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RESEARCH ARTICLE

Ginger Essential Oil for Postharvest Quality of Datterino Tomato: Effect of Immersion Duration and Storage Temperature

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ABSTRACT

Tomatoes are considered one of the most important components of human diet and there are several issues that affect their shelf-life. This study was conducted to examine the effect of immersing Datterino Tomato in ginger essential oil on qualitative traits during storage. Fruits were stored at 5ºC, 7ºC and 26.9ºC for 14 days. The experiment was laid out using Completely Randomized Design with two replications. The response parameters measured were, cumulative percentage weight loss, titratable acidity, total soluble solids, firmness, taste index and consumer acceptance. There were cases where both Temprature and Essential oil had significant difference. Fruits stored at 26.9ºC lost weight faster than those stored at 5ºC and 7ºC. Samples treated with ginger essential oil however experienced the lowest weight loss as compared to the control samples at all temperatures. The results obtained on firmness, TSS, flavour and acceptance demonstrated significant difference at $P \leq 0.05$ due to both Ginger essential oil and temperature treatments. Fruit firmness at the end of the experimental period revealed that, samples treated with Ginger essential oil for 30 minutes recorded the highest firmness values. Results indicated that, samples treated for 20 minutes recorded the lowest decline in TSS. The results demonstrated that no significant difference at $P \leq 0.05$ was found on both TA, TI and sweetness. Based on the results from the study conducted, Ginger essential oil immersion combined with lower temperatures of 5ºC and 7ºC demonstrated effectiveness in maintaining postharvest quality of Datterino tomato fruit.

Keywords: Datterino tomato, postharvest quality, temperature, essential oil, sensory quality

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INTRODUCTION

Storage of food commodities for later consumption has been necessary in the development of human societies. Most governments of developing nations have focused on the production of perishable food crops such as tomatoes, lettuce, pepper (Isaac et al., 2016) which are difficult to preserve. Tomato losses after harvest remain unacceptably high, and application of appropriate food and postharvest technologies could make a major contribution to improving the world's food supply. Due to the perishable nature of the tomato fruits coupled with challenges faced in logistics and storage facilities, farmers are always faced with high rates of losses. Currently, chemical treatment to reduce postharvest losses is common among the players in supply-chain. But there are concerns about the health and environmental risks associated with this method. The purpose of this study is to explore alternative methods to extend the shelf-life of tomato fruits by providing a

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barrier against hazards, retard moisture migration, reduce respiration rate and delay changes in textural properties using essential oils. Essential oils are defined as the layer of the oil which can be consumed and provide a barrier to oxygen, microbes of external source, moisture and solute movement on preserved fruits (Hoda et al., 2013). Essential oils include aromatic oily extracts obtained from plant materials (Burt, 2004).The role of botanical extract coating treatment in extending postharvest qualities has been demonstrated in some varieties of tomatoes (Zapata et al., 2008; Asgar, et al., 2010).The hydrophobic nature of essential oils and their components enables these compounds to penetrate lipid of fungal cell membrane and mitochondria thus disturbing their structure (Cox et al., 2000). Essential oils are concentrated, hydrophobic liquid containing volatile aromatic compounds that have shown a potential to controlling postharvest quality (Lee et al., 2007). Fruits treated with essential oils have a moderate decline in total soluble solids as associated to some coating materials (Rabiei et al., 2011; Ayman, 2016). Sensory evaluation of treatments coated with essential oils and combined coating with gum and essential oils revealed higher scores (El-Anany et al., 2009; Hoda et al., 2013). Essential oils enhance the ability of the coatings to control gas exchange, thereby reducing moisture loss and increasing juiciness (Plooya et al., 2009). Determination of an appropriate storage temperature is also vital to increase the shelf life of perishables. Grandison (2006) reported that shelf life would double for each 10°C reduction. Visual quality can be maintained by storing tomatoes at 10°C for short period and 5°C for longer period (Cantwell and Saltveit, 2015). Market trends indicate that consumers are paying much attention to flavour and nutritional attributes of foods rather than to texture and colour characteristics (Pardo and Niranja, 2006) and therefore refrigerated products are gaining more importance in the marketplace due to the ability of this technology to maintain the quality factors (Kader, 2001).

Although, separate research work on the effects of essential oils from plants products had been reported, there has not been enough research on combine effects of essential oils from ginger and temperature on perishables. Specifically, the researchers used essential oils extracted from ginger and stored at different temperatures to establish factual evidence of essential oil and temperatures on the storability of Datterino Pachino tomato fruits. To achieve the objectives of the study, weight loss, Total Soluble Solids, (TSS), Firmness, Titratable acid, TSS and acidity ratio, sensory analysis of treated and untreated stored “Datterino Pachino” tomatoes were critically assessed.

MATERIALS AND METHODS

Plant Material

The experimental sample material “Datterino” tomato fruits was harvested at a farm in a local community called Logu in the Upper West Region of Ghana. Fruits were harvested with about 5-10mm long of peduncle on the fruit, free from blemish and defects, with uniform colour. A total of 180 fruits were harvested at the farm for the study. Also, 10 kilograms of Ginger rhizomes were purchased from the Wa Central Market which was used for the oil extraction.

Essential Oil Extraction using steam distillation method

In this research, the separation process that was chosen was steam distillation. Steam distillation is one of the separation processes that use solid-liquid extraction theory. The extraction by steam distillation dried over anhydrous Na_2SO_4 at Wa SH School’s Chemistry laboratory was done using the Clevenger Apparatus. The extractor for this process had three main parts, the Clevenger Apparatus. First, the steam supplied into the vessel. The steam in contact with the ginger rhizome and forces the essential oil out of it. Secondly, a condenser was used to change the mixture of vapour into two separate layers of water

and oil. The distillate in layer occurs because of the difference in density. Lastly, the mixture of water and essential oil (distillate) collected in a conical flask and distillate dried over Na_2SO_4.

Experimental Procedures

Weight loss

Weight loss was evaluated by measuring fruit weight on the first day and weight at storage using an electronic weighing scale, Kern and Sohn GmbH, Germany. The weight loss was computed using in the following formula;

$$\text{Weight Loss} = \frac{W1-W2}{W1} \times 100;\ w_1 \text{ as Initial weight and } w_2 \text{ as Final weight.}$$

The Firmness

Fruit firmness of the stored fruits was determined by measuring the force required for making a pre-determine pierce using fruit pressure tester Model FT327, Italy . The registered force at the penetration of a standard probe up to a certain depth is read as the firmness. The 8mm plunger was used because those with smaller probes are more sensitive to measure changes in texture during refrigerated storage as suggested by Milza et al. (2007). The firmness of the fruits measured using probe and were expressed in kgf.

The TSS content of tomato pulp

The Total Soluble Solid (TSS) content of tomato fruit pulp was determined by using a 76mm Immersion Brannan, UK refractometer by placing a drop of pulp solution on its prism. The percentage of TSS was obtained from direct reading of the refractometer and values reported as per cent Brix.

Total Titratable Acidity content of tomato pulp

At first sample blended, filtered, and transferred to a 250mls beaker, Titrated with 0.1NNaOH. The result was expressed as grams of citric acid g/l.

$$\text{formula: } = V_{NaOH} \times N_{NaOH} \times \left(\frac{0.150}{2}\right) \times \left(\frac{1000}{5}\right) \text{ (Barry, 2014).}$$

TSS and acidity ratio of tomato pulp (Taste Index)

The TSS and acidity ratio of fruit pulp was calculated using the following formula as suggested by Moneruzzaman, et al. (2008)

$$\text{Taste Index} = \frac{\%\text{TSS content of fruit}}{\%\text{Acidity in fruit}}$$

Sensory analysis

Acceptance test was used to determine how much each sample is liked based on a 3 and a 9-point hedonic scales for three attributes. Taste was scored on 3-point hedonic where 3=sweet and 1=poor, flavour using 3= flavourful and 1= poor and

overall acceptance, where 9=excellent and 1=poor. The consumer evaluation test was done by 15 panellists selected using the Triangular approach. These panellists were served 9 plates with samples to chose at random from all replications of the three treatment methods.

Experimental design

The experiment was conducted on a two-way factorial design in a Completely Randomized Design (CRD) arrangement. The design (3^2) has three levels (essential oil treated 20, 30 minutes and Non-treated) and three levels of temperature (26.9ºC, 7ºC and 5ºC) respectively. Each treatment made up of 18 sample materials.

Data Analysis

The trend analysis method was used for firmness, TA, TSS and marketability only on the last day. Data on weight, firmness, TSS, were taken in every two days and TA on day 0 and 14 of the experimental period. Also, data on marketability was assessed on the last day of the experimental period. The analysis of the data was done using Minitab version 17. The data was analysed using the general linear regression model and means were claimed significant at $p \leq 0.05$. Means separation was done using.

RESULTS AND DISCUSSION

Weight loss

Analysis of data generated from the experiment revealed a general cumulative increase in percentage weight loss for all treatments. Fruits stored at 26.5ºC demonstrated that at the end of the experimental period, weight loss value of 6.35% was produced by fruit sample not immersed (CE_0), while immersed fruit for twenty minutes (CE_{20}) was 9.41% and treatment for thirty minutes (CE_{30}) recorded 7.76% (Fig.1).

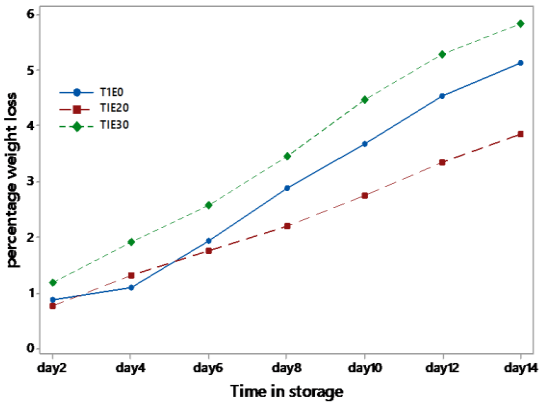

Figure 1: Percentage Weight Loss of tomato fruits treated with ginger essential oil for 20, 30 minutes and control stored at 26.9^0 C for 14 days.

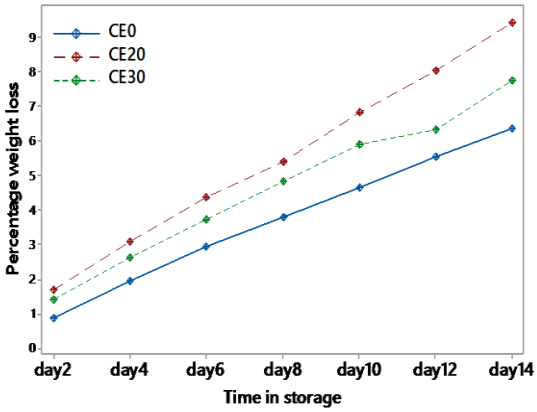

Figure 2: Percentage Weight Loss of tomato fruits treated with ginger essential oil for 20, 30 minutes and control stored at 7^0 C for 14 days.

At lower temperature of 7 ºC, the results indicated that the least cumulative weight loss was produced by immersed fruits for twenty minutes (T_1E_{20}) with a 3.84% compared with 5.13% for sample not immersed ($T_1E_{0,}$) and 5.84% for immersed fruits for thirty minutes (T_1E_{30}) (Fig.2). Fruits stored at 5 ºC showed that, the highest weight loss was produced by sample immersed for twenty minutes (T_2E_{20}) with 6.51% compared with 5.68 for thirty minutes (T_2E_{30}) and 5.23% for fruits not immersed (Fig.3). Comparison of the nine treatments revealed that immersed sample for Twenty minutes was best at low temperature but poor in weight loss at higher temperature. In general analysis of data showed that temperature had significant difference in weight loss. However statistical analysis revealed that ginger essential oil could not produce significant effect on weight.

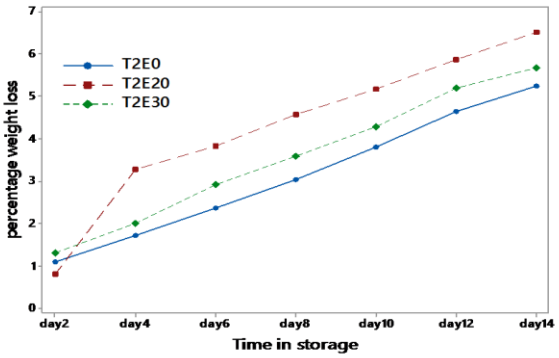

Figure 1: Percentage Weight Loss (PWL) of tomato fruits treated with ginger essential oil for 20, 30 minutes and control stored at 5^0 C for 14 days.

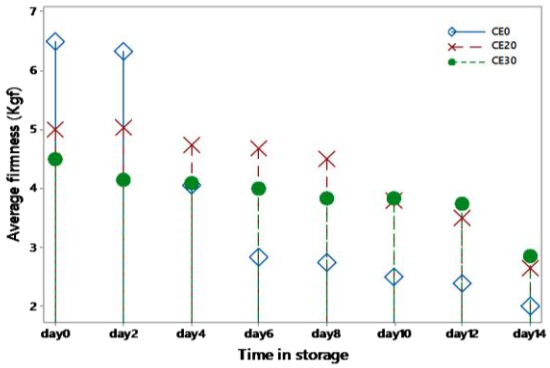

Figure 4: Firmness for Control, 20 and 30 minutes' ginger essential oil treatments held at 26.9^0 C for 14 days.

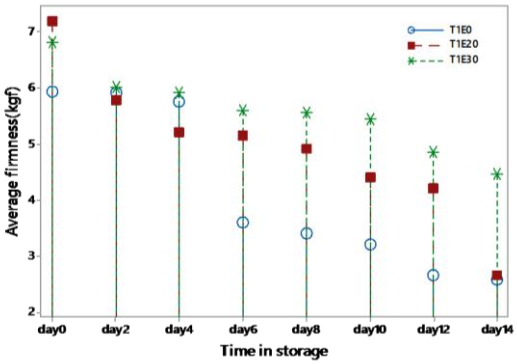

Figure 5: Firmness for Control, 20 and 30 minutes' ginger essential oil treatments held at 7^0 C for 14 days.

Firmness

Analysis of data from the experiment revealed that fruits held at 26.9^0C showed a general decline on firmness. Firmness values recorded for CE_0 was 2.4kgf compared with 2.65 for CE_{20} and 2.85kgf for CE_{30}. Ginger essential oil treatment for 30 minutes recorded highest firmness values. Storage at 7^0C indicated that the fruit sample not immersed (T_1E_0) produced the least firmness with 2.58kgf compared with 2.65kgf for T_1E_{20} and 4 for T_2E_{30} on day 14 (Fig 6). In general, it was clear that for all treatment combinations, longer immersion duration was better in maintaining fruit firmness. The results was clear that the

30 minutes' essential oil immersed fruit recorded the highest firmness. Firmness for fruits held at 5^0C demonstrated inconsistent pattern. At the end of the experimental period firmness values recorded was 2.30kgf for T_2E_0, 3.15kgf for T_2E_{20} and 3.40kgf. Immersion duration and temperature had significant difference on firmness.

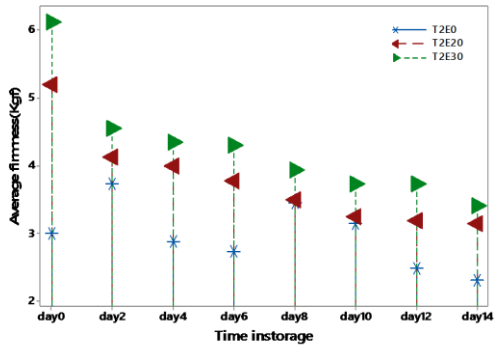

Figure 6: Firmness of Control, 20 and 30 minutes' ginger essential oil treatments at 5^0

Total Soluble Solids (TSS)

The results revealed that, TSS for all treatments generally increased and decline at later stages of the storage period. At the end of the experiment CE_0 produced the least TSS of 2.68% compared with 3.30% for CE_{20} and 4.15% for CE_{30} (Fig.7).Tomato fruits held at 7^0C showed that the highest TSS was found with T_1E_0 with 4%, T_1E_{20} was 5% and T_1E_{30} was 4.% (Fig. 8). For sample held at held at 5^0C, T_2E_0 recorded 4% as compared with T_2E_{20} with 5% and T_2E_{30} with 4% (Fig. 9). It was shown that, 20 minutes' treatment with ginger essential oil recorded the highest content of TSS on day 14 when the experiment was terminated. Results from statistical analysis revealed that ginger essential oil immersion duration treatment have shown significant difference on TSS as well as temperature.

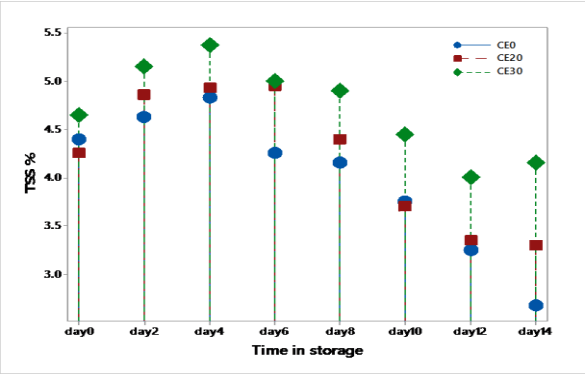

Figure 7: TSS (%) of Control, 20 and 30 minutes' ginger essential oil treatments at 26.9^0 C for 14 days.

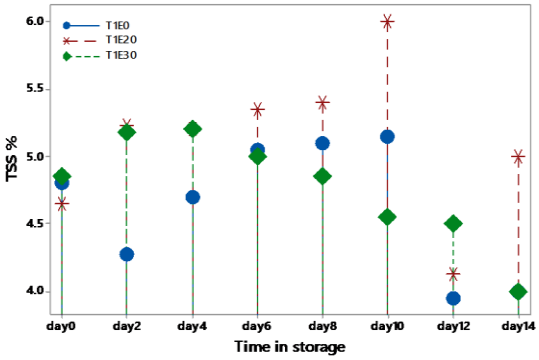

Figure 8: TSS (%) of Control, 20 and 30minutes ginger essential oil treatments at 7^0 C for 14

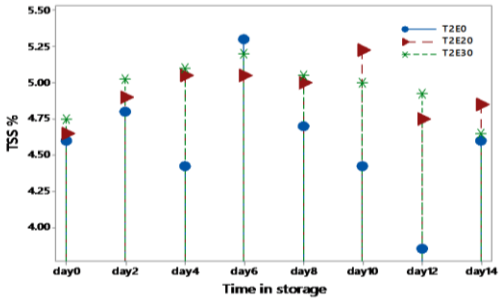

Figure 9: TSS (%) of Control, 20 and 30minutes ginger essential oil treatments at 50 C for 14 days.

Titratable Acid

The results of the study for TA for samples held at 26.9^{0}C demonstrated a general decline of TA for all treatment combinations. TA of Control sample was 6.3g/l of juice, 20 minutes immersion duration was 6.25g/l juice and 30 minutes' treatment was 5.1g/l juice (Fig.10). Also, the results from the experiment for TA values for sample held at 7ºC showed that the control segment of the experiment recorded value of 6.15g/l, compared with 6.3g/l for 20 minutes' treated sample and 8.4g/l 30minutes' immersion duration. The results of tomato fruits held at 5^{0}C revealed that control sample was 6.0g/l compared with 7.95g/l for 20minutes duration and 7.65g/l for 30 minutes (Fig. 11). The results produced from statistical analysis indicated that both ginger essential oil immersion duration and temperature could not produce significant effect on TA (Fig. 12).

Figure 10: TA of Control, 20 and 30 minutes' ginger essential oil treatments stored for 14days at 26.9ºC.

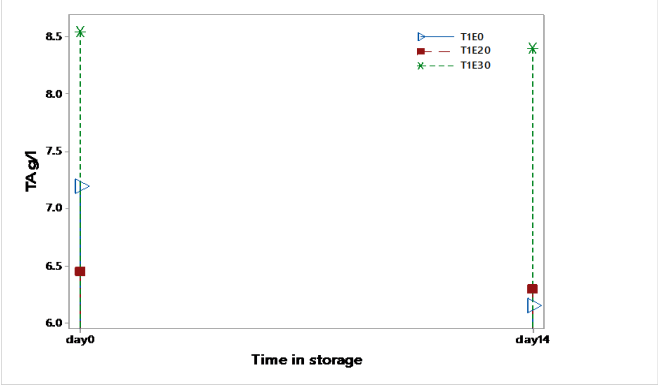

Figure 11: TA of Control, 20 and 30 minutes' ginger essential oil treatments stored for 14 days at 7^0 C.

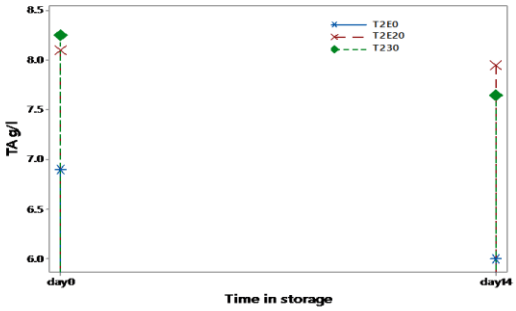

Figure 12: TA of Control, 20 and 30 minutes' ginger essential oil treatments stored for 14 days at 5^0 C.

Taste Index

Samples held at 26.9^{0}C showed that the least Taste Index of 0.42% was found in CE_0 compared to 0.54% for CE_{20} and 0.81% for CE_{30}. The fruits held at 7^{0}C demonstrated that the least Taste Index was found in T_1E_{30} with 0.48% compared with 0.65% and 0.79% for T_1E_0 and T_1E_{20} respectively. However, results for fruits held at 5^{0}C indicated that the highest Taste Index was found in T_2E_0 with 0.77% compared with 0.61% for T_2E_{20} and T_2E_{30} immersion durations (Table 1). Results indicated that ginger essential oil applied as treatment and temperature could not produce any significant difference.

Table 1: Taste Index for all treatments

Days	CE0	CE20	CE30	T1E0	T1E20	T1E30	T2E0	T2E20	T2E30
0	0.60	0.67	0.89	0.67	0.72	0.57	0.67	0.57	0.58
14	0.42	0.54	0.81	0.65	0.79	0.48	0.77	0.61	0.61

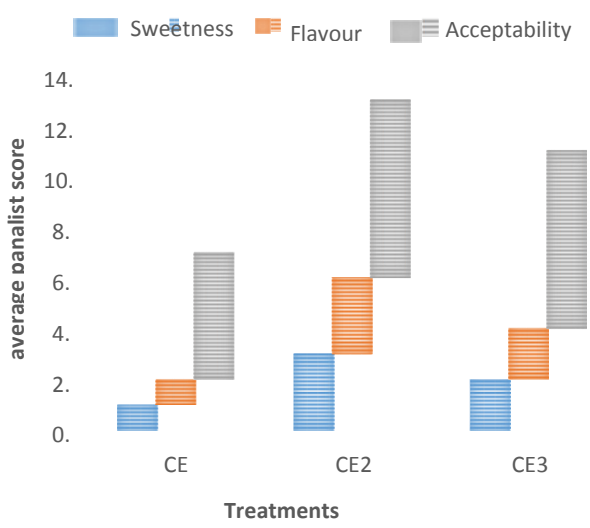

Figure 13: Average Scores of Sensory Analysis for Control, 20 and 30 minutes' essential oil treatments stored for 14 days at 26.9

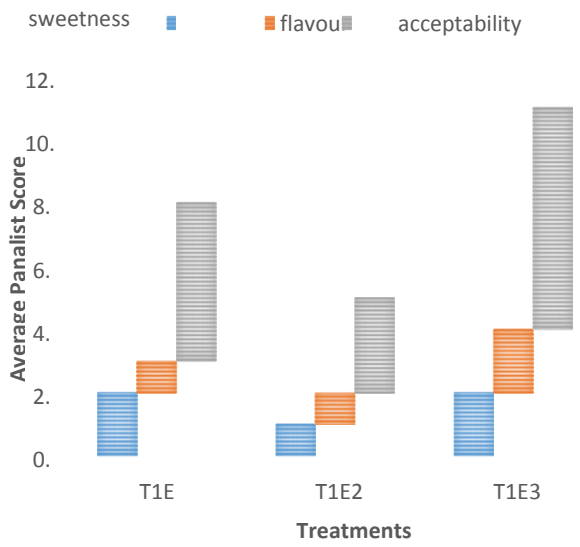

Figure 14: Average Scores of Sensory Analysis for Control, 20 and 30 minutes' essential oil treatments stored for 14 days at 7^0 C

Sensory Analysis

The results produced from the sensory analysis on consumer acceptance for sample held at 26.5C indicated that panalist described sweetness of control sample as sour compared with average sweetness for 30 minutes' essential oil treatment and sweet as the best for 20 minutes immersion duration. The control sample was described as poorly flavoured and average for 30 minutes treated sample. The best flavour was found in fruits immersed for 20 minutes with highest score of 3. For consumer acceptance, immersing durations of 20 and 30 minutes were described as very good but the control sample was at

limit of marketability (Fig 13).Sweetness for control and 30 minutes immersion duration 'held at 7^0C were described as average, but 20 minutes' essential oil treatment described as sour. For flavour, it was clear the control and 20 immersion were described poorly flavoured but 30 minutes immersion duration was found to be average. (Fig.14). The best overall acceptance of very good was found with 30 minutes immersion duration. Results from fruits sample held at 5^0 C showed that, for sweetness the control sample was described as average compared with poor for 20 and 30 minutes treated samples. For flavour, control and 20 minutes were better than 30 minutes' treatment which was scored 1 to mean poorly flavoured. (Fig. 15). All the treatments for overall acceptance were found to be at the limit of marketability. Statistical analysis revealed that, both ginger essential oil and temperature had significant effect on flavour and acceptability but not sweetness.

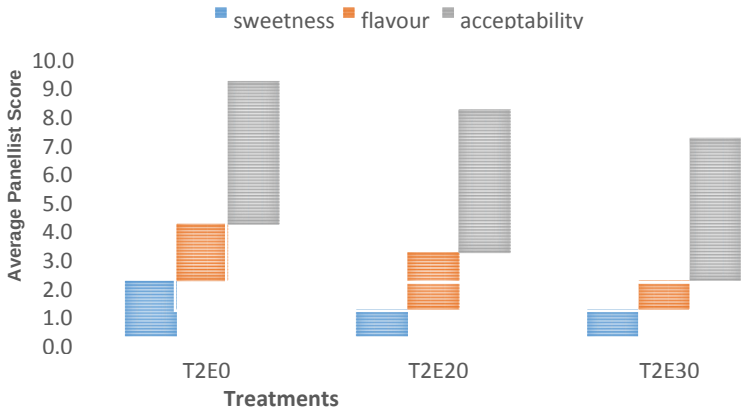

Figure 15: Average Scores of Sensory Analysis for Control, 20 and 30 minutes' essential oil treatments stored for 14 days at 5^0 C

DISCUSSION

Weight loss

The results demonstrated that temperature had significant effect at $P \leq 0.05$. However, no significant difference was found at $P \leq 0.05$ with fruits sample in weight loss due to ginger essential oil treatment. The reasons that may account for the significance differences among treatments could be due to the wide range of temperature differences and respiratory activities. The current research findings partially agreed with earlier research conducted by Genanew, (2013) who revealed that both essential oil and temperature could produce differences among treatment means. Additionally, similar research indicated that typical, Q_{10} values for spoilage reactions are approximately 2, implying that spoilage rates would double for each 10°C rise, or conversely that shelf life would double for each 10°C reduction (Grandison, 2006). Cantwell and Saltveit, (2015) found that temperature produced significant difference among treatment means which further supported the findings of the current research by storing the tomatoes at 5°C for up to 14 days.

Firmness

The results produced from the statistical analysis on Datterino tomato fruits firmness demonstrated that, there was significant difference at $P \leq 0.05$ due to ginger essential oil and temperature. The differences that occurred could be due to the essential oil retardation of exchange of gases and cell wall degradation as well the immersion duration. The differences that was found due to temperature could be because of the warm and cold state of the fruits in the difference storage conditions. The

research findings agreed with several related works that suggested that ginger essential oil provide a barrier to oxygen, microbes of external source, moisture and solute movement on preserved fruits firmness (Lee et al., 2007; Zapata et al., 2008; Hoda et al., 2013). In this research, longer immersion duration maintained better firmness which concurred with related findings that Ginger essential oil treatments delayed the softening of whole tomato significantly during storage with relation to immersion duration (Brummell and Harpster, 2001; Chien et al., 2008; Asgar et al., 2010).

TSS

Statistical analysis of the data revealed that, ginger essential oil demonstrated to have significant difference at $P \leq 0.05$ on TSS as well as temperature at $P \leq 0.05$. In the current research, ginger essential oil treatment could minimise the use of sugars through respiratory metabolism, which resulted in gradual decline in TSS. These findings confirmed the assertion that tomatoes treated with essential oils have a moderate decline in total soluble solids as compared to some materials (Rabiei et al., 2011; Ayman 2016). The findings showed the ability of lower temperatures of 5^0 C and 7^0 C to maintain TSS levels better which is in conformity with research findings that reported that, refrigerated products at lower temperature lead to slower biochemical spoilage and have gained more importance in the marketplace due to the ability of this technology to maintain quality (Kader, 2001; Grandison, 2006).

TA

The results demonstrated that no significant difference at $P \leq 0.05$ was found in TA of Datterino tomato fruit due the immersion in ginger essential oil likewise temperature had no significant difference at $P \leq 0.05$. Although no significant difference was shown, yet the lowest TA was obtained from treatments with ginger essential due to its providing additional semi permeable barrier by decreasing solute migration, oxidative reaction rates and respiration as disclosed by (Park 1999; Castro et al., 2005; Hamid et al., 2011; Hoda et al., 2013). The results of the present study agree with the outcome of Asgar et al. (2010) who observed a lower titratable acidity in treated tomatoes than the control fruits.

Taste Index

Out of the treatments, the highest variations of taste index (TSS/TA) were found in the lowest storage temperatures. However, results showed that taste index in 26.9^0C storage first reached the maximum value of 0.89%. TSS/TA values for CE_{30} were higher than the others. Hodges et al. (2006) found that soluble solids to titratable acidity ratio was highest in higher atmosphere storage of cauliflower which was confirmed by the outcome of the current research. However, essential oil has no significant difference at $P \leq 0.05$ as well as temperature

Sensory Analysis

Both storage time and applied treatments affect the total acceptance of tomato fruit. Sensory evaluation results revealed that treated tomatoes with ginger essential oils and temperature had significant effect at $P \leq 0.05$ on flavour and acceptability. However, ginger essential oil treatment performed better on sweetness than the control. Sensory evaluation of treatments with essential oils and combined temperature revealed higher scores than untreated fruits. The study findings agreed with Asgar, et al. (2010), that control fruits recorded lower acceptance as compared to essential oil treated fruits. Similar results were revealed by El-Anany et al. (2009) when they treated 'Anna' apples with gum arabic coating.The findings also

contradicted findings by Abdul-Rahaman et al. (2016) that immersion and temperature could not influence acceptance scores of fruits.

CONCLUSION

Based on the results from the study conducted, ginger essential oil immersion combined with lower temperatures of 5^0C and 7^0 C demonstrated effectiveness in maintaining postharvest quality of Datterino tomato fruit. The results produced regarding fruit firmness and TSS for fruits immersed in ginger essential oil for 30 minutes at 7^0C and 5^0C which together contributed to a higher consumer acceptable values performed better than the control. Also, the results for TA and weight loss revealed that 20 minutes' immersion period were much appropriate at 7^0C and 5^0C. Based on the results it can confidently be stated that the use of ginger essential oil immersion and lower temperature can be applied for small scale fresh produce and retail sectors.

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