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EFFECT OF SOME PREHARVEST TREATMENTS ON YIELD, FRUIT QUALITY AND STORABILITY OF STRAWBERRY GROWN IN SANDY SOIL

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ABSTRACT: This experiment was carried out during two successive winter seasons of 2016/2017 and 2017/2018 at a Private Farm of El-Salhia El-Gadeeda, Sharkia Governorate, Egypt and Post-Harvest Lab. Hort. Dept., Fac. Agric., Zagazig University, to study the effect of foliar spray preharvest with calcium (as Fertoll calcium 12%) at 1, 2 and 3%, Zn EDATA as Micronate Zn 15% at 0.5, 1 and 1.5 g/l, Chitosan at 1, 2 and 3% as well as spraying with water on yield, fruit quality and storability of strawberry under sandy soil conditions. Spraying with Zn EDTA as Micronate at 1.5 g/l four times at 75, 90, 105 and 120 days after transplanting increased yield/ plant, average fruit weight and total yield/ fad., and the increases in the total yield (%) as average three concentrations of Ca as Fertoll, Zn EDTA as Micronate and Chitosan were about 16.25 and 15.51, 17.36 and 17.19 and 16.59 and 16.47% than unsprayed in the 1st and 2nd seasons, respectively. Spraying strawberry plants with chitosan at 3% increased total soluble solids (TSS), TSS/acid ratio and fruit firmness and decreased total acidity and pH in fruits compared to water (control) in both seasons. While spraying with Zn EDTA at 1 g/l increased vitamin C content in fruits. Spraying with Ca as Fertoll at 3 ml/l decreased weight loss and decay (%) in strawberry fruits, followed by spraying with chitosan at 3% at 16 days of storage plus shelf life in both seasons. Conclusively: Spraying plants with Zn EDTA as Micronate at 1.5 g/l increased yield, average fruit weight, total yield /fad., vitamin C; spraying chitosan at 3% increased TSS, TSS/acid ratio and fruit firmness and decreased total acidity, and pH in fruits, as well as, spraying Ca at 3 ml/l as Fertoll calcium 12% decreased weight loss and decay (%) in strawberry fruits.

Key words: Strawberry, calcium, Zn EDTA, Chitosan, yield, storability.

INTRODUCTION

Strawberry (*Fragaria* x *ananassa* Dutch) is a highly appreciated world wide not only for its unique taste and distinct flavor, but also for its health benefits. Usually, strawberries contain nutrients, such as minerals and vitamins, and a diverse range of anthocyanins, flavonoids and phenolic acids with biological properties, such as antioxidant, anticancer, anti-neurodegenerative and anti-inflammatory activities (**Seeram *et al.*, 2006**). The phytochemical composition is influenced through environmental conditions and pre- and post-harvest factors. Crop yield and early harvests of the most important target for growers, and fruit quality is a considerable important to the consumers.

Calcium is an important nutrient that plays a key role in the structure of cell walls and cell membranes, fruit growth, and development, as well as general fruit quality (**Kadir, 2004).** In this regard, **Chéour *et al.* (1990**) studied the effects of the foliar application with $CaCl_2$ on the shelf life and Ca-content of the strawberry fruits. Calcium was repeatedly applied, 3 days, 3 and 6 days, or 3, 6, and 9 days before harvest at 0, 10, or 20 kg ha^{-1}. They illustrated that calcium application influenced amounts of the free sugars and organic acids, color, and texture during storage in air at 4°C in addition, **Rab and Haq (2012)** stated that spraying tomato plants with $CaCl_2$ resulted in a significant increases in fruit firmness compared to the control treatment and **Kazemi (2013**) indicated that spraying

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strawberry with $CaCl_2$ increased yield and TSS, total acidity and vitamin C in fruits compared to control. While, **Hamail *et al.* (2018**) pointed out that spraying strawberry plants with different sources of calcium or chitosan had a significant effect on number of fruits/ plant, average fruit weight and total yield/plant than unsprayed plant. In addition, **Zakaria *et al*. (2018)** demonstrated that fruits harvested from plants, which were sprayed with nano-calcium at 15 ppm gave the lowest values of weight loss and zero decay percentage, also, maintained fruit firmness, total sugars, and L-ascorbic acid concentration and decreased color development through the storage period plus shelf life. Furthermore, it also gave fruits with good appearance after 20 days of storage at 0°C plus 2 days of shelf life at 10°C compared to the other tested treatments under this study.

Zinc has an important role on pollination, fruit set and yield (**Motesharezade *et al.*, 2001**). Among the micronutrients, zinc plays an important role either as a metal component of enzymes or as a functional, structural or regulatory factor of a large number of enzymes (**Bowler *et al.*, 1994**) and also induces pollen tube growth through functioning tryptophan as an auxin precursor biosynthesis (**Chaplin and Westwood 1980**).Zinc can be increased fruit number, size and quality by controlling growth of receptacle through auxin which is synthesized in achenes (**Archbold and Dennis, 1984**) moreover, its allow the development of new leaves (**Barker and Pilbeam, 2006**). Foliar application of zinc increases fruit size, total soluble solids (**Dixi and Gamdagin, 1978**) and increasing sugar and decreasing acidity (**Abedy 2001**). In addition, **Mahnaz *et al*. (2010**) claimed that $ZnSO_4$ as a source of zinc had a positive effect in increasing TSS, acidity and Vitamin-C of strawberry fruits. **Singh (2013)** indicated that spraying strawberry plants with zinc sulphate at 0.4% recorded the maximum No. of fruits/plant, fruit length and average fruit weight and **Kazemi (2014)** reported that spraying zinc sulfate at 150 mg/l is recommended for increasing the strawberry yield. In addition, **Chandrakar, *et al*. (2018**) confirmed that total soluble solids, TSS/acid ratio, total sugar, reducing sugar, non-reducing sugar and ascorbic acid contents recorded the maximum values under the treatment of $ZnSO_4$ at 0.6% compared than sprayed plants with water.

Chitosan, a deacetylated derivate of chitin, is a high molecular weight cationic linear polysaccharide composed of D -glucosamine and, to a lesser extent, N-acetyl- D -glucosamine with a β-1,4-linkage. Chitosan-based coatings are considered the best edible and biologically safe preservative coatings for different types of fruits, with functional advantages, such as slower respiration rates, extended storage periods, firmness retention and controlled microbial growth (**Romanazzi *et al*., 2015**). In this concern, **Reddy *et al* (2000**) studied the effect of pre-harvest sprays of chitosan on post-harvest decay, quality of strawberries stored at 3 and 13°C was also investigated, strawberry plants were sprayed with 2, 4 and 6 g/1, chitosan solutions as the fruit were turning red and second spray was performed after 10 days and fruits were picked 5 and 10 days after each spray. Results showed that the second spray of chitosan extended the protective effect against decay of fruit from subsequent picks. The fruits from chitosan sprayed plants were firmer and ripened at a slower rate as indicated by anthocyanin content and titratable acidity than berries from non-treated plants.

El-Miniawy *et al*. (2013) found that chitosan spraying did not affect fruit firmness, titratable acidity and ascorbic acid content, however, total soluble solids showed tendency to increase in response to chitosan application. **Petriccione *et al*. (2015)** cleared that chitosan treatment significantly reduced water loss and delayed the qualitative changes in color, titratable acidity and ascorbic acid content in dose- and cultivar-dependent manners. In addition**, Mandour (2017**) indicated that the lowest total weight loss and decay percentages and highest values of TSS in strawberry fruits were noticed when the plants were sprayed with chitosan compared than unsprayed plants.

Therefore, the aim of the present study is to investigate the effect of foliar spray with calcium, zinc and chitosan to obtain high yield, improve quality and prolong storage of strawberry fruits during cold storage.

MATERIALS AND METHODS

This experiment was carried out during two successive winter seasons of 2016/2017 and 2017/2018 at a Private Farm at El-Salhia El-Gadeeda District, Sharkia Governorate, Egypt and Post-Harvest Laboratory in Horticulture Department, Faculty of Agriculture, Zagazig University, to investigate the effect of foliar spray with calcium, zinc and chitosan concentrations on yield, fruit quality and storability of strawberry under sandy soil conditions. The experiment included ten treatments, *i.e.*, spraying with Ca as Fertool calcium 12 % at 1,2 and 3 ml/l; Zn EDTA as Micronate Zn 15% at 0.5, 1 and 2g /l and chitosan at 1, 2 and 3% as well as control (water).

These treatments were arranged in a randomized complete blocks design with three replications. The experimental unit area was 12.6 m^2, which contains three dripper lines, (6 m length and 70 cm distance between the two drippers lines). The distance between each two transplants in the dripper line was 25cm. Frigo transplants of strawberry (Festival cultivar) were transplanted on 25th and 28th September during the 1st and 2nd seasons, respectively

Foliar application treatments were sprayed four times at 75, 90, 105 and 120 days after transplanting. Untreated plants were left as a control treatment and sprayed with tap water. One row was left between each two experimental units as a guard area to avoid the overlapping of foliar application.

Calcium was sprayed in the form of Fertoll calcium 12%, which produced by Wadi El-Remal Company, Zn EDTA was sprayed in the commercial form of Micronate Zn 15% produced by Misr for Agriculture Development Company and chitosan powder (Poly–(1,4-B-D-glycopyranosamine); 2-Amino-2-deoxy- (1->4)-B-D-glucopyranan) was prepared by dissolving 1.5% chitosan in 0.5% acetic acid solution and manufactured by Chengdu Newsun Biochemistry Co., Ltd, China.

The agricultural practices concerning cultivation, irrigation, fertilization as well as insect and disease control were conducted according to the recommendation of the Ministry of Agriculture for strawberry commercial production.

Data Recorded

Yield and its components

Total yield was recorded from each plot all over the harvested season up to the mid of May, then the average fruit weight, yield / plant and total yield per faddan (ton) was calculated.

Fruit quality

They were measured after six weeks from the first harvest as follows:

1. Total soluble solids content (TSS) as brix^{o}: samples of ten ripe fruits were randomly chosen from each experimental plot at full ripe stage to measure the percentage of total soluble solids content using the hand refractometer.
2. Total titratable acidity (TA%): Samples of 100g fruits from each experimental plot at full ripe stage were randomly chosen to determine the total titratable acidity of juice by titration with 0.1 NaOH soluation, using phenolphthalein indicator, according to the method described in **AOAC (2000)**. pH in fruits was determined by HANNA instruments pH Miter.
3. TSS/acid ratio: were calculated by divided TSS on acidity
4. Ascorbic acid content, it was determined in mg/100g fresh weight using 2, 6 Di chloro phenol indophenol for titration as the method mentioned in **AOAC (2000)**.
5. Fruit firmness was determined by using a Chattilon pressure meter equipped with a plunger (N,4, USA) a needle 3mm diameter.

Storability

About 250 g of strawberry fruits of each experimental plot of uniform size and color were freshly harvested, washed thoroughly to remove any extraneous material, surface-dried using blotting paper, divided into four lots, (4, 8, 12 and 16 days) and were stored at zero C$^{\circ}$ ± 1 C$^{\circ}$ and 90 -95% relative humidity (RH), in cold storage period. After each cold storage period, the fruits were subjected to conditions of 8±2 ºC and 85- 90% RH for four days as a shelf life (similarly as super market conditions) to determine the following data:

Weight loss (%)

Weight loss percentage was measured after 4, 8, 12 and 16 days. The weight measured (Digital Electrical Balance) at zero days was taken as reference weight and calculated by using the following equation;

Weight loss (%) = Initial weight of fruits – Weight of fruits at different sampling dates ÷ Initial weight of fruits × 100

Fruits of each treatment was weighed at 4 days by intervals, then weight loss percentage was calculated.

Fruit decay (%)

Fruit decay (%) was measured after 4, 8, 12 and 16 days and calculated according to the following equation;

Fruit decay (%) = Initial fruit – fruit decay during storage/ Initial fruit × 100

Statistical Analysis

Recorded data were subjected to the statistical analysis of variance according to **Snedecor and Cochran (1980)**, and means separation were done according to Duncan multiple test at 5% probability **(Duncan, 1958).**

RESULTS AND DISCUSSION

Yield and its Components

Results in Table 1 show that spraying strawberry cv. Festival grown in sandy soil with Ca as Fertall calcium 12% at 1,2 and 3 ml/l, Zn EDTA as Micronate Zn 15% at 0.5, 1 and 1.5 g/l and chitosan at 1, 2 and 3% at 75, 90, 105 and 120 days after transplanting had a significant effect on yield/plant, average fruit weight and total yield/fad., compared to spraying with water (control treatment). Spraying with Zn EDTA as Micronate Zn 15% at 1.5 g/l significantly increased yield/ plant, average fruit weight and total yield/fad., without significant differences with the plants which sprayed with Zn EDTA as Micronate Zn 15% at 1g/l in the 1st season. This mean that foliar spray of strawberry plants with Zn ADTA as Micronate Zn 15% at 1.5 g/l gave the highest values of total yield/fad., followed by foliar spray with Zn EDTA as Micronate Zn 15% at 1g/l.

The increases in total yield/fad., were about 20.70 and 23.85% for Zn EDTA as Micronate Zn 15% at 1.5 g/l and 20.05 and 19.99% for Zn EDTA as Micronate Zn 15% at 1g/l over the control (water) in the 1st and 2nd seasons, respectively.

In general, total yield (ton/fad.) as average of three concentrations were about (16.25 and 15.51) for Ca as Fertall calcium 12%, Zn EDTA as Micronate Zn 15% (17.36 and 17.19) and (16.59 and 16.47) for chitosan in the 1st and 2nd seasons, respectively. This mean that Zn EDTA gave the highest total yield followed by chitosan and calcium.

Calcium is an important nutrient that plays a key role in the structure of cell walls and cell membranes, fruit growth, and development, as well as general fruit quality (**Kadir, 2004**), also zinc has important role on pollination; fruit set and yield (**Motesharezade *et al.*, 2001**) in addition, zinc plays an important role either as a metal component of enzymes or as a functional, structural or regulatory factor of a large number of enzymes (**Bowler *et al.*, 1994**) and induces pollen tube growth through functioning tryptophan as an auxin precursor biosynthesis (**Chaplin and Westwood, 1980**). The results are similar to those obtained by **Kazemi (2013**) and **Zakaria *et al*. (2018)** on strawberry respecting Ca effect, **Mahnaz *et al.* (2010**), **Singh (2013)** and **Kazemi (2014)** as for Zn effect, and **Reddy *et al.* (2000)** as for chitosan effect.

Fruit Quality at Harvest Time

Respecting TSS (Brix^{o}) and TSS acid ratio, Results in Table 2 indicate that spraying strawberry plants with chitosan at 3% increased TSS and TSS acid ratio in fruits, while there was no significant effect with chitosan at 1 and 2% with respect to TSS in the 1st season. As for total acidity and pH, results in the same Table show that spraying plants with water increased total acidity and pH, meanwhile chitosan at 3% caused a decreased in total acidity and pH in fruit in both growing seasons. With respect to fruit firmness, the results in Table 2 illustrate that spraying with Ca as Fertall calcium 12% at 3 ml/l gave the highest fruit firmness compared to the other treatments and control in both seasons. Concerning Vitam C content, results showed that foliar spray with Zn EDTA as Micronate Zn 15 % at 1g/l increased Vitam. C content in fruits in both seasons.

Table 1. Effect of foliar spray with calcium, zinc and chitosan, on yield and its components of strawberry plants during 2016/2017 and 2017/2018 seasons

Treatment	Yield/plant (g)	Average fruit weight (g)	Total yield (ton/fad.)	Relative increases in total yield (%)
		2016/2017 season		
Ca as Fertall Ca 12% at 1 ml/l	230.67 f	22.63 e	15.904 g	109.58
Ca as Fertall Ca 12% at 2 ml/l	243.07 de	23.14 cde	16.334 f	112.54
Ca as Fertall Ca 12% at 3 ml/l	246.13 cde	24.29 bc	16.540 de	113.96
Zn EDATA as Micronate Zn 15% at 0.5 g/l	252.36 bc	23.88 bcd	17.160 b	118.23
Zn EDATA as Micronate Zn 15% at 1.0 g/l	259.29 ab	25.00 ab	17.424 a	120.05
Zn EDATA as Micronate Zn 15% at 1.5 g/l	260.70 a	25.85 a	17.519 a	120.70
Chitosan at 1%	240.74 e	22.85 de	16.379 ef	112.85
Chitosan at 2%	247.22 cde	23.58 cde	16.613 cd	114.46
Chitosan at 3%	249.82 cd	24.23 bc	16.788 c	115.67
Control (water)	215.98 g	19.83 f	14.514 h	100.00
		2017/2018 season		
Ca as Fertall Ca 12% at 1 ml/l	222.83 f	20.68 e	15.176 f	106.13
Ca as Fertall Ca 12% at 2 ml/l	231.06 e	21.31 e	15.527 e	108.59
Ca as Fertall Ca 12% at 3 ml/l	238.33 d	22.94 d	16.016 d	112.01
Zn EDATA as Micronate Zn 15% at 0.5 g/l	246.88 c	24.31 c	16.725 c	116.97
Zn EDATA as Micronate Zn 15% at 1.0 g/l	255.31 b	25.44 b	17.157 b	119.99
Zn EDATA as Micronate Zn 15% at 1.5 g/l	263.53 a	26.63 a	17.709 a	123.85
Chitosan at 1%	238.34 d	20.71 e	16.151 d	112.95
Chitosan at 2%	246.73 c	23.37 d	16.580 c	115.95
Chitosan at 3%	248.20 c	24.84 bc	16.679 c	116.64
Control (water)	212.78 g	19.01 f	14.299 g	100.00

Means followed by different letters are significantly different at P≤0.05 level with Duncan multiple range test.

Table 2. Effect of foliar spray with calcium, zinc and chitosan on fruit quality of strawberry at harvest time during 2016/2017 and 2017/2018seasons

Treatment	TSS (brix^{o})	Total acidity (mg/100 ml juice)	pH	TSS/acid ratio	Firmness (g/cm^{2})	Vitamin C (mg/100 ml juice)
			2016/2017 season			
Ca as Fertall Ca 12% at 1 ml/l	8.14 c	0.43 cde	3.29 d	18.93 c	248.30 bc	52.60 d
Ca as Fertall Ca 12% at 2 ml/l	9.17 b	0.48 b	3.25 d	19.10 c	248.30 bc	58.50 c
Ca as Fertall Ca 12% at 3 ml/l	10.03 a	0.42 de	3.17 e	23.88 ab	265.00 a	62.50 ab
Zn EDATA as Micronate Zn 15% at 0.5 g/l	9.00 b	0.46 bcd	3.63 b	19.57 c	231.65 de	54.60 d
Zn EDATA as Micronate Zn 15% at 1.0 g/l	9.00 b	0.48 b	3.61 b	18.75 c	233.30 de	64.05 a
Zn EDATA as Micronate Zn 15% at 1.5 g/l	9.16 b	0.47 bc	3.51 c	19.49 c	225.00 e	61.55 b
Chitosan at 1%	9.83 a	0.42 de	3.11 f	23.40 b	236.65 d	52.50 d
Chitosan at 2%	10.16 a	0.43 cde	3.11 f	23.63 ab	240.00 cd	58.10 c
Chitosan at 3%	10.16 a	0.40 e	3.08 f	25.40 a	255.00 ab	58.10 c
Control (water)	7.20 d	0.60 a	3.92 a	12.00 d	178.30 f	42.50 e
			2017/2018 season			
Ca as Fertall Ca 12% at 1 ml/l	8.21 d	0.45 c	3.49 c	18.24 d	228.44 bc	54.50 de
Ca as Fertall Ca 12% at 2 ml/l	9.21 c	0.42 d	3.35 d	21.93 c	298.44 a	56.16 c
Ca as Fertall Ca 12% at 3 ml/l	10.00 ab	0.42 d	3.36 d	23.81 bc	293.80 a	63.00 a
Zn EDATA as Micronate Zn 15% at 0.5 g/l	9.00 c	0.47 bc	3.75 b	19.15 d	213.12 cd	52.42 f
Zn EDATA as Micronate Zn 15% at 1.0 g/l	9.00 c	0.48 b	3.73 b	18.75 d	214.64 cd	64.49 a
Zn EDATA as Micronate Zn 15% at 1.5 g/l	9.05 c	0.46 bc	3.72 b	19.67 d	207.00 d	59.09 b
Chitosan at 1%	9.43 bc	0.42 d	3.30 d	22.45 bc	217.72 b-d	53.40 ef
Chitosan at 2%	10.00 ab	0.41 d	3.30 d	24.39 b	220.80 b-d	55.78 cd
Chitosan at 3%	10.50 a	0.38 e	3.16 e	27.63 a	234.60 b	55.78 cd
Control (water)	7.50 e	0.58 a	4.16 a	12.93 e	184.04 e	39.80 g

Means followed by different letters are significantly different at P≤0.05 level with Duncan multiple range test.

In general, foliar spray with Ca as Fertall calcium 12 %, Zn EDTA as Micronate Zn 15% and chitosan at different concentrations increased TSS, TSS acid ratio, fruit firmness and Vitam. C in fruits compared to foliar spray with water only (control treatment), whereas the same treatments decreased total acidity and pH in fruits compared to water (control) in both growing seasons.

These results are confirmed with those of **Cheour *et al.* (1990)** who found that strawberry plants sprayed with calcium improved fruit firmness at harvest time, this can be explained by (1) the complexing of calcium ions with cell wall and middle lamella pectin (**Morris, 1980**), (2) stabilization of the cell membrane by the calcium ions (**Picchioni *et al*., 1995**) and/ or (3) the effect of calcium on cell turgor pressure (**Mignani *et al*., 1995**).

Results are in harmony with those reported by **Kazemi (2013**) who indicated that spraying strawberry with $CaCl_2$ increased TSS and vitamin C in fruits compared to control. Concerning Zn effect, **Dixi and Gamdagin (1978)**, **Abedy (2001**) and **Mahnaz *et al.* (2010**) showed that $ZnSO_4$ as a source of zinc had a positive effect in increasing TSS, acidity and Vitamin-C of strawberry fruits. As for chitosan effect**, El-Miniawy *et al*. (2013**), **Petriccione *et al*. (2015)** and **Mandour (2017**) concluded that spraying strawberry preharvest gave the best fruit quality than unsprayed plants.

Storability

Weight loss (%)

Results in Tables 3 and 4 and Fig 1 indicate that fruit weight loss percentage increased with prolonging cold storage period up to 16 days plus 4 days shelf life. Spraying with Ca as Fertall calcium 12%, Zn EDTA as Micronate Zn 15% and chitosan at different concentrations decreased weight loss (%) during cold storage periods plus shelf life compared to spraying plants with water (control). At 16 days of storage plus shelf life spraying with Ca as Fertall calcium 12%, at 3 ml/l, decreased weight loss (%) in strawberry fruits, followed by spraying with chitosan at 3%.

Decay (%)

The obtained results in Tables 5 and 6 and Fig. 2 indicated that decay (%) in strawberry fruits increased with prolonging cold storage periods plus shelf life. There were no fruits with decay after 4 days of storage+ shelf life. Ca as Fertall calcium 12 %, Zn EDTA as Micronate Zn 15% and chitosan at different concentrations as foliar application decreased fruit decay compared to spraying plants with water (control). Foliar spray of strawberry with Ca as Fertall calcium 12 % at 3 ml/l or with chitosan at 3% recorded a minimum values of decay (%) in both seasons.

Ca is one of the most important macro nutrients. The beneficial effects of Ca on maintaining fruit quality and increasing shelf life are well documented by many researchers (**Bakshi *et al*., 2005**). Pre and post-harvest application of Calcium have been practiced commercially in many fruits for improving quality, delaying senescence, reducing post-harvest decay and controlling the physiological disorders (**Poovaiah, 1986; Conway *et al*., 1994**). Foliar applications of calcium during the vegetative growth have been reported to delay ripening and mold development in strawberries (**Cheour *et al*., 1991; Chung *et al*., 1995**). The stimulation effect of chitosan on storability of strawberry fruits may be due to that, chitosan forms a film on the surface of the fruits which regulates the exchange of gases and hence reduces the transpiration, fruit ripening and water loss (**Shehata *et al*., 2012**). Also, the positive effect of chitosan on storability characters may be due to increased the acidity and total sugars as found in strawberry (**Abdel- Mawgoud *et al*., 2010**) and sweet pepper (**Ghoname *et al*., 2010**).

These results coincide with those reported by **Chéour *et al*. (1990**) and **Zakaria *et al*. (2018)** they found that fruits harvested from plants, which were sprayed with calcium at 15 ppm gave the lowest value for each of weight loss and zero decay percentage and gave fruits with good appearance after 20 days of storage at 0°C plus 2 days of shelf life at 10°C compared to the other tested treatments under this study.

Regarding chitosan effect, **Petriccione *et al*. (2015)** cleared that the fruits of strawberry were coated with 1% and 2% chitosan solution and stored at 2°C for nine days. Chitosan treatment significantly reduced water loss and delayed the qualitative changes in color, and **Mandour (2017**) showed that the lowest total weight loss and decay percentages were noticed when the plants were sprayed with chitosan than unsprayed plants.

Table 3. Effect of foliar spray with calcium, zinc and chitosan on weight loss percentage of strawberry fruits stored at 0ºC and RH 95% during 2016/2017 and 2017/2018 seasons

Treatment	Weigh loss (%)				
	Days from storage				
	Zero time	4 days	8 days	12 days	16 days
	2016/2017 season				
Ca as Fertall Ca 12% at 1 ml/l	0	0.75 c	1.69 cd	2.78 def	3.76 gh
Ca as Fertall Ca 12% at 2 ml/l	0	0.65 d	1.64 cd	2.65 f	3.80 g
Ca as Fertall Ca 12% at 3 ml/l	0	0.62 d	1.39 e	2.40 g	3.58 i
Zn EDATA as Micronate Zn 15% at 0.5 g/l	0	0.87 b	2.00 b	3.15 b	4.66 b
Zn EDATA as Micronate Zn 15% at 1.0 g/l	0	0.95 b	1.74 c	2.95 bcd	4.55 c
Zn EDATA as Micronate Zn 15% at 1.5 g/l	0	0.90 b	1.66 cd	3.06 bc	4.36 d
Chitosan at 1%	0	0.87 b	1.69 cd	2.93 cde	4.14 e
Chitosan at 2%	0	0.78 c	1.67 cd	2.76 def	3.95 f
Chitosan at 3%	0	0.74 c	1.62 d	2.72 ef	3.70 h
Control (water)	0	1.23 a	2.26 a	4.16 a	5.17 a
	2017/2018 season				
Ca as Fertall Ca 12% at 1 ml/l	0	0.67 c	1.51 bc	2.48 de	3.54 de
Ca as Fertall Ca 12% at 2 ml/l	0	0.55 d	1.46 c	2.37 e	3.39 efg
Ca as Fertall Ca 12% at 3 ml/l	0	0.55 d	1.24 e	2.23 f	3.29 g
Zn EDATA as Micronate Zn 15% at 0.5 g/l	0	0.78 b	1.79 a	2.72 b	4.34 b
Zn EDATA as Micronate Zn 15% at 1.0 g/l	0	0.85 ab	1.55 b	2.63 bc	4.06 c
Zn EDATA as Micronate Zn 15% at 1.5 g/l	0	0.80 b	1.48 bc	2.73 b	4.16 c
Chitosan at 1%	0	0.78 b	1.54 b	2.53 cd	3.61 d
Chitosan at 2%	0	0.67 c	1.49 bc	2.46 de	3.53 def
Chitosan at 3%	0	0.66 c	1.49 bc	2.41 de	3.38 fg
Control (water)	**0**	0.92 a	1.76 a	3.54 a	4.82 a

Means followed by different letters are significantly different at P≤0.05 level with Duncan multiple range test.

Table 4. Effect of foliar spray with calcium, zinc and chitosan on weight loss percentage of strawberry fruits stored at 0ºC and RH 95% plus 4 days (shelf life) at 10ºC and RH 85% during 2016/2017 and 2017/2018 seasons

Treatment	Weigh loss (%)			
	Days from storage			
	4days+4	8 days +4	12 days +4	16 days +4
	2016/2017 season			
Ca as Fertall Ca 12% at 1 ml/l	1.86 cd	4.16 cd	5.98 ef	8.20 d
Ca as Fertall Ca 12% at 2 ml/l	1.57 fg	3.72 ef	5.69 fg	7.48 e
Ca as Fertall Ca 12% at 3 ml/l	1.41 g	3.16 g	5.44 g	7.14 e
Zn EDATA as Micronate Zn 15% at 0.5 g/l	1.97 bc	4.54 b	7.14 b	10.56 b
Zn EDATA as Micronate Zn 15% at 1.0 g/l	2.15 b	3.95 de	6.69 c	10.32 bc
Zn EDATA as Micronate Zn 15% at 1.5 g/l	2.04 bc	3.76 ef	6.61 cd	9.88 c
Chitosan at 1%	1.98 bc	4.33 bc	6.64 c	8.42 d
Chitosan at 2%	1.77 de	3.79 ef	6.25 de	8.15 d
Chitosan at 3%	1.62 ef	3.68 f	5.52 g	7.58 e
Control (water)	2.95 a	5.12 a	7.89 a	11.73 a
	2017/2018 season			
Ca as Fertall Ca 12% at 1 ml/l	1.71 bc	3.17 bc	5.21 ef	7.44 de
Ca as Fertall Ca 12% at 2 ml/l	1.31 e	3.06 c	4.98 f	7.13 ef
Ca as Fertall Ca 12% at 3 ml/l	1.16 e	2.61 d	4.68 g	6.02 h
Zn EDATA as Micronate Zn 15% at 0.5 g/l	2.08 a	3.77 a	6.77 b	9.12 b
Zn EDATA as Micronate Zn 15% at 1.0 g/l	1.79 ab	3.25 b	6.27 c	8.52 c
Zn EDATA as Micronate Zn 15% at 1.5 g/l	1.68 bcd	3.11 c	5.73 d	8.73 c
Chitosan at 1%	1.64 bcd	3.09 c	5.31 e	7.58 d
Chitosan at 2%	1.41cde	3.14 bc	5.16 ef	7.11 f
Chitosan at 3%	1.38 de	3.14 bc	5.06 ef	6.35 g
Control (water)	1.94 ab	3.84 a	7.44 a	10.13 a

Means followed by different letters are significantly different at P≤0.05 level with Duncan multiple range test.

Table 5.Effect of foliar spray with calcium, zinc and chitosan on decay percentage of strawberry fruits stored at 0ºC and RH 95% during 2016/2017 and 2017/2018 seasons

Treatment	Decay (%)			
	Days from storage			
	4 days	8 days	12 days	16 days
		2016/2017 season		
Ca as Fertall Ca 12% at 1 ml/l	0.00	2.17 c	8.35 f	17.09 c
Ca as Fertall Ca 12% at 2 ml/l	0.00	0.00 d	9.66 de	14.59 d
Ca as Fertall Ca 12% at 3 ml/l	0.00	0.00 d	6.25 g	13.16 e
Zn EDATA as Micronate Zn 15% at 0.5 g/l	0.00	6.19 b	14.53 b	19.20 b
Zn EDATA as Micronate Zn 15% at 1.0 g/l	0.00	2.22 c	11.05 c	19.22 b
Zn EDATA as Micronate Zn 15% at 1.5 g/l	0.00	0.00 d	9.01 ef	15.85 c
Chitosan at 1%	0.00	0.00 d	10.64 cd	16.40 c
Chitosan at 2%	0.00	0.00 d	6.13 g	12.64 e
Chitosan at 3%	0.00	0.00 d	5.08 g	10.09 f
Control (water)	0.00	9.56 a	20.59 a	33.32 a
		2017/2018 season		
Ca as Fertall Ca 12% at 1 ml/l	0.00	0.00 c	7.54 d	13.38 c
Ca as Fertall Ca 12% at 2 ml/l	0.00	0.00 c	7.79 cd	13.78 c
Ca as Fertall Ca 12% at 3 ml/l	0.00	0.00 c	5.04 e	10.61 de
Zn EDATA as Micronate Zn 15% at 0.5 g/l	0.00	8.22 b	13.33 b	20.32 b
Zn EDATA as Micronate Zn 15% at 1.0 g/l	0.00	0.00 c	8.91 cd	12.78 cd
Zn EDATA as Micronate Zn 15% at 1.5 g/l	0.00	0.00 c	5.65 e	15.50 c
Chitosan at 1%	0.00	0.00 c	9.39 c	14.03 c
Chitosan at 2%	0.00	0.00 c	4.94 e	10.19 de
Chitosan at 3%	0.00	0.00 c	4.10 e	8.14 e
Control (water)	0.00	10.13 a	24.64 a	38.90 a

Means followed by different letters are significantly different at P≤0.05 level with Duncan multiple range test.

Table 6.Effect of foliar spray with calcium, zinc and chitosan on decay percentage of strawberry fruits stored at 0ºC and RH 95% plus 4 days (shelf life) at 10ºC and RH 85% during 2016/2017 and 2017/2018 seasons

Treatment	Decay (%)			
	Days from storage			
	4days+4	8 days +4	12 days +4	16 days +4
	2016/2017 season			
Ca as Fertall Ca 12% at 1 ml/l	0.00	5.95 d	13.79 e	31.70 e
Ca as Fertall Ca 12% at 2 ml/l	0.00	4.77 de	21.31 c	30.61 ef
Ca as Fertall Ca 12% at 3 ml/l	0.00	0.00 f	20.63 cd	23.56 g
Zn EDATA as Micronate Zn 15% at 0.5 g/l	0.00	22.4 b	26.47 b	45.60 b
Zn EDATA as Micronate Zn 15% at 1.0 g/l	0.00	11.6 c	24.38 b	34.97 d
Zn EDATA as Micronate Zn 15% at 1.5 g/l	0.00	0.00 f	19.46 cd	34.96 d
Chitosan at 1%	0.00	3.67 e	18.69 d	38.39 c
Chitosan at 2%	0.00	0.00 f	13.52 e	27.88 f
Chitosan at 3%	0.00	0.00 f	8.41 f	17.40 h
Control (water)	0.00	27.71 a	46.47 a	65.14 a
	2017/2018 season			
Ca as Fertall Ca 12% at 1 ml/l	0.00	5.22 d	16.70 d	32.11 de
Ca as Fertall Ca 12% at 2 ml/l	0.00	4.18 e	12.10 g	33.07 d
Ca as Fertall Ca 12% at 3 ml/l	0.00	0.00 g	10.10 h	20.66 g
Zn EDATA as Micronate Zn 15% at 0.5 g/l	0.00	19.70 b	27.99 b	48.77 b
Zn EDATA as Micronate Zn 15% at 1.0 g/l	0.00	10.22 c	21.38 c	37.20 c
Zn EDATA as Micronate Zn 15% at 1.5 g/l	0.00	0.00 g	13.56 f	30.67 e
Chitosan at 1%	0.00	3.22 f	15.54 e	33.67 d
Chitosan at 2%	0.00	0.00 g	11.86 g	24.46 f
Chitosan at 3%	0.00	0.00 g	7.38 i	19.00 g
Control (water)	0.00	24.31 a	34.54 a	54.16 a

Means followed by different letters are significantly different at P≤0.05 level with Duncan multiple range test.

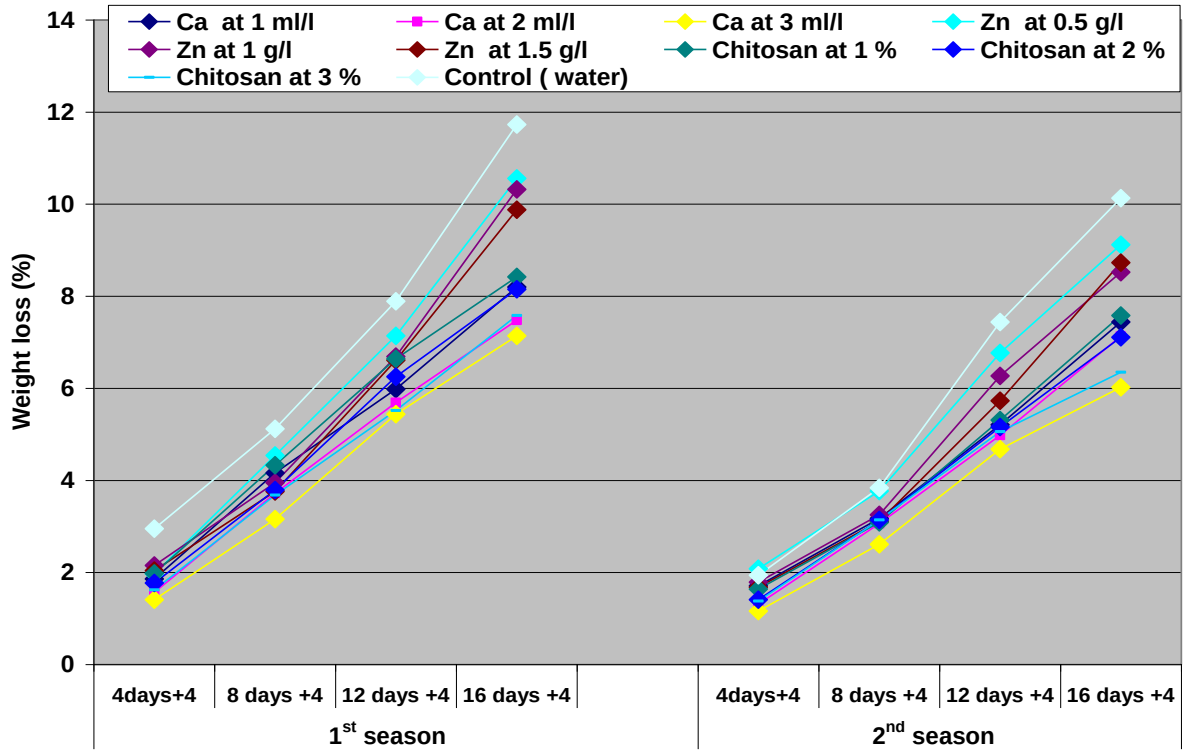

Fig. 1. Effect of foliar spray with calcium, zinc and chitosan on weight loss percentage of strawberry fruits stored at 0ºC and RH 95% plus 4 days (shelf life) at 10ºC and RH 85% during 2016/2017 and 2017/2018 seasons

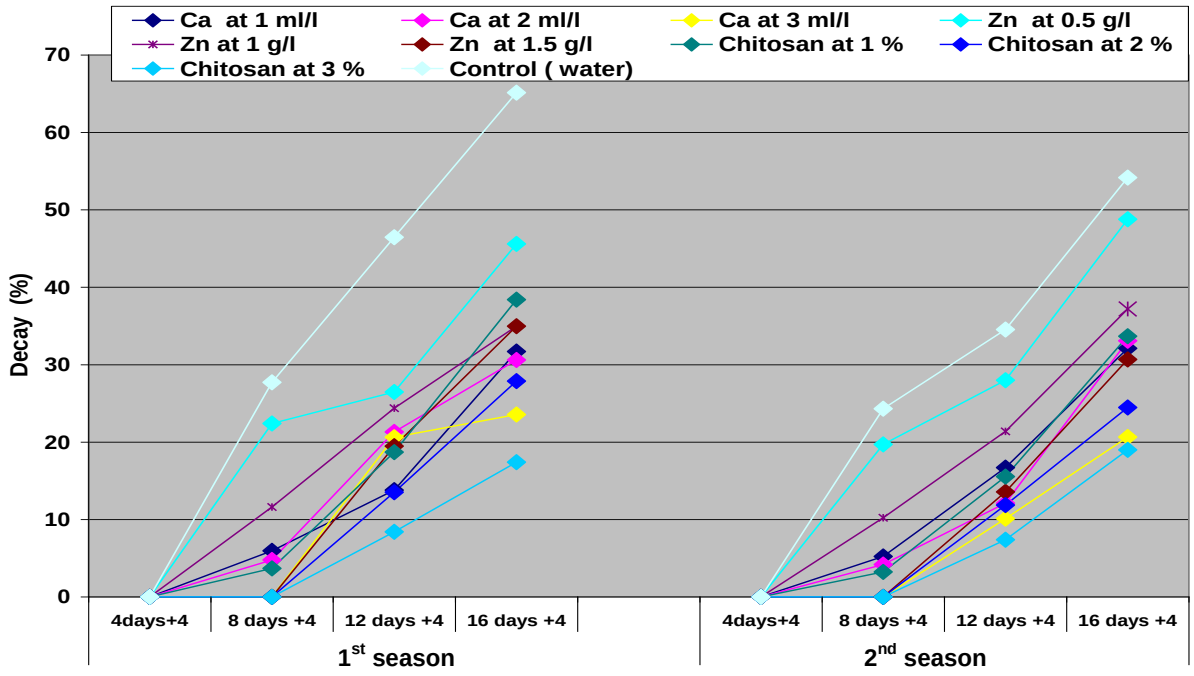

Fig. 2. Effect of foliar spray with calcium, Zn and chitosan on decay percentage of strawberry fruits stored at 0ºC and RH 95% plus 4 days (shelf life) at 10ºC and RH 85% during 2016/2017 and 2017/2018 seasons

Conclusion

Spraying plants with Zn EDTA as Micronate at 1.5 g/l increased yield, average fruit weight, total yield/fad., Vitam. C; chitosan at 3% increased TSS, TSS/acid ratio and fruit firmness and decreased total acidity, and pH in fruits, as well as, Ca as Fertall calcium 12% at 3 ml/l decreased weight loss and decay (%) in strawberry fruits.

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تأثير بعض معاملات ما قبل الحصاد على المحصول، جوده الثمار والقدرة التخزينية للفراولة النامية فى الأرض الرملية

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أجريت هذه التجربة خلال موسمى شتاء ٢٠١٦/٢٠١٧ ، ٢٠١٧/٢٠١٨م بمزرعة خاصة بمنطقة الصالحية الجديدة- محافظة الشرقية- مصر ، ومعمل معاملات ما بعد الحصاد- قسم البساتين- كلية الزراعة- جامعه الزقازيق بهدف دراسة تأثير الرش الورقى قبل الحصاد بكل من الكالسيوم على صورة فرتول الكالسيوم ١٢% بتركيز ١، ٢ ، ٣ ملليتر/لتر ، الزنك المخلبى فى صورة ميكرونيت زنك ١٥ % بتركيز ٠.٥ ، ١ ، ١.٥ جرام /لتر ، والشيتوزان بتركيز ١، ٢ ، ٣ (%) بالإضافة الى الرش بالماء فقط على المحصول، جودة الثمار والقدرة التخزينية للفراولة النامية تحت ظروف الأرض الرملية، سجلت معامله رش نباتات الفراولة بالزنك المخلبى فى صوره ميكرونيت زنك ١٥ % بتركيز ١.٥جم / لتر أربعة مرات عند ٧٥، ٩٠، ١٠٥، ١٢٠ يوم بعد الشتل الى زيادة كل من محصول النبات، متوسط وزن الثمرة والمحصول الكلى للفدان، وكان مقدار الزيادة فى المحصول الكلى كمتوسط للتركيزات الثلاثة من الكالسيوم على صوره فرتول الكالسيوم ١٢% ، الزنك المخلبى فى صورة ميكرونيت زنك ١٥%، والشيتوزان كالتالى ١٦.٢٥ ، ١٥.٥١ و ١٧.٣٦ ، ١٧.١٩ و ١٦.٥٩ ، ١٦.٤٧% عن عدم الرش (الرش بالماء فقط) فى الموسم الأول والثانى على التوالى، كما سجل رش النباتات بالشيتوزان بتركيز ٣% الى زيادة كل من تركيز المواد الصلبة الكلية الذائبة، نسبه المواد الصلبة الكلية الذائبة إلى الحموضة، وصلابة الثمار وإلى تناقص كل من حموضة وتركيز الأس الهيدروجينى فى الثمار مقارنة بمعاملة المقارنة فى كلا الموسمين، بينما سجلت معاملة الرش بالزنك المخلبى فى صورة ميكرونيت زنك ١٥% بتركيز ١ جم/لتر الى زيادة محتوى الثمار من فيتامين ج، أدت معاملة الرش بالكالسيوم على صوره فرتول الكالسيوم ١٢% بتركيز ٣ ملليتر/لتر الى تناقص كل من النسبة المئوية للفقد الكلى فى الوزن والتلف فى الثمار، يليها معاملة الرش بالشيتوزان بتركيز ٣% وذلك بعد ١٦ يوم من التخزين المبرد + فترة عرض الثمار فى كلا الموسمين، أدى رش نباتات الفراولة بالزنك المخلبى فى صورة ميكرونيت زنك ١٥% بتركيز ١.٥ جم/لتر إلى زيادة كل من محصول النبات ، متوسط وزن الثمرة والمحصول الكلى للفدان ومحتوى الثمار من فيتامين ج. والرش بالشيتوزان بتركيز ٣% أدى الى زيادة كل من تركيز المواد الصلبة الكلية الذائبة، نسبه المواد الصلبة الكلية الذائبة الى الحموضة، وصلابة الثمار وتناقص كل من الحموضة والأس الهيدروجينى والرش بالكالسيوم على صوره فرتول الكالسيوم ١٢% بتركيز ٣ ملليتر/ لتر الى تناقص النسبة المئوية للفقد الكلى فى الوزن والتلف فى الثمار.

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