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Enhancing Post Harvest Storage Life of Tomato (*Lycopersicon esculentum* Mill.) Cv. Rio Grandi Using Calcium Chloride

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Abstract: The present study was conducted to enhance the post harvest storage life of tomato fruit using $CaCl_2$ treatments. Different concentration of $CaCl_2$ such as 1% (T_1), 2% (T_2) and 3 % (T_3) were prepared and the fruit were dipped for 1 to 2 minutes, while (T_0) was left without calcium chloride treatment as control so as to test the effect of post harvest treatments to prolong shelf life. The fruit were packed in polyethylene (0.6 mm) and store at ambient temperature for total period of 30 days. Physio-chemical analysis of fruit was made in ten days interval. Statistical analysis showed that storage intervals and treatments have significant ($P<0.05$) effects on the quality parameters of the tomato fruits during storage. 2 % calcium chloride packed in ventilated 0.6 mm polyethylene cover found highly effective in controlling storage losses as well as in maintaining the quality of produce during storage. The finding has significant contribution to reduce economic losses of perishable fruits and evidence to researchers.

Key words: $CaCl_2$ · Tomato fruits · Post harvest treatment · Quality · Shelf life · Polyethylene

INTRODUCTION

Tomato *(Lycopersicon esculentum* Mill.*)* is one the most popular and versatile food crop of the world that belongs to the solanaceae family [1]. It is an integral part of human diet being widely consumed as fresh [2], or used as a raw material for the production of derived products [3-5]. Tomato and tomato based products are believed to be healthy food owing to its low calories, cholesterol-free and good source of fiber [6]. In addition tomatoes are rich in vitamin A, C, β-carotene, lycopene [7-9] and other antioxidants. The tomato is believed be an important functional food in preventing and curing of malignant diseases like prostate cancer, breast cancer [10], lungs cancer [11] and other diseases like cataracts, heart diseases [12,13], diabetics, hyperglycemia [14], inflammation, arthritis, immune system decline, brain dysfunction [15, 16] and maintenances of body homeostasis [17].

Being the highly perishable commodity it encounters several problems in its transportation, storage and marketing [1]. Owing to lack of knowledge on post-harvest handling, packaging, temperature etc, the fruits not only lose their quality but also encounter a substantial loss. It is estimated that post-harvest losses in tropical countries reaches to 20-50 % between harvesting, transportation and consumption of fresh tomato [18]. As a climacteric fruit, ripening can happen even after harvest, causes the increase production of ethylene [19, 20] that is responsible for adverse changes in fruit [21]. So to delay changes and extend its quality post harvest techniques are applied mainly focused on the action of ethylene [22]. Ethylene is considered as harmful because it is responsible for fruit pathogen susceptibility physiological disorders and senescence and decreases the shelf life. Its level should not higher than $0.10\mu LL^{-1}$ as it increase directly related to quality loss [23]. But these disorders in depend upon ethylene concentration, duration of exposure, atmospheric composition and temperature [24].

Even though some research efforts have raised the production of tomato to some extent but the purpose to maximize the profit will be fourfold if the increased production is supplemented with the effort to minimize the post harvest losses and enhance the shelf life. In the past, few efforts have been made in employing certain

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chemical to delay ripening, to reduce losses and to improve and maintain the colour and quality by retarding the metabolic activities [25]. Conversely, optimum treatments for each ripening inhibition, endogenous ethylene are always a problem. Ethylene absorbents, such as calcium chloride and potassium permanganate in conjugation to controlled storage atmosphere have a notable commercial potential in future [1]. Different studies explained that calcium chloride reduced post harvest decay, controlled the development of physiological disorder, improved quality and delayed aging or ripening [19]. Fruit treated with calcium chloride rated superior in appearance, aroma, flavor and texture and over all acceptability [26]. According to different studies, it improved Ca^{+2} contents, lycopene content, ascorbic acid contents, firmness index [8] and reduced the disease index. In view of above mentioned reports, the present study has been undertaken to evaluate the potential of post harvest treatment of calcium chloride on the shelf life and physiochemical characteristics of tomato fruit during its storage.

MATERIALS AND METHODS

Experimental Site: The experiment was carried out in post harvest laboratory section in the department of Food Technology at the PMAS- Arid Agriculture University Rawalpindi, Pakistan. The average annual temperature is 20°C (during the growing season 23°C).

Selection of Fruits: Twenty kilogram of tomato fruits (var. Rio Grandi) at USDA stage 3 were manually picked from the fields of Usman Khattar, Taxila, Pakistan. Fruits of uniform size, color, undamaged, free from disease and bruises were selected for experimental purposes.

Preparation of Sample: The fruit were subjected to washing to remove dirt and dust. After removing the fruit were surface sterilized with sodium hypochlorite solution (500ppm) for 10 minutes so as to remove fungal infestation and air-dried. The post harvest treatments were conducted as per completely randomized design with four lots with three replicates (T) viz

- Control (T_0)
- 1% $CaCl_2$ + polyethylene (T_1)
- 2% $CaCl_2$ + polyethylene (T_2)
- 3% $CaCl_2$ + polyethylene (T_3)

Twelve samples were prepared for the study. Fruits were dipped in the respective calcium chloride solutions for 1 to 2 minutes and then dried under a fan at room temperature. The treated fruit were packed with ventilated (perforated; 0.6 mm polyethylene with 6 vents) polythene bag cover. Each polyethylene cover has a width of 12 cm and length of 35 cm. The proportion of vents share 0.35 % of total area of polythene bag. These fruits were then stored in corrugated soft board cartons at ambient temperature for experimentation in the laboratory.

Data Recorded: Data Recorded: The pH value was determined by using electronic pH meter (HANNA, pH 210 HANNA Instruments, USA) whereas total soluble solid (TSS) was calculated by degree brix (°B) with the help of refractometer (Model PAL-1, Kemco Instruments Co., Inc. USA) based on *Abbe principle.* Titratable acidity was determined by titration with 1 N NaOH until pH indicator such as phenolphthalein changes in color . The weight of fruits measured by beam balance and ascorbic acid were determined by 2, 6-dicholorphenol indophenols method whereas the total sugar was calculated by titration using Fehling solution as described in AOAC [27]. The lycopene content was evaluated extracting and suspending the fruit in acetone and petroleum ether until it become colourless. The optical density of solution is measured at 503 nm by by spectrometer (CE-2021, 2000 series CECIL Instruments Cambridge, England) using petroleum ether blank [28]. The data were taken from each replication in ten days interval for 1 month.

Statistical Analysis: Data on above parameter was taken in triplicate and analyzed statistically by using Randomized Complete Block Design (RCBD) while means were separated by Least Significant Difference (LSD) test at 5% level of significance as described by Steel *et al*. [29].

RESULTS AND DISCUSSION

pH: pH is a good index of ripening indicating the degradation or respiration of organic acids into sugar. It progresses linearly with the advancement of ripening stages as the ripened fruit has less quality attributes and high production of ethylene. In the present study, pH of all treated fruit and control were measured during 30 days of storage at ambient temperature (Table 1). The pH of the fruit pulp of treated fruits was found relatively in

Table 1: Effect of post harvest treatment on pH during storage interval (mean±SE)

Treatments	Day 0	Day 10	Day 20	Day 30	Treatment mean
Control (T_0)	5.05±0.002^{ab}	5.0±0.001^{a}	4.90±0.004^{bc}	4.91±0.005^{bc}	4.94^{a}
1% $CaCl_2$ + polyethylene (T_1)	5.05±0.002^{ab}	4.95±0.002^{bc}	4.65±0.002^{h}	4.82±0.005^{efg}	4.87^{bc}
2% $CaCl_2$ + polyethylene (T_2)	5.05±0.002^{ab}	4.85±0.001^{def}	4.75±0.001^{gh}	4.82±0.003^{def}	4.87^{c}
3% $CaCl_2$ + polyethylene (T_3)	5.05±0.002^{ab}	4.90±0.003^{cd}	4.81±0.002^{fg}	4.90±0.002^{cde}	4.91^{b}
Days Interval Mean	5.05^{a}	4.93^{b}	4.78^{d}	4.84^{c}	

NB. Mean value with similar superscript letters in columns indicates that there is no significant differences at á=0.05 using DMRT

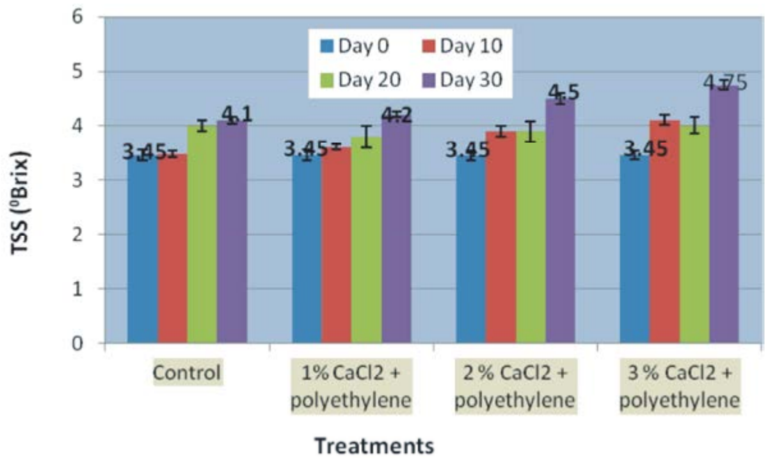

Fig. 1: Effect of different concentration of $CaCl_2$ on total soluble sugar during storage interval.

lesser range (4.65-4.95) as compared to fruits of control set having high pH (4.90-5.05) during storage intervals. The treatments and their interactions had highly significant ($p<0.05$) effect on pH value. The overall lowest means (after 30day of storage) was recorded T_1 and T_2 (1% $CaCl_2$ + polyethylene and 2% $CaCl_2$ + polyethylene) with the value of 4.87 indicating slowing down the ripening process followed by T_3 (3% $CaCl_2$ + polyethylene) that is 4.91. The means of the pH among storage days revealed that the treatment has significant effect on the respiration as the value is lesser then initial value. The results indicated the significant role of $CaCl_2$ as an ethylene absorbent and the modified atmosphere created by treatment as compare to control. The present findings suggest that lower concentration of calcium caused significant effect which is in line with the find of Andrea *et al* and Pila *et al* [30, 18].

Total Soluble Sugar (^{0}Brix): The maturation and ripening cause the increase in the amount of total soluble solids (TSS) from mature green to red ripe stage. The major component of total soluble solid (TSS) is sugar mainly glucose and fructose. The changes in the TSS values of treated and untreated (control) tomato fruit during their post harvest storage which is present in Fig. 1 show that TSS proceed almost constantly in all treatment. The highest TSS value was observed in T_3 (3% $CaCl_2$ + polyethylene) with the value of 4.75 followed by T_2 (2% $CaCl_2$ + polyethylene) and T_1 (1% $CaCl_2$ + polyethylene) with the value of 4.50 and 4.20 respectively after 30 days of storage. The control shows the value in the range of 3.45 to 4.1 indicating the lower rate of respiration and metabolic process as compare to other. Our results are in consistent with the finding of Pila *et al* ([18] on tomato, who reported that the concentration of TSS progressively increased with storage. Data indicated that $CaCl_2$ as ethylene absorbent and modified atmosphere has no effect on TSS during storage, which could be due to unlike liquids and gases, solids didn't reduce much by volume.

Titratable Acidity: Total titratable acidity was measured from extracted juice and expressed as citric acid (%) in tomato fruit. During maturation there is loss of titratable acidity and found to be lost as fruit ripens. The results of present study indicated that titratable acidity increased upto 20th day of storage reaching to maximum value of 0.13 % in T_0 and $T_2$and tended to sharp decline in acidity in 30th day of storage (Fig 2). The results are in conclusive to Žnidarčič *et al* [31] who reported the increment of titratable acidity which is caused by the gaseous condition (elevation of CO_2 concentration and reduction of O_2). These can affect the glycolytic enzymes resulting built up of acids. On the other hand, Wills and Warton

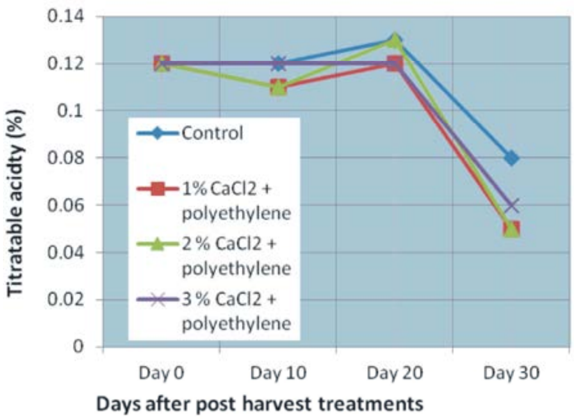

Fig. 2: Effect of different concentration of $CaCl_2$ on titratable acidity during storage interval.

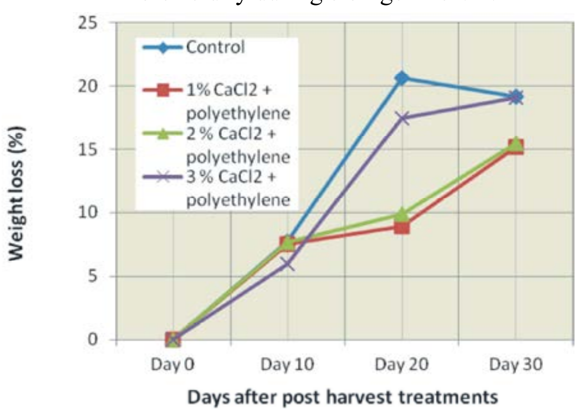

Fig. 3: Effect of different concentration of $CaCl_2$ on weight loss (%) during storage interval.

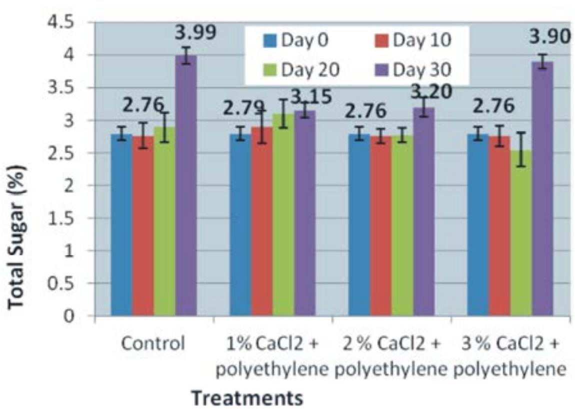

Fig. 4: Effect of different concentration of $CaCl_2$ on during storage interval.

[23] mentioned that the amount of organic acid usually decreased during maturity as the sharp decline in titratable acidity was observed in 30th day of storage. The decrease in the content of acidity reduces the desire quality of fruits.

Weight Loss (%): Weight loss of tomatoes is primarily due to transpiration and respiration. Transpiration is a mechanism in which water is lost due to difference in vapour pressure of water in the atmosphere and the surface. Respiration causes a weight reduction due to catabolism reaction. Physiological loss of weight can influence the economic returns. The data on physiological loss in weight as influenced by postharvest treatment are presented in Fig. 5 indicating that there were statistically significant ($p<0.05$) higher weight loss on the control as compare to other chemical treatments. The least physiological weight loss was observed in fruits treated with 1 % $CaCl_2$ (15.22 %) followed by fruits treated with 2% $CaCl_2$ (15.5 %) and packed with ventilated polyethylene cover whereas the maximum loss in weight (19.20 %) were recorded in control fruit (Fig. 6). This indicated the significant role of $CaCl_2$ as an ethylene absorbent. This could be attributed by the membrane functionality and integrity maintenance quality of calcium. The maintenance of high humidity in the microatmosphere with in the packages by respiring fruits and due to low water vapours transmission rate of packaging material [1, 8].

Ascorbic acid: Ascorbic acid is the predominant form of vitamin C in fruit, and the primary oxidation product. Since the oxidized form is more prone to decomposition during storage , leading to the loss of biological activity, the change in ascorbic acid forms are important in both, technological and nutritional terms. Ascorbic acid content during storage was continuously increasing with the slight fall during the 20th day of storage. The ascorbic acid content of control during 30th days of storage was 10 mg/100 m, whereas for treated fruit on the same day were 11.1, 11.2 and 10.2 mg/100 ml, respectively for 1, 2 and 3 % $CaCl_2$ (Fig. 6). The increase in ascorbic acid content is thought to be indication that the fruit is still in ripening process [18]. The accumulation of ascorbic of in ripening stages of tomatoes was also observed by Abushita *et al* [32] and Giovanelli *et al* [33] and Kalt *et al* [43]. The high temperature, titrable acidity and phenolic substances are responsible for stability and accumulation of ascorbic acid [35].

Total Sugar: Total sugar percentage is an important factor for determining the quality of the fruits. The flavour of a product depends on sugar percentage. Figure 6 showed that during advancement the high sugar content were found in untreated fruit (3.99 %) indicating higher respiration rate. After 30th day of storage,the fruit treated

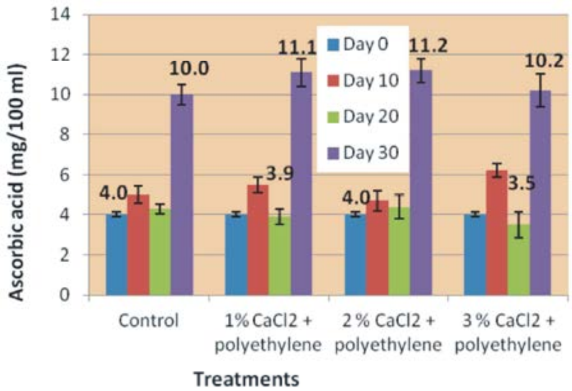

Fig. 5: Effect of different concentration of $CaCl_2$ on ascorbic acid during storage interval.

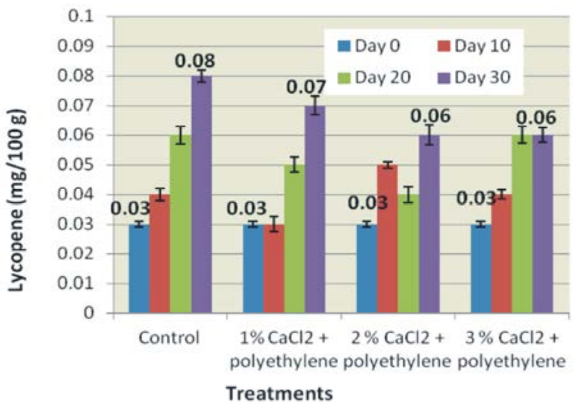

Fig. 6: Effect of different concentration of $CaCl_2$ on lycopene during storage interval.

with 1 and 2 % $CaCl_2$ showed significant lower sugar content (3.15 and 3.20 %). The decreased rate of respiration caused slow degradation of sugar into carbon dioxide and water is also reduced [19].

Lycopene (mg/100g): Lycopene synthesis increases as maturity progresses. Furthermore, there is linear correlation between lycopene synthesis and ethylene production. The result indicated that lycopene is accumulated in all treatments over storage time (Fig. 6). The least lycopene content was observed in fruit treated with 2% $CaCl_2$ followed by 3% $CaCl_2$ with the value of 0.06 mg/ 100g. The control showed much greater value of lycopene (0.03-0.08 mg/100 g) exhibiting that treatment has significant ($p<0.05$) effect on lycopene. The fruit treated showed value of 0.03-0.07 mg/100 g for 1% $CaCl_2$ and 0.03-0.06mg/100g for 2 and 3 % $CaCl_2$, respectively. The data suggest the significant effect of calcium chloride as ethylene absorbent. The reduced respiration rate and chlorophyll degradation are responsible for slow rate of lycopene synthesis [8].

CONCLUSION

The finding of the study indicated that storage time generally led to increase in pH, titratable acidity, weight loss, ascorbic acid, total sugar and lycopene content. However total soluble solids (TSS) was found to be constant over the storage period. Tomato fruit treated with 2 % $CaCl_2$ and covered with polyethylene bag found to be highly significant (p,0.05) minimum losses. This indicates the role of $CaCl_2$ as an ethylene absorbent and effect of controlled storage atmosphere which is able to extend shelf life of tomato fruit while retaining its nutritional quality.

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