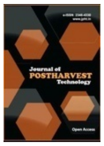

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RESEARCH ARTICLE

Effects of postharvest dipping of sodium hypochlorite and hydro-cooling on the quality of 'Petomech' tomato fruits

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ABSTRACT

A continuing increase in the demand for fresh and processed tomatoes in Ghana from national and international supply points is an indication of the importance of the crop in the fresh produce and retail sectors. The handling of tomato fruits comes with ripening variability which contributes to the faster deterioration during storage. The physiochemical quality of 'Petomech' tomato variety in response to different concentrations of sodium hypochlorite (NaOCl) and hydro-cooling treatments were studied during short term storage at ambient temperature of 25.9°C and relative humidity of 80-85%. The NaOCl at 0, 5% and 10% were applied. Fruits were hydro-cooled by immersion for 15 minutes in water at 23.7°C, agitated water at 20.5°C and non-cooled. The results demonstrated that tomato fruits treated with the combined NaOCl at 5% and hydro-cooling with agitated water significantly delayed weight changes, maintained firmness and gave better soluble solids, titratable acidity and pH compared to uncoated fruits ($P \leq 0.05$). For disease incidence higher beneficial effects were found due to interaction of NaOCl at 5% and hydro-cooling with agitated water (4.47%). Fruits not treated with NaOCl and hydro-cooling gave a significant higher incidence of 33.35%. Based on the results of this study, it was concluded that the combination of NaOCl at 5% as disinfectant and hydro-cooling with agitated water can be applied for short term storage of 'Petomech' tomato fruits. It was also established that treatments can be used as an effective technology to reduce the activity of opportunistic organisms that cause disease incidence at storage.

Keywords: Agitated, Hydro-cooling, postharvest treatment, storage, Tomato.

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INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is one of the most important food crops produced for consumption across the world. Tomato is the second most important economic vegetable produced in the world in terms of land area under cultivation and consumption (Melomey et al., 2022; Piscitelli et al., 2020). The world's total fresh tomato production was approximately 187

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million Metric Tonnes, (FAO 2020). 'Petomech' tomato fruit is a common variety produced at the Dignafuro in the Wa municipality that deteriorates few days after harvest due to lack of postharvest treatments. Paul and Pandey, (2013) reported that approximately 25-40% tomato losses occur due to lack of suitable methods of postharvest storage. Improper cooling and non-application of disinfectants to the fruits results in physiological changes that affect quality. Disinfectants such as anolyte, chlorinated water, thiabendazole solutions are either non available or expensive for small scale farmers. Sodium hypochlorite (NaOCl) is a compound used to maintain and reduce microbial population (Allende et al., 2009: Sun et al., 2012: Zandonadi et al., 2015). Sodium hypochlorite when applied limits the contact between viable pathogenic fungi and the surface of fresh produce eventually killing microorganisms. Cooling of tomato fruits involves the removal of heat to reduce the deteriorative and senescence processes of the fruits (Baladihya and Doshi, 2016). Some benefits of produce cooling has been reported. Cooling minimises metabolic and microbial activity (Tolesa and Workneh, 2017), influenced rate of temperature and moisture loss (Praeger et al., 2020) and reduced the respiration rate (Dirapan et al., 2021: Garrido et al., 2015: Ranjbaran and Datta, 2019). Li et al. (2019) showed that cooling treatment maintained fruit firmness, retarded hydrolysis of polysaccharides to soluble sugar, and decreased fruit decay during storage. Although, the available literature supports the application of hypochlorite or hydro-cooling for treatments of fruits and vegetables, information on the combined effect on the Pectomech variety of tomato fruits during postharvest handling is limited which is the basis for the current study. The main objective of this research was to determine the postharvest dipping effects of sodium hypochlorite and hydro-cooling on the physiochemical quality of 'Petomech' tomato fruits during storage.

MATERIALS AND METHODS

Plant materials

The 'Petomech' tomato fruits were obtained from a local farmer in Dignafuro in the Wa municipality of the Upper West Region of Ghana on the 14th September 2022. The healthy tomato fruits were harvested by hand picking at horticultural maturity with the quality to be used by consumers. The fruits were visually selected on the consideration that they are similar in sizes and maturity with absence of clear visual symptoms of disease. The fruits were carefully placed in corrugated board boxes taken to the postharvest laboratory for the experiment.

Sodium hypochlorite solution

The solution was prepared using w/v% = mass of solute (g)/volume of solution (ml) × 100 according to a procedure described by Shih et al. (2012). Briefly, 5g of NaOCl was dissolved in 100mL of distilled water to prepare 5% NaOCl solution and 10g of NaOCl was dissolved in 100mL of distilled water to prepare 10% NaClO solution at (pH 6.5～7.0).

Hydro-cooling and NaOCl treatments

The tomato fruits of 'Petomech' variety were pre-washed with clean water to remove dirt and allow to air dry. The fruits were divided into 3 groups, (control, 5% NaOCl and 10% NaOCl solutions). A group each was immersed in 5% NaOCl while the other group was immersed in the 10% NaOCl solution for 3min and allow to air dry for 5min. The fruits were hydro-cooled by immersion in tap water at temperature of 23.7◦C and agitated water of 20.5°C at the ratio of sample to washing water 1:10 (w/v) for 15min (figure 1). The non-cooled fruits were fruits that were not immersed in the water. The fruits after hydro-cooling were placed in corrugated cardboard boxes to air dry and kept in ambient temperature of 25.9°C at short term storage for 8 days (figure 2).

Figure 1: Hydro-cooled fruits

Figure 2: Hydro-cooled fruits at storage

Determination of weight changes

The weight of the tomato fruits (10 fruits per replication) was measured on day 0 and every two days by using an electronic weighing scale CEN-TECH China -95364.The weight loss in percentage of the tomato fruits were determine by calculating a percentage of the difference between initial weight and weight at storage as a percentages on a fresh weight basis as described by Moneruzzaman et al. (2009).

$$\text{Weight loss (\%)} = \frac{\text{Initial fruit weight} - \text{Final fruit weight}}{\text{Initial fruit weight}} \times 100$$

Determination of tomato fruit firmness

Firmness was measured using the procedure described by Polenta et al. (2015). The fruit flesh firmness of the three tomato fruits from the replicates were assessed using hand held penetrometer FT 011 standard penetrometer Italy with a plunger of 3mm. Each fruit was tested at two opposite sides by measuring the amount of force (N) to puncture a hole in the fruit and the readings average out.

Determination of total soluble solid

The total soluble solids of the fruits were determined using a handheld refractometer. Three fruits from each treatment was used for this analysis. The fruits were cut into smaller pieces and blended with an electric blender. The juice extracted and sieved with the help of the piece of muslin cloth. A single drop of the sample was carefully placed on the prism of the refractometer using a plastic dropper, and the reading obtained directly as percentage soluble solids concentration (AOAC, 2007).

pH

The fruit pH value was measured using the procedure described by Tigist et al. (2013). Three fruits from each treatment were macerated in a fruit blender and the juice passed through a muslin cloth into a plastic container. Five (5mLs) of sample juice was measured into a clean plastic container and the pH meter was inserted onto the sample juice for 15seconds. The pH is recorded as displays on the pH meter.

Determination of titratable acidity

Titratable acidity was determined using the method suggested by Islam et al. (2013). Briefly a standard NaOH solution (0.1N) was used by measuring 0.1g of NaOH and dissolved in 100ml of Distilled water. 0.5g of phenolphthalein was measured and dissolved in 25mL of ethyl ether to make up the volume of 50mLs with distilled water. Tomato fruits were cut into small pieces and blended in an electric blender.10mLs of the juice was filtered using a funnel with filter paper in a beaker and the volume made up to the 10mLs mark using distilled water. Thereafter, two drops of phenolphthalein indicator were added. 0.1N NaOH was added drop wise and the solution shaken thoroughly until a pink colour is obtained. The volume of NaOH solution used for the titration was recorded. Percent titratable acidity was calculated using the formula below

%Titratable acidity = $(\frac{[\mathbf{V}]\times[\mathbf{N}]\times[\mathbf{E}]}{\mathbf{W}})$ x 100 Where; N is the normality of NaOH, V is the volume of base used, E = factor of citric acid (0.0647) and W is the weight of the sample.

Disease incidence

The disease incidence was assessed as described by Akhtar and Alam (2002) based on the consideration that clear visual signs of fruit discolouration, cracks and loss of firmness were shown.

Disease incidence (DI) = X/N× 100

Where X= number of infected fruits and N = total number of fruits sampled.

Design of experiment

The factors in the experiment were NaOCl (3) and hydro-cooling (3). The experimental design was 3 x 3 factorial design in Complete Randomised Design. Treatment combination was 3 x 3 = 9. There were 3 replications. Total units were 9 x 3 =27 units. Fruits per unit was 15 and total number of fruits was 405.

Data analysis

The data obtained from the study was subjected to an Analysis of Variance (ANOVA) using the computer software MiniTab version 17. The least significant difference (LSD) tests were used to compare differences between treatments at p ≤ 0.05 alpha level.

RESULTS AND DISCUSSION

Weight loss

Weight loss significantly (P ≤ 0.05) increased with storage periods for both treated and control 'Petomech' tomato fruits. The weight loss of tomato fruits as influenced by the interaction effect of hydro-cooling and NaOCl was significantly different (Table 1). At the end of storage, the weight loss was significantly lower in fruits treated in agitated water at 5% concentration of NaOCl (2.71%) compared with the highest non-cooled without NaOCl (12.39%).The reduced weight loss observed for the treated fruits was possibly due to the influence of smaller vapour pressure deficit between the fruit and the surrounding storage environment. The findings are consistent with related research that reported accelerated ripening process of tomato fruits in storage at ambient conditions without cooling as evident in higher physiological weight loss (Cherono et al., 2018;

Sibanda and Workneh, 2019). Similarly, the findings of related studies confirmed the outcome of the interaction effect with the least percentage weight loss for hydro-cooled fruits dipped in NaOCl compared with tap water and non-cooled.(Abba et al., 2017: Abiso et al., 2015)

The results showed a general decrease in the firmness of 'Petomech' tomato fruits during storage. The firmness of tomato fruits as influenced by the interaction effect of hydro-cooling and NaOCl with the exception of day 0 were significantly ($P \leq 0.05$) different (Table 1). At the end of storage, the control clearly showed the least firmness. The firmness was significantly higher in fruits in agitated water at 5% concentration of NaOCl (6.11N) compared with the least non-cooled without NaOCl (0.52N). In the current study the interaction of agitated water hydro-cooling at 5% NaOCl maintained higher firmness which could be attributed to better cell turgor pressure and less enzyme activity. Except that values obtained in the current study were lower than those obtained in related studies, the consequences of using hydro-cooling to delay loss of fruits firmness was reported (Al-Dairi et al., 2021; Pinheiro et al., 2013). On the contrary it was reported that a maximum firmness was found in 1% concentration of sodium hypochlorite for short term water dipping of tomato fruits during storage relative to the control (Ramesha et al., 2018).

Table 1: Hydro-cooling and NaOCl effect on weight and firmness during storage

		Weight loss (%)			Firmness (N)		
Hydro-cooling	NaOCl	0	4	8	0	4	8 (days)
Non-Cooled	0	*	5.86^{a}	12.39^{a}	9.50	4.21^{d}	0.52^{e}
	5%	*	4.58^{bc}	10.97^{b}	10.17	5.69^{cd}	1.38^{cde}
	10%	*	4.69^{bc}	11.53^{ab}	10.57	5.12^{d}	1.15^{de}
Tap H2O	0	*	5.41^{ab}	7.88^{c}	10.17	4.65^{d}	0.75^{e}
	5%	*	4.32^{c}	6.38^{d}	9.46	7.10^{bc}	2.70^{bc}
	10%	*	4.42^{c}	6.64^{d}	10.43	5.92^{bcd}	2.29^{cd}
Agitated	0	*	5.01^{b}	7.20^{cd}	10.00	4.88^{d}	0.86^{de}
	5%	*	1.48^{e}	2.71^{f}	10.31	10.51^{a}	6.11^{a}
	10%	*	3.13^{d}	4.81^{e}	0.99	7.58^{b}	3.96^{b}
F-LSD(0.05)		*	0.88	0.91	NS	1.88	1.53

NS= NO significant difference. * = percent weight loss not computed on day 0. Means in each column followed by the same letter are not significantly different ($p \leq 0.05$) according to the ANOVA and F-LSD test.

TSS

The total soluble solids of tomato fruits as influenced by the interaction effect of hydro cooling and NaOCl was significantly ($P \leq 0.05$) different (Table 2). The Total soluble solids of the tomato fruits as influenced by the interaction effect of hydro-cooling and NaOCl was significantly lower in fruits treated in agitated water at 5% concentration of NaOCl (4.53%) compared with the highest non-cooled without NaOCl (6.81%). Storage at ambient conditions without cooling probably caused the faster conversion of soluble sugars of fruits that resulted in higher TSS values (% Brix) for the control samples. In the current study, interaction of hydro-cooling and NaOCl gave significantly lower TSS that suggested a gradual consumption of primary substrates and ripeness possibly due to lower respiration rate and limited action of pathogenic mircobes. In a related study, Tolesa and Workneh (2017) reported that storage at ambient condition with pre-storage disinfection treatment significantly reduced the levels of TSS content which confirmed the findings of the current study. The values of the TSS of this study, were however higher than those found in a study when cooling and ambient storage were combined on tomato fruits (Awulachew, 2019; Tolasa et al., 2021). The change in TSS of tomato during disinfection process was reported non-significant (Ramesha et al., 2018).

pH

The pH significantly ($P \leq 0.05$) increased with storage periods for both treated and control 'Petomech' tomato fruits. The pH as influenced by the interaction effect of hydro-cooling and NaOCl was significantly lower in fruits treated in agitated water at 10% concentration of NaOCl (4.27) compared with the highest non-cooled without NaOCl (6.55).The combined effects of hydro-cooling and NaOCl treatments significantly demonstrated pH values within acidic range capable of reducing proliferation of microbial activity. The non-cooled fruits stored without NaOCl treatment gave pH values above the desirable threshold of 4.6 possibly due to the faster ripeness level at storage. Similarly, a lower pH of cooled tomato fruits were deductively inferred to be gradual loss of acid content due to its conversion to sugars (Cherono et al., 2018; Pobiega et al., 2020). Contrary to the findings of this study, no significant difference was observed in the pH values of tomato fruits when no cooling and disinfectant were applied (Degwale et al., 2022; Yusufe et al., 2017)

Table 2: Hydro-cooling and NaOCl effect on Total soluble solid and pH during storage

		Total soluble solid (%)			pH		
Hydro-cooling	NaOCl	0	4	8	0	4	8 (days)
Non-Cooled	0	2.73^{ab}	4.74^{ab}	6.81^{a}	4.31	4.84	6.55^{a}
	5%	2.08^{abc}	3.95^{bc}	5.55^{bc}	4.34	4.46	5.28^{bc}
	10%	2.29^{abc}	4.29^{b}	5.88^{b}	4.21	4.31	5.62^{b}
Tap H_2O	0	3.17^{a}	5.01^{a}	6.39^{ab}	3.82	4.31	6.12^{ab}
	5%	1.750^{bc}	3.39$^{d.}$	4.77^{cd}	3.83	4.03	4.51^{cd}
	10%	1.46^{c}	3.68^{bc}	5.05^{c}	4.19	4.36	4.79^{c}

Agitated	0	2.81^{ab}	4.30^{b}	5.62^{bc}	3.69	3.96	5.36^{bc}
	5%	2.00^{bc}	2.23^{de}	4.53^{cd}	3.98	4.36	5.85^{b}
	10%	1.46^{c}	4.79^{ab}	6.11^{b}	4.01	4.12	4.27^{cd}
F-LSD(0.05)		1.21	0.75	0.64	NS	NS	0.67

NS= NO significant difference. Means in each column followed by the same letter are not significantly different (p≤0.05) according to the ANOVA and F-LSD test

Titratable acidity

Titratable acidity generally decrease during storage in both control and treated fruits. The control clearly showed the least titratable acidity at the end of the storage. The titratable acidity of tomato fruits as influenced by the interaction effect of hydro-cooling and NaOCl was significantly (P ≤ 0.05) different (Table 3). The titratable acidity of the tomato fruits as influenced by the interaction effect of hydro cooling and NaOCl was significantly lower in fruits non-cooled without NaOCl (0.49) compared with the highest treated in agitated water at 10% concentration of NaOCl (1.39).The results demonstrated lower percentage of titratable acidity for the non-cooled fruits without NaOCl treatment probably due to highest utilization of citric acid as a primary respiratory substrate. The results collaborated the findings of related study that revealed significant reduction of metabolic changes of organic acids and ripeness of tomato fruits when cooling and disinfectants were applied before storage (Tagele et al., 2022). Contrary to the findings of this study, non-significant difference was observed in titratable acidity after 5days of storage among different cooling treatments (Chandra et al., 2012). The titratable acidity content of control fruits reduced faster than the treated fruits similar to those found in cherry tomatoes (Wu et al., 2016).

Table 3: Hydro-cooling and NaOCl effect on Titratable acidity (%) during storage

		Titratable acidity (%)		
Hydro-cooling	NaOCl	0	4	8 (days)
Non-Cooled	0	2.12	1.42^{b}	0.49^{d}
	5%	2.07	1.42^{b}	0.77^{c}
	10%	2.12	0.80^{d}	0.52^{cd}
Tap H_2O	0	2.06	1.71^{a}	$0 .80^{bc}$
	5%	2.09	1.10^{cd}	0.85^{b}
	10%	2.27	1.28^{c}	1.06^{b}
Agitated	0	2.02	1.54^{ab}	0.81^{b}
	5%	2.42	1.39^{b}	1.14^{ab}

	10%	2.14	1.52^{ab}	1.39^{a}
F-LSD(0.05)		NS	0.40	0.31

NS= NO significant difference. Means in each column followed by the same letter are not significantly different ($p \leq 0.05$) according to the ANOVA and F-LSD test

Disease incidence

The disease incidence was significantly ($P \leq 0.05$) different for both control and treated fruits as storage progressed (figure 3). The interaction of the hydrocooling and NaOCl influenced the percent of disease incidence. In general, the fruits that were treated with agitated water and NaOCl at 5% concentration (4.47%) was significantly lower than all other interactions of hydro-cooling and NaOCl treatments.The highest interaction effect was observed in non-cooled fruits without NaOCl at 33.35%. The disease incidence for non-cooled fruits without NaOCl was higher, probably due to changes from breaker to red mature stages that weakens the cell tugor.The reduction in diesease incidence in treated fruits could be as a result of reduction of microbial load on surface of tomato fruits. Except that the storage durations differed and values reported after precooling were higher than those obtained in this study, the results collaborated general increase in disease incidence of fruits at storage (Moneruzzaman et al., 2009; Rab et al., 2013). The cooling slows metabolic activity which suggests that integrating cooling and disinfectance could maintain the quality and reduce disease incidence of tomato fruits (Tagele et al., 2022).

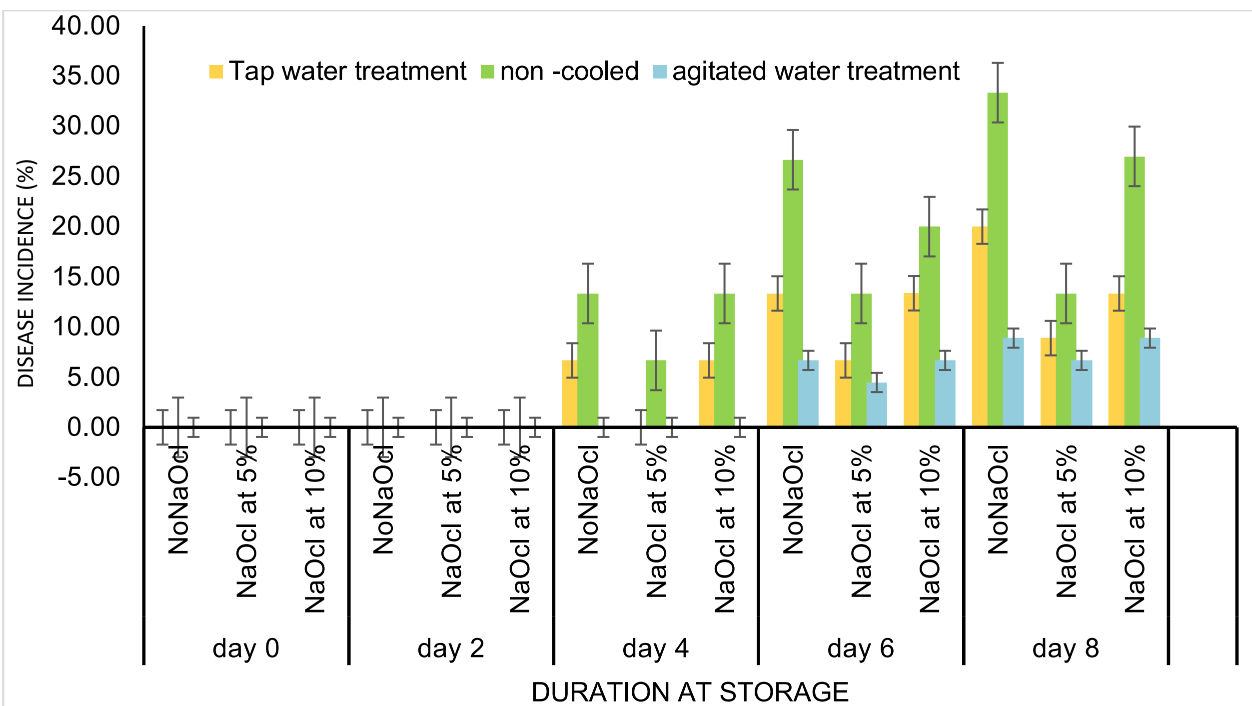

Figure 3: Disease Incidence of ‘Petomech’ Tomato Fruits for Non-Cooled, Tap Water, Agitated Water Hydro Cooling and Non Naocl, NaOCl at 5% and 10% Concentrations stored for a period of 8 days.

CONCLUSION

The hydro-cooling and NaOCl influenced the postharvest qualities in weight loss, firmness, pH, titratable acidity, Total soluble solids and disease incidence. From the results of the study, it was concluded that disease incidence in treated fruits was lower due to reduction of microbial load on surface of tomato fruits. The research revealed that, agitated water hydro-cooling combined with 5% NaOCl maintained fruits quality better relative to all other treatments. The combination of hydro-cooling and NaOCl could provide remedy for short term storage challenges of 'Petomech' tomato fruits. Further studies could be conducted in relation to two levels of agitated water and NaOCl formulations to different storage temperatures.

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