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Effect of some biostimulants on mango fruit drop and quality

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ABSTRACT

Current experiment was carried out on two Egyptian traditional mango varieties, "Eiwess and Hendi" to investigate the effect of some natural plant Biostimulants "Kaolin &Chitosan and Jasmine oil" on fruit drop, Fruit storage ability and quality, when applied to young mango trees (5years old) in the preharvest period. The above-cited Biostimulants were sprayed 3 times on healthy mango trees in an orchard adopting recommended agricultural practices. First application was achieved on fruit set stage, the 2nd application one month later, and the 3rd application after another month, during the years of 2018 and 2019. The mango farm is situated in El Sadat district, Monofeya. Immediately after harvest, a sample of 100 mature intact fruits was taken from each treatment and control. Fruits were transported to fruit handling research laboratory for cold storing (13 ± 1°C and RH 85-90%) and estimating fruit quality. The results indicated that treatments caused a pronounced beneficial effect in lowering fruit drop, counted after 2 months of fruit setting, compared to control trees which recorded a percentage of drop between 80% and 94%, in both seasons and always higher than treatments, while jasmine oil treatment resulted in 66% with Eiwess trees and 58% for Hendi trees in first season, followed by chitosan and kaolin, but in second season fruit drop results were mixed with no consistent pattern. Other fruit quality parameters revealed that all treatments induced generally a slower pace of maturity in cold store compared to control. Fruit weight loss percentage of control was higher always compared to treatments fruits, recording in 1st year a range of 4.7% to 6.8%, for Eiwess mango and 4.4% to 6.8 % for Hendi fruits after 2 weeks in cold store, compared to 8.4%-8.6% for control and increased a little bit after 3 weeks and reached a higher level over 10 % after 4 weeks. Second season fruit weight loss was a little bit higher but jasmine oil treatment gave the least weight loss. Fruit firmness of control declined quickly compared to all treatments that had acceptable values till after 2 weeks in cold store (between 3.7-4.8 lb. /in2 for Eiwess, and a range of 4.7-5.8 lb./in2 for Hendi fruits in both seasons) and after 4 weeks fruits were remarkably softer. Fruit freshness, measured by L* values was nearly similar all over the experiment period. The evolution of yellowness of pulp was nearly the same for all treatments and control and after 3 weeks in cold store, it was a little bit quicker for chitosan with Eiwess fruits, (91 degrees) and kaolin for Hendi fruits (91-96 degrees). Values of TSS % increased gradually for all treatments with higher values for control fruits (as it is expected to be more advanced in ripening) and recording about 22% after 3 weeks in cold storage compared to a range of18.7-21% for treatments for Eiwess fruits in both seasons, while values of TSS% of Hendi were smaller and followed the same trend. Control fruits acidity during cold storage had the lowest values compared to treatment fruits whose acidity declined also but slower than control. After 3 weeks in cold storage treatments fruits were healthy with no decay compared to 20-40 %of control fruit decay while after 4 weeks in cold storage, chilling injury affected all treatments, in a range of 33-60% for both varieties and both seasons, making these fruits unacceptable for marketing. Best eating quality of these mango fruits was found after 2 weeks of cold storage but still, it was acceptable after 3 weeks in cold room. The results indicated the effectiveness of spraying mango trees with the above-mentioned Biostimulants and especially Jasmine oil to decrease fruit drop rate and slow maturity progress after harvest to keep fruit quality after 3 weeks in cold storage and not to prolong cold storage after a time limit.

Keywords: Mango, Biostimulants, Kaolin, Chitosan, Jasmine oil, Fruit drop, Quality.

INTRODUCTION

Mango is a very nutritious fruit because of its content of antioxidants. It is considered one of the most important fruits in Egypt, with a production close to 1.5 million tons (FAO 2021). Egypt has a wide range of mango varieties, local traditional varieties and newly introduced mangoes. Two of the best traditional varieties are Eiwess and Hendi, which are strongly desired in local and export markets for their excellent flavor, and eating quality. But it was noted in recent years a decrease in productivity of these varieties, Therefore continuous efforts should be exerted to enhance the yield and quality of the above-mentioned local varieties of mango. Eiwess variety fruits are very appreciated locally and abroad for their attractive orange color, good taste (TSS 23% or more) as cited by (Elsheshetawy 2016) and the flesh is free from fibers. Hendi variety fruits have particularly good taste and aroma, but the seed occupies a big portion of the fruit, in addition to a high content of fibers attached to seed. They also have a low aptitude for cold storage (Elsayed *et al.*, 2018) Biological and organic biostimulant compounds are used to enhance vegetative and fruit growth by encouraging nutrient uptake and transportation and also to protect against decay pathogens, worldwide in fruit trees. In this study, three available locally and affordable Biostimulants were applied to mango trees in the preharvest phase, to get a high yield and good fruit quality at harvest time. Chitosan, one of the Biostimulants used in this experiment, is a natural oligo saccharide compound extracted from insects and seafood shells and used to induce plant defense system in applications, pre and post-harvest on fruits and vegetables (Ma *et al.,* 2013), and(Sajid *et al.,* 2020) found that when chitosan at 1%applied on peach after 50 days of full bloom, it improved most of the peach attributes (fruit volume, yield per tree, fruit firmness, acidity and vitamin C content, and TSS%). Kaolin,

the second Biostimulant used in this experiment is a natural mineral with the formula $Al_2Si_2O_5(OH)_4$, and found in Egypt and used as a foliar spray on fruit trees to protect them against abiotic stresses like extreme environmental conditions, (temperate light, and deficiencies in nutrition). Zaghloul *et al.,* (2017) specified that spraying kaolin at 4%, three times in summer months, on mandarin trees, was effective in reducing fruit pre-harvest disorders and improving yield and fruit quality at harvest, in addition to increasing storage time of mandarin compared to control. In another experiment by (Eldeen *et al.,* 2015), it was concluded that treatments of spraying kaolin, young mango trees gave a high effect on improved growth parameters of these trees. Essential oils are also beneficial as a pre-harvest and post-harvest quality (Shukla 2018). Jasmine oil a natural substance activated by an oxidizing agent proved to stimulate plant growth and strengthen resistance to pests, because of its contents of compounds of hormonal effects, like geranial, linalool, auxin-like substances, Methyl Jasmonate (MJ) and Jasmines acid, which alleviate stress factors like chilling temperatures. Zaky and Elzayat (2008) found that dipping carnation-cut flowers in activated Jasmine oil (0.03%) was effective in prolonging their life and delayed flower opening, (Gonzalez-Aguilar *et al.,* 2001) found that treatments of mango fruits (kent) with methyl Jasmonate at 5°C (14days) reduced chilling injury symptoms and enhanced skin color. Jasmine oil also gave a promising result in keeping a mixed load of fruits in a good sanitary state (Elzayat *et al.,* 2015). This experiment was achieved for charity and to test the effectiveness and usefulness of the application of the three above-mentioned Biostimulants on trees of two local mango varieties under the harsh condition of new desert land in Egypt, for the sake of increasing fruit set, reducing fruit drop, enhancing yield and fruit quality after harvest and cold storage.

MATERIAL AND METHODS

This study was carried out during two successive seasons of 2018 and 2019 using fruits of Eiwess and Hendi mango varieties. Young trees (5 years old planted at3× 5 m in sandy clay soil under drip irrigation system) in a private orchard at El-Sadat, Monofeya Governorate, Egypt. Chosen randomly as nine trees/treatment, in a separate row. Selected trees were sprayed three times in each season using above 25liters of the Biostimulant solution to cover the tree completely, treatments were carried out at fruit set, one month later and after another month during the seasons of 2018 and 2019.

The treatments:

Selected trees were sprayed with these liquids in separate treatments:

T1: Chitosan at 0.05%

T2: Kaolin at2%

T3: Jasmine oil at 0.03%

T4: Control (Water only)

Immediately after harvest sound mature mango fruits, free from apparent pathogen infection, uniform in shape, weight and color were picked separately from each treated trees. Fruits were harvested in the first half of August during each season. Then fruits were transported to the laboratory and packed in perforated carton boxes in three replicates for each treatment. Each treatment packed in six boxes; they are classified into three groups. The first group contains fruits for periodical determination of physical and chemical quality properties, second group contains fruits for determination of weight loss and third group contains fruits for determination of the decay percent. Fruits stored at 13 ± 1°C with relative humidity (RH) 85-90% for four weeks. Quality parameters of the stored fruits were determined at weekly intervals, as a following:

Physical Properties:-

Fruit Drop percentage:

This was calculated based on the initial count shown in tables.

1) Initial count was achieved after full fruit setting in late March.
2) 1st drop count was achieved one month after initial count.
3) 2nd drop count was achieved two month after initial count.

$$fruit\ Drop\ \% = \frac{Initial\ number\ of\ the\ fruits - remaining\ number\ of\ the\ fruits}{remaining\ number\ of\ the\ fruits} x100$$

Weight loss percentage:

The difference between the initial weight of the fruits at the beginning of storage and that recorded at the date of sampling was noted as weight loss percentage and calculated as follows:

$$Weight\ loss\ \% = \frac{Initial\ weight\ of\ the\ fruits\ (g) - Weight\ at\ the\ date\ of\ sampling\ (g)}{Initial\ weight\ of\ the\ fruits\ (g)} x100$$

Fruit Firmness (Lb.\inch^2):

Fruit firmness was determined as Lb/inch^2 by using fruit pressure tester mod. FT 327 (3-27 Lbs.).

Fruit color:

Lightness and hue angle was estimated using Minolta Calorimeter (Minolta Co. Ltd., Osaka, Japan) as described by (McGuire1992).

Decay percentage:

The percentage of all defected fruits which are not marketable, by consequence of either microbial infection, or internal disorders, including all spoiled fruits by rots, fungus, bacteria or by chilling injury or other physiological disorders were assessed and counted all together as decay during cold storage. The decay percentage was calculated as follows:

$$Decay\ \% = \frac{\text{No. of fruit decayed}}{\text{No. of fruit at the beginning of storage}}$$

Chemical Properties

Total soluble solids (TSS):

The percentage of SSC was determined in fruit juice using Digital refractometer PR32 (0.32% Atago Palate ATago.CO .LTD. Japan).

Titratable acidity (TA %):

The percentage of TA was determined by titrating the juice against 0.1 N sodium hydroxide using phenolphthalein indicators and expressed as percentage of malic acid according to (A.O.A.C. 2000).

Evaluation of organoleptic (eating) quality:

A panel of 3persons has given their estimation of eating quality of mango according to this scale (from 0.0 to 10 based on absence of strange taste and the flavor of fruits): Excellent: 8-10, good: 6.1-8, acceptable: 4.1-6, unacceptable: less than 4. This evaluation was carried out after 1, 2 and 3 weeks of cold storage only and stopped after 4 weeks due to the prevailing decay of fruits.

Statistical analysis:

A randomized complete block design was used to analyse of variance for comparison between the control and the other. All data were subjected to statistical analysis according to the procedures reported by (Snedecor and Cochran 1990) and means were compared by (Duncan 1955) multiple range tests at the 5 % level of probability.

RESULTS

Fruits drop:

The data in Tables (1 and 2) indicated the effectiveness of all treatments in lowering fruit drop percentage compared to control whose trees had a drop percentage of more than 80% 1st season and over 90 % in 2nd season after 2 months of full flowering and it was clear also that the bulk of fruit drop happened after one month of full flowering. It was evident from data that Jasmine oil treatment gave the least fruit drop, especially in first season after 2 months from full flowering, followed by kaolin and Chitosan, in both seasons and for both varieties of mango, in the meantime jasmine oil was effective in first season in lowering fruit drop of Hendi mango trees despite that these trees had generally a higher fruit drop compared to Ewiss trees.

Table 1. Effect of some Biostimulants treatments on fruits drop of Eiwess mango during 2018 and 2019 seasons.

Treatments	Average of fruits No. at setting	Average Of fruits drop%. After 1 month of setting.	Average Of fruits drop%. After 2 months of setting.	Average of fruits No. at setting	Average Of fruits drop%. After 1 month of setting.	Average Of fruits drop%. After 2 months of setting.
	First season			Second season		
Chitosan	62	63.27B	69.39B	49	59.52B	64.68B
Kaolin	76	85.53A	89.47A	49	54.29C	55.24C
Jasmine oil	65	61.54C	66.15C	35	64.52B	83.87A
Control	70	87.1A	88.2A	42	72.1A	80.5A

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Table 2. Effect of some Biostimulants treatments on fruits drop of Hendi mango during 2018 and 2019 seasons.

Treatments	Average of fruits No. at setting	Average Of fruits drop%. After 1 month of setting.	Average Of fruits drop%. After 2 month of setting.	Average of fruits No. at setting	Average Of fruits drop%. After 1 month of setting.	Average Of fruits drop%. After 2 month of setting.
	First season			Second season		
Chitosan	95	69.51A	83.93B	82	84.78A	86.96B
Kaolin	77	33.33B	85.71A	66	34.4C	85.7B
Jasmine oil	80	33.88B	58.26C	90	82.50B	93.75A
Control	95	62.6A	90.5A	90	85.6A	94.1A

Note: Harvesting was done after 2weeks from last date of drop counting.

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Weight loss percentage:

Table (3) displayed a gradual increase in weight loss of Eiwess mango fruits at the end of the storage period (4 weeks). It is noted that after 2weeks in cold storage weight loss was acceptable in the range of 4.7% to 6.7% for Eiwess in both seasons and from 4.4% to 6.8% for Hendi in both seasons compared to an average of 8.5% for control fruits. After 3 weeks weight loss increased, but after 4weeks the loss was noticeably higher. Significant differences were found between all treatments. The lowest weight loss percentage (7.97 and 8.90%) by end of storage was recorded by jasmine oil treatment in both seasons, respectively. On the other hand, control fruits exhibited the highest weight loss value (15.10 and 14.40%) in the first and second seasons, respectively, followed by chitosan treatment in both seasons. Data in Table (4)noted that weight loss in Hendi mango fruits had the same trend as above, with significant differences between all treatments. Fruits treated with jasmine oil confirmed 1st season results and recorded the lowest weight loss percentage generally, while control treatment resulted in the highest weight loss value in two seasons (15.1 and 14.8 respectively).

Table 3. Effect of some Biostimulants treatments on weight loss % of Eiwess mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	0.00	4.58B	6.66B	9.14B	11.15B
Kaolin	0.00	3.55C	5.87C	8.27C	10.40C
Jasmine oil	0.00	3.20D	4.73D	6.78D	7.97D
Control	0.00	5.10A	8.60A	10.60A	15.10A
	Second season				
Chitosan	0.00	2.99C	4.91C	7.50B	10.80B
Kaolin	0.00	2.86D	5.00B	7.53B	9.60C
Jasmine oil	0.00	3.15B	4.94C	6.73C	8.90D
Control	0.00	5.11A	8.84A	9.56A	14.80A

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Table 4. Effect of some Biostimulants treatments on weight loss % of Hendi mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	0.00	4.47C	6.83B	9.52B	11.48B
Kaolin	0.00	4.63B	6.85B	9.55B	11.44B
Jasmine oil	0.00	4.16D	6.07C	8.43C	10.13C
Control	0.00	5.10A	8.40A	10.10A	14.60A
	Second season				
Chitosan	0.00	2.98C	4.51C	7.09C	10.90B
Kaolin	0.00	3.28B	5.31B	7.62B	10.50C
Jasmine oil	0.00	2.78D	4.41D	6.05D	10.80B
Control	0.00	5.40A	8.60A	9.90A	13.70A

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Fruit firmness (Lb. /in^2):

Data on fruit firmness, presented in Tables (5 and 6) indicates that firmness decreased with progress in storage period in both seasons. All treatments yielded lower fruit firmness values than control fruits firmness. There were significant differences among all treated fruits in both seasons due to treatments and also because of some natural variability among fruits. After 3weeks firmness begins in declining and after 4weeks in cold storage (at the end of storage) fruits were relatively soft (2-2.9Lb/ in2) and control fruits were softer than treatment fruits. kaolin treatment showed more efficiency in slowing fruit softening for Eiwess fruits (average of 2.8lb/in^2 in both seasons) compared to control (1.45lb./in^2) and the same trend was observed with Hendi fruits as Kaolin recorded the highest firmness (2.6&2.5lb./in^2) by end of storage in both seasons compared to control whose fruits were softer (1.4-1.5 lb. /in^2) and chitosan treatment came 2nd while Jasmine oil treatment resulted in the lowest fruit firmness values among all treatments.

Table 5. Effect of some Biostimulants treatments on Firmness of Eiwess mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	12.13A	5.37A	3.73B	2.90B	2.20B
Kaolin	11.03C	4.43D	3.87A	3.10A	2.70A
Jasmine oil	11.47B	4.67C	3.67B	2.95B	2.00C
Control	10.87D	4.80B	3.55C	1.80C	1.40D
	Second season				
Chitosan	12.00A	8.20B	4.67D	3.77B	2.50B
Kaolin	11.90AB	9.10A	4.83A	3.80A	2.90A
Jasmine oil	11.80B	7.90C	4.77B	3.77B	2.10C
Control	11.60C	6.60D	4.70C	1.90C	1.50D

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Table 6. Effect of some Biostimulants treatments on Firmness of Hendi mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	11.90A	8.00B	4.73C	3.57C	2.10B
Kaolin	11.87A	8.60A	6.10B	4.00A	2.60A
Jasmine oil	11.80B	8.10B	7.60A	3.87B	1.95C
Control	11.80B	5.60C	3.20D	1.80D	1.40D
	Second season				
Chitosan	12.00B	8.40B	4.80B	3.60B	2.00B
Kaolin	12.20A	8.90A	5.80A	3.70AB	2.50A
Jasmine oil	11.90B	7.85C	4.00C	3.80A	1.90C
Control	12.00B	5.40D	3.60D	1.75C	1.45D

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Fruit color:

A- Brightness of peel or fruit freshness (L value of Hunter colorimeter):

Values of freshness of fruits shown in Table (7) indicated that fruits values of brightness were similar to each other with minor differences between 3rd and 4th weeks in cold storage lightness (L*)of Eiwess peel mango fruits decreased gradually and significantly with prolonging of storage period during both seasons. At the end of the storage period, fruits treated with Jasmine oil recorded the highest value of peel freshness (L value) and was significantly different in both seasons. While, Kaolin fruits treatment exhibited the lowest values of L* in both seasons (52.9 and 53 respectively) while kaolin and chitosan and control had nearly similar values of 2nd. Indicating effectiveness of jasmine oil in slowing decline of mango skin color with time.

Table 7. Effect of some Biostimulants treatments on L* of peel Eiwess mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	59.53B	55.01B	53.78B	53.58B	52.10B
Kaolin	58.30C	54.08C	53.52C	52.62C	51.78C
Jasmine oil	64.67A	61.42C	61.26A	56.05A	52.94A
Control	59.43B	55.01B	53.78B	53.58B	52.10B
	Second season				
Chitosan	53.63B	51.92B	51.91A	51.10A	52.00BC
Kaolin	53.72A	52.16A	51.46B	49.99B	51.80C
Jasmine oil	53.38C	50.75C	50.26C	49.65C	53.00A
Control	48.56D	45.62D	45.56D	44.68D	52.20B

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

From Results noted in Table (8) it can be concluded that skin brightness (L*)of Hendi mango peel fruits decreased also gradually with the progress of storage period during the both seasons but Hendi fruits were more responsive and had a fresher appearance than control. At the end of storage period, fruits treated by Jasmine oil recorded also highest value of L, the same trend like Eiwess fruits (averaging 46.5) in the both seasons. On the other hand, control fruits treatment exhibited the lowest values of L* in the both seasons.

Table 8. Effect of some Biostimulants treatments on L* of peel Hendi mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	53.69A	52.77A	51.17A	48.61B	46.86B
Kaolin	52.06B	50.45C	50.40B	48.09C	46.86B
Jasmine oil	51.43C	50.84B	50.37B	50.13A	47.81A
Control	53.69A	52.77A	51.17A	48.61B	45.65C
	Second season				
Chitosan	54.12B	53.77B	51.88B	50.98B	44.90B
Kaolin	53.51C	51.31C	51.10C	49.49C	44.10C
Jasmine oil	56.34A	54.35A	54.07A	53.40A	45.45A
Control	52.20D	50.80D	49.90D	48.10D	43.80D

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Hue angle (hº value) of fruit pulp:

Values of Hue angle (hº) of Eiwess mango fruits pulp decreased (that means an increase in density of yellow color) with the advance in cold storage period Tables (9 and 10). Significant differences between all treatments were observed in 2018 and 2019 seasons and control fruits developed less yellow pulp color than all treatments. At the end of storage period, the lowest value of hº (the highest density of yellow color) was recorded by Jasmine oil in the two seasons for Eiwess fruits and that means a positive effect of jasmine oil treatments in developing more yellow color cleared of mango pulp by end of 4 weeks of storage (86.1 and 89.9 1st and 2nd year respectively.On the contrary, Jasmine oil treatment didn't amelio rate pulp color of Hendi Mango 4 weeks of cold storage while chitosan treatment Hendi mango had the best pulp color, more yellowish (hº) 94.2 and 86.4 1st and 2nd year and that indicates a variation in the response of mango varieties to these biological materials and this different response of Hendi mango may be due to its thick peel that hinders penetration of Jasmine oil vapor.

The highest value of Hº was recorded by control and fruit treated by Kaolin in the first and second seasons, respectively. While, Chitosan fruits treatment gave the least value of Hº in the both seasons.

Table 9. Effect of some Biostimulants treatments on Hº of pulp Eiwess mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	97.63B	92.85A	94.89A	91.26A	90.64A
Kaolin	93.99C	90.52C	88.52C	87.45B	88.65B
Jasmine oil	109.3A	91.15B	89.28B	91.30A	86.12C
Control	97.63B	92.85A	94.89A	91.26A	90.64A
	Second season				
Chitosan	84.90D	94.85B	89.24B	91.23B	90.60A
Kaolin	90.40A	94.70C	85.05C	91.71A	90.50A
Jasmine oil	87.12C	94.78A	84.88C	91.58A	89.90C
Control	88.90B	91.80D	90.25A	91.25A	90.10B

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Table 10. Effect of some Biostimulants treatments on H* of pulp Hendi mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	104.2B	102.5A	99.43B	95.67D	94.24D
Kaolin	104.7A	101.8B	101.3A	97.46B	96.53B
Jasmine oil	104.0B	98.82C	99.30B	96.97C	96.07C
Control	103.4C	101.6B	98.60C	98.20A	97.90A
	Second season				
Chitosan	85.41D	103.7C	85.28D	91.27C	86.40D
Kaolin	91.24A	105.7A	88.10C	99.10A	87.60A
Jasmine oil	89.05B	104.6B	90.40B	98.00B	87.40B
Control	86.20C	103.4C	92.20A	91.10D	87.10C

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Total soluble solid (T.S.S) percentage of juice:

It is clear from the results in Table (11) that, Total soluble solid content of fruits was increasing gradually with the advance in cold storage periods. The statistical analysis indicated that there was a significant difference between the treatments during the storage periods in both seasons of the study. After 4 weeks of storage, the highest values of T.S.S% were noticed with Eiwess fruits treated by Kaolin,(24.5%-23.4% 1st and 2nd year respectively)followed by jasmine oil treatment. In the meantime control fruits treatment had the highest value of T.S.S after 3 weeks, but they exhibited the lowest percentage of T.S.S in both seasons (around 20%) after 4 weeks of cold storage.It was noticed an increase in T.S.S% for Eiwess fruits after completing 4 weeks of storage. Data in Table (12) indicated also that T.S.S % of Hendi mango fruits increased with the progress of storage period. At the end of storage, it was found that fruits treated with kaolin recorded the highest value of T.S.S although that 2ndyear values of T.S.S were higher than 1st year values. Control fruits were more advanced in ripening than all treatments till 3d week but gave the least TSS values by end of storage in the two seasons.

Table 11. Effect of some Biostimulants treatments on TSS % of Eiwess mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	9.50A	19.10A	20.03B	20.17D	23.20B
Kaolin	9.00C	16.67B	19.70C	20.63C	24.53A
Jasmine oil	9.00C	13.00C	16.57D	21.97B	22.70C
Control	9.10B	19.20A	22.10A	23.10A	20.10D
	Second season				
Chitosan	9.97C	12.07D	15.13B	18.70D	21.80C
Kaolin	10.00C	12.43C	15.07BC	19.40B	23.40A
Jasmine oil	10.17B	13.00B	15.03C	19.17C	22.20B
Control	10.80A	19.00A	21.60A	22.80A	19.80D

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Table 12. Effect of some Biostimulants treatments on TSS % of Hendi mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	8.33C	13.70B	14.00C	14.40C	14.77B
Kaolin	10.20A	13.33C	14.80B	15.23B	15.73A
Jasmine oil	8.20D	12.80D	13.17D	13.30D	13.73C
Control	9.60B	14.20A	15.20A	15.60A	13.40D
	Second season				
Chitosan	8.63C	10.00D	12.07D	15.10B	18.63B
Kaolin	9.13A	10.17C	12.23C	14.90C	19.13A
Jasmine oil	8.93B	11.60B	13.40B	15.40A	19.20A
Control	9.00B	13.20A	15.20A	14.80C	13.20C

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Titratable acidity (TA %):

The acidity percentage juice of mango fruits decreased in all treatments with the progress of cold storage period during both seasons of the study Tables (13 and 14). Control fruits recorded the lowest TA% in the two seasons because they have a more rapid maturity than other treatments and aside certain effects of the treatments for slowing maturity of Eiwees and Hendi mango. Meanwhile, the fruit treated by Kaolin recorded the highest TA% in both seasons (0.08% and 0.09% 1st and 2nd seasons) by end of cold storage. The highest fruit acidity at end of cold storage among treatments was noted for jasmine oil-treated fruits 1st year (0.21%) and kaolin-treated fruits 2ndyear (0.21%).

Table 13. Effect of some Biostimulants treatments on Acidity percentage of Eiwess mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	2.48B	1.68B	0.64A	0.37A	0.08B
Kaolin	2.00C	1.76A	0.43C	0.34B	0.13A
Jasmine oil	3.20A	1.44C	0.54B	0.26C	0.13A
Control	2.00C	1.01D	0.38D	0.15D	0.04C
	Second season				
Chitosan	1.05A	0.34B	0.19D	0.13A	0.09B
Kaolin	0.98B	0.35B	0.31B	0.12AB	0.11A
Jasmine oil	0.98B	0.29C	0.26C	0.11B	0.10AB
Control	0.99B	0.51A	1.51A	0.13A	0.03C

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Table 14. Effect of some Biostimulants treatments on Acidity percentage of Hendi mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	1.84A	1.20A	0.40A	0.24A	0.16B
Kaolin	1.44C	1.12A	0.43A	0.21B	0.14C
Jasmine oil	1.60B	0.96B	0.29B	0.21B	0.21A
Control	1.40C	0.98B	0.22B	0.11C	0.08D
	Second season				
Chitosan	0.99C	0.32C	0.23C	0.13C	0.18B
Kaolin	1.02C	0.36B	0.34A	0.28A	0.21A
Jasmine oil	1.50B	0.35B	0.32B	0.26B	0.18B
Control	1.60A	0.38A	0.31B	0.09D	0.04C

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Effect of treatments on decay (Chilling Injury and other disorders) of mango fruits during cold storage:

Fruits of all treatments were in a good sanitary state till three weeks and tolerated cold storage well with no fungal infections but after 4weeks it was clear that mango fruits were badly affected by refrigeration temperature (12° - 13°c) and about 30-60% had chilling injury signs betting of peel. Chitosan and jasmine oil treatments gave the best results and had the lowest average of decayed fruits in both varieties (33-40% in Eiwess fruits and 30-33% in Hendi fruits), followed by Jasmine oil treatment, which gave 50% rotting rate in Eiwess fruits and 43-45% in Hendi fruits, then kaolin treatment, which gave 50%-55% rotting rate in Eiwess fruits and 43 - 45% in Hendi fruits, finally the comparison treatment showed the highest percentage of rotting fruits (60-66% in Eiwess fruits and 66-68% in Hendi fruits).

Table 15. Effect of some Biostimulants treatments on decay percentage of Eiwess mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	0.0A	0.0A	0.0A	0.0A	33D
Kaolin	0.0A	0.0A	0.0A	0.0A	55B
Jasmine oil	0.0A	0.0A	0.0A	0.0A	50C
Control	0.0A	0.0A	0.0A	20B	60A
	Second season				
Chitosan	0.0A	0.0A	0.0A	0.0A	40C
Kaolin	0.0A	0.0A	0.0A	0.0A	50B
Jasmine oil	0.0A	0.0A	0.0A	0.0A	50B
Control	0.0A	0.0A	0.0A	30B	66A

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Table 16. Effect of some Biostimulants treatments on decay percentage of Hendi mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

Treatments	Storage periods per weeks				
	0	1	2	3	4
	First season				
Chitosan	0.0A	0.0A	0.0A	0.0A	33D
Kaolin	0.0A	0.0A	0.0A	0.0A	60B
Jasmine oil	0.0A	0.0A	0.0A	0.0A	45C
Control	0.0A	0.0A	0.0A	40B	66A
	Second season				
Chitosan	0.0A	0.0A	0.0A	0.0A	30D
Kaolin	0.0A	0.0A	0.0A	0.0A	60B
Jasmine oil	0.0A	0.0A	0.0A	0.0A	43C
Control	0.0A	0.0A	0.0A	40B	68A

Values in the same column followed by the same letter don't significantly differ from each other according to Duncan test at 5%.

Effect of treatments on eating quality of mango:

It is clear from data and histogram of eating quality evaluation Fig. (1 and 2) that the best-eating quality for Eiwess mango fruits were detected after 2 weeks of storage and then decreased a little bit after 3 weeks, and Hendi mango values of eating quality have a similar trend after 2 and 3 weeks. The best eating quality of Eiwess mango treated as above mentioned was noted for Kaolin and jasmine oil and chitosan compared to control (rates of 9 and 8 respectively compared to 7 for control) after 2 weeks in storage in 1st season and in 2nd season.

The trend was different for Hendi mango as the impact of treatments was higher than with Eiwess fruits and it was evident that eating quality was good but having lower rates than Eiwess mango. A better eating quality rate was observed with Jasmine-treated Hendi mango after 2 weeks in cold storage (note of 7 in 1st and in 2nd seasons) followed by Chitosan (note of 6 in both seasons). All treated fruits had a slower maturation and ripening in cold storage and especially with Hendi mango variety.

After three weeks in cold storage both varieties fruits were acceptable for eating in both seasons as it is clear in the histogram but after 4 weeks all fruits taste was unacceptable.

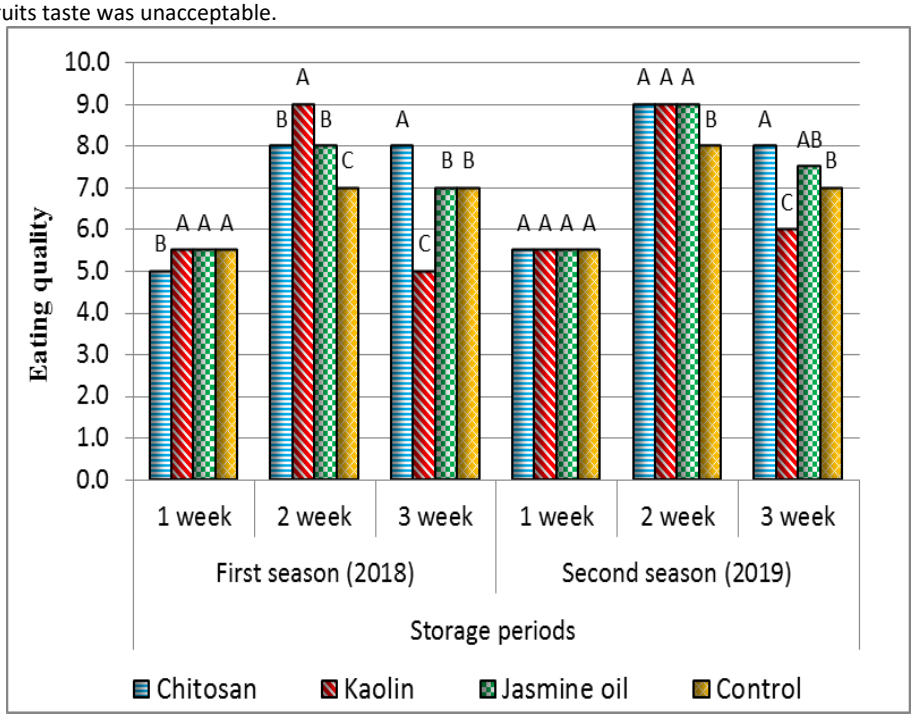

Fig 1. Effect of some Biostimulants treatments on Eating Quality of Eiwess mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

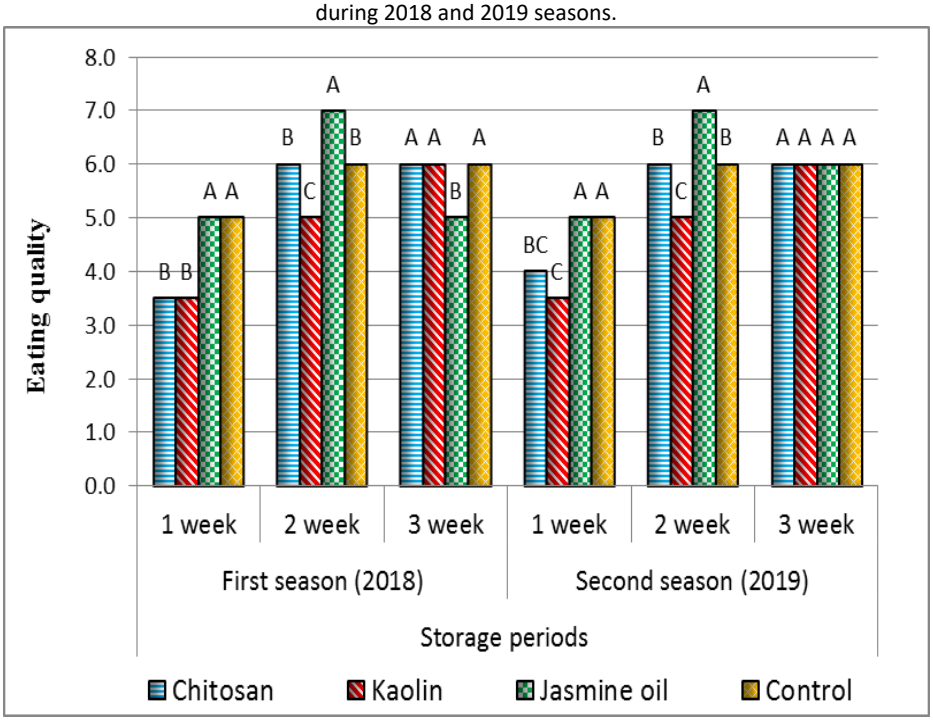

Fig 2. Effect of some Biostimulants treatments on Eating Quality of Hendi mango fruits at cold storage (13 ± 1°C and RH 85-90%) during 2018 and 2019 seasons.

DISCUSSION

A general notice emerged from results of these applied Biostimulants on mango trees indicated that fruit measured physical and chemical characteristics were noticeably positive and more pronounced with Jasmine oil in keeping fruits in good conditions during cold storage, despite that kaolin and chitosan were effective also but in a lower level.

The efficacy of Jasmine oil followed by kaolin in reducing fruit drops was clear. (Kondo 2010) indicated a certain role played by jasmonates when applied on fruit trees for resisting environmental stresses and temperature fluctuations in preharvest stage because it appeared that jasmonates interfere and hinders ethylene synthesis in conditions of stress, and that may explain the positive effect of Jasmine oil in better protecting small mango fruits against climate fluctuations and lowering fruit drop, especially in first season. In a review article by (Reyes-Diaz *et al.*, 2016) reasonable explanation for lowering fruit drop by methyl jasmonate(M.J) was presented, citing that M.J caused decreasing in activity of enzymes involved in the hydrolysis of glycosidic links of cell wall molecules, and by consequence keeping fruit firmness and lowering fruit drop. Kaolin positive effect in lowering fruit drop was supported by the paper of (Glenn *et al.,* 2001) on the apple as spraying apple trees with kaolin particulate 1.5 percent was effective in increasing yield by its role in the reduction of leaves temperature, especially in hot summer, and by consequence alleviating and transpiration intensity. As for weight loss, jasmine oil treatment had resulted in fruits with the least weight loss compared to other treatments. This positive effect was demonstrated in the Jasmonic application (2000 ppm) on apple trees reducing fruit weight loss after 30 days of storage at (1°C) in the study of (Fan *et al.,* 1997) who mentioned that methyl Jasmonate applied on apple and pears after fruit set interfered with ethylene synthesis and strongly reduced climacterics ethylene production at harvest and constricted fruit softening and kept a low fruit metabolism in cold storage. In the meantime, Kaolin-treated fruits data showed also a lower weight loss than chitosan and that result was supported by the study of (Abd El-Gawad *et al.,* 2020) on palms.

This trend was similar for both Eiwess and Hendi mango(but to a lesser extent), and as displayed, in 2nd season Kaolin had the least weight loss by end of cold storage, taking into consideration the natural variability among fruits may play a role also.

The results of firmness above cited are in agreement with a study of (Zaghloul *et al.,* 2017), in which 4 concentrations of kaolin 1%, 2%, 3% and 4% were applied on balady mandarin trees, and after fruit cold storage, all kaolin treated fruits were firmer than control. The slight effect of Jasmine oil on keeping mango fruit firmness in this essential oil was corroborated with research done by Rehman *et al*. (2021) on navel orange as applied methyl jasmonte reduced significantly fruit firmness when compared to control.

Concerning fruit freshness represented by L value, The pertinent results showed the effectiveness of Jasmine oil in keeping the look of freshness of mango Eiwess and Hendi fruits, and that was in concordance with the results of (Mirdehghan *et al.,* 2012) when using methyl Jasmonate application on pomegranate, the M.J treated fruits had good freshness look, equal to the peel freshness L values of salicylic acid and potassium sulfate treated fruits (62.0 as an average) (Pastopoulos, 2012) in a study conducted on quince fruit, concluded that kaolin sprays on quince tree (5%) kept high firmness of quince fruits.

For Eiwess mango pulp color or hue angle, results of stimulating pulp color by Jasmine oil are supported by the work of (Ozturk *et al.,* 2015) as methyl Jasmonate sprays on "Fuji" apples resulted in significantly more colored fruits. In a study by (Muengkaew *et al.,* 2016) after spraying mango trees with methyl jasmonate, a noticeable increase in fruit pulp color was noticed after storage, and measurements of phytocompounds indicated an increase in phenylalanine ammonia lays(PAL), carotene, and anthocyanin content of fruit which may explain this increase in yellowness of fruit pulp.

On the contrary, Jasmine oil treatment didn't ameliorate pulp color of Hendi Mango after 4 weeks of cold storage while chitosan treatment on Hendi mango had the best pulp color, and was more yellowish (hº) 94.2 and 86.4 1st and 2nd year.A study by (Ketsa *et al.*, 1999) it was found that green peel mango varieties (similar to Hendi var.) had higher rates of ethylene production when ripe , than yellow peel mango. Therefore chitosan stimulated clearly pulp yellowing in Hendi pulp more than jasmine oil. This indicates a variation in the response of mango varieties to these biological materials which act on fruit metabolism through different mechanisms and that weak response of Hendi mango to jasmine oil may be due to its thick peel that hinders penetration of Jasmine oil vapor.

The highest value of Hº was recorded by control and fruits treated by Kaolin in the first and second seasons, respectively. While the chitosan fruits treatment gave the least value of Hº in both seasons. For analysing results of TSS contents, kaolin raised TSS% in fruits more than other treatments. One explanation is that the applied kaolin on trees caused a cover coating on mango leaves and protect from high sun radiation and reduced leaf temperature,(Chamchaiyaporn *et al.,* 2013),this low temperature reduce energy consumption by leaves and increase sugar storage and that contribute to the increase in sweetness of fruits(Maughan *et al.,* 2017).

For acidity results, control fruits were more advanced in ripening stage and had the highest TSS% values till 3rd week of storage and it seemed that they exhausted a great part of their sugars content in the 4th week of cold storage due to their high chilling injury, and by consequence, their TSS content decreased considerably. Control fruit had also the least acidity values due to their quick ripening. It was found that chitosan-treated trees yielded fruits with relatively fewer acidity values by end of cold storage compared to other treatments, despite that natural variability among fruits may interfere also in these results. Both Eiwess and Hendi mango had approximately similar results in both seasons. This finding of chitosan effect agrees with the work of (Prashanth *et al.,* 2016) on Alphonso mango fruits coated with Chitosan, which resulted in a certain maturity delaying effect but with noticeable less acidity during storage period compared to other treatments.

The effects of Kaolin in slowing the speed of maturation when applied on both Eiwess and Hendi mango fruit may explain the fruit high content of acidity, and that was also evident and supported by results obtained Ergun (2012) on apple fruits. The mentioned results of decay are confirmed by work of (Ibrahim *et al.,* 2019) on Alphonso, Sediek and Keitt mango varieties which

showed an occurrence of chilling injury damage on fruit after 3 weeks of cold storage at 10°c. For what concerns eating quality, all treatments had good eating quality after 2 weeks of cold storage as their metabolism was still normal, but after 3 weeks in cold storage this organoleptic parameter has declined a little bit due to a cooling effect on fruit tissues, and it was clear from data that Eiwess variety had better and acceptable taste in both seasons and that this variety is more adapted to cold storage than Hendi fruits, especially for chitosan treatment while Hendi fruit had hardly an acceptable taste after the same period in cold storage This finding is in agreement with (Yahia 1999), in his technical report about mangoes in Egypt, mentioned that Eweiss variety has a consistent pattern of ripening and more flesh color and better taste.

CONCLUSION

All three treatments of Chitosan, Kaolin and Jasmine oil on mango trees, gave positive results with both Eiwess and Hendi Mango fruits as a preharvest application on mango trees and were more effective in slowing maturity and keeping a good quality of Eiwess and Hendi Mango fruits till 3 Weeks in cold storage (13°C), but after 4weeks, chilling injury damage appeared on fruits, therefore it is recommended to store these mango varieties no more than 3weeks in cold storage, and in the meantime, to apply these Biostimulants on the mango trees in the preharvest stage, especially on Eweiss mango trees. Kaolin and Jasmine oil, available locally, may be used successfully to limit fruit drops in the preharvest stage and to enhance mango quality during cold storage.

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تأثير بعض المنشطات الحيوية على تساقط وجودة ثمار المانجو

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تم اجراء هذه التجربة على صنفين من أصناف المانجو المصرية المحلية "العويس والهندي" بمزرعة خاصة بمنطقة السادات بمحافظة المنوفية لدراسة تأثير بعض المنشطات الحيوية الطبيعية "الكاولين والشيتوزان وزيت الياسمين" على تقليل التساقط والقدرة على تخزين الثمار و جودتها ، عند معاملة أشجار المانجو في فترة ما قبل الحصاد, تم رش المنشطات الحيوية المذكورة أعلاه 3 مرات على أشجار مانجو عمر 5 سنوات " ألاولى في مرحلة عقد الثمار،والثانية بعد شهر واحد، والثالثة بعد شهر أخر " خلال موسمي 2018 و 2019 مع اتباع الممارسات الزراعية الموصى بها .وقد أشارت البيانات إلى فعالية الكاولين وزيت الياسمين في تقليل تساقط الثمار ،وأظهرت بيانات الجودة الأخرى التي تم جمعها بعد 1 ، 2 ، 3 و 4 أسابيع من التخزين البارد أن جميع المعاملات كانت فعالة في إبطاء النضج والتسبب في إصابة أقل بأضرار البرودة. وأدت المنشطات الحيوية المستخدمة إلى إبطاء النضج والحفاظ على معايير الجودة الجيدة ، حتى الأسبوع الثاني و تراجعت ببطء في الأسبوع الثالث حيث بقيت الثمار سليمة دون ظهورعلامات إصابة ، ولكن بعد 4 أسابيع ، ظهرت أضرارًا بمعظم المعاملات. وقد أظهرت المعاملة بالشيتوزان جودة طعم أفضل نسبيًا وحموضة أقل. بينما أظهرت المعاملة بزيت الياسمين بطئا في نضج الثمارمقارنة بالمعاملات الأخرى. ولذا يوصى باستخدام أي من هذه المنشطات الحيوية ، وخاصة زيت الياسمين على أشجارالمانجومع هذين الصنفين المحليين في مرحلة ما قبل الحصاد ،وعدم الاحتفاظ بالثمارلأكثر من 3 أسابيع في التخزين البارد.

الكلمات المفتاحية: المانجو، المنشطات الحيوية، الكاولين، الشيتوزان، زيت الياسمين، تساقط الثمار، الجودة.