

# EFFECT OF FOLIAR SPRAY WITH CHITOSAN AND SOME ORGANIC ACIDS ON PRODUCTIVITY AND FRUIT QUALITY OF STRAWBERRY FESTIVAL CULTIVAR

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## ABSTRACT:

This work was carried out during 2023/2024 and 2024/2025 seasons in a strawberry Private Farm, Kafr El Sahaby, Shebin El Kanater District, Qalubia Governorate, Egypt , to study the effect of chitosan and some organic acids on yield and fruit quality of strawberry Festival cultivar under sandy soil conditions. This experiment included nine treatments as follows: Control (spraying with water), chitosan (Ch) at 0.5 and 1%, ascorbic acid (AsA) at 100 and 200 mg/l, folic acid (FA) at 100 and 200 mg/l and salicylic acid (SA) at 100 and 200 mg/l. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Spraying strawberry cv Festival grown in sandy soil with chitosan and some organic acid at different concentrations increased early, total yield and fruit quality (vit C, TSS, glucose, fructose, anthocyanin and pH) compared to control. Spraying with SA at 200 ppm gave the highest values of average fruit weight, yield/plant, total yield, marketable yield and reduced deformed fruits (total , shape and color) followed by spraying with SA at 100 ppm.

**Conclusion:** Treating strawberry cv Festival grown in sandy soil with chitosan and some organic acid at different concentrations increased early, total yield and fruit quality (vit C, TSS, glucose, fructose, anthocyanin and pH) compared to control. Spraying with SA at 200 ppm gave the highest values of average fruit weight , yield / plant, total yield, marketable yield, followed by SA at 100 ppm. Foliar spray with SA at 200 reduced deformed fruits followed by SA at 100 ppm.

**KEYWORDS:** Strawberry, chitosan , organic acids , productivity , fruit quality , early and total yield, deformed fruits.

## INTRODUCTION

Strawberry (*Fragaria x ananassa* Duch.) is one of the most important fruit crops grown in Egypt for fresh consumption, export, and processing due to its high nutritional and medicinal value. It is classified as small fruit crop belonging to the rosaceae family. Strawberries are important for human health because they are a rich source of vitamin C, along with potassium, iron, and comprehensive antioxidants (Halvorsen *et al.*, 2002).

Festival is an important strawberry variety that has been widely grown in Egypt in recent years. A short-day variety, the fruit is mostly conical in shape. The outside of the ripe fruits is dark red and shiny, while the inside is bright red. It has a firm, crunchy texture and excellent flavor. Increasing yield while maintaining fruit quality is an important goal, which can be achieved by foliar application of nutrients widely used to promote growth and fruit set in many crops.

Recently, a great attention has been focused on the possibility of using natural and safe substances in order to improve plant growth. In this regard, vitamins such as folic acid have synergistic effects on growth, yield and yield quality of many plant species. These compounds have beneficial effects on catching the free radicals or the active oxygen that are produced during photosynthesis and respiration processes (Foyer *et al.* 1991 and Fardet *et al.* 2008). Vitamins have also an auxinic action (Fardet *et al.* 2008). The most familiar vitamins are ascorbic acid (vitamin C) and folic acid (vitamin B9) which are synthesized in higher plants and affect plant growth and development (Samiullah *et al.* 1988).

Chitosan, a natural polysaccharide derived from chitin, has gained attention for its potential to enhance strawberry production. With origins in sources like crab shells and fungi, chitosan is environmentally friendly and non-toxic (Kumaresapillai *et al.*, 2011). Chitosan is promising in promoting vegetative growth, yield, and biochemical contents in various plants (Ray *et al.*, 2023 and Khanam *et al.*, 2023).

AsA as an abundant component of plants functions as an antioxidant and an enzyme cofactor. It participates in a variety of processes, including photosynthesis, cell wall growth and cell expansion, resistance to environmental stresses and synthesis of ethylene, gibberellins, anthocyanine and hydroxyl proline (Galal *et al.*, 2000).

FA helps in the transport of amino acids to appropriate location in the protein chain creation (Kelly 1998) and is involved in methylation of amino acids, DNA and RNA (Lucock *et al.* 1996).

SA, a naturally occurring plant hormone, acts as an important signaling molecule and enhances tolerance of treated plants against biotic stresses (**Khan *et al.*, 2012**). SA also has a vital role in plant growth, ion uptake, and nutrient transport within the plant. As a phenolic compound, SA is present in many plants and is also involved in local and systemic resistance to fungal pathogens (**Meena *et al.*, 2001**). A significant role for SA has been suggested in plant water relations, photosynthesis, and growth in plants (**Arfan *et al.*, 2007**). Several functions in plants, including heat production, disease resistance, seed germination, sex polarization, and ethylene synthesis, are regulated by salicylic acid (**Raskin, 1992**). Plants are vulnerable could be treated exogenously with salicylic acid in harmless amounts to increase their resistance to fungi. It also acts as a possible non-enzymatic antioxidant and plant growth regulator (**Zhang *et al.*, 2011**).

SA treatment of the strawberry cultivars (Sweet Charli, Festival, and Vertona). increased early, late, and total fresh weight yield per unit area. SA application had significant effects on variable fruit quality (water content, vitamin C, TSS, and titratable acidity) of the three tested strawberry cultivars (**Mohamed *et al.*, 2017**). SA at all applied concentrations significantly improved the plant growth parameters and fruit yield of strawberry cv. Festival compared to control. Maximum of fruit fresh weight (g)/plant, and fruit volume (cm<sup>3</sup>) were recorded by SA at the rate of 4 mM, which was followed by SA at 2mM. (**Emam *et al.*, 2023**).

Fruit physical characteristics of strawberry cv Festival, i.e., fruit weight, fruit height, fruit diameter, and fruit hardness increased significantly due to the application of SA (2 mm/l) , or Ch (5 mg/l) compared to the sprayed water (control). Also, spraying with SA and Ch significantly improved the chemical composition of the fruits in terms of increasing the percentage of total soluble solids, sugar content, and vitamin C in addition to decreasing acidity compared to the control treatment (**Masoud *et al.*, 2024**).

Treated strawberry plants by folic acid, as compared to the control treatment improved quality and agronomic characteristics. Application of folic acid (40 mM) increased yield, weight of primary and secondary fruits and number of their achenes, total soluble solid, inducing sugar, titratable acidity, anthocyanin, phenol, and vitamin C (**Raeisi *et al.*, 2017** ).

Therefore, the aim of this work was to obtained high yield and good quality of strawberry plants by using chitosan and some organic acids (AsA, FA and SA) as foliar application

## MATERIALS AND METHODS

This work was carried out during 2023/2024 and 2024/2025 seasons in a strawberry Private Farm, Kafr El Sahaby , Shebin El Kanater District, Qalubia Governorate, Egypt , to study the effect of chitosan and some organic acids on yield and fruit quality of strawberry Festival cultivar under sandy soil conditions.

This experiment included nine treatments as follows: Control , Chitosan; Ch at 0.5% and 1%, Ascorbic acid ; AsA (C<sub>6</sub>H<sub>8</sub>O<sub>6</sub>) at 100 and 200 mg/l, Folic acid ; FA (C<sub>19</sub>H<sub>19</sub>N<sub>7</sub>O<sub>6</sub>) at 100 and 200 mg/l and Salicylic acid ;SA (C<sub>7</sub>H<sub>6</sub>O<sub>3</sub>) at 100 and 200 mg/l. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The source of Chitosan powder was Qingdao Fraken International Trading CO.,LTD and Salicylic acid, Ascorbic acid, Folic acid and Boric acid was Technogen Company, EL-Dokky, Cairo, Egypt .

Fresh transplants of strawberry Festival cultivar was obtained from local nurseries. The experimental unit area was 8.8 m<sup>2</sup> and each unit contained one ridge with 11 m length and 80 cm width. The transplants were planted on 5<sup>th</sup> and 14<sup>th</sup> September in the 1<sup>st</sup> and 2<sup>nd</sup> seasons , respectively . The transplants were dipped for 10 minutes at doses of 1g/ L Benlet+1g/L Rizolex and planted on the ridge (80 cm) in 4 rows . The distance between strawberry transplants within the row was 25 cm and between the rows was 20 cm (25 x 20 cm). Soil plastic mulch and drip irrigation system were used. Plants were sprayed five times, once before flower initiation (vegetative stage) and four times started at the beginning of flowering stage (flowering and fruiting stages ) with 10 days intervals between each one. The agricultural practices concerning cultivation, irrigation, fertilization and insect and disease control were conducted according to the recommendation of the Ministry of Agriculture for strawberry commercial production.

### Data recorded:

**Early and its components:** The early yield was determined by the weights of all harvested fruits from each plot during February and March months, and then early yield per plant and / fad. were calculated, also early average fruit weight was determined.

**Total yield and its components:** Total yield was recorded from each plot as weights of all harvested fruits during the season up to mid of May, then, yield per plant (g) and total yield per fad. (ton) were calculated, also average fruit weight was determined. (fad.= 4200 m<sup>2</sup>=0.42 ha.).

**Deformed fruits :** Deformed fruits percent (total , shape and color deformed fruits) in early and total yield were determined.

**Fruit quality:** At harvest (120 days after planting) , samples of ten ripe fruits were chosen randomly from each experimental unit at full ripe stage to measure : **Ascorbic acid (Vit. C)** content was determined in mg/100 g fresh weight using 2, 6 Di chloro phenol Indophenol for titration as the method mentioned in **AOAC (2005)**. **Total soluble solids (TSS )** as brix<sup>o</sup> using the hand refractometer. **Glucose and Fructose (%)**: It was determined according to both methods described by **Forsee (1938)**. **Anthocyanins mg/100g FW**: The anthocyanin content in fruits was determined according to the method described by **Geza *et al.* (1984)**. pH: The

acidity: It was estimated by titrating known volume of juice against 0.1 N NaOH using phenolphthalein as an indicator (AOAC,2005)

**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 (1955)**.

## RESULTS AND DISCUSSION

### Early yield and its components

Treating strawberry cv. Festival with Ch and some organic acid at different concentrations increased early yield and its components, except yield of deformed fruits compared to control treatment in both seasons (Table 1). Spraying with SA at 200 ppm gave the highest values of early number of fruits/plant (10.33 and 9.87), early average fruit weight (21.43 and 22.19 g), early yield/plant (221.40 and 219.01 g), early total yield /fad. (8.654 and 8.586 ton/fad.) and early marketable yield (8.424 and 8.356 ton/fad.) in both seasons followed by SA at 100 ppm. The increase in early total yield /fed. were about 65.66 and 50.58 % for spraying with SA at 200 ppm over the control treatment in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively. fad.= 4200 m<sup>2</sup>=0.42 ha.).

### Early deformed fruits

Treating strawberry cv. Festival with Ch and some organic acid at different concentrations decreased early deformed fruits compared to control. The lowest values of early yield deformed fruits percentage in total yield were about 2.74 and 2.05 % for chitosan at 1 %, 2.67 and 2.69 % for SA at 200 ppm and 3.24 % and 3.98 % for SA at 100 ppm (Table 1).

**Table 1. Effect of chitosan and some organic acids on early yield and its components of strawberry cv. Festival during 2023/2024 and 2024/2025 seasons under sandy soil conditions**

| Treatments        | Early yield                       |                                    |                         |                  |                  |                                 |                |                                 |
|-------------------|-----------------------------------|------------------------------------|-------------------------|------------------|------------------|---------------------------------|----------------|---------------------------------|
|                   | Numb<br>er of<br>fruits/<br>plant | Averag<br>e fruit<br>weight<br>(g) | Yield /<br>plant<br>(g) | Yield<br>/feddan | Marketable yield |                                 | Deformed yield |                                 |
|                   |                                   |                                    |                         |                  | ton<br>/fed.)    | (%) in<br>the<br>total<br>yield | ton<br>/fed.)  | (%) in<br>the<br>total<br>yield |
|                   | 2023/2024 season                  |                                    |                         |                  |                  |                                 |                |                                 |
| Control           | 7.80 h                            | 17.08<br>f                         | 133.20<br>g             | 5.224 g          | 4.704c           | 90.04                           | 0.521a         | 9.96                            |
| Ch at 0.5%        | 8.26 g                            | 17.88<br>e                         | 147.73<br>f             | 5.720f           | 5.500f           | 96.15                           | 0.221f         | 3.86                            |
| Ch at 1 %         | 8.53 f                            | 18.05<br>e                         | 153.93<br>f             | 5.967e           | 5.804e           | 97.27                           | 0.163g         | 2.74                            |
| AsA at 100 ppm    | 9.03 e                            | 19.79<br>d                         | 178.66<br>e             | 7.035d           | 6.529d           | 92.81                           | 0.507a         | 7.20                            |
| AsA at 200 ppm    | 9.22 d                            | 19.89<br>cd                        | 183.40d<br>e            | 7.223d           | 6.789d           | 93.99                           | 0.435b         | 6.02                            |
| FA at 100 ppm     | 9.26 d                            | 20.36bc<br>d                       | 188.53c<br>d            | 7.477c           | 7.084c           | 94.74                           | 0.394c         | 5.27                            |
| FA at 200 ppm     | 9.43 c                            | 20.47<br>bc                        | 193.06<br>c             | 7.470c           | 7.254c           | 97.10                           | 0.328d         | 4.39                            |
| SA at 100 ppm     | 10.06 b                           | 20.66 b                            | 207.86<br>b             | 8.115b           | 7.853b           | 96.77                           | 0.263e         | 3.24                            |
| SA at 200 ppm     | 10.33 a                           | 21.43 a                            | 221.40<br>a             | 8.654a           | 8.424a           | 97.34                           | 0.231f         | 2.67                            |
| LSD at 0.05 level | 0.15                              | 0.62                               | 7.73                    | 0.204            | 0.288            | --                              | 0.020          | --                              |
|                   | 2024/2025 season                  |                                    |                         |                  |                  |                                 |                |                                 |
| Control           | 7.41 e                            | 19.88<br>d                         | 147.29<br>f             | 5.702g           | 5.217g           | 91.49                           | 0.485b         | 8.51                            |
| Ch at 0.5%        | 7.80 d                            | 22.93 a                            | 178.84<br>e             | 6.959f           | 6.674f           | 95.91                           | 0.285e         | 4.09                            |
| Ch at 1 %         | 8.00 d                            | 23.14 a                            | 185.08d<br>e            | 7.208e           | 7.061e           | 97.96                           | 0.148g         | 2.05                            |
| AsA at 100 ppm    | 8.84 c                            | 21.34 c                            | 188.61c<br>d            | 7.431d           | 6.861e<br>f      | 92.33                           | 0.570a         | 7.68                            |
| AsA at 200 ppm    | 9.06 bc                           | 21.75<br>bc                        | 197.09b<br>c            | 7.719c           | 7.283d           | 94.35                           | 0.436c         | 5.65                            |
| FA at 100 ppm     | 9.15 b                            | 21.74                              | 198.93                  | 7.793bc          | 7.352d           | 94.34                           | 0.442c         | 5.67                            |

|                          |        |          |          |        |        |       |        |      |
|--------------------------|--------|----------|----------|--------|--------|-------|--------|------|
|                          |        | bc       | b        |        |        |       |        |      |
| <b>FA at 200 ppm</b>     | 9.21 b | 21.99 bc | 202.50 b | 7.950b | 7.715c | 97.04 | 0.236f | 2.96 |
| <b>SA at 100 ppm</b>     | 9.76 a | 22.05 b  | 215.25 a | 8.457a | 8.121b | 96.02 | 0.337d | 3.98 |
| <b>SA at 200 ppm</b>     | 9.87 a | 22.19 b  | 219.01 a | 8.586a | 8.356a | 97.32 | 0.231f | 2.69 |
| <b>LSD at 0.05 level</b> | 0.23   | 0.65     | 8.79     | 0.165  | 0.203  | --    | 0.531  | -    |

Ch=chitosan , AsA=ascorbic acid , FA=folic acid and SA=salicylic acid

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range Test at 0.05 level of probability.

### Total yield and its components

Spraying strawberry cv Festival with SA at 200 ppm gave the highest values of average fruit weight (22.90 and 23.60 g), yield / plant ( 519.73 and 511.70g) , yield /fad.( 20.374 and 20.171 ton) marketable yield / fed.(19.153 and 19.360 ton) in both seasons followed by SA at 100 ppm ( Table 2). For all treatments , average fruit weight of Festival cultivar were around from 18.67 and 22.90 g in the 1<sup>st</sup> season and around from 21.68 to 23.60 g in the 2<sup>nd</sup> season, also, number of fruits/ plant were around 19.31 to 23.58 in the 1<sup>st</sup> season and around 21.68 to 23.60 g in the 2<sup>nd</sup> season.

SA treatment of the strawberry cultivars (Sweet Charli, Festival, and Vertona). increased early, late, and total fresh weight yield per unit area of the three tested strawberry cultivars (Mohamed *et al.* 2017).SA at all applied concentrations significantly improved fruit yield of strawberry cv. Festival compared to control. Maximum of fruit fresh weight (g)/plant, and fruit volume (cm<sup>3</sup>) were recorded by SA at the rate of 4 mM, which was followed by SA at 2mM.( Emam *et al.*, 2023). Fruit physical characteristics of strawberry cv Festival, i.e., fruit weight, fruit height, fruit diameter, and fruit hardness increased significantly due to the application of SA acid (2 mm/l) , or Ch (5 mg/l) compared to the sprayed water (Masoud *et al.*, 2024). Application of FA ( 40 mM) increased yield, weight of primary and secondary fruits and number of their achieves compared to control (Raiesi *et al.*,2017 ).

**Table 2. Effect of chitosan and some organic acids on total yield and its components of strawberry cv. Festival during 2023/2024 and 2024/2025 seasons under sandy soil conditions**

| Treatments        | Total yield            |                          |                   |                        |                  |                        |                |                        |
|-------------------|------------------------|--------------------------|-------------------|------------------------|------------------|------------------------|----------------|------------------------|
|                   | Number of fruits/plant | Average fruit weight (g) | Yield / plant (g) | Total yield (ton/fad.) | Marketable yield |                        | Deformed yield |                        |
|                   |                        |                          |                   |                        | ton /fed.)       | (%) in the total yield | ton /fed.)     | (%) in the total yield |
|                   | 2023/2024 season       |                          |                   |                        |                  |                        |                |                        |
| Control           | 19.31 g                | 18.67 e                  | 360.46 g          | 14.278 g               | 12.639c          | 88.52                  | 1.640a         | 11.49                  |
| Ch at 0.5%        | 21.97 d                | 18.65 e                  | 409.69 f          | 16.156 f               | 14.815f          | 91.70                  | 1.342cd        | 8.31                   |
| Ch at 1 %         | 21.78 d                | 19.71 d                  | 429.28 e          | 17.019 e               | 15.750e          | 92.54                  | 1.271de        | 7.47                   |
| AsA at 100 ppm    | 23.58 a                | 18.55 e                  | 437.48 de         | 17.263 e               | 15.728e          | 91.11                  | 1.535b         | 8.89                   |
| AsA at 200 ppm    | 23.58 a                | 18.62 e                  | 439.10 de         | 17.436d e              | 16.007e          | 91.81                  | 1.429c         | 8.20                   |
| FA at 100 ppm     | 20.89 f                | 21.66 c                  | 452.43c d         | 17.859 d               | 16.617d          | 93.05                  | 1.242ef        | 6.96                   |
| FA at 200 ppm     | 21.41 e                | 21.90 bc                 | 469.01 c          | 18.519 c               | 17.306c          | 93.45                  | 1.214ef        | 6.56                   |
| SA at 100 ppm     | 22.37 c                | 22.08 b                  | 493.97 b          | 19.431 b               | 18.261b          | 93.98                  | 1.170f         | 6.03                   |
| SA at 200 ppm     | 22.70 b                | 22.90 a                  | 519.73 a          | 20.374 a               | 19.153a          | 94.01                  | 1.222ef        | 6.00                   |
| LSD at 0.05 level | 0.23                   | 0.31                     | 16.73             | 0.575                  | 0.581            | --                     | 0.098          | --                     |
|                   | 2024/2025 season       |                          |                   |                        |                  |                        |                |                        |
| Control           | 19.80 e                | 21.68 d                  | 429.34 g          | 16.975 f               | 14.793g          | 87.15                  | 2.182a         | 12.86                  |

|                          |             |             |             |              |              |            |              |           |
|--------------------------|-------------|-------------|-------------|--------------|--------------|------------|--------------|-----------|
| <b>Ch at 0.5%</b>        | 19.91 e     | 22.57 c     | 449.44 f    | 17.693 e     | 16.742f      | 94.78      | 0.896ef      | 5.23      |
| <b>Ch at 1 %</b>         | 20.35 d     | 22.84 c     | 464.85 e    | 18.417 d     | 17.550d e    | 95.30      | 0.867f       | 4.71      |
| <b>AsA at 100 ppm</b>    | 20.81 c     | 22.78 c     | 474.00 d    | 18.740c d    | 17.043e f    | 90.95      | 1.697b       | 9.06      |
| <b>AsA at 200 ppm</b>    | 21.44 b     | 22.76 c     | 487.90 c    | 19.281 bc    | 17.819c d    | 92.42      | 1.461c       | 7.58      |
| <b>FA at 100 ppm</b>     | 21.24 b     | 23.20 b     | 492.74 bc   | 19.436 b     | 18.388b c    | 94.61      | 1.048d       | 5.39      |
| <b>FA at 200 ppm</b>     | 20.99 c     | 23.42 ab    | 491.52 bc   | 19.354 bc    | 18.522b      | 95.71      | 0.831f       | 4.30      |
| <b>SA at 100 ppm</b>     | 21.26 b     | 23.48 ab    | 499.25 b    | 19.693 ab    | 18.704b      | 94.98      | 0.988de      | 5.03      |
| <b>SA at 200 ppm</b>     | 21.68 a     | 23.60 a     | 511.70 a    | 20.171 a     | 19.360a      | 95.98      | 0.812f       | 4.02      |
| <b>LSD at 0.05 level</b> | <b>0.20</b> | <b>0.32</b> | <b>8.07</b> | <b>0.630</b> | <b>0.601</b> | <b>---</b> | <b>0.105</b> | <b>--</b> |

Ch=chitosan , AsA=ascorbic acid , FA=folic acid and SA=salicylic acid

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range Test at 0.05 level of probability.

SA is a phenolic endogenous growth regulator normally produced in plants in very small amounts that regulates a number of physiological and biochemical processes in plants, including seed germination, plant growth, flowering induction, nutrient uptake and transport, water-plant relations, membrane permeability, stomatal conductance, photosynthesis, and enzyme activity (Arfan *et al.* , 2007; Hayat *et al.* , 2010 ; Youssef *et al.* ,2017 and Mohamed *et al.*,2018). Chitosan is widely used in agriculture, mainly to promote plant defense (Naeem *et al.*, 2010). Chitosan also promotes plant growth, development and productivity and improves yield components of various crops (El-Tantawy , 2009 ; El-Tanahy *et al.* , 2012 and El-Miniawy *et al.*, 2013).

#### Total deformed fruits

Treating strawberry cv Festival with Ch and some organic acid at different concentrations decreased total , shape and color deformed fruits compared to control. The lowest values of total deformed fruits percentage in total yield were about 6.00 and 4.02 % for SA at 200 ppm in the 1<sup>st</sup> and 2<sup>nd</sup> seasons, respectively .Also, SA at 200 ppm recorded minimum values of shape deformed (3.07 and 2.56 %) and color deformed (2.93 and 1.46 %) in total yield in both seasons (Tables 2 and 3 and figs 1 and 2) .

**Table 3. Effect of chitosan and some organic acids on deformed yield ( ton/fed.) in shape and color of strawberry cv. Festival during 2023/2024 and 2024/2025 seasons under sandy soil conditions**

| Treatments               | Shape deformed         |                        |                        |                        | Color deformed         |                        |                        |                        |
|--------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
|                          | Yield ( ton/fed.)      |                        | (%) in total yield     |                        | Yield ( ton/fed.)      |                        | (%) in total yield     |                        |
|                          | 1 <sup>st</sup> season | 2 <sup>nd</sup> season | 1 <sup>st</sup> season | 2 <sup>nd</sup> season | 1 <sup>st</sup> season | 2 <sup>nd</sup> season | 1 <sup>st</sup> season | 2 <sup>nd</sup> season |
| <b>Control</b>           | 0.939a                 | 1.399a                 | 6.58                   | 8.24                   | 0.701b                 | 0.784a                 | 4.91                   | 4.62                   |
| <b>Ch at 0.5%</b>        | 0.722cd                | 0.626d                 | 4.47                   | 3.54                   | 0.621c                 | 0.298g                 | 3.84                   | 1.69                   |
| <b>Ch at 1 %</b>         | 0.711d                 | 0.585e                 | 4.18                   | 3.18                   | 0.560e                 | 0.282h                 | 3.29                   | 1.53                   |
| <b>AsA at 100 ppm</b>    | 0.794b                 | 1.097b                 | 4.60                   | 5.85                   | 0.741a                 | 0.601b                 | 4.29                   | 3.21                   |
| <b>AsA at 200 ppm</b>    | 0.748c                 | 0.878c                 | 4.29                   | 4.55                   | 0.681b                 | 0.584c                 | 3.91                   | 3.03                   |
| <b>FA at 100 ppm</b>     | 0.655ef                | 0.601e                 | 3.67                   | 3.09                   | 0.588d                 | 0.447d                 | 3.29                   | 2.30                   |
| <b>FA at 200 ppm</b>     | 0.637fg                | 0.504f                 | 3.44                   | 2.61                   | 0.577de                | 0.327f                 | 3.12                   | 1.69                   |
| <b>SA at 100 ppm</b>     | 0.670e                 | 0.594e                 | 3.45                   | 3.02                   | 0.501f                 | 0.395e                 | 2.58                   | 2.01                   |
| <b>SA at 200 ppm</b>     | 0.626f                 | 0.517f                 | 3.07                   | 2.56                   | 0.613c                 | 0.295g h               | 2.93                   | 1.46                   |
| <b>LSD at 0.05 level</b> | <b>0.027</b>           | <b>0.023</b>           | <b>--</b>              | <b>--</b>              | <b>0.023</b>           | <b>0.015</b>           | <b>--</b>              | <b>--</b>              |

Ch=chitosan , AsA=ascorbic acid , FA=folic acid and SA=salicylic acid , 1<sup>st</sup> season =2023/2024 season , 2<sup>nd</sup> season =2024/2025 season

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range Test at 0.05 level of probability.

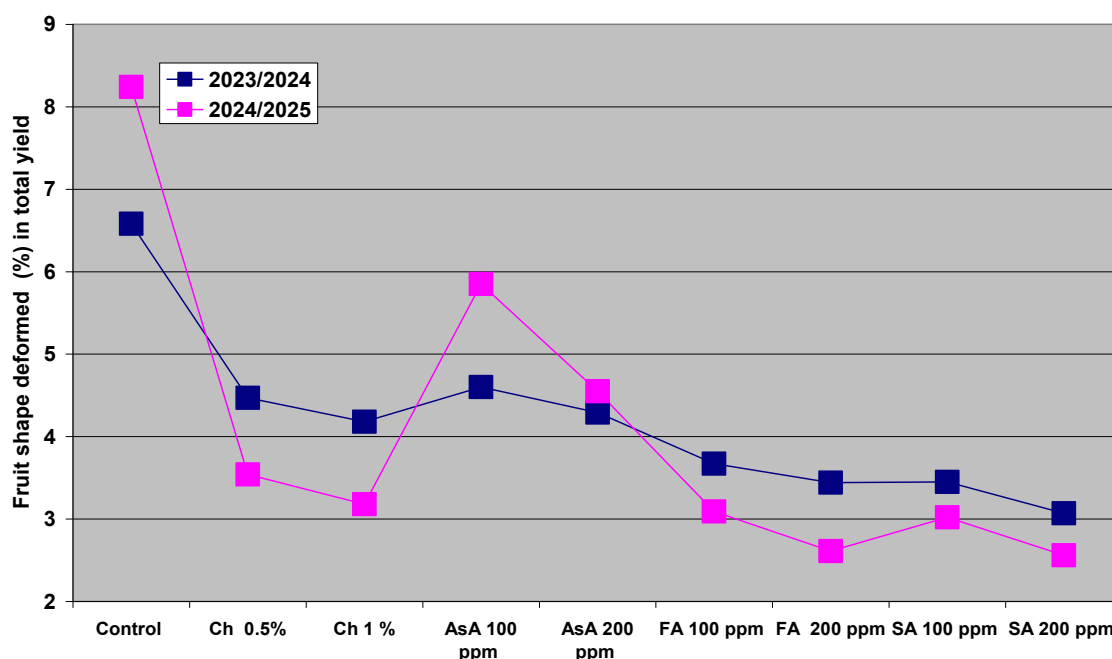


Fig (1). Effect of chitosan and some organic acids on fruit shape deformed (%) in total yield of strawberry cv. Festival during 2023/2024 and 2024/2025 seasons under sandy soil conditions.

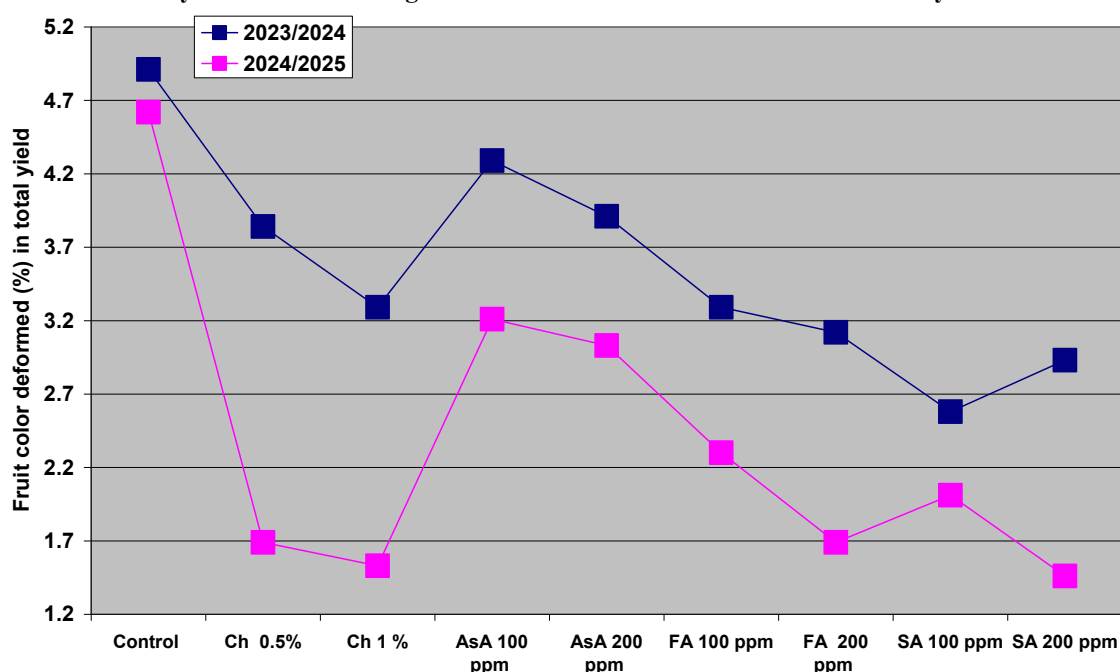


Fig (2). Effect of chitosan and some organic acids on fruit color deformed (%) in total yield of strawberry cv. Festival during 2023/2024 and 2024/2025 seasons under sandy soil conditions.

### Fruit quality

In the first season, foliar spray with AsA at 200 ppm, SA at 100 ppm, Ch at 1%, Ch at 0.5%, SA at 200 ppm and AsA at 100 ppm increased vit C, TSS, glucose, fructose, anthocyanin and pH in fruit, respectively (Table 4). Whereas, in the second season, spraying with AsA at 200 ppm produced the highest values of vit C, glucose, fructose, anthocyanin and pH, while spraying with FA at 100 ppm produced the highest values of TSS in fruits. In general treating strawberry plants cv. Festival with chitosan and some organic acids increased vit C, TSS, glucose, fructose, anthocyanin and pH in fruits compared to control treatment in both seasons.

Treated strawberry plants by FA as compared to the control treatment improved quality and agronomic characteristics. Application of FA at 40 mM increased total soluble solid, inducing sugar, titratable acidity, anthocyanin, phenol, and vitamin C (Raeisi *et al.*, 2017). SA application had significant effects on variable fruit quality (water content, vitamin C, TSS, and titratable acidity) of the three tested strawberry cultivars (Mohamed *et al.*, 2017). Spraying with SA and chitosan significantly improved the chemical composition of the fruits in

terms of increasing the percentage of total soluble solids, sugar content, and vitamin C in addition to decreasing acidity compared to the control treatment (Masoud *et al.* , 2024).

## CONCLUSION

Treating strawberry cv Festival grown in sandy soil with chitosan and some organic acid at different concentrations increased early, total yield and fruit quality (vit C, TSS, glucose, fructose, anthocyanin and pH) compared to control. Spraying with SA at 200 ppm gave the highest values of average fruit weight, yield / plant, total yield, marketable yield followed by SA at 100 ppm. Foliar spray with SA at 200 reduced deformed fruits followed by SA at 100 ppm.

**Table 4. Effect of chitosan and some organic acids on fruit quality of strawberry cv. Festival during 2023/2024 and 2024/2025 seasons under sandy soil conditions**

| Treatments              | Vitamin C<br>mg/100<br>FW | TSS<br>(%) | Glucose<br>(%) | Fructose<br>(%) | Anthocyanins<br>mg/100g FW | pH      |
|-------------------------|---------------------------|------------|----------------|-----------------|----------------------------|---------|
| <b>2023/2024 season</b> |                           |            |                |                 |                            |         |
| Control                 | 30.15 g                   | 5.41 h     | 2.27 g         | 3.09 f          | 13.887 f                   | 2.96 f  |
| Ch at 0.5%              | 33.98 f                   | 6.28 g     | 3.46 b         | 3.65 a          | 15.620 cde                 | 3.28 e  |
| Ch at 1 %               | 35.11 e                   | 6.47 f     | 3.59 a         | 3.70 a          | 16.130 bcd                 | 3.44 cd |
| AsA at 100 ppm          | 38.99 b                   | 6.89 b     | 3.13 e         | 3.34 d          | 16.230 bcd                 | 3.57 ab |
| AsA at 200 ppm          | 40.30 a                   | 6.74 d     | 3.25 cd        | 3.43 c          | 16.290 bc                  | 3.69 a  |
| FA at 100 ppm           | 36.39 d                   | 6.55 e     | 2.79 f         | 3.24 e          | 14.390 ef                  | 3.22 e  |
| FA at 200 ppm           | 36.97 cd                  | 6.77 d     | 3.07 e         | 3.35 d          | 14.940 def                 | 3.34 de |
| SA at 100 ppm           | 37.60 c                   | 7.06 a     | 3.22 d         | 3.48 c          | 17.080 ab                  | 3.53 bc |
| SA at 200 ppm           | 37.63 c                   | 6.83 c     | 3.31 c         | 3.58 b          | 18.050 a                   | 3.60 ab |
| LSD at 0.05 level       | 0.66                      | 0.05       | 0.07           | 0.05            | 1.32                       | 0.12    |
| <b>2024/2025 season</b> |                           |            |                |                 |                            |         |
| Control                 | 31.86 g                   | 5.17 g     | 2.37 g         | 3.02 f          | 13.13 f                    | 2.99 f  |
| Ch at 0.5%              | 33.97 f                   | 6.23 f     | 3.08 e         | 3.35 d          | 14.56 d                    | 3.36 de |
| Ch at 1 %               | 35.01 e                   | 6.46 e     | 3.29 d         | 3.49 c          | 15.30 c                    | 3.47 cd |
| AsA at 100 ppm          | 38.95 b                   | 6.89 bc    | 3.55 b         | 3.69 a          | 16.25 b                    | 3.74 ab |
| AsA at 200 ppm          | 40.77 a                   | 6.86 bcd   | 3.66 a         | 3.71 a          | 17.26 a                    | 3.80 a  |
| FA at 100 ppm           | 35.52 e                   | 6.99 a     | 2.94 f         | 3.27 e          | 13.63 ef                   | 3.25 e  |
| FA at 200 ppm           | 37.02 d                   | 6.77 d     | 3.09 e         | 3.39 d          | 14.16 de                   | 3.41 d  |
| SA at 100 ppm           | 37.26 cd                  | 6.80 cd    | 3.30 d         | 3.52 c          | 15.35 c                    | 3.57 c  |
| SA at 200 ppm           | 37.90 c                   | 6.95 ab    | 3.49 c         | 3.59 b          | 15.95 bc                   | 3.60 bc |
| LSD at 0.05 level       | 0.72                      | 0.09       | 0.04           | 0.05            | 0.65                       | 0.14    |

Ch=chitosan, AsA=ascorbic acid, FA=folic acid and SA=salicylic acid

Means within a row followed by different letter (s) are statistically different using the Duncan Multiple Range Test at 0.05 level of probability.

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