Effect of Rosemary Plant Extract and Calcium Chloride Sprays on the Some Fruit Quality and Storability of Strawberry (*Fragaria* X *Ananassa* Duch) Grown under Plastic House Conditions.

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ABSTRACT

This experiment was carried out in plastic house at a private orchard, Sulaimani governorate- Iraqi, Kurdistan Region. During (2016 and 2017) growing season to investigate the effect of two factors (rosemary plant extracts (0, 3 and 6%) and two concentrations of calcium chloride (0 and 0.5%). Randomized Complete Block Design (RCBD) was used in this experiment, with three replicates. Foliar application was used at twice. The first time was applied before blossom on 12 March (before flowering phase) and second time after fruit set on 3April, (fruit setting phase).

Fruits harvested early in the morning (5:00 am) at full ripening stage every 4 days at (April 15, to May 29, 2017), fruit displaying surface defects, damage and decayed were discarded. They were then packed in 1 kg containers (PP Material Dinnerware Sets Disposable Fruit Packaging Box with Lid 200PCS/LOT Transparent Rectangle Thicken Package Containers). All treated fruits were stored in cold storage ($2^{\pm 1}$°C) with a relative humidity 85-90% for 30 days with continuous monitoring.

The obtained results could be summarized as follows that whole parameters were measured after 30 days of storage fruits, but Fresh weight loss was only recorded before storage.

The study revealed that the application of rosemary plant extract at highest concentration 6% decreased the Fresh weight loss% and Decay %. With respect to 3% concentration caused increase total sugars % and Calcium content (mg/100g). Application of 0.5% $CaCl_2$ resulted the decrease in Fresh weight loss% and Decay% while maintain berry hardness (N), increased total soluble solids (TSS %) and calcium content (mg/100 g). With respect to the interactions between the 3% rosemary plant extract and 0.5% $CaCl_2$ resulted increased the berry hardness (N), total soluble solids (TSS %), total sugars % and Calcium content (mg/100g), while the interactions between the 6% rosemary plant extract and 0.5% CaCl2 resulted decrease in Fresh weight loss%.

Key wards: ***Strawberry, rosemary plant extract, Calcium Chloride, Quality of fruit***

INTRODUCTION

Strawberry plant (*Fragaria*× *ananassa* Duchesne), is a member of the family Rosaceae, from the genus Fragaria L., **(65)**, it is a delicious fruit with a special economic position in the fruit industry because of its post-harvest processing and antioxidant functional value. There are a large number of cultivars grown worldwide, encompassing major regions distributed across all six continents and the most economically important soft fruit worldwide **(39).** Strawberry is an important small fruit, cultivated at least in 63 countries grown throughout the world. It is deep red in colour

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with unique shape and flavour. The estimated production of strawberries in the world during 2013 was 7,739,622 tons from 361,662 ha area in world **(80).**

Alongside with economic sector nutrients of strawberry also contains other compounds for health benefits such as anticancer, antioxidant, anti-neurodegenerative and anti-inflammatory activities, furthermore, a good choice among foodstuffs containing plentiful amounts of several essential components, such as vitamin C, potassium, calcium and magnesium **(33; 75 and 49)**.

Strawberry is a non-climacteric fruit with short postharvest shelf-life and highly perishable, susceptible to mechanical injury, physiological disorders, water loss, and decay **(7)**. The reason for its relatively short period of harvest compels the producer to sell his production immediately, evidently prejudicing him with respect to the reduced price due to its sale in large volumes. Furthermore, strawberry cultivation in spite of facing several problems such as, less sweetness, short shelf-life, colour degradation and damage during transportation **(43).**

In order to maintain the productivity, more and more chemicals are being added in the natural environment, which enter the food chain through water, soil, and air resulting serious harmful effect in human health **(67)**. 50,000 people in developing countries are annually poisoned with 5,000 were died regarding WHO survey as a result of the effects of toxic agents that was used in agriculture. **(12).** To avoid the use of these horrible diseases causing synthetic chemicals, the plants and their product should be utilized to combat the diseases causing pathogens. As plants are known to possess various secondary metabolites, which showed inhibitory effect against the growth of pathogens. Keeping these problems in view, efforts are underway to search economic safe phytochemicals, which could be utilized for disease control.

Recently, post-harvest life of strawberries can be extending by natural substances for instance, Rosemary extract (*Rosmarinus officinalis*). Therefore, it is edible, Cheap, environmentally friendly, health benefits and can be caused to prolong storage life of strawberry through a reduction of loss moisture, gas exchange, respiration rate and oxidative reaction rates with provide a barrier against hazards (**23).**The rosemary belongs to the Lamiaceae family and has been a good potential with desirable technological properties, that may be refers to the antioxidant, antimicrobial and anti-inflammatory of rosemary **(23; 29 and 66)**.However, concentration of rosemary extract is not conducted in many research so far.

Calcium Chloride is a Chemical compound that is another factor to improve and extend of strawberry post-harvest, because of calcium play significant role to maintain the cell wall structure in fruit by interacting with the pectic acid in the cell walls to form calcium pectate **(7).** In addition, researcher demonstrated that increase calcium in to strawberry plant have been influence in forming cross-bridges with cell wall strength and maintained fruit firmness and soluble solid contents, without affecting their sensory quality **(27;52 and 25)**. Moreover, postharvest strawberry fruit treated with calcium can be prevents postharvest disorder, retards fruit ripening and decreases postharvest decay **(72)**. Recently demand for locally and off-season produces of fresh fruits and viable commodity exports the production to spread greenhouses **(10).** Therefore, to decrease damage and losses strawberry fruit production different preservation techniques were conducted such as cooling, chemical fungicides, modified atmosphere packaging and edible coating, which is being increasingly used as a possible option **(7).**

The aims of this project were to improve fruit quality and storability of strawberry under greenhouse condition, which are key traits of agronomic importance for Small fruits. To extend of storability during storage by reducing

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postharvest decay and also regulate marketing with the great demand from the consumers.

MATERIALS AND METHODS

This study was carried out during 2016-2017 growing season at a private orchard located in Suse village, 35 Km northwestern of Sulaimani governorate at 582 m above sea level with 35° 22' 25 1" N latitude and 45° 43' 25 21" E longitude **(32)**.

A plastic house, 450 m^2 of total area was used in the experiment that was included 18 treatments (2 × 3 × 3). Distance between the plots was1.5 m, and between the replicates was1m. (24) strawberry plants was then planted in each plot and the distance between the seedlings within a plot was 0.2 m. In addition, mulching system was used to protect the plant in weeds and resistance to diseases and also to increased temperature in plastic house (See Figure 1).

Figure 1: designed strawberry plants in the plastic house.

In addition, before started the experiment soil texture was checked that was salty clay (Clay 30%; Sand 28% and Salt 42%), but after spray soil also was checked that Clay 20%; Sand 46% and Salt 34%) were recorded as result soil texture is salty. And also some chemical and physicals properties were checked as describe in (Table 1)

Table 1 shows that the analyses of some chemical and physical properties of soil in the plastic house.

Some chemical and physical soil property analyses	Before spray	After spray
K	40ppm	60ppm
P	19.2ppm	95.9ppm
EC	0.40ml/cm3	0.89
PH	6.61	6.78
Ca	6.86meg/l	2.82
Gorganic matter	1.82%	1.58
N	5.62ppm	5.78
Cl	0.3meg/l	1.0

Randomized Complete Block Design (RCBD) with three replications was utilized in this experiment. The Analysis of Variance (ANOVA) and Least Significant Difference

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(L.S.D. at 0.05 levels) were used to separate the means **(5).** Data were analyzed using statistical program of Statistics and Graphics Guide **(XLSTAT).**

(30 and 60 g) leaves of rosemary powder were weighed (referred to as the concentration of (3 and 6%), and then cold double-distilled water was used to extract and then kept in the dark at room temperature for 24 hours. Solutions were then filtered through a filter paper, and immediately used for the experiment **(70).**

According to calcium chloride dehydrate ($CaCl_2.2H_2O$), (0% and 0.5% concentrations was used that was foliar applied at twice. The first application was before blossom on 12 March (before flowering phase) and second after fruit set on 3April, (fruit setting phase).

Fruits were harvested early in the morning (5:00 am) at full ripening stage every 4 days at (April 15, to May 29, 2017), fruit displaying surface defects, damage and decayed were discarded. They were then packed in 1 kg containers (PP Material Dinnerware Sets Disposable Fruit Packaging Box with Lid 200PCS/LOT Transparent Rectangle Thicken Package Containers) and then kept in shade place until transferred a cold storage ($2^{\pm 1}$°C) after sterilized with 10 $ml.L^{-1}$ 36% formalin and 2% sodium hypochlorite with 85-90% a relative humidity for 30 days with continuous monitoring,

The following parameters were measured:

1. Fresh weight loss % (FWL %)

Measured as the loss of initial fresh fruit weight and expressed as a percentage **(38).** The same samples were evaluated for weight loss by the following formula:

Fresh weight loss (%) = [(A-B)/A] x 100

A: the initial fruit weight.

B: fruit weight after storage period.

2. Decay %

Fruits affected with either pathological or physiological disorders were weighted the defects were calculated as follows:

$$\text{Decay\%} = \frac{\text{No. of decayed fruits}}{\text{No. of fruits at the beginning of storage}} \times 100$$

3. Hardness of fruits (N)

Hardness was determined by Texture Analyzer as described in **(1)** using 6 mm spindle diameter and 5 kg load cell, which is moving at a speed (2 mm.sec-1) with the depth of 5 mm.

4. Total titratable acidity (TA%)

Calculated by titration with NaOH and phenolphthalein index, the acidity was determined as citric acid content (g 100 ml^{-1} juice) **(1).**

5. Total soluble solids (TSS%)

Total Soluble Solid was determined by Hand Refractometer as described in (**1)**

6. Total sugars %

Total soluble sugars have been determined according to **(47)**

7. Anthocyanins (mg100 g^{-1}. F. W.)

Pigment content in the strawberry fruits has been determined using the method described by **(68**) based on a soft weight.

8. Calcium content (mg100 g^{-1})

Calcium content was determined according to the method described by **(71)**

RESULTS

1. Fresh weight loss % (FWL %):

It can be observed from table (2) that the fresh weight loss of (control) 0% and 3% rosemary plant extract was higher than 6% rosemary plant extract treatments, but no significant difference was found between 0% and 3%. Also the 0 % $CaCl_2$ strawberry fruit fresh weight loss incidence was higher significantly than 0.5% $CaCl_2$ treatments, but the best results to

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decreased of fresh weight loss% appeared from 0.5% $CaCl_2$.

Data presented in the same table confirm that there were significant differences among rosemary plant extract with $CaCl_2$ on fresh weight loss%. The highest value was recorded (7.359%) from the interaction between 3% rosemary plant extract with 0% $CaCl_2$, while the lowest value was observed (5.269%) from 6% rosemary plant extract with 0.5% of $CaCl_2$. These results were similar to the studies of **(54)** from these results, the decreased of weight loss may be attributed to controlling of decay and its damages through the biological activity of rosemary extract and chitosan against postharvest diseases and make a thin film surrounding the fruit peel and induced a modification of atmosphere around the fruits. The water loss had a negative effect on the strawberry fruit appearance, leading to shrivelling and a dull appearance of the epidermis.

Generally, the weight loss occurs during the fruit storage due to its respiratory process, the transference of humidity and some processes of oxidation **(9)**. It is clear that all treatments significantly reduce the weight loss of strawberry fruits during the storage compared to the control. These results were similar to the studies of (**7)** that the essential oil of thyme plants and calcium chloride were significant effect on reduce the weight loss of strawberry. In addition, **(28**) also confirmed that pre-harvest application with 2% $CaCl_2$ +1% chitosan was most effective in minimizing weight loss (%) and increase shelf life of peach fruits, early Swelling CV.

Weight loss of fruit was mainly associated with respiration and moisture evaporation through the skin. Highest losses of weight were obtained at the end of storage period **(20)**.Normally, this occurs during the fruit storage due to respiratory process, the transference of humidity and some processes of oxidation **(9)**.

Calcium applications are effective in terms of membrane functionality and integrity maintenance, which may also be the reason for the lower weight loss found in calcium treated fruits**. (73)** reported that pear fruit treated with calcium chloride proved to be most effective in reducing weight loss compared to non-treated fruit. The lower weight loss in samples treated with $CaCl_2$ dip may also be due to the effect of $CaCl_2$ on the delaying of natural physiological processes like respiration, onset of the climacteric, ripening process and senescence as reported by **(40)**

Table (2) Effect of rosemary plant extract and $CaCl_2$ and their interaction on fresh weight loss % of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days

$CaCl_2$ %	Rosemary plant extract %			Main effect of $CaCl_2$%
	0	3	6	
0.0	7.049 ab	7.359 a	5.727 c	6.712 a
0.5	6.694 b	5.560 c	5.269 c	5.841 b
Main effect of Rosemary plant extract	6.871 a	6.459 a	5.498 b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test ($p \leq 0.05$).

2. Decay %

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Table (3) shows that, fruit decay percentage decreased by increasing rosemary plant extracts concentrations, the largest decay (2.709%) was obtained from 0% rosemary plant extract concentration, while the lowest decay (1.827%) was obtained from 0% rosemary plant extract concentration. besides, no significant differences were found between 0% and 0.5% rosemary plant extract concentration. The same trend was also true for the $CaCl_2$ treatment; fruit decay percentage decreased by increasing $CaCl_2$ concentrations, the lowest decay% (1.895) was obtained from 0.5% $CaCl_2$, Whereas the highest decay% (2.416) gave from control (0% $CaCl_2$).
Regarding to rosemary plant extract with $CaCl_2$ treatments fruit decay percentage which significant differences were found between the control (0% rosemary plant extract and 0% $CaCl_2$) gave the highest value (3.661%), but the interaction between 3% rosemary plant extract and 0% $CaCl_2$ recorded the least fruit decay(1.556%). Fruit decay percentage was decreased by increasing rosemary plant extracts concentrations and plants supplied with supplemental of $CaCl_2$. These results are in harmony with **(42)** who found that Navel orange fruits treated with rosmarinic acid in rosemary extract treatments reduced the percentage of decay than control fruits.
Results here may be attributed to the role of calcium ions in reducing fruit softening by strengthening the cell walls, as well as results of this study are in agreement with previous reports which indicated that calcium chloride spray reduces physiological disorders of fruits and increases their resistance to infection than untreated ones **(51)**. Pre- and post-harvest calcium applications have been used to delay aging or ripening, to reduce post-harvest decay, and to control the development of many physiological disorders in fruits and vegetables **(63;19).**Foliar application of calcium chloride has been reported to delay ripening and retard mold development in strawberries **(15; 16)** and raspberries **(56). (17)** have indicated that calcium enhanced tissue develops resistance to fungal attack by stabilizing or strengthening cell walls, thereby making them more resistant to harmful enzymes produced by fungi, and that it also delays aging of fruits. Furthermore, **(26)** have demonstrated that the post-harvest dip in calcium chloride reduced strawberry decay during shelf life.

Table (3) Effect of rosemary plant extract and $CaCl_2$ and their interaction on decay % of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days.

$CaCl_2$ %	Rosemary plant extract %			Main effect of $CaCl_2$%
	0	3	6	
0.0	3.661 a	1.556 c	2.031 bc	2.416 a
0.5	1.757 bc	2.306 b	1.623 bc	1.895 b
Main effect of Rosemary plant extract	2.709 a	1.931 b	1.827 b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test ($p \leq 0.05$).

Ca is the major ingredient of middle lamella in cell walls and modifies cell wall rigidity by thickening the middle lamella of cell wall owing to increased formation and deposition of Ca-pectate and this reduced the rate of decay **(21).** The incorporation of calcium ions in fruit tissue

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promotes new cross-links between anionic homo galacturonans, strengthening the cell wall and particularly the middle lamella which is responsible for holding cells together. Thus, increase the stability of the cell wall and middle lamella of the fruits **(58)**. Similar findings with decay of plum fruits at low temperature were reported by **(53).** Therefore calcium dips raise the possibility of producing fruit less susceptible to decay during storage, while the higher decay content in untreated fruits was the result of lesser tissue strength and cellular disorganization.

3. Hardness of fruits (N)

As shown in table (4), with regard to strawberry firmness, strawberry plants treated with rosemary plant extract no significant difference was observed on hardness of fruits (N), whereas, 0.5% $CaCl_2$ was significantly more firm than control strawberry fruits.

It can be noticed from data presented in same table significant differences were observed from effect of rosemary plant extract and $CaCl_2$ on hardness of fruits. The highest value was recorded (3.751 N) from the interaction between 3% rosemary plant extract with 0.50% $CaCl_2$ while, the lowest value was also observed (2.676 N) from 3% rosemary plant extract with 0% $CaCl_2$. No significant difference was obtained between all interactions (rosemary plant extract and $CaCl_2$) on hardness of fruits of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days.

Table (4) Effect of rosemary plant extract and $CaCl_2$ and their interaction on hardness of fruits (N) of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days.

$CaCl_2$ %	Rosemary plant extract %			Main effect of $CaCl_2$%
	0	3	6	
0.0	2.904 b	2.676 b	3.040 b	2.873 b
0.5	3.258 ab	3.751 a	3.240 ab	3.417 a
Main effect of Rosemary plant extract	3.081 a	3.213 a	3.140 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test ($p \leq 0.05$).

These results are in agreement with those obtained **by (61 and 46).)** The lowest values of firmness were recorded with untreated treatment (control). Texture is a critical quality attribute influencing consumer acceptability of fresh fruit and vegetables. It is related to metabolic changes and water content **(27).**

Strawberry fruit is a highly perishable fruit that suffers a high rate of softening after harvest and decrease its shelf-life potential, $CaCl_2$ treatment significantly maintained firmness compared with control. On the other hand, it also significantly increased was observed between combinations of 3% rosemary plant extract with 0.50% $CaCl_2$ and among three factors as well. Many researchers suggested that $CaCl_2$ improves fruit firmness.**(57)** demonstrated that increase in firmness without any alteration of the color and weight of the strawberry fruits was observed after immersed in 0.18% $CaCl_2$ solution for 5 minutes, and storing them in polyethylene bags. In addition, pre-harvest sprays of 200 ppm Ca-chelate for 'Nyoho' strawberries that was grown in the traditional soil culture, fruit firmness was increased during the fruit growth and development certainly and decreased rate of softening during storage for 2 days at 20°C **(59).**

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Firming and resistance to softening resulting from addition of calcium have been attributed to the stabilization of membrane systems and the formation of Ca-pectates, which increase rigidity of the middle portion and cell wall of the fruit **(31; 45)**. This inhibits the degradation of the middle portion and cell wall **(14)** and improves the skin strength **(55)**.The retention of firmness in samples either calcified only or calcified and irradiated is due to fact that calcium plays an important role in maintaining cell wall structure by interaction with pectic acids in the cell walls to form calcium pectate **(63; 18)**Cell wall integrity is preserved when deesterified pectic acid residues form cross-bridges between negatively charged carboxylic groups and divalent cations such as calcium, thus minimizing pectic substance solubilisation **(31; 50).** Calcium appears to serve as an intermolecular binding agent that stabilizes protein-pectin complexes of the middle lamella **(21)**, thus plays a role in maintaining cell wall structure by interacting with pectic acids in the cell wall to form calcium pectate. Further, both irradiation as well as calcium is known to delay the natural physiological processes like respiration, ripening and senescence responsible for the solubilization and depolymerisation of pectic substances and other cell wall polymers **(44; 3; 69; 8; 24 and 48).** Application of calcium chloride helps in reducing the fruit respiration rate thus slows down the ripening process and maintained the fruit firmness **(77).** The retention of firmness in samples calcified is due to fact that calcium plays an important role in maintaining cell wall structure by interaction with pectic acids in the cell walls to form calcium pectate **(18)**. Cell wall integrity is also preserved when de-esterified pectic acid residues form cross-bridges between negatively charged carboxylic groups and divalent cations such as calcium, thus minimizing pectic substance solubilization **(50).**

4. Total titratable acidity (TA%)

It can be noticed from data presented in (table 5) no significant differences were observed from effect of rosemary plant extract and $CaCl_2$ on total titratable acidity. Regarding to rosemary plant extract with $CaCl_2$ treatments on total titratable acidity which no significant differences appeared between all interactions treatments. These results are in line with those obtained by **(74 and 62);** they found that treated fruits with **(54)** thus reduce production of compounds responsible for acidity (organic acids) in fruits and release hydrogen ions, contributing to decrease fruit titratables acidity and delay the senescence stage progress.

Table (5) Effect of rosemary plant extract and $CaCl_2$ and their interaction on Total titratable acidity (TA %) of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days.

$CaCl_2$ %	Rosemary plant extract %			Main effect of $CaCl_2$%
	0	3	6	
0.0	0.556 a	0.542 a	0.538 a	0.545 a
0.5	0.499 a	0.545 a	0.510 a	0.518 a
Main effect of Rosemary plant extract	0.527 a	0.543 a	0.524 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test ($p \leq 0.05$).

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5. Total soluble solids% (TSS %)

Table (6) shows that there were no significant differences between all concentration of rosemary plant extract treatments on total soluble solids (TSS %) of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days, Besides, significant differences were found between 0% and 0.5% $CaCl_2$ treatments, the highest percentages were from the last treatment (16.967).

Data presenting significant differences were observed for interaction effect between rosemary plant extract with $CaCl_2$ on total soluble solid that the highest value was recorded (17.200%) from the interaction between 3% rosemary plant extract with 0.5% $CaCl_2$, while, the lowest value was also observed (15.542%) from 0% rosemary plant extract with 0% $CaCl_2$. These results are in harmony with **(79; 22 and 4)** whose found that Navel orange fruits treated with chitosan showed the significant increase in total soluble solids percentage over the storage periods.

Table (6) Effect of rosemary plant extract and $CaCl_2$ and their interaction on total soluble solids (TSS %) of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days.

$CaCl_2$ %	Rosemary plant extract %			Main effect of $CaCl_2$%
	0	3	6	
0.0	15.542 c	16.075 bc	16.225 bc	15.947 b
0.5	17.025 a	17.200 a	16.675 ab	16.967 a
Main effect of Rosemary plant extract	16.283 a	16.638 a	16.450 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test ($p \leq 0.05$).

The total soluble solids of fruit increased with increasing storage time, a plausible explanation for the observed increment in total soluble solids is the considerable loss of water during storage **(37)**.The brix is known as the soluble solids in strawberry and the main source of soluble solid is glucose, fructose and sucrose, TSS of the strawberry fruit increased over storage period after treated with 0.5% $CaCl_2$, which may suggest that at higher concentration these mineral nutrient increases sugar content due to cell damage by osmotic stress of the nutrient solution. In general, a decrease in TSS is associated with the respiration process in fruits. The slightly lower TSS in the 1% and 2% calcium chloride treated samples might be due to inhibition by the calcium chloride of the enzymatic conversion of higher polysaccharides, such as starches and pectins, into simple sugars **(41).**

Total soluble solids content of fruits is a major quality parameter which is correlated with texture and composition **(6)**. The TSS content of fruit is influenced by application of Ca, K, Zn, Cu and B **(13 and 35)**. The total soluble solids were not significantly affected by 1-2% calcium chloride applied alone, but increased significantly with 3% calcium chloride and Borax combinations. Thus, increase in TSS content with application of $CaCl_2$ +Borax strengthened this opinion, though relatively high Ca concentration (3%) was required for increase in total soluble solids in litchi fruit **(36).** On the other hand, similar result was achieved that **(78)** reported that chitosan had no effect on TSS of mango fruits. A similar response was also showed in strawberry **(58)**.

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6. Total sugars %:

After storage for 30 days, rosemary plant extract treatments, especially 3% were effective in attaining the highest values of total sugars in comparison with 6%, but no significant difference was found between 0% and 3% (table 7). However, the significant differences were clear between 3% rosemary plant extract 0.5% $CaCl_2$ gave the highest values (4.412%) of total sugars. whereas the lowest (3.812) was from 6% rosemary plant extract 0% $CaCl_2$.

(60) reported significant affected in sugar content by storage time and respiration rate. Generally, increased storage period caused to reduce sugar, total sugars content increased at the interaction between rosemary plant extract and $CaCl_2$ compared to the control and also have a higher significant increase of total sugar in 3% rosemary plant extract, Some essential oils including (Bergamot, Lemongrass, Thyme, Rosemary, Pepper mint, Lavender, Dill and Coriander) are reported by **(2)** that essential oils especially Bergamot oil is applied on `Florda 7/2 'nectarine fruits in organic culture that results concluded; maintained the quality parameters as delayed in the changes in the losses of weight, firmness and vitamin C and acidity, soluble solids, total sugars content, total phenols, anthocyanins content, respiration rate, decreased the decay, extended post-harvest life of `fruits and intended for long distance shipping for export.**(76)** demonstrated that higher total sugar content of strawberries was observed by coating treatments during the storage period compared to the control because of, coated strawberries might reduce respiration rate; it may be refer to delay the use of total sugar in the enzymatic reactions of respiration.

Table (7) Effect of rosemary plant extract and $CaCl_2$ and their interaction on total sugars % of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days.

$CaCl_2$ %	Rosemary plant extract %			Main effect of $CaCl_2$%
	0	3	6	
0.0	4.227 ab	4.078 ab	3.812 b	4.039 a
0.5	4.103 ab	4.412 a	3.813 b	4.109 a
Main effect of Rosemary plant extract	4.165 ab	4.245 a	3.813 b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test ($p \leq 0.05$).

7. Anthocyanins (mg100 g^{-1}. F. W.)

Table (8) shows that there were no significant differences between control (0% rosemary plant extract and the other two treatments 3 and 6% in anthocyanins contents. Besides, no significant differences appeared between all the treatments combinations rosemary plant extract and $CaCl_2$on anthocyanins contents. Strawberries contain a large number of secondary plant metabolites. Storage of strawberry fruits at 8 °C for 11 weeks caused a significant loss of the anthocyanin content, which emphasizes the high sensitivity of these substances to oxidation, light, and heat **(34).**

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Table (8) Effect of rosemary plant extract and $CaCl_2$ and their interaction on anthocyanins (mg/ 100 g. F. W.) of strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days.

$CaCl_2$ %	Rosemary plant extract %			Main effect of $CaCl_2$%
	0	3	6	
0.0	47.540 a	47.698 a	46.592 a	47.277 a
0.5	42.887 a	44.637 a	43.300 a	43.608 a
Main effect of Rosemary plant extract	45.213 a	46.168 a	44.946 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test ($p \leq 0.05$).

8. Calcium content (mg100g^{-1})

Significant differences were observed from effect of rosemary plant extract on Ca content that the highest value was recorded (28.700 mg/100g) from the 3% rosemary plant extract while, the lowest value was observed (25.992 mg/100g) from 0% rosemary plant extract (table 9). In addition, strawberry plant treated with 0.5% $CaCl_2$ exceeded significantly control (0% $CaCl_2$) in calcium content. Data present in the same table confirm that there were significant differences among rosemary plant extract with $CaCl_2$ on Ca content due to this character, The highest value was recorded (33.200 mg/100g) from the interaction between 3% rosemary plant extract with 0.5% $CaCl_2$ while, the lowest value was observed (23.583 mg/100g) from 0% rosemary plant extract with 0% of $CaCl_2$.

It is clear that Calcium plays a significant role in maintaining fruit quality with cell functions, including reducing softening **(11).** Calcium application usually leads to an increase in apoplectic Ca concentration **(64)** that may affect the structure and functions of cell walls and membranes and certain aspects of cell metabolism **(30).** Calcium concentration of strawberry fruit shows a significantly increased in all treatments as compering with controls, it is indicated that preharvest apply of calcium let to increase of calcium content in the fruit. Similar result was concluded by **(15)** that confirmed the foliar application of $CaCl_2$ led to increased Ca content of strawberry fruits and delayed ripening.

Table (9) Effect of Rosemary plant extract and $CaCl_2$ and their interaction on Calcium content (mg/100g) of Strawberry fruits cv. Rubygem stored at 2±1°C and 85-90% RH for 30 days.

$CaCl_2$ %	Rosemary plant extract %			Main effect of $CaCl_2$%
	0	3	6	
0.0	23.583 c	24.200 c	19.200 d	22.328 b
0.5	28.400 b	33.200 a	31.400 ab	31.000 a
Main effect of Rosemary plant extract	25.992 b	28.700 a	25.300 b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test ($p \leq 0.05$).

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