.74 and 7.90) in the 1st and 2nd seasons, respectively. The decreasing in total soluble solids may be due to the increasing in the cut surface area which leads to an increase in the rate of water loss by transpiration and dry matter by respiration.

Regarding to the effect of dipping solutions, results revealed that, there were significant differences among dipping solution treatments and control on total soluble solids during storage. Snap bean pods treated with various dipping solutions treatments gave higher values of total soluble solids as compared with control. However, snap bean pods treated with

Table 5. Effect of some postharvest treatments on TSS(%) of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		TSS%											
Full pods	Control (Tap water)	8.79	7.55	7.13	6.90	6.50	**7.37**	9.00	7.64	7.31	7.23	6.93	**7.62**
	Chitosan 0.5%	8.79	7.78	7.40	7.30	6.64	**7.58**	9.00	7.93	7.76	7.52	7.05	**7.85**
	Chitosan 1%	8.79	8.12	7.84	7.59	7.00	**7.87**	9.00	8.37	8.11	7.82	7.22	**8.10**
	Nano Chito. 25ppm	8.79	8.28	8.08	7.72	7.18	**8.01**	9.00	8.56	8.27	7.91	7.30	**8.21**
	Nano Chito. 50ppm	8.79	8.61	8.20	7.97	7.24	**8.16**	9.00	8.72	8.25	7.60	6.85	**8.08**
	Mean	**8.79**	**8.07**	**7.73**	**7.49**	**6.91**	**7.80**	**9.00**	**8.24**	**7.94**	**7.61**	**7.07**	**7.97**
Cutting pods	Control (Tap water)	8.79	7.46	7.10	6.83	6.42	**7.32**	9.00	7.58	7.24	7.10	6.81	**7.54**
	Chitosan 0.5%	8.79	7.71	7.32	7.27	6.59	**7.53**	9.00	7.84	7.79	7.48	6.90	**7.78**
	Chitosan 1%	8.79	8.07	7.78	7.52	6.93	**7.82**	9.00	8.29	8.00	7.72	7.09	**8.02**
	Nano Chito. 25ppm	8.79	8.20	8.00	7.67	7.12	**7.95**	9.00	8.48	8.20	7.83	7.19	**8.14**
	Nano Chito. 50ppm	8.79	8.53	8.14	7.90	7.18	**8.11**	9.00	8.64	8.19	7.52	6.79	**8.03**
	Mean	**8.79**	**7.99**	**7.67**	**7.44**	**6.85**	**7.74**	**9.00**	**8.16**	**7.86**	**7.53**	**6.95**	**7.90**
General mean		**8.79**	**8.03**	**7.70**	**7.46**	**6.88**	**-**	**9.00**	**8.20**	**7.90**	**7.57**	**7.01**	**-**
Control (Tap water)		8.79	7.50	7.11	6.86	6.46	**7.34**	9.00	7.61	7.27	7.16	6.87	**7.58**
Chitosan 0.5% (Chito.)		8.79	7.74	7.36	7.28	6.61	**7.56**	9.00	7.88	7.72	7.50	6.97	**7.81**
Chitosan 1% (Chito.)		8.79	8.09	7.81	7.55	6.96	**7.84**	9.00	8.33	8.05	7.77	7.15	**8.06**
Nano Chito. 25ppm		8.79	8.24	8.04	7.69	7.15	**7.98**	9.00	8.52	8.23	7.87	7.24	**8.17**
Nano Chito. 50ppm		8.79	8.57	8.17	7.93	7.21	**8.13**	9.00	8.68	8.22	7.56	6.82	**8.05**

LSD at 5%	Cutting method (C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	0.05	0.08	0.08	0.12	0.12	0.16	0.26
2nd season	0.05	0.08	0.08	0.11	0.11	0.18	0.26

nano chitosan at 50 ppm and/or 25 ppm gave the highest values of total soluble solids, followed by chitosan at 1% with no significant differences among them in the second season. On the other hand the lowest ones were obtained from control treatment that gave 7.34 and 7.58 in the 1st and 2nd seasons, respectively.

The effect of chitosan coating in maintaining the total soluble solids was probably due to the slowing down of respiration and metabolic activity, hence retarding the ripening process **(Ali *et al*., 2011)**, these results were achieved in the two seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

Concerning to the interaction among cutting method, dipping solutions and storage period, it is clear from the results in Tale 5 that, the highest values of total soluble solids at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50ppm which gave 7.24 and 6.85 in the first and second seasons, respectively followed by the interaction treatment among cutting pods and dipping in nano chitosan (50ppm) at the end of storage period that gave 7.18 and 6.79 g/cm^2 in the 1st and 2nd seasons, respectively.

Crude Fiber (%)

Results in Table 6 show the effect of cold storage periods on fiber (%) of snap bean pods during storage in the two seasons. Results revealed that fiber content of snap bean pods increased with the prolongation of storage period, where the minimum values were occurred at the harvesting time (12.65 and 12.50 %) in the 1st and 2nd seasons respectively. Meanwhile the maximum values were noticed at the end of storage period (16 days) 15.61 and 15.58% in the 1st and 2nd seasons, respectively. In generally, this means that, there were positive correlation between weight loss percentage (Table1) and crude fiber percentage. These results were achieved in the two seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

Regarding the effect of cutting method, it is obvious from the results in Table 6 that the two cutting methods did not reflected any significant effect on crude fiber percentage, these results were achieved in the two seasons of study. With respect to the effect of dipping solutions, results revealed that there were significant differences among dipping solution treatments and control on crude fiber percentage during storage. Snap bean pods treated with all various dipping solutions treatments gave the lowest values of crude fiber percentage as compared with control. However, snap bean pods treated with nano chitosan at 50 ppm and/or 25 ppm gave the lowest values of fiber content with no significant differences between them in the two seasons, followed by chitosan at 1%. On the other side, the highest ones were obtained from control treatment that gave 14.40 and 14.33% in the 1st and 2nd seasons, respectively. These results were achieved in the two seasons and were in agreement with those obtained by **El-hamahmy *et al*. (2017)** and **Gad El-Rab (2018)** on snap bean pods.

The favorable effect of chitosan in reducing of fiber content of snap bean pods during storage may be due to chitosan inhibited the activity of peroxidase (POD), polyphenol oxidase (PPO) and phenylalanine ammonia-lyase (PAL), which delays the process of fiber synthesis of common beans pods **(Ying *et al*., 2012).** Also, **El-Hamahmy *et al*. (2017)** found that thickness of fibrous tissue was reduced in pea pods treated with chitosan coating probably due to its high induction of different antioxidants which delayed the process of fiber synthesis.

As for the interaction among cutting method, dipping solutions and storage period, it is clear from the results in Table 6 that, the lowest values of crude fiber percentage at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50ppm which gave 14.70 and 14.64 % in the first and second seasons, respectively followed by the interaction treatment among cutting pods and dipping in nano chitosan (50ppm) at the end of storage period that gave 14.95 and 14.92% in the 1st and 2nd seasons, respectively without significant differences between them.

Total Microbial Count

Results in Table 7 show the effect of cold storage periods on total microbial count of snap bean pods during storage in the two seasons. Results revealed that total microbial growth in snap bean increased with prolongation of storage

Table 6. Effect of some postharvest treatments on crude fiber (%) of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		Crude fiber (%)											
Full pods	Control (Tap water)	12.65	13.95	14.30	14.60	16.34	**14.37**	12.50	13.86	14.28	14.58	16.29	**14.30**
	Chitosan 0.5%	12.65	13.45	13.87	14.25	15.74	**13.99**	12.50	13.36	13.84	14.21	15.72	**13.92**
	Chitosan 1%	12.65	13.28	13.62	14.00	15.56	**13.82**	12.50	13.24	13.62	13.99	15.51	**13.77**
	Nano Chito. 25ppm	12.65	13.07	13.36	13.70	15.25	**13.60**	12.50	13.00	13.27	13.41	15.23	**13.48**
	Nano Chito. 50ppm	12.65	12.83	12.97	13.21	14.70	**13.27**	12.50	12.74	12.93	13.20	14.64	**13.20**
	Mean	**12.65**	**13.31**	**13.62**	**13.95**	**15.51**	**13.81**	**12.50**	**13.24**	**13.59**	**13.88**	**15.48**	**13.74**
Cutting pods	Control (Tap water)	12.65	14.11	14.37	14.68	16.41	**14.44**	12.50	13.96	14.35	14.65	16.37	**14.36**
	Chitosan 0.5%	12.65	13.82	14.17	14.41	15.90	**14.19**	12.50	13.74	14.15	14.39	15.86	**14.13**
	Chitosan 1%	12.65	13.61	14.08	14.36	15.86	**14.11**	12.50	13.50	14.00	14.33	15.85	**14.03**
	Nano Chito. 25ppm	12.65	13.16	13.45	13.92	15.41	**13.72**	12.50	13.12	13.41	13.98	15.38	**13.68**
	Nano Chito. 50ppm	12.65	12.95	13.23	13.46	14.95	**13.45**	12.50	12.80	13.16	13.35	14.92	**13.34**
	Mean	**12.65**	**13.53**	**13.86**	**14.16**	**15.70**	**13.98**	**12.50**	**13.42**	**13.81**	**14.14**	**15.67**	**13.91**
General mean		**12.65**	**13.42**	**13.74**	**14.06**	**15.61**	**-**	**12.50**	**13.33**	**13.70**	**14.01**	**15.58**	**-**
Control (Tap water)		12.65	14.03	14.33	14.64	16.37	**14.40**	12.50	13.91	14.31	14.61	16.33	**14.33**
Chitosan 0.5% (Chito.)		12.65	13.63	14.02	14.33	15.82	**14.09**	12.50	13.55	13.99	14.30	15.79	**14.03**
Chitosan 1% (Chito.)		12.65	13.44	13.85	14.18	15.71	**13.97**	12.50	13.37	13.81	14.16	15.68	**13.90**
Nano Chito. 25ppm		12.65	13.11	13.40	13.81	15.33	**13.66**	12.50	13.06	13.34	13.69	15.30	**13.58**
Nano Chito. 50ppm		12.65	12.89	13.10	13.33	14.82	**13.36**	12.50	12.77	13.04	13.27	14.78	**13.27**

LSD at 5%	Cutting method (C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	NS	0.53	0.53	0.75	0.75	1.18	1.66
2nd season	NS	0.47	0.47	0.67	0.67	1.05	1.49

Table 7. Effect of some postharvest treatments on microbial count of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		Total microbial count (log 10CFU/g)											
Full pods	Control (Tap water)	0.63	1.39	1.88	3.00	3.80	**2.14**	0.54	1.36	1.83	2.96	3.75	**2.09**
	Chitosan 0.5%	0.63	1.21	1.58	2.56	3.48	**1.89**	0.54	1.20	1.56	2.52	3.43	**1.85**
	Chitosan 1%	0.63	1.17	1.42	2.37	3.37	**1.79**	0.54	1.15	1.39	2.31	3.34	**1.74**
	Nano Chito. 25ppm	0.63	1.06	1.29	2.18	2.96	**1.62**	0.54	1.02	1.25	2.13	2.92	**1.57**
	Nano Chito. 50ppm	0.63	0.86	1.11	1.72	2.61	**1.38**	0.54	0.72	1.08	1.67	2.58	**1.32**
	Mean	**0.63**	**1.14**	**1.46**	**2.36**	**3.24**	**1.76**	**0.54**	**1.09**	**1.42**	**2.31**	**3.20**	**1.71**
Cutting pods	Control (Tap water)	0.63	1.50	2.04	3.20	3.96	**2.28**	0.54	1.47	2.00	3.12	3.90	**2.20**
	Chitosan 0.5%	0.63	1.30	1.73	2.81	3.72	**2.04**	0.54	1.31	1.70	2.77	3.67	**2.00**
	Chitosan 1%	0.63	1.27	1.67	2.69	3.61	**1.97**	0.54	1.25	1.63	2.63	3.56	**1.92**
	Nano Chito. 25ppm	0.63	1.12	1.33	2.24	3.18	**1.70**	0.54	1.10	1.30	2.20	3.16	**1.66**
	Nano Chito. 50ppm	0.63	0.92	1.23	1.96	2.88	**1.52**	0.54	0.88	1.14	1.93	2.83	**1.46**
	Mean	**0.63**	**1.22**	**1.60**	**2.58**	**3.47**	**1.90**	**0.54**	**1.20**	**1.55**	**2.53**	**3.42**	**1.85**
General mean		**0.63**	**1.18**	**1.53**	**2.47**	**3.35**	**-**	**0.54**	**1.14**	**1.48**	**2.42**	**3.31**	**-**
Control (Tap water)		0.63	1.44	1.96	3.10	3.88	**2.20**	0.54	1.41	1.91	3.04	3.82	**2.14**
Chitosan 0.5% (Chito.)		0.63	1.25	1.65	2.68	3.60	**1.96**	0.54	1.25	1.63	2.64	3.55	**1.92**
Chitosan 1% (Chito.)		0.63	1.22	1.54	2.53	3.49	**1.88**	0.54	1.20	1.51	2.47	3.45	**1.83**
Nano Chito. 25ppm		0.63	1.09	1.31	2.21	3.07	**1.66**	0.54	1.06	1.27	2.16	3.04	**1.61**
Nano Chito. 50ppm		0.63	0.89	1.17	1.84	2.74	**1.45**	0.54	0.80	1.11	1.80	2.70	**1.39**

LSD at 5%	Cutting method(C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	0.09	0.15	0.15	0.21	0.21	0.34	0.47
2nd season	0.05	0.08	0.08	0.11	0.11	0.18	0.25

period, where the minimum values were occurred at the harvesting time (0.63 and 0.54 log 10CFU/g) in the 1st and 2nd seasons respectively. Meanwhile the maximum values were noticed at the end of storage period (16 days) 3.35 and 3.31 log 10CFU/g in the 1st and 2nd seasons, respectively. These results were achieved in both seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

With regard to the effect of cutting method, the results in Table 7 show that there were significant differences between the two cutting methods in total microbial count, where cutting pods gave the maximum values of total microbial count (1.90 and 1.85 log 10CFU/g), whereas full pods recorded the minimum values of total microbial count (1.76 and 1.71 log 10CFU/g), in the 1st and 2nd seasons, respectively. The increasing in total microbial count may be due to the increasing in the cutted pods surface area which leads to an increase in microbial growth. These results were achieved in the two seasons of study. Similar results were reported by **Kasim and Kasim (2015)** and **Gad El-Rab (2018)** on fresh-cut snap bean.

With respect to the effect of dipping solutions, results revealed that there were significant differences among dipping solution treatments and control on total microbial count during storage. Snap bean pods treated with all various dipping solution treatments gave the lowest values of total microbial count as compared with control. However, snap bean pods treated with nano chitosan at 50ppm and/or 25 ppm gave the lowest values of total microbial count, followed by chitosan at 1%. On the other side, the highest ones were obtained from control treatment which gave 2.20 and 2.14 log 10CFU/g in the 1st and 2nd seasons, respectively. These results were achieved in the two seasons of study.

Concerning the interaction among cutting method, dipping solutions and storage period, it is clear from the results in Table 7 that the lowest values of total microbial count at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50ppm which gave 2.61 and 2.58 log 10CFU/g in the first and second seasons, respectively followed by the interaction treatment among cutting pods and dipping in nano chitosan (50ppm) at the end of storage period that gave 2.88 and 2.83 log 10CFU/g in the 1st and 2nd seasons, respectively without significant differences between them.

Polyphenol Oxidase Activity (PPO)

Results in Table 8 show the effect of cold storage periods on polyphenol oxidase activity (PPO) of snap bean pods during storage in the two seasons. Results revealed that PPO of snap bean increased with prolongation of storage period, where the minimum values were occurred at the beginning of storage period (0.430 and 0.415 unit/g fresh weight) in the 1st and 2nd seasons, respectively, meanwhile the maximum values were noticed at the end of storage period (16days) 0.527 and 0.522 unit/g fresh weight in the 1st and 2nd seasons, respectively. These results were achieved in both seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

With regard to the effect of cutting method, the results in Table 8 show that there were significant differences between the two cutting methods on polyphenol oxidase activity, where cutting pods gave the maximum values of polyphenol oxidase activity (0.486 and 0.477 unit/g fresh weight), whereas full pods recorded the minimum values of PPO (0.479 and 0.470 unit/g fresh weight) in the 1st and 2nd seasons, respectively. These results were achieved in the two seasons of study and were in agreement with those obtained by **Kasim and Kasim (2015)** who suggested that PPO enzyme activity increase when snap bean pod was cut and that the activity of phenolase was closely associated with the development of browning.

With respect to the effect of dipping solutions, results revealed that there were significant differences among dipping solution treatments and control on polyphenol oxidase activity during storage. Snap bean pods treated with all various dipping solution treatments gave the lowest values of polyphenol oxidase activity as compared with control. However, snap bean pods treated with nano chitosan at 50ppm and/or 25 ppm gave the lowest values of polyphenol oxidase activity, followed by chitosan at 1%. On the other side the highest ones were obtained from control treatment which gave 0.509

Table 8. Effect of some postharvest treatments on polyphenol oxidase activity (PPO) of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		Polyphenol oxidase activity (unit/g fresh weight)											
Full pods	Control (Tap water)	0.430	0.493	0.512	0.533	0.563	**0.506**	0.415	0.472	0.510	0.530	0.560	**0.497**
	Chitosan 0.5%	0.430	0.468	0.487	0.508	0.531	**0.485**	0.415	0.453	0.479	0.506	0.526	**0.476**
	Chitosan 1%	0.430	0.461	0.480	0.499	0.523	**0.479**	0.415	0.448	0.472	0.499	0.519	**0.471**
	Nano Chito. 25ppm	0.430	0.450	0.468	0.489	0.506	**0.469**	0.415	0.434	0.455	0.486	0.500	**0.458**
	Nano Chito. 50ppm	0.430	0.439	0.452	0.473	0.491	**0.457**	0.415	0.421	0.442	0.471	0.489	**0.448**
	Mean	**0.430**	**0.462**	**0.480**	**0.500**	**0.523**	**0.479**	**0.415**	**0.446**	**0.472**	**0.498**	**0.519**	**0.470**
Cutting pods	Control (Tap water)	0.430	0.499	0.520	0.541	0.570	**0.512**	0.415	0.479	0.518	0.539	0.566	**0.503**
	Chitosan 0.5%	0.430	0.484	0.499	0.522	0.542	**0.495**	0.415	0.462	0.490	0.520	0.537	**0.485**
	Chitosan 1%	0.430	0.473	0.493	0.514	0.539	**0.490**	0.415	0.457	0.484	0.511	0.530	**0.479**
	Nano Chito. 25ppm	0.430	0.456	0.472	0.494	0.511	**0.473**	0.415	0.440	0.467	0.492	0.506	**0.464**
	Nano Chito. 50ppm	0.430	0.442	0.460	0.481	0.497	**0.462**	0.415	0.428	0.449	0.478	0.491	**0.452**
	Mean	**0.430**	**0.471**	**0.489**	**0.510**	**0.532**	**0.486**	**0.415**	**0.453**	**0.482**	**0.508**	**0.526**	**0.477**
General mean		**0.430**	**0.467**	**0.484**	**0.505**	**0.527**	**-**	**0.415**	**0.449**	**0.477**	**0.503**	**0.522**	**-**
Control (Tap water)		0.430	0.496	0.516	0.537	0.566	**0.509**	0.415	0.475	0.514	0.535	0.563	**0.500**
Chitosan 0.5% (Chito.)		0.430	0.476	0.493	0.515	0.536	**0.490**	0.415	0.458	0.485	0.513	0.532	**0.480**
Chitosan 1% (Chito.)		0.430	0.467	0.486	0.506	0.531	**0.484**	0.415	0.453	0.478	0.505	0.524	**0.475**
Nano Chito. 25ppm		0.430	0.453	0.470	0.492	0.508	**0.471**	0.415	0.437	0.461	0.489	0.503	**0.461**
Nano Chito. 50ppm		0.430	0.441	0.456	0.477	0.494	**0.460**	0.415	0.424	0.446	0.474	0.490	**0.450**

LSD at 5%	Cutting method (C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	0.003	0.004	0.004	0.006	0.006	0.009	0.012
2nd season	0.002	0.004	0.004	0.005	0.005	0.008	0.012

and 0.500 unit/g fresh weight in the 1st and 2nd seasons, respectively. These results were achieved in the two seasons and were in agreement with those obtained by **Nguyen and Nguyen (2020)** who reported that coating strawberry with 0.2% and 0.4% nano-chitosan preserved the overall quality index of the fruit up to 21 days. These treatments inhibited polyphenol oxidase activity of the stored fruit.

As for the interaction among cutting method, dipping solutions and storage period, it is clear from the results in Table 8 that the lowest values of polyphenol oxidase activity at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50ppm which gave 0.457 and 0.448 unit/g fresh weight in the first and second seasons, respectively followed by the interaction treatment among cutting pods and dipping in nano chitosan (50 ppm) at the end of storage period that gave 0.486 and 0.477 unit/g fresh weight in the 1st and 2nd seasons, respectively.

Total phenolic content (mg/g fresh weight)

Results in Table 9 show the effect of cold storage periods on total phenolic content of snap bean during storage at 4°C. Results indicated that total phenolic content was decreased with prolongation of storage period. Where the maximum values were occurred at the beginning of storage period (0.410 and 0.425 mg/g fresh weight) in the 1st and 2nd seasons, respectively. Meanwhile the minimum values were noticed at the end of storage period (16 days) 0.219 and 0.226 mg/g fresh weight in the 1st and 2nd seasons, respectively. The decrease in phenolic content at the longest storage period might be due to that phenolic compounds have significant role oxidation processes as antioxidants and as substrates in browning reactions. During storage, the enzymatic oxidation is continued, and the resulted quinones are polymerized non-enzymatically to give darker pigments, which explain the parallel consumption of phenols with the development of blackness throughout the storage period (**Robards *et al*., 1999).** These results were achieved in both seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

Regarding to the effect of cutting method, the results in Table 9 show that there were significant differences between the two cutting methods on the total phenolic content, where cutting pods gave the minimum values of total phenolic content (0.317 and 0.325 mg/g fresh weight), whereas full pods recorded the maximum values of PPO (0.326 and 0.333 mg/g fresh weight) in the 1st and 2nd seasons, respectively. The decrease in phenolic content on fresh-cut snap bean is probably due to the oxidation of PPO enzyme to give the colored quinones and quercetin was oxidized directly by PPO **(Queiroz *et al*., 2008)**. These results were achieved in the two seasons of study and were in agreement with those obtained by **Gad El-Rab (2018)** on fresh-cut snap bean.

With respect to the effect of dipping solutions results revealed that, there were significant differences among dipping solutions treatments and control on total phenolic content during storage. Snap bean pods treated with all various dipping solutions treatments gave the highest values of total phenolic content as compared with control. However, snap bean pods treated with nano chitosan at 50ppm and/or 25 ppm gave the highest values of total phenolic content. On the other side, the lowest ones were obtained from control treatment which gave 0.291 and 0.301 mg/g fresh weight in the 1st and 2nd seasons, respectively. Also, chitosan coatings have been proved to be applicable for prevention the bioactive compounds in fruit and vegetables during storage (**Gol *et al*., 2013 and Kerch, 2015**).

Concerning to the interaction among cutting method, dipping solutions and storage period, it is clear from the results in Table 9 that, the highest values of total phenolic content at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50ppm which gave 0.349 and 0.357 mg/g fresh weight in the first and second seasons, respectively followed by the interaction treatment among cutting pods and dipping in nano chitosan (50ppm) at the end of storage period that gave 0.345 and 0.352 mg/g fresh weight in the 1st and 2nd seasons, respectively. This means that there were negative correlation between phenolic content and polyphenol oxidase activity of pods.

Crude Protein (%)

Results in Table 10 show the effect of cold storage periods on crude protein (%) of snap bean

Table 9. Effect of some postharvest treatments on total phenolic content of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (days)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		Total phenolic content (mg/g fresh weight)											
Full pods	Control (Tap water)	0.410	0.335	0.290	0.254	0.181	**0.294**	0.425	0.342	0.296	0.261	0.191	**0.303**
	Chitosan 0.5%	0.410	0.368	0.319	0.291	0.215	**0.321**	0.425	0.369	0.321	0.298	0.217	**0.326**
	Chitosan 1%	0.410	0.372	0.324	0.302	0.220	**0.326**	0.425	0.380	0.328	0.310	0.225	**0.334**
	Nano Chito. 25ppm	0.410	0.388	0.335	0.317	0.243	**0.339**	0.425	0.390	0.339	0.320	0.249	**0.345**
	Nano Chito. 50ppm	0.410	0.395	0.347	0.327	0.265	**0.349**	0.425	0.403	0.352	0.331	0.272	**0.357**
	Mean	**0.410**	**0.372**	**0.323**	**0.298**	**0.225**	**0.326**	**0.425**	**0.377**	**0.327**	**0.304**	**0.231**	**0.333**
Cutting pods	Control (Tap water)	0.410	0.330	0.282	0.250	0.171	**0.289**	0.425	0.336	0.289	0.254	0.187	**0.298**
	Chitosan 0.5%	0.410	0.351	0.304	0.270	0.199	**0.307**	0.425	0.356	0.310	0.279	0.206	**0.315**
	Chitosan 1%	0.410	0.360	0.312	0.275	0.203	**0.312**	0.425	0.362	0.317	0.287	0.209	**0.320**
	Nano Chito. 25ppm	0.410	0.380	0.330	0.311	0.231	**0.332**	0.425	0.385	0.335	0.316	0.237	**0.340**
	Nano Chito. 50ppm	0.410	0.391	0.342	0.320	0.260	**0.345**	0.425	0.397	0.349	0.325	0.266	**0.352**
	Mean	**0.410**	**0.362**	**0.314**	**0.285**	**0.213**	**0.317**	**0.425**	**0.367**	**0.320**	**0.292**	**0.221**	**0.325**
General mean		**0.410**	**0.367**	**0.318**	**0.292**	**0.219**	-	0.425	**0.372**	**0.324**	**0.298**	**0.226**	-
Control (Tap water)		0.410	0.333	0.286	0.252	0.176	**0.291**	0.425	0.339	0.292	0.258	0.189	**0.301**
Chitosan 0.5% (Chito.)		0.410	0.360	0.311	0.280	0.207	**0.314**	0.425	0.362	0.316	0.289	0.211	**0.321**
Chitosan 1% (Chito.)		0.410	0.366	0.318	0.289	0.211	**0.319**	0.425	0.371	0.323	0.299	0.217	**0.327**
Nano Chito. 25ppm		0.410	0.384	0.333	0.314	0.237	**0.335**	0.425	0.387	0.337	0.318	0.243	**0.342**
Nano Chito. 50ppm		0.410	0.393	0.345	0.324	0.262	**0.347**	0.425	0.400	0.350	0.328	0.269	**0.354**

LSD at 5%	Cutting method(C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	0.004	0.006	0.006	0.008	0.008	0.013	0.019
2nd season	0.004	0.006	0.006	0.008	0.008	0.014	0.019

Table 10. Effect of some postharvest treatments on crude protein percentage of fresh cut and full pods of snap bean during cold storage periods at 4°C in 2016/2017 and 2017/2018 seasons

Cutting method	Dipping solution	2016/2017 season						2017/2018 season					
		Storage period (day)											
		0	4	8	12	16	Mean	0	4	8	12	16	Mean
		Crude protein (%)											
Full pods	Control (Tap water)	18.33	16.86	16.52	14.00	12.11	**15.56**	18.56	16.91	16.38	14.33	12.43	**15.72**
	Chitosan 0.5%	18.33	17.32	16.93	14.63	13.00	**16.04**	18.56	17.65	17.00	15.10	13.22	**16.30**
	Chitosan 1%	18.33	17.63	17.32	15.00	13.12	**16.28**	18.56	17.81	17.41	15.31	13.46	**16.51**
	Nano Chito. 25ppm	18.33	18.00	17.64	15.83	13.79	**16.72**	18.56	18.27	17.86	16.12	13.86	**16.93**
	Nano Chito. 50ppm	18.33	18.23	17.93	16.65	14.37	**17.10**	18.56	18.40	18.07	16.90	14.61	**17.31**
	Mean	**18.33**	**17.61**	**17.27**	**15.22**	**13.28**	**16.34**	**18.56**	**17.81**	**17.34**	**15.55**	**13.51**	**16.55**
Cutting pods	Control (Tap water)	18.33	16.65	16.41	13.86	11.88	**15.42**	18.56	16.87	16.30	13.94	11.90	**15.51**
	Chitosan 0.5%	18.33	17.04	16.74	14.12	12.65	**15.77**	18.56	17.22	16.43	14.43	12.76	**15.88**
	Chitosan 1%	18.33	17.19	16.85	14.36	12.81	**15.91**	18.56	17.46	16.57	14.57	12.95	**16.02**
	Nano Chito. 25ppm	18.33	17.85	17.51	15.31	13.50	**16.50**	18.56	17.93	17.72	15.67	13.72	**16.72**
	Nano Chito. 50ppm	18.33	18.14	17.84	16.23	14.21	**16.95**	18.56	18.32	17.95	16.64	14.52	**17.20**
	Mean	**18.33**	**17.37**	**17.07**	**14.77**	**13.01**	**16.11**	**18.56**	**17.56**	**16.99**	**15.05**	**13.17**	**16.26**
General mean		**18.33**	**17.49**	**17.17**	**15.00**	**13.14**	**-**	**18.56**	**17.68**	**17.17**	**15.30**	**13.34**	**-**
Control (Tap water)		18.33	16.75	16.46	13.93	11.99	**15.49**	18.56	16.89	16.34	14.13	12.16	**15.62**
Chitosan 0.5% (Chito.)		18.33	17.18	16.83	14.37	12.82	**15.91**	18.56	17.43	16.71	14.76	12.99	**16.09**
Chitosan 1% (Chito.)		18.33	17.41	17.08	14.68	12.96	**16.09**	18.56	17.63	16.99	14.94	13.20	**16.26**
Nano Chito. 25ppm		18.33	17.92	17.57	15.57	13.64	**16.61**	18.56	18.10	17.79	15.89	13.79	**16.82**
Nano Chito. 50ppm		18.33	18.18	17.88	16.44	14.29	**17.02**	18.56	18.36	18.01	16.77	14.56	**17.25**

LSD at 5%	Cutting method (C)	Treatments (T)	Storage period (S)	C× T	C× S	T × S	C×T×S
1st season	NS	0.56	0.56	0.80	0.80	1.26	1.78
2nd season	NS	0.58	0.58	0.81	0.81	1.29	1.82

during storage at 4°C. Results revealed that protein content of snap bean pods decreased with prolongation of storage period, Where the maximum values were occurred at the beginning of storage period (18.33 and 18.56%) in the 1st and 2nd seasons, respectively. Meanwhile the minimum values were noticed at the end of storage period (16 days) and valued 13.14 and 13.34 % in the 1st and 2nd seasons, respectively. These results were achieved in the two seasons of study and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

Regarding to the effect of cutting method, it is obvious from the results in Table 10 that, the two cutting methods did not reflected any significant effect on crude protein percentage, these results were achieved in the two seasons of study.

With respect to the effect of dipping solutions results revealed that there were significant differences among dipping solution treatments and control on crude protein % during storage. Snap bean pods treated with all various dipping solution treatments gave the highest values of crude protein (%) as compared with control. However, snap bean pods treated with nano chitosan at 50ppm and/or 25 ppm gave the highest values of crude protein (%). On the other hand the lowest ones were obtained from control treatment which gave 15.49 and 15.62% in the 1st and 2nd seasons, respectively. The reduction of protein content of pods by using chitosan, treatments may be attributed to these materials reduced respiration rate, therefore, it can delay the use of protein in the enzymatic reactions of respiration **Gad El-Rab (2018)**. These results were achieved in the two seasons and were in agreement with those obtained by **Gad El-Rab (2018)** on snap bean pods.

As for the interaction among cutting method, dipping solutions and storage period, it is clear from the results in Table 10 that the highest values of protein content % at the end of storage period (16 days) were noted by full pods when dipped in nano chitosan at 50ppm which gave 16.34 and 16.55 % in the first and second seasons, respectively followed by the interaction treatment among cutting pods and dipping in nano chitosan (50ppm) at the end of storage period that gave 16.11 and 16.26 % in the 1st and 2nd seasons, respectively without significant differences between them. However, **Rabea *et al*., (2003)** detected that the antimicrobial of chitosan may be proceeded by the combination between chitosan and the microbial cell membranes, which leads to the leakage of proteins constituents.

Conclusion

From the pervious results, it could be concluded that, snap bean full pods which dipped in nano chitosan at 50 and/or 25 ppm significantly reduced weight loss, total soluble solids, crude fiber, total microbial count and PPO activity and maintained pod quality and gave pods with good appearance, total chlorophyll, firmness and total phenolic after 12 days of storage at 4ºC.

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تأثير بعض معاملات ما بعد الحصاد على جودة قرون الفاصوليا الخضراء الكاملة والمجزأة الطازجة أثناء التخزين المبرد

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تزداد الخسائر الاقتصادية التي تتكبدها ثمار الخضر بعد القطف من خلال التلف أثناء التبريد خلال مرحلتي النقل والتخزين، والتي يمكن التحكم فيها بأمان بواسطة بعض المواد عديدة السكر مثل الشيتوزان، لوحظ تأثير معاملات النقع المختلفة وهى الكنترول (ماء الصنبور لمدة ٥ دقائق) والشيتوزان بتركيز ٠.٥ و ١% لمدة ٥ دقائق وكذلك النانو شيتوزان بتركيز (٢٥ و ٥٠ جزء في المليون لمدة ٥ دقائق) على قرون الفاصوليا الكاملة والمقطعة لصنف بوليستا أثناء التخزين المبرد، لذا أجريت تجربتان في المزرعة البحثية بمحطة بحوث البساتين بالقصاصين بمحافظة الإسماعيلية ومعمل ما بعد الحصاد في قسم البساتين كلية الزراعة جامعة الزقازيق، مصر، خلال موسمي الخريف المتتاليين لأعوام ٢٠١٦/ ٢٠١٧ و٢٠١٧/٢٠١٨، حيث أن النسبة المئوية للفقد فى وزن القرون، المظهر العام، المحتوى الكلي من الكلوروفيل (وحدة سباد)، درجة الصلابة (جم/سم^{٢})، المواد الصلبة الكلية الذائبة (وحدة بركس)، النسبة المئوية للألياف الخام، العدد الكلي للميكروبات (لوغاريتم ١٠ CFU/ز)، نشاط إنزيم البولي فينول أوكسيديز (وحدة/ جم كوزن طازج)، محتوى الفينولات الكليه (ملجم/جم كوزن طازج) والنسبة المئوية للبروتين الخام لقرون الفاصوليا تم تقديرها عند صفر، ٤، ٨، ١٢ و١٦ يومًا من التخزين المبرد على ٤°م ورطوبة نسبية ٩٠%، أوضحت النتائج المتحصل عليها أن معاملات النقع فى محاليل الشيتوزان بتركيز ١% أو النانو شيتوزان بتركيز ٥٠ أو ٢٥ جزء فى المليون سجلت أفضل النتائج بالنسبة للفقد فى الوزن (%)، المواد الصلبة الكلية الذائبة، النسبة المئوية للألياف الخام، العدد الكلى للميكروبات، نشاط إنزيم البولي فينول أوكسيديز، كما أنها حافظت على جودة القرون بمظه رجيد ومحتوى الكلوروفيل الكلى، الصلابة وكذلك الفينولات الكلية بعد مرور ١٢ يوما من التخزين المبرد على ٤°م ورطوبة نسبية ٩٠% مقارنة بالمعاملات الأخرى ومعاملة الكنترول خلال فترات التخزين المبرد المختلفة.

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