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Effect of Post Harvest Treatments on Storage Behavior and Quality of Tomato Fruits

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Abstract: Different concentrations of $CaCl_2$ with and without modified atmosphere were investigated on storage behavior and quality of tomato (Lycopersicon esculentum, Mill.) fruits under laboratory conditions so as to test the effect of post harvest treatments to prolong shelf life of perishable fruits. The fruits were prepared for eight treatments with three replications in completely randomized design (CRD). Physio-chemical analysis of the fruit was made in seven days interval. The results indicate that the role of $CaCl_2$ as an aspect of ethylene absorbents and delay of ripening rates by facilitating retention of firmness, quality and improving shelf life. Tomatoes treated with $CaCl_2$ concentrations and covered with ventilated polythene bags were found to be best suited to the presence for more than a month without much affecting quality. Statistically significant ($P<0.01$) minimum loss of physiochemical characteristics was observed on fruits treated with 8% $CaCl_2$ and packed in ventilated polythene cover as compared to the control. Thus, it could be concluded that ethylene absorbents in conjugation with controlled storage atmosphere may have a prominent commercial potential to prolong shelf life of tomato fruits and reduce economic losses. The findings have significant contribution to reduce economic post harvest losses of perishable fruits and evidence to researchers.

Key words: $CaCl_2$ · Polythene bags · *Post harvest treatment* · *Spoilage* · *Tomato fruits*

INTRODUCTION

Extending post–harvest life of horticultural products requires knowledge of all factors that can cause loss of quality so as to develop affordable technologies that minimize rate of deterioration [1]. Length of storage, respiration, transpiration, chemical composition, external appearance, anatomical structures, delay harvesting, taste qualities and other post harvest behaviors have significant impact on fruit quality. These controllable and uncontrollable factors affect the attainment of maximum quality of fruits at the time of harvest [2, 1]. Considerable maturity variations exist among the different varieties and even strains of fruits and vegetables [1]. These variations may be evaluated by establishing harvesting criteria such as visual means, physical means, chemical analysis, computation and physiological methods. Harvesting of tomatoes, solanaceae family, depends on the purpose for which it is grown and time of shipping. Its maturity can be measured by light transmittance technique, color intensity; wave length and brightness [3, 4].

Post-harvest losses of fresh fruits and vegetables such as tomatoes reach staggering proportion in tropical agriculture. The economic loss associated with this deterioration is less evident. A few delaying fruits can produce sufficient ethylene (C_2H_4) to cause premature ripening of many fruits in the same storage compartment. Uneven handling of tomatoes can result in the damage of the fruit cell wall leading to softening and reduced marketability of the product [5]. Exported products increases several folds in value in moving from the plantation to the consumer as the result of harvesting cost, packing, transportation, refrigeration and selling. The monetary loss associated with spoilage, therefore,

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escalates as the commodity advances up the distribution ladder. However, it is very short sighted management to economize on measures which control deterioration in long distance shipment.

Storage is usually required to ensure continuous supply of raw materials to the processing line so as to extend the length of processing season and to assure certain commodities. The ultimate role of post harvest technology is to device methods by which deterioration of product is restricted as much as possible during the period between harvest and end use [4], which provides flexibility to produce and traders in when and where to market commodities in order to obtain maximum net return. Hence, the attainment of maximum possible storage is the goal of storage studies; usually combinations of treatments are used. Thus, waxing, low O_2, high CO_2 and ripening inhibitors are now and then combined to prolong storage life [6]. Conversely, optimum treatments for each ripening inhibition, endogenous ethylene (C_2H_4) are always a problem. Thus, many chemical formulations have been tried to keep the ethylene below the threshold level. Ethylene absorbents, such as Calcium chloride ($CaCl_2$) and Potassium per manganent ($KMnO_4$), in conjugation with controlled storage atmosphere have a notable commercial potential in the future. The objective of this study is to evaluate effect and suitable concentration of post harvest application of $CaCl_2$ on storage and quality of tomato fruits to keep the ripening agent below threshold level. The main challenge to be considered here is that cost and access of post harvest treatments.

MATERIALS AND METHODS

Experimental Site: the experiment was carried out in horticulture laboratory section in the department of plant Sciences at the former Alemaya University of Ethiopia. The mean minimum and maximum temperature inside the laboratory was 19°C and 24°C respectively.

Sample Collection: Twenty five kilogram of fresh tomato fruits representing the same variety shape, size, color, ripeness and quality were harvested from Tony farm horticulture orchard (Research site), Ethiopia. Fruits of uniform size, color, undamaged, free from disease and bruises and equally matured were selected for the experimental purposes.

Treatments and Experimental Design: Tomato fruits of uniform size were selected and they have been sorted out to eliminate bruised, damaged and punctured ones. After removing the dust from the surface of the fruits, they were surface sterilized with sodium hypochlorite (500ppm) for 10 minutes so as to reduce the fungal infection and air-dried. The post harvest treatments were conducted as per completely randomized design with eight treatments with three replicates (T):

1. 4% CaCl2 (T1)	5. 8% $CaCl_2$ + PC 6 vents, (T5)
2. 8% $CaCl_2$ (T2)	6. 12% $CaCl_2$ + PC 6 vents, (T6)
3. 12% $CaCl_2$, (T3)	7. Control + water dip, (T7)
4. 4% $CaCl_2$ + *PC 6 vents, (T4)	8. Control + PC 6 vents, (T8)

where: + *PC 6 vents represent polythene cover with six vents

Twenty four samples were prepared for the study. Fruits were dipped in the respective $CaCl_2$ solutions for ten minutes then packed with ventilated (perforated) polythene bag cover. Each polythene cover has a width of 10 cm and length of 33 cm with six vents. Each vent has 9 diameters of 5mm. The proportion of vents share 0.36% of the total area of polythene bag. Treated tomato fruits were stored for experimentation in the laboratory.

Data Recorded: Weight of the fruits measured by beam balance, volume of the fruits by volume displacement under graduated cylinder, juice content and juice volume were obtained after grinding and squeezing the juice from the sampled fruit whereas total soluble solids (TSS) was determined by degree brix (°B) with the help of refractometer based on the *Abbe principle.* Titratable acidity was determined in a sample of extracted juice by titration with an alkaline solution (normally 0.1N NaOH) until pH indicator such as phenolphthalein changes in color. Color change, spoilage and marketability were observed, measured and recorded in terms of percentage. All percentages were calculated with reference to the original status of the fruit. The data were taken from each replication in seven days interval for four consecutive weeks. The data recorded at the fourth week was used for interpretation of the results.

Data Analysis: Data generated from laboratory analysis were analyzed by comparing the eight treatments analytically using descriptive statistics and analysis of variance to detect whether differences in the fruit attributes studied differed significantly ($p<0.05$) between and within the treatments or not. The LSD (Fisher's protected mean separation) method was employed to distinguish the means that were significantly different. The data were analyzed using the Statistical Package for Social Sciences (SPSS) release 15 [7].

RESULTS AND DISCUSSION

Physiological Loss in Weight (PLW %): Water loss from fruits equates to loss of saleable weights and thus direct loss in marketing. The results of the experiment indicated that there were statistically significant ($p< 0.01$) higher weight loss on the control (water dip) tomato fruits as compared to other chemical treatments (Table 1, Figure 1). The least physiological weight loss (<10%) was observed in fruits treated with 8% $CaCl_2$ and packed with ventilated polythene cover whereas the maximum physiological loss in weight (47%) were recorded in control fruits (H_2O dip) (Figure 1). This indicated the significant role of $CaCl_2$ as an ethylene (C_2H_4) absorbent and this aspect together with modified atmosphere able to extend the storage period of tomato fruits beyond a month after harvest over control. Different researchers proved the role of $CaCl_2$ to delay ripening, improve firmness and shelf life of tomato fruits [8, 9]. Likewise, atmospheric modification through reducing the concentration of O_2 and increasing the concentration of CO_2 helps to retard senescence and ripening by reducing respiration and ethylene production sensitivity [10].

Percent Loss in Fruit Volume: Moisture loss from fruits in the form of water vapour greatly affects the fruit volume as compared to physiological weight loss (Figure 2). This phenomenon equates to loss saleable volumes and thus direct loss in marketing as the result of shrinkage of fruits. Percent of loss in volume of tomato fruits was increased in all the treatments over storage time (week1 to week 4). However, there were a highly significant ($p<0.01$) difference in magnitude of loss in volume between and among the treatments (Table 1). The least loss in volume (25.6%) was registered in fruits treated with 8% $CaCl_2$ and packed with ventilated polythene cover whereas the maximum loss in fruit volume (55.3%) was observed at the control (water dip) (Table 1, Figure 2). This result is in agreement with the findings of Pila *et al* (8) in tomatoes and in '*stay man*' apple who were able to reduce senescence breakdown after storage using Calcium chloride.

Juice Content: The root cause of post harvest deterioration that needs to inhibit enhanced metabolism which may be due natural senescence, physiology, biotic or abiotic stress. The main technological interventions are

Table 1: Percent of loss of physiological fruit weight, fruit volume, juice content and juice volume of tomatoes, 28 days after treatment (mean±SE)

Treatments	Fruit Weight	Fruit Volume	Juice Content	Juice Volume
(T1) 4%$CaCl_2$	26.23±0.72^{d}	40.5±1.08^{bc}	56.27±0.32^{e}	53.5±0.49^{e}
(T2) 8%$CaCl_2$	25.23±0.65^{d}	37.63±0.96^{b}	44.87±0.81^{c}	50.43±0.35^{e}
(T3) 12%$CaCl_2$	41.2±1.13^{f}	50.83±1.37^{d}	47.27±0.69^{cd}	50.42±0.79^{e}
(T4) 4%$CaCl_2$ + *PC	19.43±0.58^{c}	30.3±1.04^{a}	39.33±1.09^{b}	39.13±1.04^{c}
(T5) 8%$CaCl_2$+ PC	9.80±0.90^{a}	25.77±0.12^{a}	15.6±1.12^{a}	23.73±0.52^{a}
(T6) 12%$CaCl_2$ + PC	14.12±0.76^{b}	26.8±0.64^{a}	18.5±0.75^{a}	29.8±0.79^{b}
(T7) Control(water dip)	47.17±0.90^{g}	55.47±1.01^{d}	54.47±0.69^{e}	50.67±0.73^{e}
(T8) PC (without $CaCl_2$)	35.87±0.86^{e}	39.06±2.17^{c}	50.17±0.34^{d}	44.57±0.34^{d}
F-value	252.67	117.98	400.5	265.4
P-Value	0.00	0.00	0.00	0.00

NB. Mean values with same superscript letters in columns indicate that there is no significant differences at α=0.01 using Tukey test; *PC- polythene cover

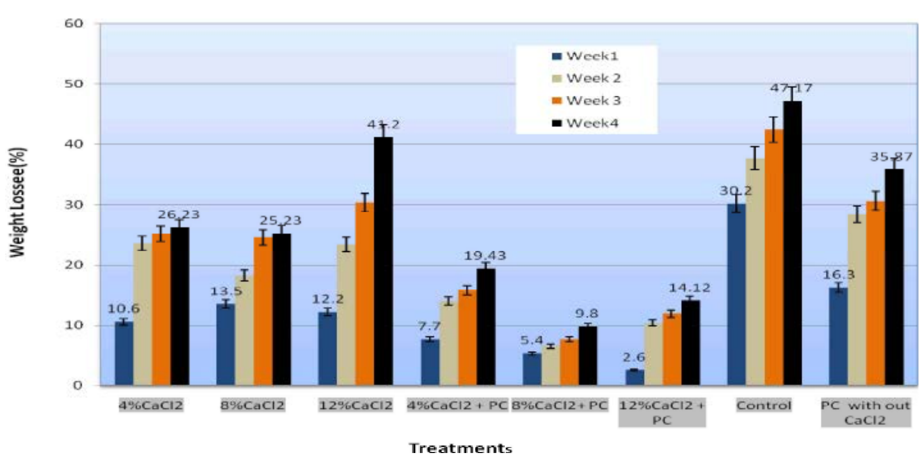

Fig. 1: Effect of different level of Calcium chloride on weight loss (%) of Tomatoes

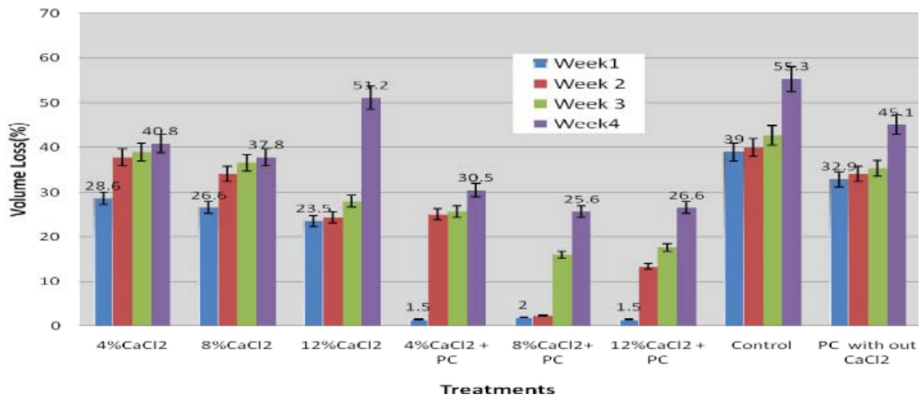

Fig. 2: Effect of different concentration of $CaCl_2$ on fruit volume loss(%)

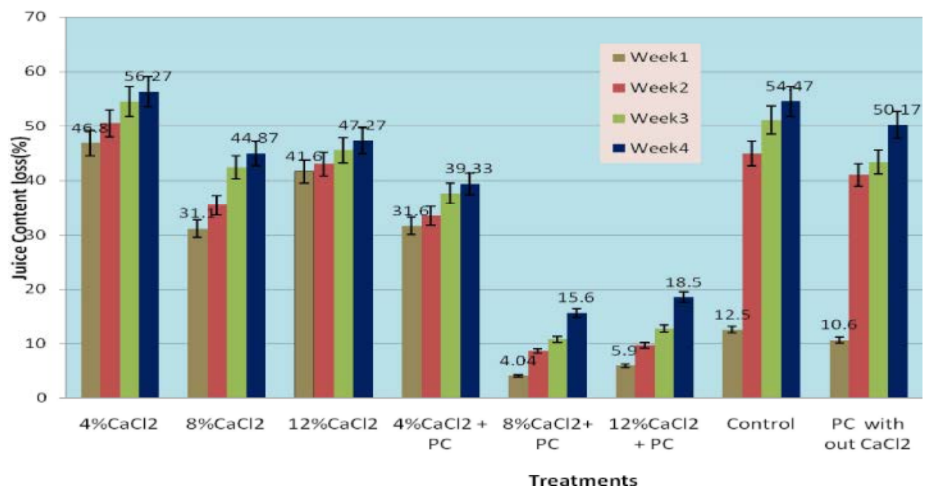

Fig. 3: Effect of different concentration of $CaCl_2$ on juice content of Tomato fruits

controlling temperature and humidity of atmosphere around the fruits. The results of the study indicated that percent of loss in juice content of tomato fruits was increased in all the treatments over storage time. Statistically significant ($p<0.01$) differences among treatments were observed over storage time. The least juice content loss (15.6%) was recorded in fruits treated with 8% $CaCl_2$ and packed with ventilated polythene cover correspondingly; maximum loss in juice content (54.47%) was recorded in control fruits (Table 1, Figure 3) at the end of the fourth week. The obtained data indicated that significant role of $CaCl_2$ as an ethylene (C_2H_4) absorbent. Here, 8% $CaCl_2$ seems to be optimum and influence of chemical on tomato contents to be appropriate with respect to juice content as compare to 4% and 12% $CaCl_2$ level. The results collaborated with the findings of Shears (11) on fruits and vegetables, Bangerth *et al*. (12) on apple, Tingwa and Young (13) on avocado and Izumi and Watada (6) on carrot who indicated that reduced respiration rate is associated with increasing calcium level in tissue. Moreover, the least loss in juice content is correlated with less spoilage and higher marketability and vice versa to the control.

Percent Loss in Juice Volume: Transpiration and subsequent water loss can result rapid loss of fruit quality due to metabolic changes which in turn reduce the volume of the juice. This event affects the appearance and the quality of saleable fruits. The results indicated that percent loss in juice volume of tomato fruits was significantly ($p<0.01$) increased in all treatments over storage time. The least loss in juice volume (23.73%) was obtained in fruits treated with 8% $CaCl_2$ and packed with ventilated polythene cover whereas maximum loss in juice volume (53.5%) recorded on fruits treated with 4% $CaCl_2$ and exposed to ambient environment (Table 1, Figure 4). This result corroborated with the findings of Jones and Lunt (14) physiological process in plants, Shears (1975) in fruits and vegetables where treatment with calcium to inhibit specific aspect of abnormal senescence.

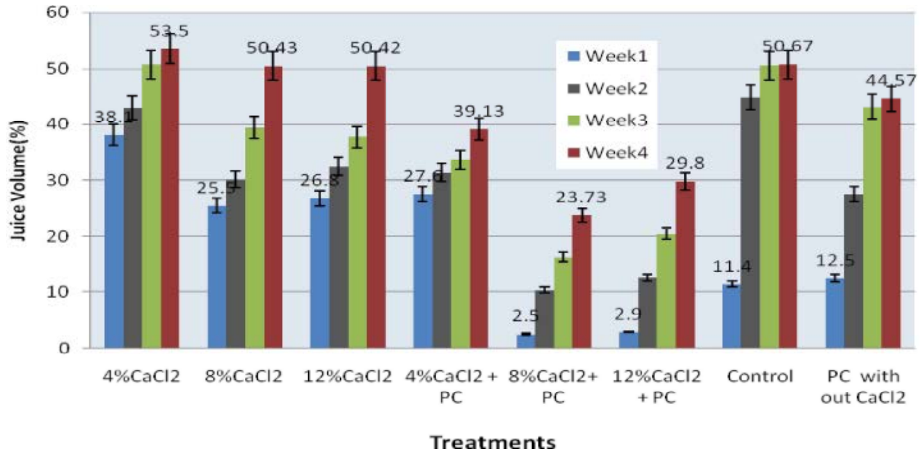

Fig. 4: Effect of different concentration of $CaCl_2$ on juice volume upto four weeks

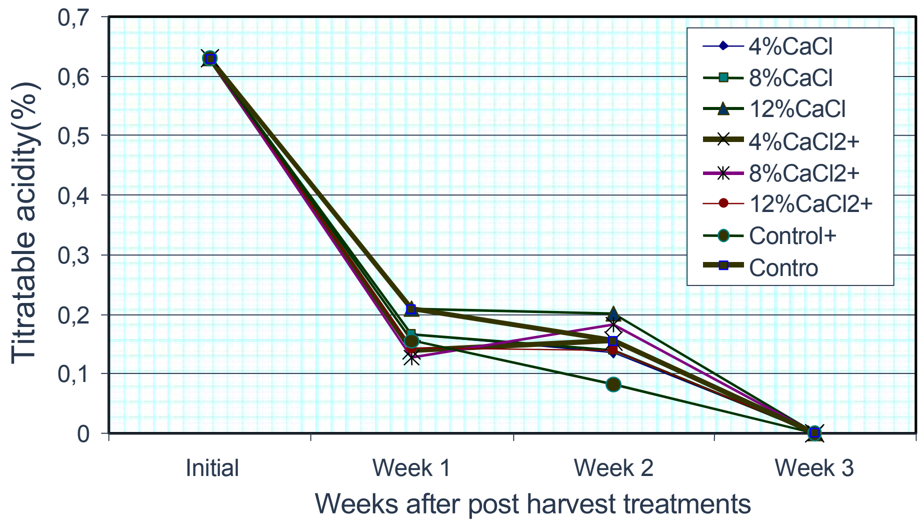

Fig. 5: Effect of post harvest treatments on titrable acidity of tomato fruits

Less spoilage and high marketability also recorded on fruits treated with 8% $CaCl_2$ level under modified atmosphere.

Titratable Acidity: Total titratable acidity was measured from extracted juice and expressed as malic acid (%) in tomato fruits. Loss of acidity during maturation and ripening was often rapid and found to be totally lost as fruit ripens. The results of the present study indicated that percent of total titratable acidity of tomato fruits were initially high in the early developmental stages (0.63%) and then declined steadily to a minimum (0.154 to 0.0%) at the third week in all treatments over storage time (Figure 5).

The reduction of titratable acidity as fruit ripens may be due to further oxidation of organic acids to sugar. The decrease in the content of acidity reduces the desire quality of fruits. Thus, measures that minimize the rapid loss should be emphasizing. Although, a difference in magnitude of reduction between and within treatments existed, the difference was not significant.

Total Soluble Solids: The maturation of fruits was shown to be accompanied with profound increase of the amount of soluble solids in extracted juice. The major component of total soluble solids (TSS) is sugar. The results indicated that TSS of tomato fruits reduced in the first week (5.6 to 3.5°B) and proceed almost constantly in all treatments (Figure 6). However, there were no significant differences between and within treatments. Data indicated that $CaCl_2$ as ethylene absorbent and modified atmosphere had no effect on TSS during storage life of tomato fruits, which could be due to unlike liquids and gases, solids didn't reduce much by volume.

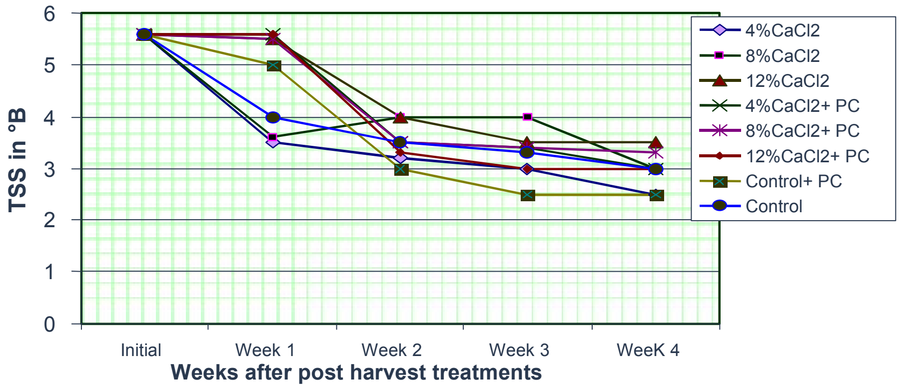

Fig. 6: Effect of post harvest treatments ($CaCl_2$) on total soluble solids (TSS) of tomato fruits

Table 2: Ratio of TSS to titratable acidity after post harvest treatments

Treatments	Initial	Week 1(7th day)	Week 2(14th Days)
(T1) 4%$CaCl_2$	8.89	20.89	23.88
(T2) 8%$CaCl_2$	8.89	21.49	28.37
(T3) 12%$CaCl_2$	8.89	26.48	29.90
(T4) 4%$CaCl_2$ + *PC	8.89	39.8	27.3
(T5) 8%$CaCl_2$+ PC	8.89	44.78	19.34
(T6) 12%$CaCl_2$ + PC	8.89	39.35	23.40
(T7) Control(water dip)	8.89	25.96	43.75
(T8) PC (without $CaCl_2$)	8.89	24.07	26.25

N.B: PC=Polythene cover with six vents

Table 3: Effect of some post harvest treatments on extent of spoilage of tomato fruits (%)

		Weeks After Harvest			
Treatments	Initial (Day 1)	1st Week (7th day)	2nd Week (14th day)	3rd Week (21th day)	4th Week (28th day)
(T1) 4%$CaCl_2$	0	0	33.3	27.3	100
(T2) 8%$CaCl_2$	0	1.7	28.5	54.5	100
(T3) 12%$CaCl_2$	0	0	6.7	0	100
(T4) 4%$CaCl_2$ + *PC	0	0	0	0	27.3
(T5) 8%$CaCl_2$+ PC	0	0	0	16.7	22.5
(T6) 12%$CaCl_2$ + PC	0	0	0	20	23.5
(T7) Control(water dip)	0	0	13.3	36.7	100
(T8) PC (without $CaCl_2$)	0	0	6.7	8.3	70

TSS: TA Ratio: The total soluble solid (TSS) to titratable acidity (TA) ratio is often better related palatability of the fruit than either sugar or acid levels alone. This ratio starts initially from 8.89 and increases as fruit matures to more than 19 to 26 (Table 2). The increase in TSS to TA ratio indicates the increase sugar content and reduction of acidity. The results of the study showed that TSS: TA of tomato fruits varies in all treatments over storage time and the ratio ends up at the second week due to complete loss of titratable acidity in the sampled fruits (Table 2). In general, fruits which are present in modified atmosphere had reduced TSS: TA in the second week than those exposed to ambient environment. Hence, TSS and TA didn't indicate the effect of post harvest treatments over the storage.

Spoilage: The condition of a commodity is a quality attribute referring usually to freshness, stage of senescence, ripeness, the extent of mechanical damage and pest or disease incidence. Physiological disorder, transpiration and subsequent water loss can result loss of quality due to spoilage. Spoilage of fruits led to loss of saleable fruits and direct loss in marketing. Proportion of spoilage was computed by dividing the spoiled fruits to the total fruit and multiplying by 100.

The results indicated that spoilage of tomato fruits was increased in all the treatments over storage time (Table 3). However, there was a difference in magnitude of spoilage between and within the treatments. The least spoilage (22.5%) was recorded in fruits treated with 8% $CaCl_2$ and packed with ventilated polythene cover whereas maximum (100%) spoilage was recorded on the treatments which were not under modified atmosphere at end of the fourth week (Table 3). This indicated a significant role of $CaCl_2$ as an ethylene absorbent and this aspect together with modified atmosphere could have less extent of spoilage on storage period. A wealth of information is available to prove that ethylene is an active metabolic product and ripening hormone. The forced evaluation of ethylene under partial vacuum caused extremely long ripening retardation [15]. This shows that sucking out most of the internal ethylene can reduce it to a physiological inactive level. The very low effective concentration of ethylene has not yet been duplicated by other chemicals. It is 100 times more effective than acetylene as agent for tomatoes [16]. By gas chromatography, it was consistently found that ethylene was obtained at or before the climacteric ascent [17]. The controlled atmosphere process could be the most important innovation in fruits and vegetables storage. This method if combined with refrigeration, markedly retards respiratory activity and may delay softening, yellowing and quality changes and other breakdown processes by maintaining an atmosphere with more CO_2 and less O_2 than in normal air.

Marketability: Fruits and vegetables quality cannot be improved after harvest, but it can be preserved. Good quality is obtained when harvesting is done after proper stage of maturity. Immature fruits when harvested will give poor quality and erratic ripening. In contrast, delay harvesting of fruits and vegetables may increase their susceptibility to decay, resulting in poor quality and hence low market value. Water loss from fruits equates to loss of saleable weights and volumes in marketing. In terms of selling produces the external criteria such as appearance (i.e size, color, shape) condition and absence of defects, taste or texture, flavor and nutritional value are important quality criteria for the consumer. Therefore, measures that minimize weight loss, excessive shrinkage, spoilage and metabolic stress after harvest will usually enhance marketability [5]. A research finding in Nigeria showed that the major determinant factor for post harvest losses of tomato production identified as seasonal nature and market distance to the farm [1].

The results indicated that marketability of tomato fruits was reduced in all treatments over storage time (Table 4). However, there was a highly difference in magnitude of marketability between and within different treatments. The least marketability (0% marketable) was recorded in fruits exposed ambient environment while maximum marketability (87.5%) was registered in fruits treated with 8% $CaCl_2$ and packed with ventilated polythene cover. This indicated important role of calcium chloride as an ethylene absorbent and this aspect together with modified atmosphere able to maintain the marketability of the fruits. Different researchers [8.9] proved significance of $CaCl_2$ as ethylene absorbent and delayed ripening. Minimum loss of physiological weight (9.7%) was recorded in 8%$CaCl_2$ under modified atmosphere along with the taste, flavour and organoleptic qualities were good. Here Marketability and spoilage were directly correlated.

The quality of finished product is affected very markedly by the length of time between picking and processing. Mechanical damage, delay harvest, temperature effect and improper handling of fruits and vegetables are the major causes of quality deterioration in flavor and toughening of texture [5]. Processing tomatoes within 6 hour from harvest is reported to prevent a loss about 9.5% of the ripe tomatoes as compared to that occurring when processing was delayed 24 hour [16]. Generally, calcium chloride has a significant impact on the shelf life of tomatoes fruits through improving firmness, quality and delay ripening.

Table 4: Effect of some post harvest treatments on marketability (%) of tomato fruits

		Weeks After Harvest			
Treatments	Initial (day1)	1st Week (7th day)	2nd Week (14th day)	3rd Week (21th day)	4th Week (28th day)
(T1) 4%$CaCl_2$	100	90	66.7	0	0
(T2) 8%$CaCl_2$	100	92	71.5	0	0
(T3) 12%$CaCl_2$	100	88	73.3	0	0
(T4) 4%$CaCl_2$ + *PC	100	100	100	95	80
(T5) 8%$CaCl_2$+ PC	100	100	100	90	87.5
(T6) 12%$CaCl_2$ + PC	100	100	100	70	75
(T7) Control(water dip)	100	80	56.67	0	0
(T 8) Control+ PC	100	95	83.3	60.7	56.5

Table 5: Effect of some post harvest treatment on color of tomato fruits

Weeks(days)	Color	Code	Description
0(0)	Turned to red	2	The juice color is yellow –pink
1(7)	Orange-red	3	The juice color almost pink
2(14)	Red	4	The juice color is becoming pink and the fruit surface was smooth
3(21)	Deep red	5	The juice color was very pink and the fruit surface very smooth
4(28)	Deep red	5	The juice color was very pink and the fruit surface very smooth

Color Change: Color is the most obvious change that occurs in many fruits and is often the major criterion used by consumers to determine whether the fruit is ripe or unripe (Table 5).

The results indicated that the color of tomato changes through time and the juice color also become deep pink were occurred at the four weeks period. Generally, three maturity stages are recognized, mature green, pink or breaker and red-ripe stage. The term 'ripe' indicates that most of the surface is pink or red.

CONCLUSION

The results of the study indicated that storage time generally led to increase in physiological loss in fruit weight, volume, juice content and juice volume, reduced titratable acidity, increase in spoilage and reduce marketability. However total soluble solids (TSS) was found to be constant over the storage period. Tomatoes treated with $CaCl_2$ and covered with polythene bag found to be best suited to preserve for a month period without much affecting fruit quality. Tomato fruits treated with 8% $CaCl_2$ and packed with ventilated polythene cover showed a highly significant ($P<0.01$) minimum losses all over treatments. 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 fruits beyond a month after harvest over control (water dip). Thus, it could be concluded:

- Treatment of calcium chloride has influence on storage behavior and quality of tomato fruits
- In the absence of chemical treatments the tomato can be stored with the use of ventilated polythene cover to retard the post harvest losses.
- Ethylene absorbents in conjugation with controlled storage atmosphere have a notable commercial potential in the future to prolong shelf life of perishable fruits.
- Further study is required for other perishable fruits and linking the technology with entrepreneur concept is advisable to the benefit of consumers and producers.

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REFERENCES

1. Babalola, D. A. Makinde, Y. O., Omonona, B. T. and Oyekanmi, M. O. 2010. Determinants of post harvest losses in tomato production: a case study of Imeko – Afon local government area of Ogun state. Journal of Life and Physical Sciences, acta SATECH, 3(2): 14-18.
2. Wickingson, B.G., 1970. Physiological disorders of fruits after harvesting. In. Hurme. A.C. (ed); the biochemistry of fruits and their products, volume, I. Academic press. New York, pp: 537.
3. Worthington, J.JA. and J.N. Yeatman, 1969. Light techniques adapted to sorting green tomatoes. Agric Res. (wash), 17(18).
4. Okolie, N.P. and T.E. Sanni, 2012. Effect of Post Harvest Treatments on Quality of Whole Tomatoes. African Journal of Food Science, 6(3): 70-76.
5. Mutari, A. and R. Debbie, 2011. The effects of postharvest handling and storage temperature on the quality and shelf of tomato. African Journal of Food Science, 5(7): 446-452.
6. Izumi, H. and A.E. Watada, 1994. Calcium treatments affect storage quality of shredded carrots. Journal of Food Science, 59(1): 106-109.
7. Bryman, A. and D. Cramer, 2006. Quantitative Data Analysis with SPSS Release 15 for Windows: A Guide for Social Scientists. Routledge, London.

8. Pila, N., N.B. Gol and T.V.R. Rao, 2010. Effect of Post harvest Treatments on Physicochemical Characteristics and Shelf Life of Tomato (*Lycopersicon esculentum* Mill.) Fruits during Storage. American-Eurasian J. Agric. & Environ. Sci., 9(5): 470-479.
9. Nasrin, T.A.A., M.M. Molla, M.A. Hossaen, M.S. Alam and L. Yasmin, 2008. Effect of Postharvest Treatments on Shelf Life and Quality of Tomato. Bangladesh J. Agril. Res., 33(3): 579-585.
10. Mitra, S.K., 2005. Post harvest physiology and storage of tropical and subtropical fruits. CABI New Delhi, India.
11. Shear, C.B., 1975. Calcium related disorder fruits and vegetables. Hort. Science, 10: 361-365.
12. Bangerth, F., D.R. Dilley and Dewey, 1972. Effect of post harvest $CaCl_2$ treatments on internal break down and respiration of apple fruit. J. Amer. Soc. Hort. Sci., 97: 679-682.
13. Tingwa, P.O. and R.E. Young, 1974. The effect of Calcium on the ripening of avocado fruits. J. Amer. Soc. Hort. Sci., 19: 540-542.
14. Jones, R.C.W. and O.R. Lunt, 1967. The function of Calcium in plants. Botanical Review, 33: 407-426.
15. Burg, S.P. and E.A. Burg, 1965. Ethylene action and ripening of fruits Science, 148: 1190.
16. Pantastico, ER.B. and D.B.JR. Mendoza, 1970. Production of Ethylene and acetylene during ripening and charring. Philipine. Agrs., 53: 8-9,477.
17. Burg, S.P. and E.A. Burg, 1962. Post harvest ripening of avocadoes. Nature, 194: 398.
18. Schultz, W.G., 1971. Field Processing of tomatoes. I. Process and Design. J. Food. Sci., 36: 397.