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Original Article

Concentrations Effect of Calcium Chloride on Post Harvested Physiology in Selected Varieties of Tomato (*Solanum lycopersicum*) Fruit Under Storage

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Abstract

Studies were carried to evaluate the effects of calcium chloride on post-harvest physiology of selected tomato varieties. An experiment was conducted in the laboratory of Biological Sciences Department, Yobe State University. The experiment comprised of 4 varieties (ROMA, UTC, IFE and RUKUTA) and was laid in a complete randomized design having 4 treatments (0%,2%,4%and 6%) the fruit were dipped for 1-2mins the control was left without calcium chloride treatment. The fruit were packed in foam trays and stored under room temperature for total period of 21days. The parameters recorded are (weight loss, textural changes, pH determination, chlorophyll and lycopene content). The result indicates that storage lead to decrease in weight loss. UTC recorded the greatest weight loss (13.019g) while ROMA recorded the least weight loss (4.022g). There is an increase in textural change of post-harvest physiology of tomato. RUKUTA recorded the highest textural change (2.500g) while IFE recorded the lowest textural change (91.00g). There is an increase in the p H determination of post-harvest tomato. UTC recorded the highest p H (5.8117) Ife recorded the lowest determination (4.9317). There is an increase in the chlorophyll content of post-harvest tomato. RUKUTA recorded the highest chlorophyll content (61.955mg/l) while ROMA recorded the lowest chlorophyll content (18.398mg/l). The result showed that there is a decrease in lycopene content. UTC recorded the highest lycopene content (2173.17mg/100ml) RUKUTA recorded the lowest lycopene content (2146.67mg/100ml) conclusively; the findings indicated that storage of the product led to increase in chlorophyll content, pH, and textural changes. However, weight loss and lycopene content were found to be decreasing during the storage period. The ROMA variety was seen to be significantly higher during the storage period and application of 4% calcium chloride was found to cause highly significant minimum lose. This shows the importance of $CaCl_2$ as a good ethylene absorbent and its effectiveness for storage purposes.

Keywords: - Calcium chloride, ROMA, UTC, IFE , RUKUTA.

Introduction

Tomato is an annual sub-tropical crop belonging to the family solanaceae. Tomato plant derives its origin from Southern part of America and then later taken to Europe at the beginning of the 16th Century and w later introduced to Eastern Africa by colonial masters in the early twentieth century (Wang, 2005). Due to increasing demands for import and export uses, the tomato crop widely cultivated (Mungai *et al*., 2000). The Tomato fruit is one of the essentials crops used for many different meals due to its high nutritive content. The fruit is a good source of Vitamin C and also have a significant amount of Vitamin A and B (Robinson, 1977). Despite its wide global cultivation, Tomato annual production in the southwestern part of Nigeria is inadequate. Adeoye *et al*. (2009) was reported to have said that most of tomato crops that are usually sold and marketed in southwestern part of the country were produced from the northern parts of Nigeria. Tomato production in southwestern Nigeria is also generally known to be inadequate and below the consumption needs of

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the entire southern region (Adeoye *et al.,* 2009). Tomato crop is among the most commonly used farm produce and one of the mostly and extensively consumed vegetable crops across all continents (Grandillo *et al*., 1999). Tomatoes are usually consumed in many different parts of the world in different ways, the fruits can be eaten raw as in salads, stews, sandwiches or salsa while, the processed tomato crops can be consumed pastes, sauces, stews, juices, and as well as drinks (Alam *et al.,* 2007). Generally, Tomato based processed foods products provide a wide range of nutritive value and numerous health benefits related to the human body. The Tomato crop also has high presence of lycopene and carotenoids contents with high antioxidant properties (Arab and Steck, 2000) which is helps in reducing the prevalence of some deadly chronic diseases (Basu and Imrhan, 2007) including cancers and different kinds of cardiovascular disorders (Freeman, and Reimers, 2011)

Economic Uses and Importance of Tomato

The Tomato crop ranks among the second most produced largest vegetables globally, immediately after the onion crop (Traore *et al.,* 2022). However, the tomato crop yield is rapidly declining from 12.5 tons t/ha in 2012 10 10.9 t/ha in 2018 (FAOSTAT, 2020). The tomato crop yield can be anually increased effectively if organic manure with mineral fertilizers are augmented to improve and applied to improve soil and boost crop productivity (Ayamba *et al* 2021 ; Bashir *et al* 2021; Bergstrand *et al* 2021) Its production accounts for 14 % of total horticultural production worldwide. The total production increase over the last years can be mainly attributed to China, world-beater for this crop which went from nearly 12 million tonnes in 1994 to 30 million tonnes in 2004. China, Egypt, India, Italy, Turkey and the USA represent the leading producing countries (Table 1.1).

Table: 1.1: Variations in world tomato production. (Source: FAO, 2004).

Country	**Production (t)**	
	1994	**2004**
USA	12,165,000(1)*	12,400,000(2)
China	12,027,980(2)	30,142,040(1)
Turkey	6,350,000 (3)	8,000,000 (3)
Italy	5,574,800 (4)	6,500,000 (6)
Egypt	5,010,682 (5)	6,780,000 (5)
India	4,930,000 (6)	7,600,000 (4)
Spain	3,108,820 (7)	3,900,000 (7)
Brazil	2,688,570 (8)	3,394,677 (8)
Iran	2,088,287 (9)	3,150,000 (9)
Greece	2,017,000 (10)	1,800,000 (11)
Mexico	1,712,879 (11)	2,148,130 (10)
World	83,382,181	115,950,851

The numbers in parenthesis indicates the world ranking position of a country in the related period.

Fruit Characteristics

The tomato fruit consists of 97-98 % pulp and juice, 1.5-2.0 % skin and 1.01.5 % seeds. There are numerous classifications of tomato fruit typology; some of them take into account: (1) the end use (table, industrial or sun – dry tomato), (2) form of the fruit, (3) size, (4) origin, (5) time and mode of harvesting. In this review the classification regarding both the time of harvest and the main end use will be considered:

1. Salad tomato generally has a flattened or cylindrical form and a weight varying between 80-100 and 180-300g.Theyareconsideredtheoldest type of tomato for fresh consumption among those in large-scale marketing.

2. Red vine tomato has a round form and excellent firmness, intense red color, is harvested as a truss, with 6-8 fruits per truss and a weight varying between 80 and 160 g.

3. Cherry tomato has round or cylindrical fruits, red color, a diameter between 15 to 35mm and an average weight of 10 to 30g. They are harvested asatrusscontaining10-25 fruits disposed as a cluster with all fruit attached to the fruiting stem. Generally, they have an organoleptic character of extreme

flavor and sweetness. Fruits bigger than35mm(35-47mm) are known as cocktail and in recent years this type of tomato has received considerable interest from European markets, because they combine the qualitative traits of the cherry-type together with the productive traits of the classic salad-types. (Serio *et.al*. 2006).

4. Processing tomato is red in color, mainly harvested when fully ripened and used in the tomato processing factory / industry.

Benefits of Tomato Crop

Tomatoes fruit contains many different types of health benefits compounds for the human body organs. Tomatoes are highly versatile healthy food substances and due to their many different preparation options, tomato diets are usually prepared to satisfy healthiness of the human body (Bhowmik *et al.,* 2012). Lycopene is the most well-known tomato containing compound, lycopene is a very important anti-oxidant compound found in the tomato crop that helps to fight against the formation of cancerous cells, as well as other different kinds of diseases in the human body. Free radicals in the human body are been helped to be flushed out by lycopene and the tomato crop is highly filled with this anti-oxidant that gives the crop its characteristics red color. Naturally human body does not generally produce lycopene but the body requires some amount of Lycopene in order to make use of it for healthy cells (Bhowmik *et al.,* 2012). The health benefits of the tomato crop are increasingly becoming more documented on daily basis as new uses and importance of this great wonderful fruit is learnt. Many different kinds of cancers have been known to be controlled by some high amounts of Lycopene. With all the many different research activities that has been carried out on the health benefits of using tomato fruit, there is still many more researches that are presently being conducted as the world medical science community have come to realize that we have not fully been exposed into the potentials presented by the tomato fruit. Among all the fruits and vegetables capable of stopping some of the deadliest known diseases in human beings ,tomatoes are one known to be one of the safest,. (Bhowmik *et al.,* 2012).

Remedies of eating tomato (*Solanum lycopersicum)*

Consumption or eating tomatoes have a lot of health benefits when eaten either raw or cooked (Zdeňka *et al.,* 2010).Major benefits of eating tomato fruits are ;

1. Tomatoes fruit contains all the four major types of carotenoids which include; alpha carotene ,beta-carotene, lutein, and lycopene.
2. Tomato has the highest carotenoid for antioxidant activity.
3. Tomatoes helps in reducing the risk of prostate cancer.
4. Tomato-based food products help in reducing the risk of pancreatic cancer.
5. Tomatoes are highly rich in potassium content.

Material and Methods

Sample Collection

The tomato fruit was randomly collected from vegetable sellers from 'Bayan Tasha located at Damaturu local government area Yobe State and was packed in polyethylene bags and brought to biology laboratory in Yobe State University Damaturu.

Experimental Site

The study was conducted at Plant Pathology laboratory in the Department of Biological sciences, Yobe State University under aseptic condition.

Sterilization of The Tomato Crop.

The tomato crop was sterilized using 1.0% sodium hypochlorite solution for about 4- 5 minutes. The tomatoes were then rinsed with sterile distilled water to completely remove the residual effect of sodium hypochlorite solution on the tomato crop.

The experiment was designed as randomized completely block design with four treatments and 3 replicates.

Control (To)
2% $CaCl_2$
4% $CaCl_2$
6% $CaCl_2$

144 Samples was used for the study. The tomato fruit were soaked in to the calcium chloride solution for 1-2 minutes and then dried at room temperature. The treated fruits were packed with foam tray. These fruits were then stored in a ventilated place at ambient temperature for experimentation in the laboratory.

Determination of Weight Loss

Data on weight loss as affected by post-harvest treatments of tomato crop was presented. The lowest weight loss was observed in tomatoes treated with 2% $CaCl_2$ followed by 4% $CaCl_2$, indicating the significant role of $CaCl_2$ as an absorbent of ethylene using electronic scale (510g/0.01g).

Textural Change Determination

The textural change of tomato was determined using hand method and firmness of the fruit was recorded with the following indexes 1: very hard, 2: hard,3: very soft, and 4: soft (Burton *et al.,* 2010).

Determination of Ph

pH was determined using electronic pH metre, 50ml of distilled water was put into a beaker after blending the solution allow the reading to stabilize before recording the reading rinse the pH metre in distilled water and swab.

Lycopene Determination

The lycopene content was determined using the method mentioned by Snell and Snell (1958).

Concentration of lycopene in mg/100ml

$$\frac{Me \quad of \ Absorbance}{Slope} \times \frac{Dilution\ factor\ (50)}{1g}$$

Chlorophyll Content

Tomato chlorophyll contents were determined using a spectrophotometer. The chlorophyll content was calculated as chlorophyll a, b and total chlorophyll in mg/L according to AOAC method(1997).

Data Analysis;

Data obtained after verifying their normality by Shapiro- Wilk test, were subjected to ANOVA. Means were separated using LSD at 5% probability level.

Results

The Concentrations of $Cacl_2$ On Weight Lossin Some Tomato Varieties Stored Under Room Temperature.

The results on different concentrations of $CaCl_2$ on the weight loss in some tomato varieties stored under room temperature are presented in Table 2.1;

The result of the analysis of variance showed at 2 days after treatment there is significance difference in the variety, but no significance different at treatment and treatment by variety interaction. At 4 days after treatment, the analysis showed that there is significance difference in the variety.

The result of the analysis indicates that there is a significant difference in the variety at 2, 4, 6, and 8 days after treatment on the weight loss by some tomatoes varieties store under room temperature. But there is no significance different across the days after treatment, similarly there is no significance difference in the variety by treatment in the result showed at 4 days, UTC recorded the highest weight loss (13.019) but IFE recorded the lowest weight loss (4.022g) at 6 days. Rukuta recorded the highest weight loss (25.55g), but Roma recorded the lowest weight loss at (10.627g).

Result indicates a significant difference in the treatment at 4, 6 and 8 days after treatment on the weight loss of some tomato variety store under room temperature. But there is no significance difference ($p>0.05$) at 2 days after treatment on weight loss, similarly there is no significance difference in the treatment by variety interaction. The result showed at 4 days after treatment 0.02% application of $CaCl_2$ records the highest weight loss (14.187g) but 0% application $CaCl_2$ recorded the highest weight loss (10.893g) but 0.06% application $CaCl_2$ recorded the lowest weight loss 3.465.

Table 2.1: The concentrations of Calcium chloride on weight loss in some tomato varieties stored under room temperature**. (g)**

Variety	2day	4days	weight loss	6days	Weight loss	8days	Weight loss
Rukuta	164,258[a]	158.38[a]	5.87	132.828[ba]	25.552	132.453[a]	0.375
Roma	158.241[a]	151.11[a]	7.131	140.483[a]	10.627	133.807[a]	6.676
UTC	138.360[b]	125.35[a]	13.01	113.837[bc]	4.513	107.604[b]	6.233
IFE	126.669[b]	122.64[b]	4.029	111.835[bc]	10.805	103.204[b]	8.631
LSD	19.961	20.432		19.33		17.305	
Treatment							
0	157.758[a]	151.45[a]	6.308	142.574[a]	8.876	134.528[a]	8.046
0.02	150.513a	141.14[a]	9.373	126.962[ba]	14.178	119.849[ab]	7.113
0.04	140.593[a]	129.70[ba]	10.893	120.088[b]	9.612	113.203[b]	6.885
0.06	138.665[a]	135.20[ba]	3.465	109.358[b]	25.842	109.488[b]	0.13
LSD	19.961	20.432		19.33		17.305	

The Concentrations of Calcium Chloride on The Textural Changes in Tomato Varieties Stored Under Room Temperature.

The result of concentrations of Calcium chloride on the textural changes in tomato varieties stored under room temperature was presented in table 2.2.

The analysis of variance indicate that at 2 days there is no significant difference in the variety, but there is no significant different at 4, and 8 days' variety by treatment interaction.

The result of the analysis indicate no significant difference in the variety at 2 days after treatment of some tomato variety stored at room temperature but there is significance differences at 4,6 and 8 days, across the days after treatment similarly there is significance difference in the variety by treatment interaction.

The result indicates that at 4,6 and 8, days Rukuta recorded the highest textural change (1.750g, 2.250g and 2.500g) respectively but IE recorded the lowest textural changes 91.00g) in the variety.
The result of analysis indicates is no significant difference at 2 days after treatment on the textural change of some variety of tomato store under room temperature. But there is significant difference at 4.6 and 8 days, across the days after treatment the result indicate that 0% application of $CaCl_2$ recorded the highest textural change (1.750g, 2.250g, 2.500g) respectively, but 0.06% $CaCl_2$ recorded the lowest textural changes.

Table 2.2a : The concentrations of calcium chloride on the textural changes in some tomato varieties stored under room temperature.

Variety	2day	4days	6days	8days
Rukuta	1.000[a]	1.750[a]	2.250[a]	2.500[a]
Roma	1.000[a]	1.250[a]	2.000[b]	2.250[a]
UTC	1.000[a]	1.250[b]	2.000[b]	2.000[c]
IFE	1.000[a]	1.00[b]	1.750[c]	2.250[b]
0	1.00[a]	1.750[a]	2.250[a]	2.5000[a]
0.02	1.00[a]	1.250[a]	2.000[b]	2.250[b]
0.04	1.00[a]	1.250[b]	2.000[b]	2.000[c]
0.06	1.00[a]	1.00[c]	1.750[c]	2.000[c]

Table 2.2b: The effect of treatment and variety interaction of textural changes of some tomato variety at different concentrations using $CaCl_2$.

Variety	0%	0.02%	0.04%	0.06%
Rukuta	2.000	2.000	2.000	1.000
Roma	2.000	1.000	1.000	1.000
UTC	2.000	1.000	1.000	1.000
IFE	1.000	1.000	1.000	1.000
Rukuta	3.000	2.000	2.000	2.000
Roma	2.000	2.000	2.000	2.000
UTC	2.000	2.000	2.000	2.000
IFE	2.000	2.000	2.000	1.000
Rukuta	3.000	3.000	2.000	2.000
Roma	2.000	2.000	2.000	2.000
UTC	2.000	2.000	2.000	2.000
IFE	3.000	2.000	2.000	2.000

The Concentrations of Calcium Chloride on the pH Determination In Some Variety of Tomato Stored Under Room Temperature.

The result of concentration of C calcium chloride on the pH determination are presented in Table 2.3

The result of analysis reveals that at 14days after treatment there are no significant differences in the variety and there is no significant difference in the treatment variety interaction.

Result showed that at 14days, treatment UTC recorded the highest pH determination (5.8117mg/l) but IFE recorded the lowest pH determination (4.9317mg/l) in the variety. Application of 0.06% of $CaCl_2$ recorded the highest pH determination (5.815mg/l) but 0% application of $CaCl_2$ recorded the lowest pH determination (5.178mg/l) in the treatment.

Table 2.3: The concentrations of calcium chloride on the pH determination in some variety of tomato stored under room temperature.

Variety	14days
Rukuta	5.6550^{a}
Roma	5.3075^{a}
UTC	5.8117^{a}
IFE	4.9317^{a}
LSD	0.6247
Treatment	
0	5.1783^{b}
0.02	5.285^{ba}
0.04	5.4300^{ba}
0.06	5.8150^{ba}
LSD	0.6247

Concentrations of Calcium Chloride on The Chlorophyll and Lycopene Content in Different Variety of Some Tomato Variety Store Under Room Temperature.

The result of concentrations of calcium chloride on the chlorophyll and Lycopene content in different variety of some tomato variety store under room temperature are presented in table 2.4;

The result of the analysis indicates that at 21 days after treatment there are significant differences at chlorophyll content in the variety, but no significance differences at lycopene content.

The result of the analysis indicates that there is significance in the variety at 21 days after treatment on the chlorophyll content. However, no significance difference at lycopene content. Similarly, there is no significant difference in the variety by treatment interaction. The result indicates at 21days on chlorophyll content Rukuta recorded the highest chlorophyll content (61.955mg) the result on Lycopene content UTC recorded the highest lycopene content (2173.17mg). However, Roma recorded the lowest chlorophyll content (18.398mg) the result on lycopene content Rukuta recorded the lowest lycopene content (2146.67mg).

The analysis indicates that there is significance differences in the treatment at 21 days after treatment on the chlorophyll content but no significance difference ($P>0.05$) at lycopene. Similarly, there is no

significance difference in the treatment by variety interaction application of $CaCl_2$ (59.18mg) the result recorded on lycopene content is 0.04% application of $CaCl_2$ (2174.83mg) recorded the lowest chlorophyll content (14.504mg) the result on lycopene content 0% application of $CaCl_2$ recorded lowest lycopene content (253.67mg).

Table 2.4: Effect of different concentrations on chlorophyll and lycopene content of tomato variety stored at room temperature at 21days after treatment(mg/100ml)
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Variety	**Chlorophyll**	**Lycopene**
Rukuta	61.955[a]	2146.67[a]
Roma	18.398[cb]	2153.67[a]
UTC	40.208[b]	2173.17[a]
IFE	26.158[cb]	2157.25[a]
LSD	15.78	36.176
Treatment		
0	14.504[a]	253.67[a]
0.02	35.412[b]	2139. 67[a]
0.04	37.623[b]	2174.83[a]
0.06	59.181[a]	2162.42[a]
LSD	15.78	36.176

Discussion

From the present study it indicates that there is a decrease in the weight loss of post harvested tomato stored under room temperature, this is in agreement to findings by Genanew (2013) who reported the significance role of $CaCl_2$ as an ethylene absorbent in tomato weight loss is mainly due to transpiration and respiration.

From the present research, study indicates that there is increase in the textural change of post-harvested tomato stored under room temperature. These disagrees with the findings of Jackman *et al* (1995), who reported that firmness of tomato crop occurs as a result of moisture loss to the loss of moisture as a result of transpiration as well as enzymatic change loss of firm and texture are processes associated with the ripening that affect quality of fruit and post-harvest storage. During storage, the tip of the fruit was the first to show symptoms of loss of firmness because of its greater fragility high water content of fruit provided high turgidity and resulted in a high level of firmness.

Results obtained from the present study, indicates that there is increase in the pH determination of post-harvested crop of tomatoes stored under room temperature, this agrees with the statement of Andrea *et al.* (2006) who stated that lower concentrations of calcium caused significant effect on the respiration. pH of tomato is determined mainly by the acidic content of the tomato.

Results also shows that, there is an increase in the chlorophyll content of post-harvested tomato stored under room temperature; this disagrees with the finding of Wills and Tirmaz (1977) who states that application of calcium chloride decrease content of chlorophyll.

From the present findings results indicates that there is decrease in lycopene content of post harvested stored tomato, this is in agreement with the findings of Gharezi *et al*. (2012) who reported the significant effect of $CaCl_2$ reduced respiration and chlorophyll degradation are responsible for slow production rate of lycopene synthesis. Lycopene is the most effective antioxidant and it depends on the ripeness and maturity at harvest.

Conclusion

In conclusion, the findings in this present work reveal that tomato storage led to improve increase in pH, textural changes and chlorophyll content. However, weight loss and lycopene content was found to be decreasing over the storage period. Roma variety of the tomato was found to be highly significant during the storage period and application of 4% calcium chloride was found out to be highly significant with little or minimum losses incurred. This shows that, the role played by $CaCl_2$ as an

absorbent of ethylene effect storage and will be able to extend its shelf life while maintain and retaining its nutritional qualities.

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Conflict of interest

The authors declare no conflict of interest.

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