Effects of Postharvest Dips on Quality and Storability of Tomato Fruits (Lycopersicon esculentum MILL) in Kura, Kano State, Nigeria

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Abstract
The estimated total postharvest loss of tomatoes in Nigeria is about 60% despite being 13th producer in the world. This translates to huge loss which prompted the search for simple postharvest treatments to extend the storage life of fresh tomatoes. The present study investigates the effects of various postharvest dips (D_1= dip in tap water, D_2= dip in 200 ppm NaOCl and NaOCl for 5 minutes each, D_3= dip in 200ppm NaOCland $C_6H_7KO_2$ for 5 and 1 minutes respectively). Tomatoes were harvested and conveyed to site early in the morning. They were sorted, divided into 3 kg lots and given the postharvest dips. Physico-chemical parameters of the fruits were analyzed on the first day and thereafter every three days for a period of 24 days. Data generated were analyzed using GLM of SAS and means separated using LSD. Results of the effect of postharvest dips revealed that dip in 200 ppm NaOCl and 1% $CaCl_2$ for 5 minutes each has significant effect on the quality parameters of tomato fruits compared to other dips. Based on the result it can be concluded that this was the best dip and is hereby recommended for use.

Key words: Quality, Dips, Tomato, Postharvest, Storage and Kura.

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1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is a herbaceous plant belonging to the family *Solanaceae*. It is believed to be domesticated in the South Americas and following its introduction to Spain in 16th century it became widely dispersed throughout African continent (De-Lennoy, 2001).It is one of the popular vegetables worldwide and plays vital role in human diet (Sibromana *et al*., 2015).Tomatoes are consumed as salads,whole peeled, cooked into soups or processed into juice, ketchup, puree and paste(Adedeji *et al*.,2005). They are rich in vitamins (particularly A and C), minerals sugars, essential amino acids, iron, dietary fibers and phosphorus (Ayendiji *et al*. 2011).Tomato fruits also contain higher amounts of lycopene, a type of caretonoid with anti oxidant properties and beneficial in reducing the incidence of some chronic diseaseslike cancer (Basu and Imrhan, 2007) and many other cardiovascular disorders (Freeman and Reimers, 2010).The quality and nutritional value of fresh tomato fruits is affected by pre and postharvest diseases, improper handling and other conditions (Kader, 1986).Nigeria is the second largest producer in Africa and 13th in the world; and produces 6 million tonnes annually prior to 1990 (FAOSTAT, 2014).The estimated total postharvest loss of tomatoes in Nigeria is about 60%(Kutama *et al*., 2007) which translates to huge economic loss.The huge loss prompted the search for simple, effective and economical method to control pre and postharvest diseases and other losses in tomatoes. Postharvest technologies like chemical treatments, packaging, storage etc greatly reduce the losses and improve the quality of produce (Srividya *et al*., 2014).

Postharvest application of chlorine solutions are known to reduce enzymatic activity and decay by pathogens thereby extending the storage life of the produce (Sood *et al*., 2011).The aim of this work was to determine the effects of various postharvest dips on the quality and storage life of fresh tomato fruits in Kura, Kano State

2. MATERIALS AND METHODS

The study was conducted between 25th March to 18th April, 2013 at Kofar Yamma in Kura local Government Area,Kano State of Nigeria located between latitude 11° 46′ N and longitude 8° 25′ E. The analyses were conducted in the Laboratories of the Department of Food Science and Technology, Kano University of Science and Technology Wudil and Kano area laboratory of Abuja Commodity Exchange Plc.The fruits (UC 82B grown in Kura) of fairly uniform sizes werecarefully hand harvested at green mature stage and free of any visible defect.The designwas a factorial design laid out in randomized complete block design (RCBD). There were three factors; postharvest treatments, packagingand storage each having 3 levels which were replicated three times.Postharvest treatments consisted of three levels which were:

i. freshly harvested tomato fruits dipped in tap water for 5 minutes (D_1)
ii. freshly harvested tomato fruits dipped in 200 ppm Sodium hypochlorite for 5 minutes and later dipped in 1% w/v Calcium chloride for 5 minutes (D_2).
iii. freshly harvested tomato fruits dipped in 200 ppm Sodium hypochlorite for 5 minutes and later dipped in 3% Potassium sorbate for 1 minute (D_3).

Each treatment consisted of 3 kg sound, unblemished mature green tomatoes dipped in the various dips and subjected to various forms of packaging and stored in the various storage structures. Determinations were conducted on the various physicochemical parameters on day one and thereafter every three days.Results were analyzed using generalized linear model (GLM) of Statistical Analysis System (SAS) and means separated using LSD.

Fruit firmness: The firmness of tomato fruits was measured with the aid of HP-FFF analog fruit firmness tester (Qualitest International Inc. Canada) using 0.25cm^2 test anvil (specifically for tomato fruits). To test the firmness the tester was placed on two different points of the fruit (opposite each other and free of blemishes) with a constant press. The degree of firmness of the fruit was calculated as a quotient of the number directly displayed on the instrument.

Percentage weight loss: The percentage weight loss of the stored tomato fruits was determined as a percentage of the total weight stored. This was done every three days for the period of storage of the tomato fruits.

$$\% \, Weight \; loss \; in \; Tomato = \frac{Initial \; weight \; stored \; - \; Final \; weight}{Total \; weight \; stored} \times 100$$

Percentage decay: For the determination of % Decay, rotted fruits were isolated and the percentage decay calculated as a percentage of the total amount of tomato fruits stored.

$$\% \, Decay \; in \; Tomato = \frac{Initial \; weight \; stored \; - \; Weight \; of \; decayed \; fruits}{Total \; weight \; stored} \times 100$$

Ascorbic acid content:The ascorbic acid content of the tomatoes fruits was determined by the indophenol method as reported by Onwuka, (2005).

The fruitwas pulped using domestic juice extractor (Master Chef Model MC-J2101).Two grams of the blended pulp was weighed and 100 ml of distilled water added to it in a volumetric flask. The solution was filtered using a filter paper to get aclear solution. Fifty milliliters of unconcentrated juice was then pipetted into 100 ml volumetric flask in triplicate.Twenty five milliliters of 20% Metaphosphoric acid was added as a stablising agent and diluted to 100 ml volume. About 10 ml of the solution was then pipetted into small flask and 2.5 ml of acetone added. The solution was titrated with 2,6 - Dichlorophenol indophenol to a faint pink colour which persisted for roughly 15 seconds The amount of ascorbic acid in the tomato fruit was calculated as follows:

$$\text{Vitamin C } (mg \,/\, 100 \; g) = 20 \times V \times c$$

Where V= ml indophenol solution in titrationand

c = mg vitamin C /ml indophenol

Lycopene content: Fresh juice was squeezed using potablefruit juice extractor (Master Chef Model MC-J2101) and drawn into a 100µl micro pipette and the outside glass bore was wiped clean using tissue paper. The pipette was allowed to stand to dispel air bubbles. The sample was then dispensed into 50 ml separating funnel and closed tightly. Blank samples using 100 µl of water was prepared. Eight milliliters of hexane: ethanol: acetone in ratio 2:1:1 was carefully added immediately and kept out of light. After10 minutes 1 ml of water was also carefully added and vortex again. The sample was then allowed to stand for another 10 minutes to allow phases to separate and bubbles disappear. The spectrophotometercuvette was then rinsed clean with upper layer from one of the blanks. The liquid was then discarded and another fresh blank was used to zero the spectrophotometer (Jenway Model 752) at 503 nm. The absorption of the upper layers of the sample was then determined. Lycopene content was then calculated using the following relationship:

$$Lycopene\ (mg/kg\ fresh\ weight) = (A_{503} \times 137.4)$$ (Onwuka, 2005)

3. RESULT AND DISCUSSION

The results of the effect of postharvest dip on tomato fruit firmnessare presented in Figure 1. Results showed that significant differences were observed on days 3, 6, 9, 15, 21 and 24 at $P \leq 0.01$ and on day 18 at $P \leq 0.05$. The highest firmness of 0.036 kg was observed on day 3 in fruits dipped in tap water while the other treatments were not significantly different. This is closely followed by the same treatment on day 6 and 9 with firmness value of 0.035 kg. The lowest firmness (0.026 kg) was observed on day 21 and 24 respectively in fruits dipped in Sodium hypochlorite(NaOCl) and Potassium sorbate ($C_6H_7KO_2$). The other treatments were not statistically different.

The results for the effect of postharvest dips on percentage fruit weight loss are presented on Table 1. Significant difference was only observed on day 18 at $P \leq 0.05$. Fruits dipped in tap water had the highest (3.46%) percentage moisture loss while fruits dipped in NaOCl and $C_6H_7KO_2$ had the lowest percentage moisture loss of 2.48%. The other treatments were not statistically different.

The results of the effects of postharvest dips on percentage tomato fruit rotting are presented on Table 2. Results showed significant difference at $P \leq 0.01$ on 15th day of storage; and on 21 and 24 days at $P \leq 0.05$.No significant difference was observed on other days of the experiment.

The highest percentage rot (25.03%) was observed in fruits dipped in NaOCl and $CaCl_2$ on 15th day of storage. The other treatments were not statistically different. The least percentage rot (2.28%) was observed in fruits dipped in NaOCl and $CaCl_2$ on 21st and 24th days of the experiment.

Table 3 presented the results of the effect of postharvest dips on ascorbic acid content of the tomato fruits. Significant differences were only observed on day 3 of the experiment (at $P \leq 0.05$) and 12th day of the experiment (at $P \leq 0.01$). No significant differences were observed on other days of the experiment. The highest ascorbic acid content of 31.63 mg/100g was observed in fruits dipped in NaOCl and $CaCl_2$ on 12th day of the experiment. The other treatments were not statistically different. The least ascorbic acid content of 15.97 mg/100g was also obtained in fruits dipped in NaOCl and $CaCl_2$ on 3rd day of the experiment.

The results for the effect of postharvest dips on the lycopene content of tomato fruits are presented on Figure 2. Significant differences ($P \leq 0.05$) were observed on days 3, 12, 18, 21 and 24 of the experiment. No significant difference was however observed on other days of the experiment. The highest lycopene content of 267.73 mg/kg was recorded in fruits dipped in NaOCl and $CaCl_2$ on days 21 and 24 of the experiment. The least amount of lycopene recorded was 102 mg/kg observed in fruits dipped in NaOCl and $CaCl_2$ on day 3 of the experiment. The other treatments were not statistically different from each other.

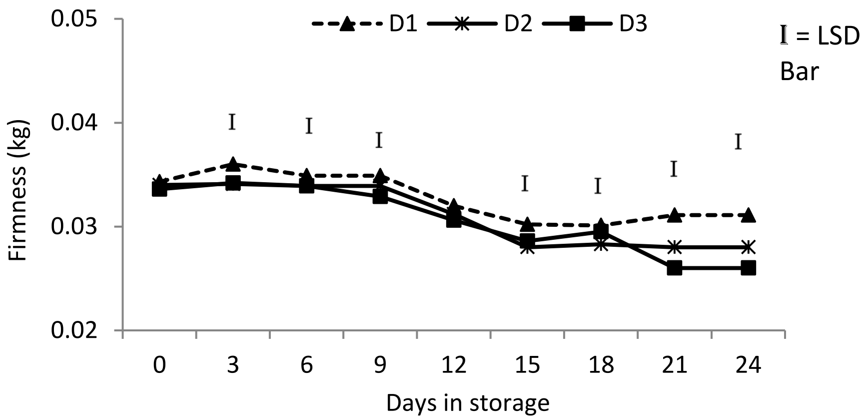

Figure 1: Effect of Postharvest Dips on Tomato Fruit Firmness

Table 1: Effect of Postharvest Dip on Percentage Tomato Fruit Weight Loss (%)

Dips	Days in Storage								
	0	3	6	9	12	15	18	21	24
D_1	-	1.977	2.384	2.384	2.820	3.304	3.458	2.560	2.560
D_2	-	2.753	2.722	2.722	56.280	4.042	3.356	2.218	2.218
D_3	-	1.847	1.839	1.839	3.320	4.068	2.478	2.413	2.413
Mean	-	2.193	2.315	2.315	19.280	3.802	3.034	2.406	2.406
LSD	-	1.076	1.367	1.367	80.032	1.830	0.740	0.973	0.973
P≤F		0.198	0.431	0.431	0.310	0.629	0.0147	0.796	0.796

(-): No values

Table 2: Effect of Postharvest Dip on Percentage Tomato Fruit Rotted (%)

Dips	Days in Storage								
	0	3	6	9	12	15	18	21	24
D_1	-	2.446	10.059	10.059	11.642	18.307	10.181	7.529	7.529
D_2	-	4.653	11.984	11.984	11.081	25.030	8.924	2.276	2.276
D_3	-	4.682	7.656	7.656	9.264	15.745	7.048	11.808	11.808
Mean	-	3.927	9.899	9.899	10.591	19.497	8.539	7.969	7.969
LSD	-	2.796	5.033	5.033	2.423	3.260	5.463	6.455	6.455
P≤F	-	0.194	0.234	0.234	0.115	0.0001	0.490	0.017	0.017

(-): No values

4. DISCUSSIONS

There was a slight decrease in the fruit firmness as storage progressed. The firmness value was slightly lower than 0.049kg reported by Ranatunga *et al*. (2009) in their work on effect of measurement of non destructive firmness on tomato quality and comparison with destructive methods. Dip in tap water had significantly higher firmness value followed by Dip in $C_6H_7KO_2$and lastly dip in $CaCl_2$. The result did not agree with the findings of many workers such as Sammi *et al*. (2007) who reported that calcium dips retarded metabolism as indicated by slow ripening rate and improvement of tomato firmness. It is also contrary to the report of Garcia *et al*. (1995) which stated that Ca^{2+} treated fruits showed higher flesh firmness during storage. It also disagreed with Senevirathma and Daundasekera (2010). The reason could be due to some soluble solutes in the tap water used.

Weight loss was significant on only 18th days of storage. Weight loss in the fruits seems to increase from 1.177 to 3.356 kg in dip in tap water. The results agreed with the findings of Nasrin (2008) who stated that physiological weight loss increase with advancement of storage period. Mutari and Debbie (2011) also stated that fruits lose weight when their metabolic rate increases with an increase in temperature around the produce resulting in loss of water associated with weight loss.On the other hand, weight loss decreased from 4.160 to 2.478 in fruits dip in $C_6H_7KO_2$. The decrease weight loss recorded could probably be attributed to the effect of potassium sorbate. Liu *et al*. (2014) in their work on effect of Bentonite/Potassium sorbate coating on the quality of mangos in storage at ambient temperature reported that Bentonite loaded with potassium sorbate resulted in decreased water loss which translates to decrease in weight loss.

Table 3: Effect of Postharvest Dip on Tomato Fruit Ascorbic Acid Content (mg/100g)

Dips				Daysin Storage					
	0	03	06	09	12	15	18	21	24
D_1	15.922	17.664	29.984	29.984	24.528	25.904	31.510	27.208	27.208
D_2	13.372	15.972	24.556	24.556	31.632	30.512	19.940	22.200	22.200
D_3	13.214	21.977	24.724	24.724	19.194	26.767	22.190	26.090	26.090
Mean	13.506	18.570	26.421	26.421	24.764	27.657	24.206	25.400	25.400
LSD	5.052	4.544	6.345	6.345	7.940	4.902	21.979	4.079	4.079
P≤F	0.198	0.0305	0.159	0.159	0.0102	0.153	0.557	0.061	0.061

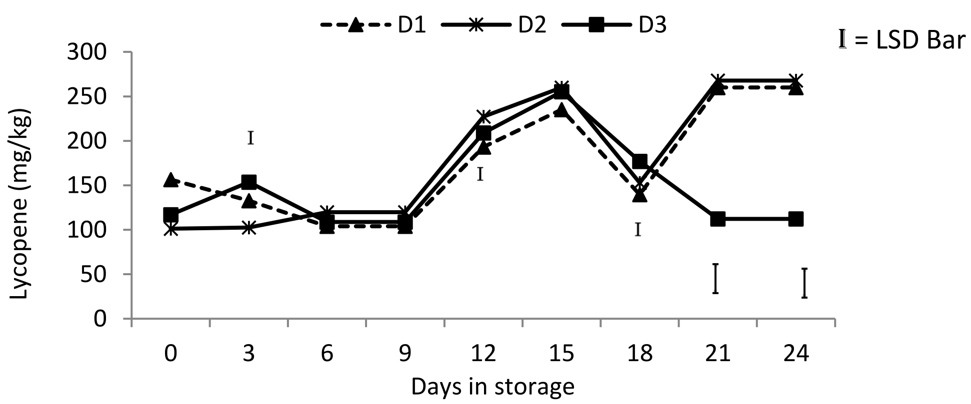

Fig. 2: Effect of Postharvest Dips on Lycopene Contents of Tomato Fruits

Tomato fruit rotting was significant at advanced stage (at 15, 21 and 24 days) of storage; and it generally reduces as storage progressed in all treatments. Fruits dipped in $CaCl_2$ recorded the highest rot of 25.030% on 15th day. The high rotting observed in $CaCl_2$treated fruits compared to Potassium sorbate treated ones can be attributed to the effect of $CaCl_2$ treatment. Moneruzzaman *et al*. (2009) in their work on the effect harvesting and storage conditions on postharvest quality of tomato fruits observed that the highest rotting were in $CaCl_2$ treated fruits.

The result contradicts Pila *et al*. (2010) who reported that $CaCl_2$ treatment resulted in reduction of decay percentage. The observed high rot in fruits dipped in tap wateris not surprising, as Hour *et al*. (2015) stated that although washing tomato fruits with tap water may remove some soil and other debris, it cannot be relied upon to remove micro-organisms and it may even result in cross contamination.

The result of ascorbic acid was significant on only 3 and 12 days. The values were within the ascorbic acid ranges reported by Shahnawaz *et al*. (2012) who reported 7.650 – 31.920 mg/100g and Moneruzzaman *et al*. (2009) who reported 21.030 – 76.56mg/100g. In this study, an increase in ascorbic acid was observed in fruits dipped in tap water and also fruits dipped in $CaCl_2$. This agreed with the finding of Sammi and Masud (2007) who reported significant increase in ripening of tomato fruits and highest Ascorbic acid in Ca^{2+} treated fruits as observed in this study. Gharezi *et al*. (2012) also reported highest Ascorbic acid content in calcium treated fruits. The increase in Ascorbic acid could be attributed to cell wall degradation during ripening process which provides substrates for ascorbic acid synthesis, explaining the ascorbic acid increase with advanced ripening stage (Singh and Yadev, 2015). Increase in Ascorbic acid content is an indication that the fruits is still in ripening stage while a decrease indicates senescent fruit (Sammi and Masud, 2007).

The trend for lycopene development was not regular but in general it can be said to increase with advancement of storage period particularly in fruits dipped in tap waterand those dipped in Calcium chloride. The increase in lycopene in could be attributed to the degradation of chlorophyll and synthesis of lycopene during ripening of tomato fruits as outlined by Gharezi *et al.*,(2012). The values reported in this study were above the values reported by other workers such as Brandt *et al*. (2003) who reported 60 – 160mg/kg and Luna-Guevera *et al*. (2014) who reported 19.9 – 50.3mg/kg. They all agreed that synthesis and development of lycopene depends on a number of factors such as soil, varietal, geographical and cultural differences as well postharvest operations. The results of the study agreed with earlier report of Gharezi *et al*. (2012) and Perumal (1990); they both reported that Calcium chloride treated tomato fruits recorded highest accumulation of lycopene.

Results of this study agreed with Vinha *et al*. (2013) who reported increase in lycopene concentration with advance storage period. Highest concentration of lycopenein fruits dipped in tap wateris in line with the findings of Pila *et al*. (2010) and Sood *et al*. (2011) who all reported accumulation of more lycopene in control set of fruits while the chemically treated fruits showed lesser and slower accumulation of lycopene.

5. CONCLUSION

Results of various postharvest chemical treatments revealed that postharvest dip in 200 ppm Sodium hypochlorite for 5 minutes and 1% Calcium chloride for 5 minutes has significant effect on the quality parameters of tomato fruits. It maintained lower weight loss, lower rot and lycopene development. On the other hand it recorded higher ascorbic values.

Based on the results of this study it can be concluded that the best postharvest chemical dip for tomato fruits in Kura, Kano State is dipping in 200 ppm Sodium hypochlorite for 5 minutes and 1% Calcium chloride for 5 minutes. This should be administered as the only postharvest treatment given to the fruits.

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