**Agricultural Science Research Journal**
ISSN 2026-6073
Baffour E.K. *et al*, Volume (11) Issue (6): 147 – 153 June – 2021.
RESEARCH PAPER

# Impact of different packaging materials on the fruit quality of tomatoes from Akumadan (Offinso North District, Ashanti region of Ghana)

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## Abstract

**Tomato (Solanum lycopersicum L.) is the most widely cultivated horticultural crop in Akumadan and its environs. It is one of the highly perishable vegetable and it changes immediately after harvesting. There are many postharvest technologies that extend marketable shelf life of tomato fruits and other vegetables. Different packaging materials were evaluated to access their impact on the shelf life and quality of tomato fruit in Akumadan in the Offinso North district in the Ashanti region of Ghana. Packaging materials (treatments) which include; jute sack, wooden box, and plastic basket were evaluated under an ambient condition (30±2oC). Laboratory bench was used to store tomato fruits term as control. 10 kg of freshly harvested tomatoes were kept in each treatment in a completely randomized design (CRD) with three (3) replications and stored for five (5) days. Tomatoes were sampled from each treatment from the bottom, middle, and the top for analysis. Fruit firmness, dry matter content, Weight loss, fruit decay, Vitamin C, Titratable acidity, total soluble solids, and pH of the various treatment were analysed. The results showed that, the treatments significantly ($p>0.005$) affected fruit decay, moisture content, and pH of the tomatoes whilst dry matter content, firmness, soluble solids, titratable acidity and vitamin C were insignificant ($p<0.005$). Decaying of tomatoes was more evident in jute sack giving an indication an aerated material is ideal for tomatoes storage.**

**Keywords: Akumadan, tomatoes, firmness, titratable acidity, soluble solids**

## Introduction

Tomato (Solanum lycopersicum L.) is one of the most important fruit vegetables consumed in Ghana. The phytochemicals component of tomato including carotenoid has necessitated the recent increased in tomato consumption in Ghana and around the world (Chapagain and Wiesman 2004). Carotenoids are responsible for the colour in tomatoes which are synthesized massively during fruit ripening. Other notable chemical component of tomato also include vitamin C. Depending on variety and growing conditions, the vitamin C content of tomatoes may vary between 39-263 mg/100 g (Guil-Guerrero et al., 2009). Postharvest handling of tomatoes is very crucial in reducing the rate of respiration and concomitant control of the ethylene production (Fagundes et al., 2015). Many strategies and techniques are being investigated to reduce these changes in tomato fruits and to enhance the quality over a period of time. Being a climacteric and perishable vegetable, tomatoes have a very short lifespan, usually 1 to 2 weeks (Sibomana et al., 2015). Several means have been used to prolong fruit storability during postharvest, such as cold storage. However, the choice of packaging materials is a key factor to obtain optimum modifications of the atmosphere and to avoid extremely low levels of O2 and /or high levels of CO2 which could induce anaerobic metabolism with the possibility of off-flavor generation and the risk of anaerobic microorganism proliferation (Ullah, 2009). Tomato fruits must be properly handled after harvest in order to maintain quality and enhance consumer appeal during sale. The quality of tomato is determined by appearance, firmness, weight, titratable acidity, soluble solids, flavour, and the nutritive value (Aramyan, and van Gogh, 2014). These quality parameters are affected by several factors such as postharvest handling techniques, packaging materials and storage conditions. Commercially, different packaging materials are used in the retail market for the sale of fresh produce such as tomatoes (Ali, 2004). As indicated above, the properties of these packaging materials may influence the product quality. Hence, this study ought to investigate the impact of packaging materials such as jute sack, wooden box, and plastic basket on the quality of freshly harvested tomato fruits in Akumadan.

## Materials and Methods

### *Study Area*

Akumadan is located in the Offinso North district in the Ashanti Region of Ghana. It is located in the extreme North-West of the region and lies within longitude 1°45W and 1°65W. The district lies within the semi-equatorial region with a bi-modal rainfall regime and annual rainfall ranging between 700 mm and 1200 mm. The major rainy seasons starts from March – Mid July whilst the minor seasons start in September and ends in mid-November. Humidity is very high during the raining season, reaching 90% between late May and early July.

### *Experimental Design*

Freshly harvested tomatoes of the same variety (Akoma) were sampled from farms in Akumadan with uniform sizes and colour without any signs of bruises or infection. The tomatoes were sorted, cleaned, weighed, and packaged in jute sack, wooden box, and plastic basket under an ambient condition 30±2oC. Laboratory bench was used to store the fruits term as control. Distilled water was used for cleaning. 10 kg of freshly harvested tomatoes were kept in each treatment in a completely randomized design (CRD) with three (3) replications and stored for five days. Tomatoes were sampled from each treatment from the bottom, middle and the top for analysis. Fruit firmness, dry matter content, weight loss, fruit decay, vitamin C, titratable acidity, total soluble solids, and pH were analysed.

### Weight loss

Tomato fruits were weighed daily and the differences in weight loss were expressed as a cumulated percentage of weight loss from the initial weight of the fruit.

The weight loss was calculated as shown in the equation below.

$$\% \text{ weight loss} = \frac{W0-Wt}{W0} \times 100$$

W0= Average weight of the tomatoes at day 0
Wt= Average weight of the tomatoes after nine days of storage

### *Firmness*

Firmness was determined by measuring the force required for making a pre-determine pierce using a standard probe. The registered force at the penetration of a standard probe up to a certain depth was read as the firmness. The firmness of the fruits was recorded using penetrometer (Giovannoni et al*.,* 1989).

### *Fruits decay*

Fruit decay was determined by visual observation for symptoms of fungal mycelia growth. Decay was expressed as accumulated percentage of the total fruit decay divided by the initial fruit number stored.

### *Vitamin C*

Vitamin C content was determined by using the 2, 6-Dichloroindophenol Titrimetric method and the results reported as mg/100g of tomato fruit (Mumneek et al.,1954).

### Titratable acidity

10ml of juice from the various treatments were samples and titrated with 0.1M NaOH. The results are expressed in percentage citric acid (AOAC, 2000).

### *Total Soluble Solids*

Soluble solids were determined using digital refractometer (Reed MT-032 Brix Refractometer, Taiwan) and the value reported as Degree Brix (Astuti et al., 2018).

### *pH*

The pH was measured by using a pH meter. The tomatoes were washed and liquefied using fruit pressing machine to obtain juice. Fifty (50) ml of tomato juice was taken from each treatment, and the pH was measured by direct immersion of the electrode in the juice (Astuti et al.,2018).

### *Statistical analysis*

Data was analysed using analysis of variance (Anova) and treatment means were separated using TUKEYS HSD at ($p \leq 0.01$). Correlation analysis was carried out to determine the association between the quality parameters using GenStat statistical package

## Results

The results showed that the treatments affected fruit decay, moisture content, and pH of the sampled tomatoes significantly($p>0.005$) whilst dry matter content, firmness, soluble solids, titratable acidity, weight loss, and vitamin C were insignificant ($p<0.005$) giving an indication that the treatments did not had any impact on these parameters. Basket and box packaging material (Figure 1) recorded the highest dry matter content whilst sack packaging material recorded the least dry matter similar to the control. The least fruit decay (Figure 2) was recorded in basket and box packaging materials with sack recording the highest percentage of fruit decay within the five days storage duration. Sack packaging material (Figure 3) recorded the least fruit firmness whilst basket and box packages maintained a higher level of firmness within the stipulated storage duration. Box packaging recorded the highest moisture content followed by the control whilst sack and basket packaging material recorded ackaging material recorded slightly higher pH level than box and basket packaging materials (figure 5). The control recorded the highest total soluble solids (Figure 6) followed by box packaging whilst basket and sack recoded slightly similar results. The titratable acidity (Figure 7) of the tomato fruits was influenced by the treatments such that sack and basket packaging. The impact of box basket packaging was evident on the vitamin C content (Figure 8) of tomato fruit followed by box packaging whilst box and basket packaging produced results similar to the control with regard to the weight loss of tomato fruit within the five days storage duration (Figure 9).

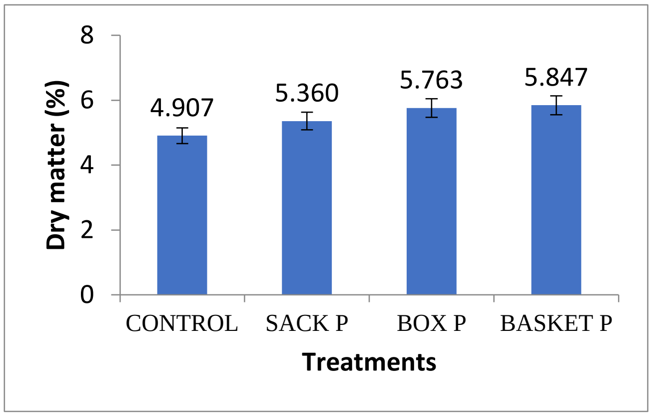


**Figure 1:** Effect of packaging materials on dry content of tomato

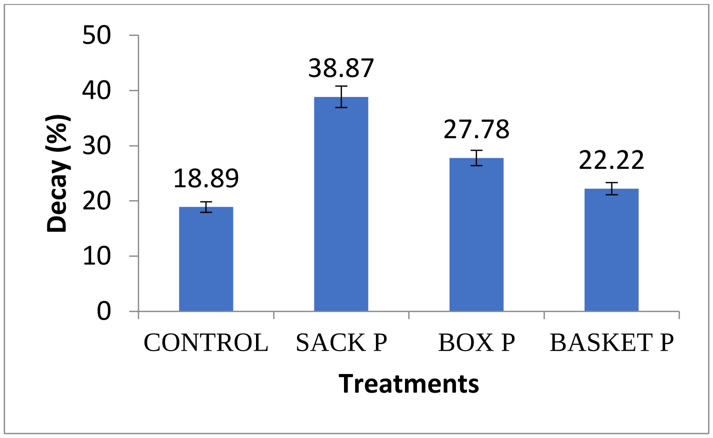


**Figure 2:** Effect of packaging materials on tomato fruit decay

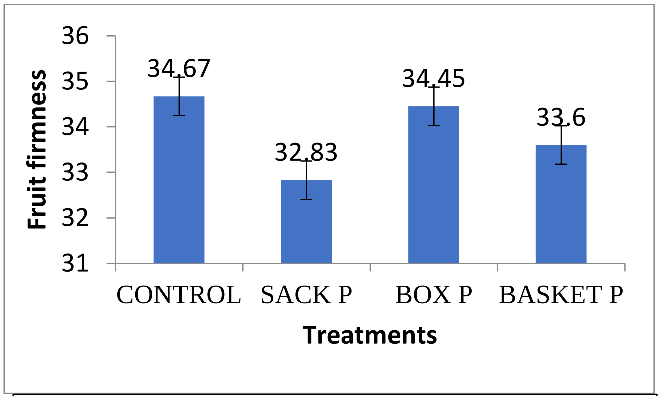


**Figure 3:** Effect of packaging materials on tomato fruit firmness

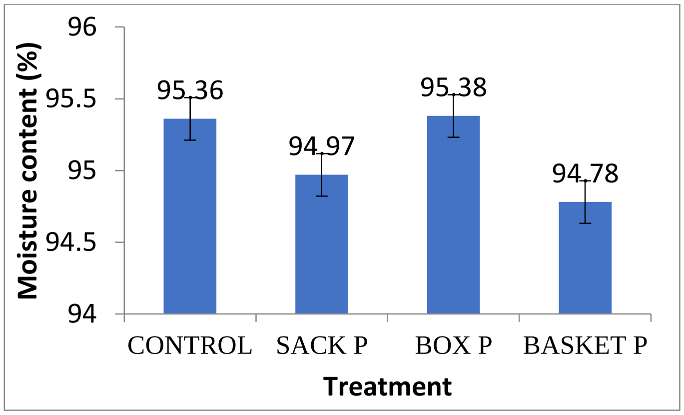


**Figure 4:** Effect of packaging materials on moisture content of tomato fruit

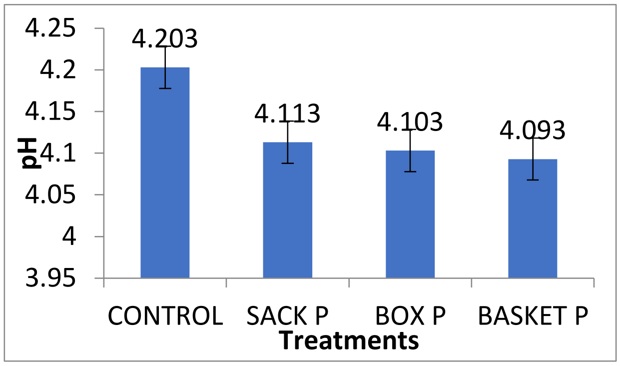


**Figure 5:** Effect of packaging materials on pH level of tomato fruit after nine days of storage

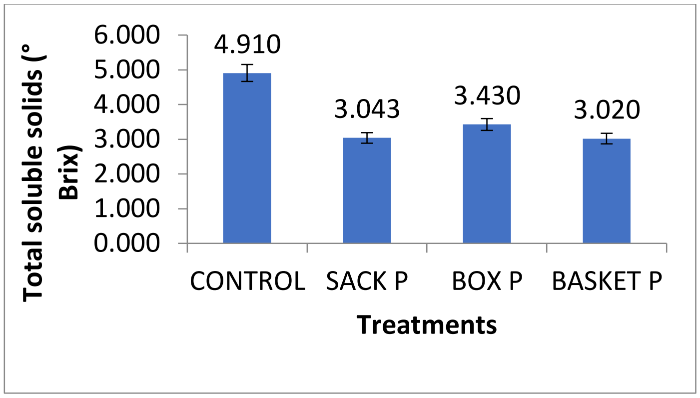


**Figure 6:** Effect of packaging materials on TSS level of tomato fruit

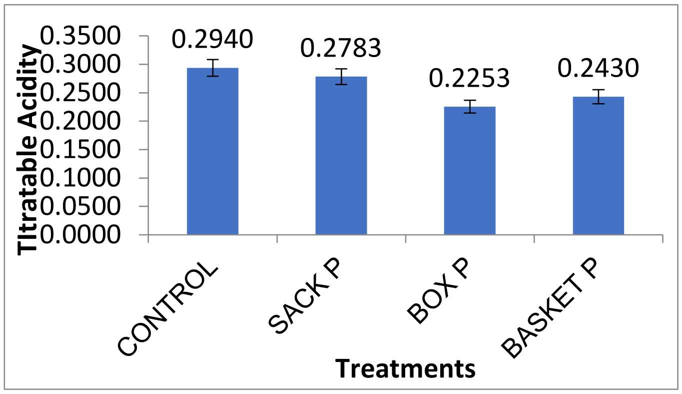


**Figure 7:** Effect of packaging materials on titratable acidity level of tomato fruit

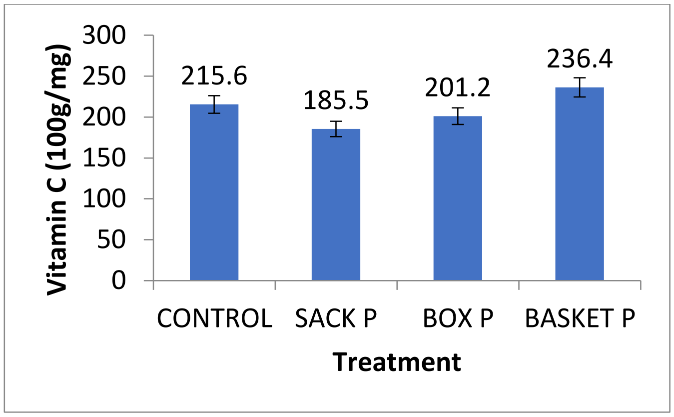


**Figure 8:** Effect of packaging materials on Vitamin C level

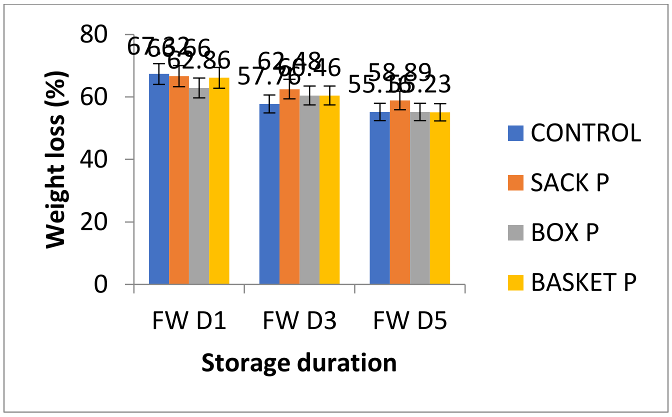
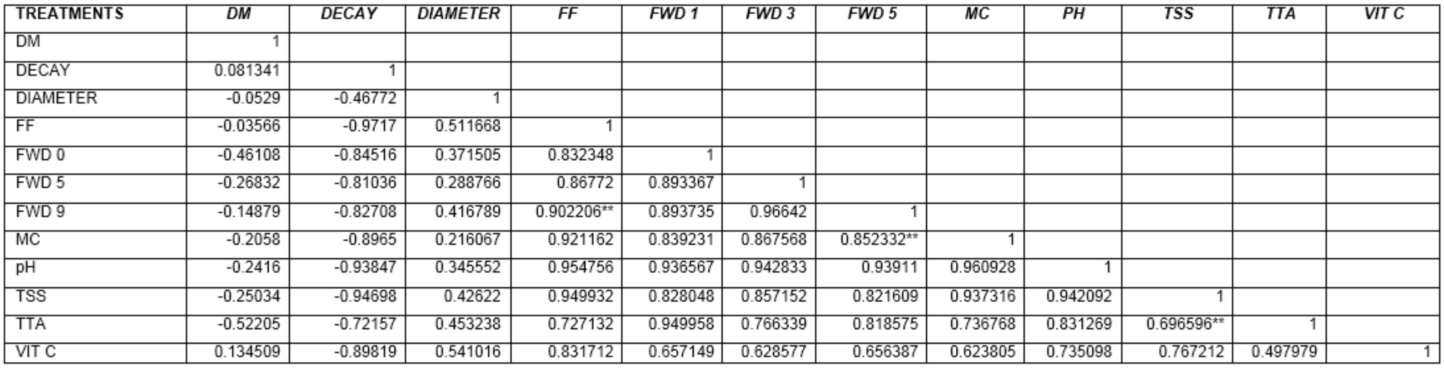


**Figure 9:** Effect of packaging materials on percentage **weight loss of tomato fruit.**

**Table 1:** Correlation coefficient (r) between quality parameters

** Significant NS not significant



| TREATMENTS | DM | DECAY | DIAMETER | FF | FWD 1 | FWD 3 | FWD 5 | MC | PH | TSS | TTA | VIT C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DM | 1 | | | | | | | | | | | |
| DECAY | 0.081341 | 1 | | | | | | | | | | |
| DIAMETER | -0.0529 | -0.46772 | 1 | | | | | | | | | |
| FF | -0.03566 | -0.9717 | 0.511668 | 1 | | | | | | | | |
| FWD 0 | -0.46108 | -0.84516 | 0.371505 | 0.832348 | 1 | | | | | | | |
| FWD 5 | -0.26832 | -0.81036 | 0.288766 | 0.86772 | 0.893367 | 1 | | | | | | |
| FWD 9 | -0.14879 | -0.82708 | 0.416789 | 0.902206** | 0.893735 | 0.96642 | 1 | | | | | |
| MC | -0.2058 | -0.8965 | 0.216067 | 0.921162 | 0.839231 | 0.867568 | 0.852332** | 1 | | | | |
| pH | -0.2416 | -0.93847 | 0.345552 | 0.954756 | 0.936567 | 0.942833 | 0.93911 | 0.960928 | 1 | | | |
| TSS | -0.25034 | -0.94698 | 0.42622 | 0.949932 | 0.828048 | 0.857152 | 0.821609 | 0.937316 | 0.942092 | 1 | | |
| TTA | -0.52205 | -0.72157 | 0.453238 | 0.727132 | 0.949958 | 0.766339 | 0.818575 | 0.736768 | 0.831269 | 0.696596** | 1 | |
| VIT C | 0.134509 | -0.89819 | 0.541016 | 0.831712 | 0.657149 | 0.628577 | 0.656387 | 0.623805 | 0.735098 | 0.767212 | 0.497979 | 1 |

DM = dry matter, FF = fruit firmness, MC = moisture content, TSS = total soluble solids, TTA = total soluble solids, VIT C = vitamin C

## Discussions

The main function of packaging material is to reduce respiration rate and water loss by transpiration, and injurious atmosphere inside the package which could affect the fruits metabolism (Ben-Yehushua, 1985). The results showed a significant difference (p> 0.005) between fruits treated with different packaging methods. Sack packaging material recorded the least dry matter content (Figure 1) which could be attributed to higher respiration rate of water from the fruit surface which led to increase in percentage weight loss, fruit firmness and moisture content. According to Isaac and Maaleku (2013) dry matter content of sampled tomato fruit from jute sack correlates with firmness, moisture, weight and decay. Basket and box packaging (Figure 1) obtained the highest dry matter content of fruits which could be attributed to the fact that controlled ripening in box and basket packaging containers showed a decrease in ethylene production and respiration rate which helped in maintaining moisture content, fruit weight and fruit dry matter (Brandt, 2006). The decay (Figure 2) of tomato was reduced in boxes and basket packaging containers compared to jute sack. In this study, it was identified that the decaying percentage of tomato increased with the storage time of fruits stored in different packaging materials compared to the control. However, decaying of tomato in jute sack was evident in the early days during storage compared to basket and box packaging containers. The main cause for fruit deterioration is fruit ripening and ethylene production. High temperature fastens the rate of fruit ripening, thus fastens the rate of fruit deterioration (Ben-Yehushua, 1985). The cooling of fruits in basket and box packaging containers by free moving air at an ambient condition reduced the inside storage temperature which slows the rate of fruit ripening and ethylene production which have a direct effect on shelf-life extension of tomato fruits. Generally, softening of fruits progress with the storage time. The reduction in fruit firmness (Figure 3) was high in jute sack packaging material comparatively which could be due to texture modification through degradation of polysaccharides such as pectin, cellulose and hemicellulose that take place during ripening (Irtwange, 2006). It is also established that texture changes in fruits are consequences of modifications by component polysaccharides that, in turn, give rise to disassembly of primary cell wall and middle lamella structures due to enzyme activity on carbohydrate polymers (Manrique and Lajolo, 2004). Hence, the differences in firmness of tomato fruits in the different treatments could partly be explained by the differences in rate of respiration that affect solubility and depolymerization of pectin as reported by Lazan et al. 1995. The moisture content (Figure 4) of sampled tomato fruits was significantly (p>0.005) affected by packaging material. Box packaging containers conserved the moisture content and reduced the weight loss. Tomatoes kept in sack and baskets on the other hand, recorded low moisture content compared to tomatoes kept on laboratory benches at an ambient condition (control).

The prevention of excessive moisture loss by box packaging containers could be due to slow rate of transpiration. The lower water vapor transmission rate of box packaging containers may also contribute to the development of relatively higher humidity inside the package (Farber et al., 2003). Lower pH content (Figure 5) observed in packaged fruits could be explained by relatively reduced respiration rate in the package material. High storage temperature leads to faster respiration rate (Rodriguez et al., 2005). Hence, lowering the storage temperature in some packaging material or containers can reduce respiration rate and delay senescence of tomato fruits. With short duration of storage time, pH of fruits could drop due to the use of the sugars as respiration substrate, which could be further aggravated by higher temperature leading to shorter shelf life of fruits (Irtwenge, 2006). The results showed, that total soluble solids (Figure 6) of jute sack packaging materials produced high levels of sugars; basket and box packaging containers (insignificantly p<0.005) used obtain low total soluble solids. Changes in total soluble solids contents of tomato fruit were natural phenomenon that occur during ripening and it resulted from hydrolytic changes in starch concentration during ripening in postharvest period. In tomatoes, conversion of starch to sugar is an important index of ripening (Kays, 1997). During ripening, the degradation of cell wall of polysaccharides occurred. Increase in total soluble solids content observed in the present investigation agrees with the report by Sarker et al. (1995) which confirms that total soluble solids of fruits increase along with the storage time. Increased in total soluble solids of box packaging container may be due to the physiological aspects of the fruits, increasing ethylene production, respiration and metabolic processes, which involve increasing total soluble solids at different magnitudes (Balibrea, 2006). According to Bhattacharya (2004), acidity of tomato is often used as an indication of maturity, as the acid content decreases over time as fruit ripe. It has also been reported that during ripening of tomatoes, malic acid disappears first, followed by citric acid which result in reduction of amount of titratable acidity (Sarker et al, 1995). The results revealed that sack and basket packaging containers used maintained a higher titratable acidity (Figure 7) whilst box packaging container recorded the least titratable acidity. The lower acidity contents at the end of the storage period were in agreement with the impact of packaging materials on the acidity content of tomato fruit described by Balibrea et al. (2006). The reduction of malic and citric acid during ripening may be the main factor responsible for the reduction in titratable acidity during storage. Microorganisms may use citric acid as a carbon source, hence, resulting in reduction in the titratable acidity (Balibrea, 2006).

The vitamin C content (insignificant $p<0.005$) of the fruits unlike the total soluble solids decreases as ripening progress. In this current study, the vitamin C content (Figure 8) in the fruits was affected by jute sack packaging material recording the least vitamin C content. This could be due to the fact that excessive ethylene production led the increased ripening causing a reduction in vitamin C content of the tomato. Moneruzzaman et al. (2008) reported that, as the tomato fruit ripens, the ascorbic acid content decreases.

## Conclusions

The tomato fruits stored wooden box and basket packaging containers recorded the lowest decay compared jute sack which had limited aeration. Weight loss of tomato fruit was closely related with packaging materials except tomato fruit stored at an ambient condition without packaging material (control) had an acceptable weight loss. Tomato fruit stored in or at aerated packaging materials or condition had more stability and greater storage life than fruit stored in an enclosed material whilst the soluble solids of the tomato fruit progressively increased with storage time. However, the titratable acidities decreased as storage time increased.

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