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# Clay cooling pots technologies for storage of Fuzzy Bomb and Bonita Roma varieties of tomato fruits

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## ABSTRACT

Tomato fruits are perishable vegetables that usually deteriorate faster due to insufficient postharvest technologies at the various stages which include harvesting, pre-cooling, packaging, and transportation during marketing and storage. The objective of this research was to evaluate the quality of tomato fruits using single wall and double wall clay pots for storage. Two varieties of mature tomato fruits were purchased from a commercial farmer in the Upper West Region of Ghana in Wa Municipality. A total of 90 fruits without any damage and decay were used for the experiment. The entire sample fruits were divided into three to represent the various treatments. Data were subjected to analysis of variance using Mintab version 16. The two-way ANOVA was used for weight loss and color changes. The general linear model was used for sensory evaluation. On day 10 of the experimental period, the results obtained from weight losses indicated that there was upward increase in weight loss on double wall Bonita Roma with 13.1% compared to Fuzzy Bomb with 9.6%. Based on the results generated on the percentage weight in single wall, Bonita Roma increased to 24.6% compared with Fuzzy Bomb with 15.8%. Eventually, it was clearly indicated that control Fuzzy Bomb recorded the highest average weight loss of 23.5% compared with Bonita Roma with 15.3%. On day 10, the results on color changes indicated that fruits stored in double wall clay pots for Fuzzy Bomb and Bonita Roma were 3.9 and 3.5, respectively, on the average. Furthermore, the comparison of color of fruits in the single wall clay pot for Fuzzy Bomb recorded 3.9 as compared to 3.6 for Bonita Roma . Then, the control Bonita Roma was 3.6 compared to Fuzzy Bomb at 3.8. The overall acceptance for single wall Fuzzy Bomb recorded 21 and Bonita Roma recorded 20.8. Eventually, it was clearly demonstrated that Fuzzy Bomb variety stored in double wall clay pot performed better when compared to Bonita Roma while Bonita Roma stored in single wall clay pot resulted in better storage compared with Fuzzy Bomb variety.

KEY WORDS: Clay pots, color, double wall, tomato fruits, single wall, sensory, total soluble solid, weight

## INTRODUCTION

Food commodity postharvest losses are part of the most serious causes of food insecurity in Ghana. Postharvest loss is any deviation from a normal state of food that prevents it from being consumed by people. Postharvest losses occur in several stages of handling such as harvesting, packaging, transportation, storage, as well as processing lines.Tomatoes are perishable fruits that are faced with short shelf life through insufficient postharvest technologies at the various stages of the supply chain. Dzivama, (2000) indicated that fresh tomato fruits deteriorated at storage and this easily brings about the gradual reduction in the quantity and quality of the commodity. Some varieties usually grown in Wa municipality in the Northern part of Ghana include Fuzzy Bomb and Bonita Roma.There is a general awareness of some challenges which the researchers identify in tomato farmers in Wa municipality which include an inadequate storage facility, inadequate knowledge in the handling technologies, insufficient pre-cooling techniques, and poor harvesting equipment resulting in short shelf life.

One traditional approach to preventing tomatoes from deterioration is using simple technology, the single wall clay pot.The main objective of this research was to evaluate the quality of tomato fruits stored in single and double wall clay pots . Specific objectives of the present study are
(i) to determine a suitable structure for preserving fresh tomato, (ii) to ascertain weight losses of tomatoes stored in single wall and double wall clay pots, (iii) to determine

the color changes in tomato fruits stored in single wall and double wall pots, (iv) to determine the sensory qualities in texture, sweetness, and consumer acceptance of tomato fruit stored in single and double wall pots, and (v) to ascertain the total soluble solid (TSS) of stored tomato fruit in single and double wall clay pots.

Postharvest losses in tomato fruits are attributable to several factors, especially poor storage structures, as well as variations in temperature. According to Cantwell, (2002) first trials of a pot-in-pot proved successful, that eggplant stayed fresh for 27 days instead of 3 days, tomato and pepper lasted for 3 weeks and more. Pinela, *et al.,* (2012) proposed that zeer pot known as double wall clay pot can be operated by the principle of evaporative cooling and can store 12 kg of vegetables keeping them fresh while costing less. Han *et al.,* (2004) proved that the mud evaporative cooler was able to drop the ambient temperature to 10°C and increase the relative humidity of incoming air from 40.3% to 92% for the storage chamber, results also indicated that the cooling capacity and efficiency was higher between 12 and 16 hrs. Buntong (2013) conducted a research with the technology and results demonstrated that the evaporative cooler can reduce the daily maximum ambient temperature from 32–40°C to 24–29°C. Effects of conditions at storage on tomato fruits quality have a greater influence in maintaining the shelf life for fresh tomato fruits. According to Thanh, (2006) tomato fruits with their harvesting details maintain quality as fresh when kept under the refrigeration cool of 35–40°C.

Brown *et al.*, (1992) also noticed that mature-green tomatoes stored at 5°C developed severe pitting after 22 days at storage, while tomatoes stored at 12°C had no pitting. Cultivar had no significance effect on fruit firmness; however, storage temperature had a significant effect, the results showed that tomatoes stored at 12°C tended to have a low firmness this view is supported by Workneh and Woldetsadik, 2004; Workneh, 2010. Several field observations have reported that about 40–50% of horticultural crops, which includes fruits and vegetables produced, are lost during pre-cooling before they can be consumed (Kitinoja, 2002).

## MATERIALS AND METHODS

This section described the constructional stages, experimental design used, and data analysis of the research.

### Construction of the Pots

The construction was started by identifying a fine clayed area at a river site and the area was dug out. The clay was pounded with pestle and mortar, sieved, and was mashed and kept in a hole dug on the ground of the backyard for 3 days in order for it to ferment and get more starch.

The mashed clay was removed and added to dry pounded clay in a pound sieve form and both dry and wet clay substances were kneaded together to get a dough-like mixture. The required number of pots was molded to the required thickness and of the required circumference, and was kept for 24 h. A smoothing stone and water were used to smoothen the pots, a decorator known locally as "*kusaahaa"* was used to put designs on the pots (Figure 1).

### Preparing the Clay Pot

In preparing the pots, an area was identified outside the backyard and lined with stones in a circular form. *Dawadawa* shelves were also lined inside the circle of stones and pots were placed inside and were covered. Fire was lit, it left to burn for 24 h, and was cooled down before the pots were removed, cleaned, and became ready for use. (Plate 1).

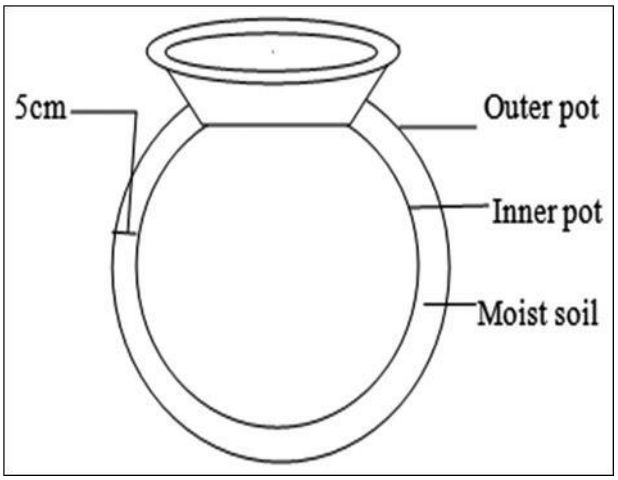


**Figure 1:** Double wall pot

**Plate 1:** Single and double wall clay pots

### Plant Materials

Mature tomato fruits were purchased from a commercial farmer in the Upper West Region Wa Municipality at a community called Kpongu. A total of 90 fruits without any damage and decay were used for the experiment. The entire fruit was divided into three to represent the various treatments. Tomato fruits were washed to remove dirt and allow to air dry naturally before storage in the different structures. Both single and double wall pots, held 5 fruits for a period of 10-day. The space between the double wall pots was filled with sand and water. The produce was then put inside the pot and data taken and finally covered with cloth.

### Design of Experiment

In this experiment, the researchers were dealing with two varieties of tomatoes, namely Fuzzy Bomb and Bonita Roma tomato stored in single wall and double wall clay pots. 6 single wall and 6 double wall pots were used each containing 5 tomato fruits and stored for a period of 10 days. 15 fruits of each of the two varieties were left on control and monitored together with the fruits in pots. Completely randomized design was the experimental design applied.

### Statistical Analysis

Data were subjected to analysis of variance using the Mintab version 16. The two-way ANOVA was used for weight loss and color changes. The General Linear Model was used for sensory evaluation. And, data on the sensory evaluation were transformed into their log forms to allow for the use of ANOVA. Means were claimed significant at $P \leq 0.05$. Means separation was done using individual Fisher's error rate, where applicable.

## RESULTS

### Percentage Weight Losses of Tomato Fruits

The results obtained from percentage weight loss of fresh fruits of Fuzzy Bomb and Bonita Roma tomato varieties stored in single wall clay pots, double wall clay pots, and control environment indicated that the Bonita Roma variety stored in double wall pot on day 2 recorded an average weight loss of 0.4% as compared with 0.7% in Fuzzy Bomb. But, single wall Bonita produced a weight loss of 4.1% compared with 1.7% by Fuzzy Bomb (Figure 2). The control samples of Bonita Roma and Fuzzy Bomb produced percentage weight loss of 2.1% and 3.3%, respectively.

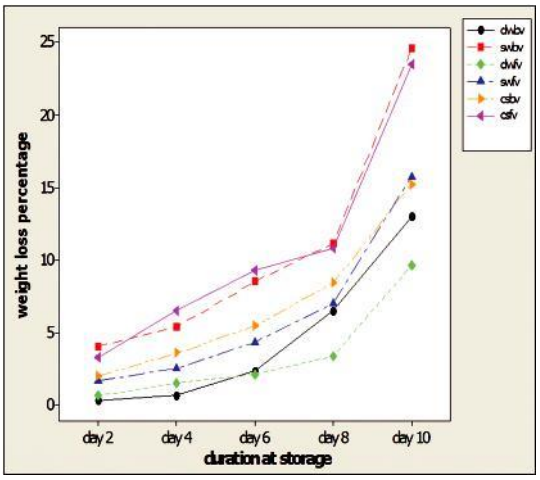


**Figure 2:** Weight losses of tomato fruits stored in double and single wall clay pots and control

Meanwhile on day 6, fruits stored in double wall pots Fuzzy Bomb recorded an average weight loss of 2.2% compared with Bonita Roma's 2.4%. Data on single wall clay pot showed that Bonita variety had increased weight loss with 8.5% as compared with 4.4% of Fuzzy Bomb.The control samples on Bonita Roma showed increase weight loss of 5.5% compared with Fuzzy Bomb with 9.3%.

However, on day 10 of the experimental period, the results obtained from weight losses indicated that there was upward increase in weight on double wall Bonita Roma 13.1% compared to Fuzzy Bomb with 9.6%. Based on the results generated on the percentage weight in single wall Bonita Roma increased to 24.6% compared with Fuzzy Bomb with 15.8%. Eventually, it was clearly indicated that control Fuzzy Bomb recorded more average weight loss of 23.5% compared with Bonita Roma with 15.3%, but the highest weight loss was found with Bonita Roma.

### Color Appearance

The results produced on color changes of tomato fruits stored in double clay pots, single wall clay pots, and control temperature indicated that on day 2 of the experimental period in the double clay pot Fuzzy Bomb recorded an average color of 1.3 compared with Bonita Roma with 1.5. Data on single wall clay pot showed that Bonita Roma recorded 1.5, while the Fuzzy Bomb recorded 1.2. The control sample of Fuzzy Bomb recorded 1.4, and the Bonita Roma recorded 1.2 (Figure 3).

Furthermore, the results obtained on color changes on day 6 double wall pot were 2.2 for Bonita Roma compared with 2.3 for Fuzzy Bomb. While single wall clay pot of Bonita Roma was 2.4 being more colorful as compared

with Fuzzy Bomb with 2.1. Fruits stored as control were changing faster from slightly yellowish to reddish which indicated that the control Fuzzy Bomb recorded the highest of 3 compared with Bonita Roma with 2.8. On day 10, results indicated that fruits stored in double wall clay pots with Fuzzy Bomb and Bonita Roma were 3.9 and 3.5, respectively. Moreover, the comparison of color of fruits in the single wall clay pot for Fuzzy Bomb recorded 3.9 as compared to 3.6 for Bonita Roma. Then, the control Bonita Roma was 3.6 compared to Bonita Roma 3.8.

### Sensory Evaluation

The results produced on the sensory evaluation from fresh tomatoes fruits stored in the three conditions were evaluated and scored by 13 untrained panelists indicated that the overall acceptance for double wall Fuzzy Bomb recorded 23. 5 compared with Bonita Roma, 23.2.Texture for Fuzzy Bomb recorded 7.8 while Bonita Roma was 7 and sweetness for Fuzzy Bomb recorded 7.2 and Bonita Roma 7.7 (Figure 4).

The overall acceptance for single wall Fuzzy Bomb recorded 21 and Bonita Roma recorded 20.8. The texture in single walls for Fuzzy Bomb recorded 7.5, while Bonita Roma was 6.2 and sweetness for Fuzzy Bomb recorded 6.2, and Bonita Roma 7.2.

The overall acceptance for control samples for Fuzzy Bomb recorded 3.3 compared with Bonita Roma with 7.3. Texture values of 2 and 0.8 were produced for Fuzzy Bomb and Bonita Roma, respectively. Sweetness for the Fuzzy Bomb was 1 while Bonita Roma 1.4.

### TSS

Based on the results produced on the TSS of tomato fruits, Bonita Roma and Fuzzy Bomb varieties stored in double wall clay pot, single wall clay pot, and the control sample for an experimental period of 10-day, Bonita Roma at day 0 was 6.5 and Fuzzy Bomb at day 0 was also 6.5 which increased to 7.2 and 6.8, respectively (Figure 5). Also, results obtained on the TSS of fruits on control sample recorded 8 for Bonita Roma compared with 7.4 for Fuzzy Bombs. Eventually, the highest TSS was found with Bonita Roma, and the least was found with Fuzzy Bomb.

## DISCUSSION

### Weight Reduction Percentage

The results obtained from the statistical analysis on percentage weight loss of tomato fruits stored in the three conditions demonstrated that there were significant differences at $P \leq 0.05$ in weight loss due to varieties of tomato fruits storage in the three conditions. However, no

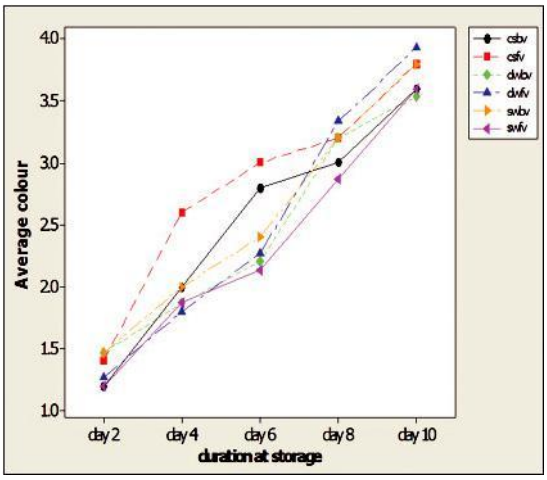


**Figure 3:** Color appearance of the tomatoes fruits stored in double and single wall clay pots and control

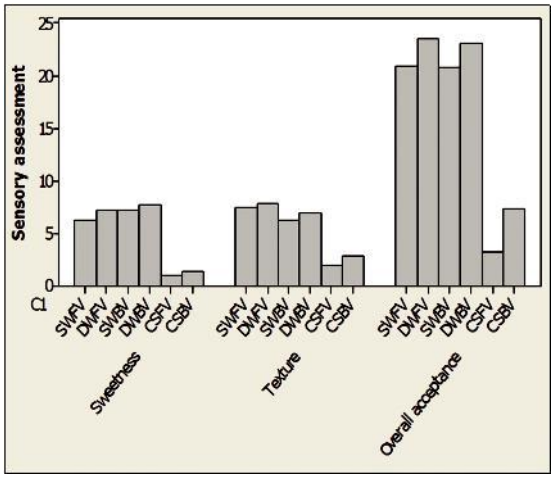


**Figure 4:** Sensory evaluations of the tomato fruits stored in the double and single wall clay pot and control

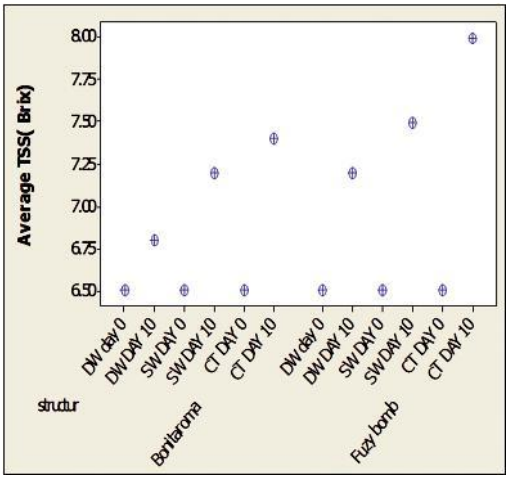


**Figure 5:** The total soluble solid of the tomatoes fruits stored in the double wall clay and single wall clay pots and control

significant difference in weight loss of tomato fruits due to the three storage conditions was produced (Tables 1 and 2).

The results; however, could not produce and interaction effect. The factors that may have accounted for the results obtained could be due to pre-harvest treatments, temperature, and relative humidity. This agrees with the findings by Parker and Maalekuu (2013) which stated that maintaining high humidity around harvested produce reduces water loss, which would result in decreased returns through poor quality and loss of saleable weight. Kitinoja (2002) also reported that due to high rates of bruising, there is water loss and subsequent decay during postharvest handling that enhances weight loss. Similarly, Mohamed, (2004) added that quality of most fruits and vegetables is affected by water loss during storage, which depends on the temperature and relative humidity.

### Color Appearance

The result produced by statistical analysis on color changes of tomato fruits stored in the three storage conditions of the experimental period demonstrated that there were significant differences at $P \leq 0.05$ in color changes due to varieties of tomatoes fruits . However, results obtained from the three storage conditions indicated that there was no significant difference at $P \leq 0.05$ due to storage structures (Tables 3 and 4).

Also, the differences that were observed on the results of color changes indicated that there was no interaction effect at $P \leq 0.05$. The results produced on color changes of Bonita Roma, and Fuzzy Bomb tomato fruits could be as a result of ripening and heat. This research partially agrees with the earlier research by Dvizama, (2000), which stated that fruit quality is affected by ripeness stage, time of removal from the plant, handling conditions and frequency, storage temperature, and time. Znidarcic and Pobrl, (2003) also discovered that tomato fruits still live and respire after harvesting; however, their quality and appearance change during postharvest handling.

### Sensory Evaluations

The results obtained from the sensory evaluation of blind taste test on overall acceptance from the score of 13 untrained panelists indicated that there were no significance differences on sweetness at $P \leq 0.05$ due to varieties of tomato fruits stored in the three conditions.

Also, results obtained from the statistical analysis on the sensory evaluation on consumer acceptance of tomato fruits stored in three storage conditions demonstrated that there were no significant differences on sweetness at $P \leq 0.05$ due to the storage structures (Table 5). Again results obtained from the statistical analysis on sensory evaluation texture of tomato fruits stored in three storage conditions revealed that there were no significance differences in texture due to varieties and no significance difference in texture due to storage structures (Table 6). The results obtained from the statistical analysis on the sensory evaluation on consumer overall acceptance of tomato fruits stored in three storage conditions indicated that there were significance differences in varieties and no significance difference due to storage structure (Tables 7 and 8).

The results could not produce any interaction effects. The difference in taste could be as a result of harvesting time and postharvest treatment such as temperature. This finding agreed with Murugan *et al.*, (2011) that the retaining ability of organoleptic value earthen pot cool chamber was better when compared to the products stored at room chamber. However, this finding contradicts with Jones (1999) research which discovered that fruit that remain attached to the plant longer are generally more flavorful but agrees with Malundo *et al.*, (1995) that taste (sweetness and sourness), and acceptability of tomatoes are normally affected by sugar and acid levels, at storage.

**Table 1: Two-way ANOVA on weight loss in double and single wall clay pots and control temperature**

| Source | DF | SS | MS | *F* | *P* |
|---|---|---|---|---|---|
| Variety | 1 | 449.31 | 449.307 | 20.27 | 0 |
| Storage structure | 2 | 143.08 | 71.542 | 3.23 | 0.057 |
| Interaction | 2 | 15.74 | 7.869 | 0.36 | 0.705 |
| Residual | 24 | 531.88 | 22.162 | | |
| Total | 29 | 1140.01 | | | |

DF: Degree of freedom, SS: Sum of squares, MS: Mean of squares

**Table 2: Single factor ANOVA on weight losses for double and single wall clay pot and control temperature**

| Variety | *N* | Mean | Grouping |
|---|---|---|---|
| Bonita Roma | 15 | 11.013 | A |
| Fuzzy Bomb | 15 | 3.273 | B |

**Table 3: Two-way ANOVA of color changes of tomato fruits**

| Source | DF | SS | MS | *F* | *P* |
|---|---|---|---|---|---|
| Variety | 1 | 15.7398 | 15.7398 | 68.19 | 0.000 |
| Storage structure | 2 | 0.2915 | 0.1458 | 0.63 | 0.54 |
| Interaction | 2 | 0.0991 | 0.0496 | 0.21 | 0.808 |
| Residual | 24 | 5.5399 | 0.2308 | | |
| Total | 29 | 21.6703 | | | |

DF: Degree of freedom, SS: Sum of squares, MS: Mean of squares

**Table 4: Single factor ANOVA on color changes of tomato fruits**

| Variety | *N* | Mean | Grouping |
|---|---|---|---|
| Bonita Roma | 15 | 3.262 | A |
| Fuzzy Bomb | 15 | 1.8133 | B |

**Table 5: ANOVA for sweetness of tomato fruits**

| Source | DF | Sequential SS | Adjusted SS | Adjusted MS | *F* | *P* |
|---|---|---|---|---|---|---|
| Variety | 1 | 0.02529 | 0.02529 | 0.02529 | 1.030 | 0.327 |
| Storage structure | 2 | 0.00762 | 0.00762 | 0.00381 | 0.16 | 0.857 |
| Residual | 14 | 0.34329 | 0.34329 | 0.02452 | | |
| Total | 17 | 0.3762 | | | | |

DF: Degree of freedom, SS: Sum of squares, MS: Mean of squares

**Table 6: ANOVA for texture for tomato fruits**

| Source | DF | Sequential SS | Adjusted SS | Adjusted MS | *F* | *P* |
|---|---|---|---|---|---|---|
| Variety | 1 | 0.00345 | 0.00345 | 0.00345 | 0.210 | 0.654 |
| Storage structure | 2 | 0.04399 | 0.04399 | 0.02199 | 1.34 | 0.294 |
| Residual | 14 | 0.23027 | 0.23027 | 0.01645 | | |
| Total | 17 | | | | | |

DF: Degree of freedom, SS: Sum of squares, MS: Mean of squares



**Table 7: ANOVA of overall acceptance for tomato fruits**

| Source | DF | Sequential SS | Adjusted SS | Adjusted MS | *F* | *P* |
|---|---|---|---|---|---|---|
| Variety | 1 | 0.125894 | 0.125894 | 0.125894 | 12.710 | 0.003 |
| Storage structure | 2 | 0.011291 | 0.011291 | 0.005645 | 0.57 | |
| Residual | 14 | 0.138672 | 0.138672 | 0.009905 | | |
| Total | 17 | 0.275857 | | | | |

DF: Degree of freedom, SS: Sum of squares, MS: Mean of squares

**Table 8: Single factor ANOVA on sensory evaluation for tomato fruits**

| Variety | *N* | Mean | Grouping |
|---|---|---|---|
| Bonita Roma | 1 | 90.5180 | A |
| Fuzzy Bomb | 2 | 90.3793 | B |

Means that do not share a letter are significantly different

## CONCLUSION

As postharvest researchers who are attempting to unearth and improve technologies to extend shelf life management of fresh fruits in horticulture, the state of the results offered a solid ground to present the following as concluding remarks.

Based on the results generated on the data analysis on percentage weight loss, color appearances, and the sensory evaluation demonstrated that Fuzzy Bomb variety stored in double wall clay pot after the 10 days maintain shelf life better when compared to Bonita Roma. For color changes, the research revealed that Bonita Roma stored in the double wall clay did better after the experiment as compared with Fuzzy Bomb while in sensory evaluation, scored by the 13 untrained panelists, Fuzzy Bomb performed better than Bonita Roma. For TSS, the researchers discovered that control Bonita Roma performed better compared with Fuzzy Bomb varieties.

- Based on the findings, the first null hypotheses cannot be validated
- Also, variety produced difference in color and the second null hypotheses cannot be accepted
- No difference was produced on texture and therefore, the null hypotheses on firmness was true and should be accepted
- Significant differences were also not found with TSS with varieties or storage conditions.

Eventually, it was clearly demonstrated that Fuzzy Bomb variety stored in double wall clay pot performed better when compared with Bonita Roma while Bonita Roma stored in single wall clay pot resulted better compared with Fuzzy Bomb variety.

## RECOMMENDATIONS

Based on the findings on the use of double wall clay pots, single wall clay pots, and control sample in cooling and storage of fresh tomato fruits, the researchers would like to come up with the following recommendations:

- Researchers should try to come out with more clay technologies for cooling and storage of perishable produce such as fresh tomatoes to ensure its availability for consumers all year round
- In subsequence research, storage structures double wall clay pots should be molded higher to prevent evaporation
- The sample size should be increased from 90 to 120 to allow for broader assessment of the treatment means
- The duration of storage of fresh tomato fruits should be extended from 10 to 15 days to determine appropriate consumer acceptability
- Trials of this experiment should be undertaken at the peak of harvest to allow for the repetition of the entire experiment
- Experiment should be conducted by placing the storage structures in the field to discover the field conditions
- Same fruit size should be used to ensure accurate treatments
- Amount of water to be used in watering the sand placed inside the space of the double wall pots should be calculated to determine effect of quantity of water
- Tomato fruit should be considered from different farming communities to determine the effect of farming practice on shelf life.
- Organically produced fruits should be compared with inorganic produce using one pot design.

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