EFFECT OF MICROBIAL ACTIVITY AND ENVIRONMENTAL FACTOR ON ASCORBIC ACID CONTENTS OF STORED TOMATO IN PASSIVE EVAPORATIVE COOLING STRUCTURES

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ABSTRACT

A study was conducted to study the effect of microbial activity and environmental factor on ascorbic acid contents of stored tomatoes in Passive Evaporative Cooling Structures. Three sets of four different types of passive evaporative cooling structures made of two different materials, clay and aluminium were constructed. One set consists of four separate cooling chambers. Two cooling chambers were made with aluminium container (round and rectangular shapes) and the other two were made of clay container (round and rectangulars). These four containers were separately inserted inside a bigger clays pot and laterite walls inter- spaced with clay soil of 5 cm(to form tin-in-pot, pot-in-pot, tin-in-wall and wall-in wall) with the outside structure wrapped with jute sack. The other two sets followed the same pattern with interspacing of 7 cm and 10 cm respectively. The set with 7 cm interspace served as the control in which the interspace soil and the jute sack were constantly wetted at intervals of between. 2 to 4 hours depending on the rate of evaporation with water at room temperature. The other two sets (5 cm and 10 cm interspaced soil) were constantly wetted with salt solution (Table salt (Nacl)) at the same interval to keep the soil in moist condition. In addition, the control has no fans and the inner cooling chambers were not lined with polyethylene nylon while the other two sets have fans and their inner cooling chambers lined with polyethylene nylon. Freshly harvested tomatoes were used for the experiment and the temperatures were monitored daily while the ascorbic acid contents were determined at interval of three days for a period of sixteen days. The average temperatures and relative humidity recorded for the tin-in-pot in the 5 cm. 7 cm and 10 cm soil interspace are 27.38^{o}C/88.33%, 27.10^{o}C /90.47% and 27.09^{o}C /91.49% respectively. The average temperatures and relative humidity recorded for the pot-in-pot in the 5 cm. 7 cm and 10 cm soil interspace are 27.39^{o}C /89.60%, 27.07^{o}C /92.27% and 27.05^{o}C /92.53% respectively. The average temperatures and relative humidity recorded for tin-in-wall in the 5 cm. 7 cm and 10 cm soil interspace are 27.94^{o}C /86.84%, 27.04^{o}C /90.95% and 27.03^{o}C /91.0% respectively while the average temperatures and relative humidity recorded for wall-in-wall in the 5 cm. 7 cm and 10 cm soil interspace are 27.59^{o}C /87.25%, 27.09^{o}C /91.99% and 26.98^{o}C /91.72% respectively. The average fungal count and ascorbic acid contents are recorded for the tin-in-pot in the 5 cm. 7 cm and 10 cm soil interspace are 3.4 x 10 ppm /22.8mg/100ml, 3.38 x 10 ppm /23.2 mg/100ml and 3.48 x 10 ppm /23.1 mg/100ml respectively. The average fungal count and ascorbic acid contents are recorded for the pot-in-pot in the 5 cm. 7 cm and 10 cm soil interspace are 2.96 x 10 ppm/23 mg/100ml, 2.92 x 10 ppm /23.3 mg/100ml and 3.32 x 10 ppm /23.2 mg/100ml respectively. The average fungal count and ascorbic acid contents are recorded for the tin-in-wall in the 5 cm. 7 cm and 10 cm soil interspace are 3.2 x 10 ppm /23 mg/100ml, 3.36 x 10 ppm /23.1 mg/100ml and 3.36 x 10 ppm /23.3 mg/100ml respectively while the average fungal count and ascorbic acid contents are recorded for the wall-in-wall in the 5 cm. 7 cm and 10 cm soil interspace are 3.02 x 10 ppm /23 mg/100ml, 3.18 x 10 ppm /23.3 mg/100ml and 3.24 x 10 ppm /22.9 mg/100ml respectively.

Keywords: Ascorbic, environmental, microbial, evaporative, tomatoes.

INTRODUCTION

The quality and storage life of fruits and vegetables may be seriously compromised within a few hours of harvest unless the crop has been cooled promptly to control deterioration. The major problem during storage is what happens to the quality parameters of these produce especially the physical

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characteristics such as; the color, texture, and freshness in which the price sometimes depend on (Jeffries & Jeger, 1990).

In order to extend their shelf life, fruits need to be properly stored. Proper storage means controlling both the temperature and relative humidity of the storage area (Susan & Durward, 1995).

Aeration, temperature and relative humidity management, microorganisms control, sanitation and preventing moisture loss greatly improves the storability of produce by maintaining a cool and uniform environment throughout the storage period (Suslov, 1997; Melnick, 1998; Wilson *et al*., 1995; Lutz & Hardenburg, 1968; Bjczvnski, 1997; Hardenurg, 1986; Geeson, 1983). Low temperature prolongs storage life by reducing respiration rate as well as reducing growth of spoilage microorganisms (Rouraa *et al*, 2000; Watada *et al*., 1996). Temperature, relative humidity and atmospheric composition during prestorage, storage, and transit could control decay (Spotts, 1984). For optimum decay control, two or more factors often are modified simultaneously and these are temperature and relative humidity. Proper management of temperature is so critical to post harvest disease control that all other treatments can be considered as supplements to refrigeration (Sommer, 1989). However, temperatures as low as possible are desirable because they significantly slow growth and thus reduce decay.

Respiration is one of the basic physiological factors, which speeds up ripening of fresh commodities and is directly related to maturation, handling, and ultimately to the shelf life (Ryall & Lipton, 1979; Ryall & Pentzer, 1982). Generally, the loss of freshness of perishable commodities depends on the rate of respiration.

A common acid found in fruit includes citric, malic and ascorbic acid. During ripening, organic acids are among the major cellular constituents undergoing changes (Salunkhe *et al*., 1991). Studies have shown that there is a considerable decrease in organic acid during ripening of fruits. Modi & Reddy (1966), in Salunkhe *et al*. (1991), showed that concentrations of citric, malic and ascorbic acids declined 10, 40 and 2.5 fold, respectively, in fruits such as tomatoes.

Higher storage temperatures are known to have an increasing effect on the rate of decrease in ascorbic acid content in tomatoes during storage (Salunkhe *et al*., 1991). However, Mohammed *et al*. (1999) showed that the ascorbic acid content in tomatoes slightly increased during ripening during storage at 20°C for 14 and 21 days. In general, the ascorbic acid content decreases rapidly after full ripening of tomatoes stored at higher storage temperatures.

As ripening of fruits and vegetables progresses, the firmness decreases and the intrinsic factors, which confer resistance during development, can no longer protect against microbial decay (Eckert *et al*., 1975, 1978). The onset of ripening and senescence in various fruit and vegetables renders them more susceptible to infection by pathogens (Kader, 1985).

Tomatoes are climacteric and show a pronounced increase in respiration during ripening. Respiration also varies with temperature and atmospheric composition (Wills *et al*., 1998).

Several important changes occur in the structure of tomatoes during ripening such as synthesis of pigments, production of flavour and aroma compounds (Grierson & Kader, 1986) and Giovanelli *et al.* (1999) reported an increase in ascorbic acid content of tomatoes during their ripening. A slight accumulation of ascorbic acid was observed during storage of tomatoes (Kalt *et al.,* 1999). Tomato is a highly acidic fruit and it shows a relatively stable ascorbic acid content during postharvest storage (Mapson, 1970). The presence of flavonoids in tomato cells may have helped to maintain the ascorbic acid content (Miller & Rice Evans, 1997). Toor & Savage (2005) also reported that during storage, a slight increase in the level of ascorbic acid occurred in the tomatoes and their possible synergistic interactions may have been responsible for the slight increase. Decaying of fruits and vegetables is increased by high temperature coupled with high relative humidity. The microbial attack to different crops becomes very slow at low temperature especially when it is below 5 °C. Relative humidity below 90 % does not permit micro-organisms to grow on the surface of fruits and vegetables (Chandy, 2000).

Evaporative cooler works on the principle of cooling resulting from evaporation of water from the surface of the structure. The cooling achieved by this device also results in high relative humidity of the air in the cooling chamber from which the evaporation takes place relative to ambient air. The atmosphere in the chamber therefore becomes more conducive for fruit and vegetable storage.

This paper focus on the effect of microbial activity and environmental factor on the ascorbic acid contents of stored tomatoes in passive evaporative cooling structures**.**

MATERIALS AND METHODS

The experiment was carried out in Minna, Niger state, Nigeria and the samples of tomatoes were sourced from Bosso Market. The fresh tomatoes were stored inside the three sets of four different types of passive evaporative cooling structures for a period of 16 days. 30 samples of fresh tomatoes were stored in each structure.

Nutritional Parameters

The ascorbic acid contents f tomatoes were analyzed in the laboratory using AOAC methods of analysis (1995). All measurements were performed in triplicate and results were given as mean ± standard error (SE).

Preparation of Salt Solution

About 15000 parts/millions (ppm) solution of sodium chloride (Nacl) was prepared by dissolving 225g of Nacl in 15 litres of water at room temperature and 450g of Nacl in 30 litres of water at room temperature for keeping the four structures in moist condition in the 5 cm and 10 cm soil inter-space respectively. The four structures in the 7 cm soil inter space were kept in moist condition using 20 litres of water.

RESULTS AND DISCUSSION

The temperature, relative humidity, fungal counts and ascorbic acid contents of tomatoes at different interspaces inside the four different types of passive evaporative cooling structures are presented in tables 1 to 4. There was generally a relatively stable ascorbic acid content of stored tomatoes in all the storage structures which are in line with Mapson (1970). The more stable values in ascorbic acid contents were observed in wall-in-wall (10cm), wall-in-wall (5cm), wall-in-wall (7cm), tin-in-pot (5cm), tin-in-pot (7cm) and tin-in-pot (10cm) as shown in tables 1 and 4 above. Also full ripening was noticed in tin-in-pot (5 cm), pot-in-pot (5cm), wall-in-wall (5cm), wall-in-wall (10cm) and tin-in-pot (7cm) on the 9th day of storage after which a decrease in the values of ascorbic acid contents was noticed on the 13th day of storage (Modi & Reddy 1966; Salunkhe *et al.,* 1991), . The decrease in ascorbic acid contents in tomatoes may be attributed to higher storage temperatures (Salunkhe *et al.,* 1991). Also higher values of relative humidity above 90% (Tables 1, 2 and 4) must have contributed to the action of microorganisms on the surface of the fruits thereby reducing their food values including the ascorbic acid contents (Chandy, 2000).

However, higher values of ascorbic acid were noticed after the first day of storage in tin-in-wall (7cm), tin-in-wall (10cm) and pot-in-pot (7cm). This may be attributed to high temperatures recorded in the storage structures which is in line with Mohammed *et al.* (1999). There was a slight increase (accumulation) in the ascorbic acid of stored tomatoes in tin-in-pot (10cm) from the beginning to the end which is in line with Kalt *et al.(* 1999) and Toor & Savage (2005). Generally, the 5 cm soil interspace structures in all the structures recorded the highest storage temperature (Figures 1 to 4).

In general, higher fungal counts were noticed in all the structures at the beginning of storage which was later reduced drastically at the end of storage. This may be attributed to the effect of salt solution as wetting media on the soil and the jute sack **(**Alexopoulos *et al.*, 1996).

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Table 1. Effects of Environmental Factors (temperature and relative humidity) and Microbial Activity (Fungal Counts) on the Ascorbic Acid Contents in Tin-in-Pot Evaporative Cooling Structure

		Storage Period			
Measured parameters	**1**	**5**	**9**	**13**	**16**
5 cm Interspace					
Temperature	28.2	26.7	26.8	26.6	26.7
Relative Humidity	86.0	88.5	74.4	96.1	87.8
Fungal Counts	3.8 x 10	3.8 x 10	3.2 x 10	3.4 x 102.8 x 10	
Ascorbic Acid	22	22	23.5	23.1	23.5
7 cm Interspace					
Temperature	27.7	26.5	26.0	26.7	26.7
Relative Humidity	90.5	90.0	78.4	95.8	90.7
Fungal Counts	3.8 x 10	3.8 x 10	3.3 x 10	3.6 x 102.6 x 10	
Ascorbic Acid	23	23	23.5	23	23.4
10 cm Interspace					
Temperature	28.0	26.7	25.5	26.9	26.6
Relative Humidity	91.5	90.8	85.0	94.5	91.1
Fungal Counts	2.9 x 10	3.8 x 10	3.2 x 10	3.8 x 10	2.8 x 10
Ascorbic Acid	23	23	23	23.1	23.6

Table 2. Effects of Environmental Factors (temperature and relative humidity) and Microbial Activity (Fungal Counts) on the Ascorbic Acid Contents in Pot-in-Pot Evaporative Cooling Structure

	Storage Period				
Measured parameters	**1**	**5**	**9**	**13**	**16**
5 cm Interspace					
Temperature	28.3	26.7	26.1	26.6	26.6
Relative Humidity	88.4	88.5	80.6	95.0	90.0
Fungal Counts	2.9 x 10	3.1 x 10	3.2 x 10	2.6 x 103.0 x 10	
Ascorbic Acid	23	23	24	22	23
7 cm Interspace					
Temperature	27.8	26.4	25.9	26.8	26.7
Relative Humidity	92.8	92.0	81.4	95.9	93.0
Fungal Counts	3.0 x 10	3.0 x 10	3.0 x 10	2.8 x 103.2 x 10	
Ascorbic Acid	24	22.5	24.5	22.5	23.1
10 cm Interspace					
Temperature	28.0	26.6	25.6	26.9	26.6
Relative Humidity	93.3	91.2	84.9	94.4	92.1
Fungal Counts	3.6 x 10	3.6 x 10	3.2 x 10	3.0 x 103.2 x 10	
Ascorbic Acid	23.5	23	24.5	22	23

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Table 3. Effects of Environmental Factors (temperature and relative humidity) and Microbial Activity (Fungal Counts) on the Ascorbic Acid Contents in Tin-in-wall Evaporative Cooling Structure.

	Storage Period				
Measured parameters	**1**	**5**	**9**	**13**	**16**
5 cm Interspace					
Temperature	29.1	27.4	27.2	27.8	26.7
Relative Humidity	86.5	86.7	71.8	93.5	89.2
Fungal Counts	3.4 x 10	3.6 x 10	3.2 x 10	3.0 x 102.8 x 10	
Ascorbic Acid	22.5	23.5	22.8	22.8	23.4
7 cm Interspace					
Temperature	27.6	26.4	25.7	27.3	26.7
Relative Humidity	92.4	91.0	79.2	93.4	90.6
Fungal Counts	3.9 x 10	3.6 x 10	3.2 x 10	3.1 x 103.0 x 10	
Ascorbic Acid	25	22.8	22.5	22.4	23
10 cm Interspace					
Temperature	27.8	26.7	25.7	26.8	26.9
Relative Humidity	91.2	91.7	79.8	94.7	90.3
Fungal Counts	3.8 x 10	3.4 x 10	3.6 x 10	3.2 x 102.8 x 10	
Ascorbic Acid	24.5	23.2	23	22.4	23.4

Table 4. Effects of Environmental Factors (temperature and relative humidity) and Microbial Activity (Fungal Counts) on the Ascorbic Acid Contents in Wall-in-wall Evaporative Cooling Structure.

		Storage Period			
Measured parameters	**1**	**5**	**9**	**13**	**16**
5 cm Interspace					
Temperature	28.6	27.3	26.6	27.6	26.5
Relative Humidity	86.6	86.6	74.8	91.9	89.1
Fungal Counts	3.6 x 10	3.1 x 10	3.4 x 10	2.8 x 102.2 x 10	
Ascorbic Acid	23	23	23	23.2	22.8
7 cm Interspace					
Temperature	27.7	26.4	25.7	27.1	26.7
Relative Humidity	92.6	92.2	85.0	93.9	91.8
Fungal Counts	3.2 x 10	3.4 x 10	3.2 x 10	3.0 x 103.1 x 10	
Ascorbic Acid	23.5	23.2	23.5	23.5	22.6
10 cm Interspace					
Temperature	27.8	26.6	25.7	26.9	26.7
Relative Humidity	91.4	91.5	83.4	95.2	91.7
Fungal Counts	3.1 x 10	3.6 x 10	3.4 x 10	2.9 x 103.2 x 10	
Ascorbic Acid	23	23	23	23.2	22.6

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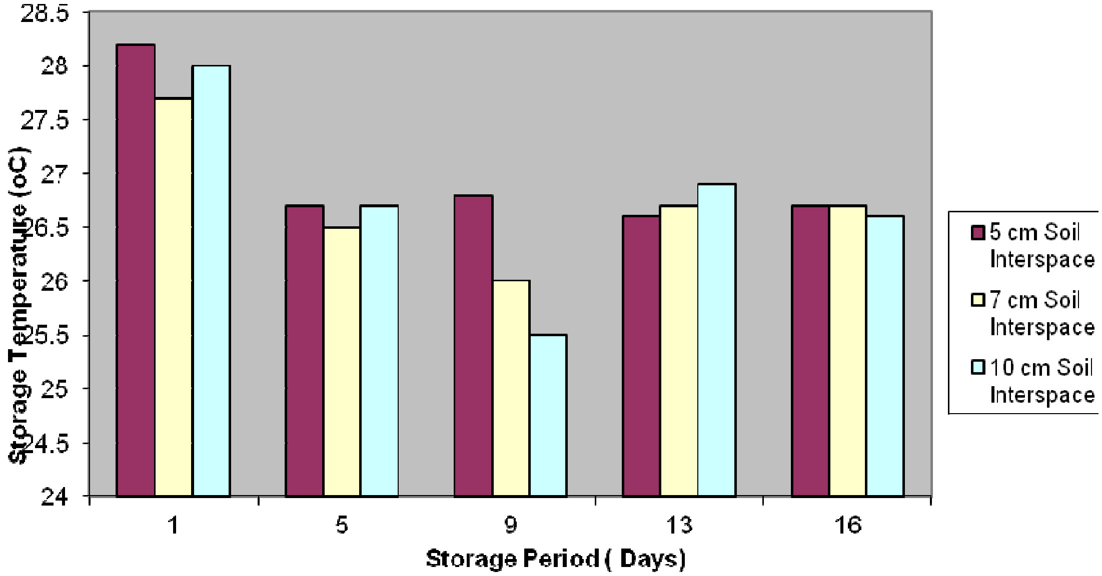

Figure 1: Variations in Temperature on Stored Tomatoes with Different Soil Interspace inside the Tin-in-pot Cooling Structures

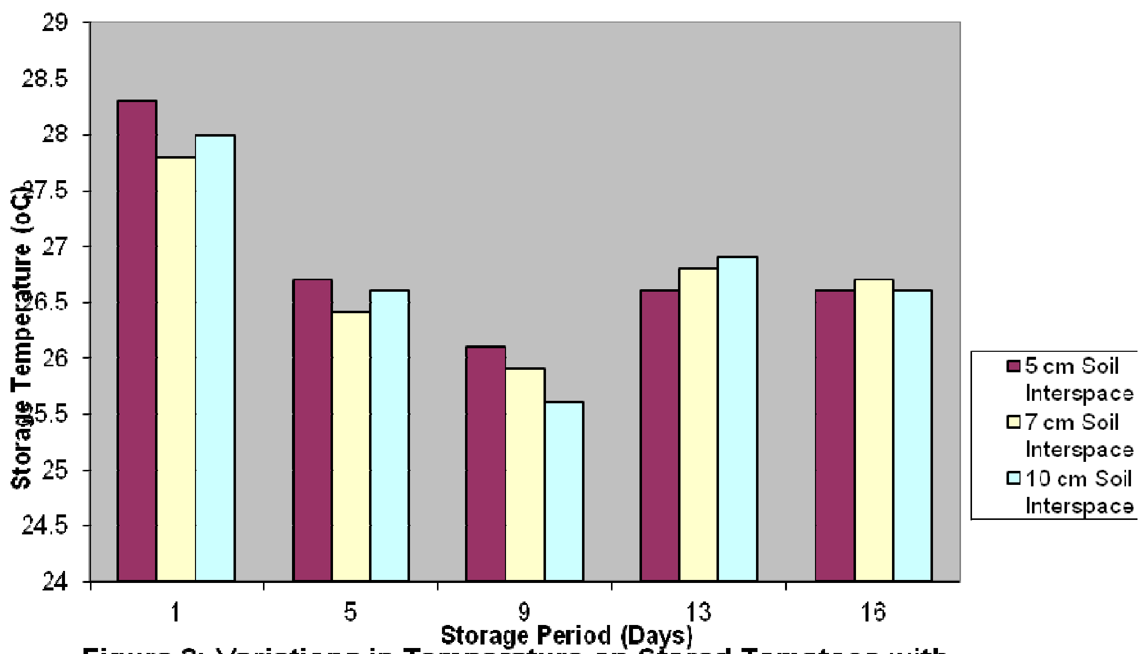

Figure 2: Variations in Temperature on Stored Tomatoes with Different Soil Interspaces inside the Pot-in-pot cooling Structures

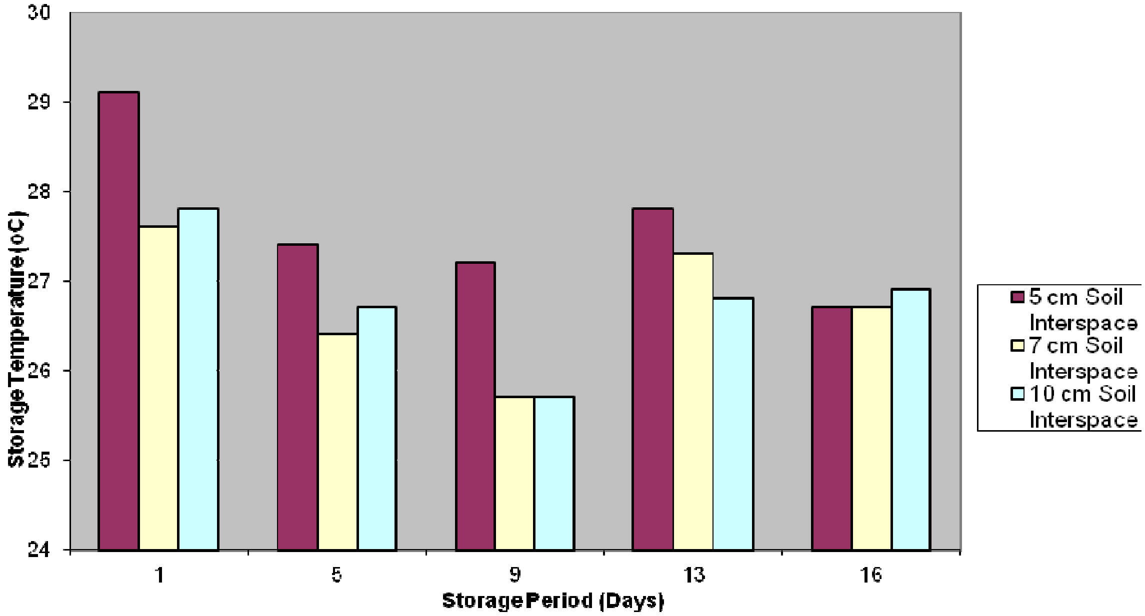

Figure 3:Variations in Temperature on Stored Tomatoes with Different Soil Interspaces Inside the Tin-in-wall Cooling Structures

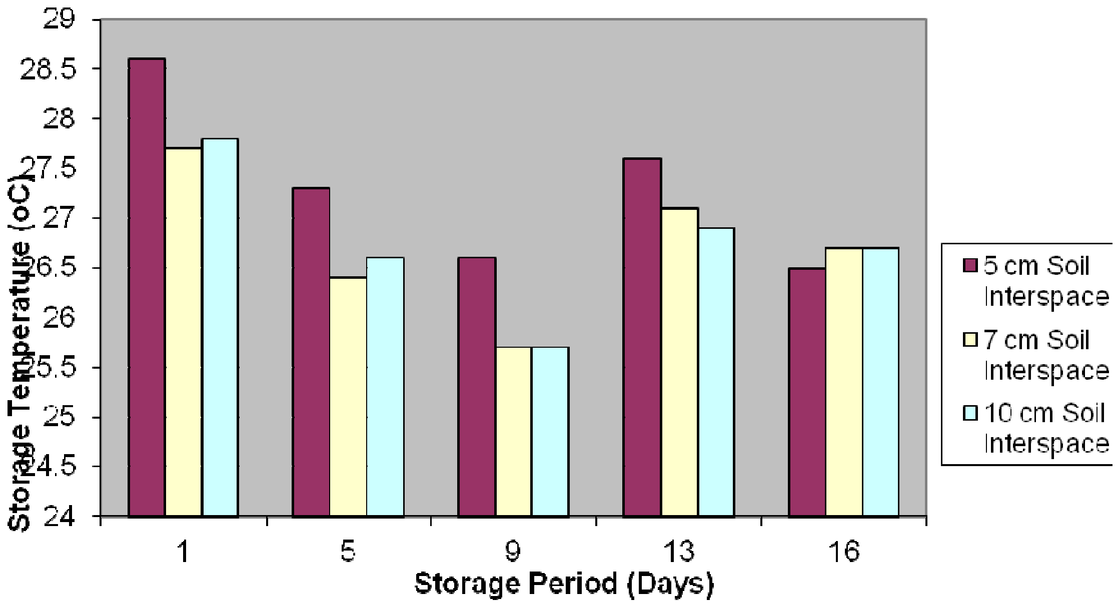

Figure 4 : Variations in Temperature on Stored Tomatoes with Different Soil Interspaces inside the Wall-inwall Cooling Structures

CONCLUSION

This research focused on the effect of environmental factors and microbial activity on the ascorbic acid contents of stored tomatoes in four different types of evaporative cooling structures. It was observed that the ascorbic acid contents were much more stable wall –in-wall (5 cm and 10 cm) and also in tin-in-pot (10cm). However, due to the average higher average temperatures recorded in the

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5 cm structures which allowed the fungi to multiply rapidly thereby attacking the fruits and reducing their quality. Also the fruits respire a lot at high temperatures, thereby hastening their ripening. After ripening, deterioration sets in, thereby preventing them from being stored for a long period of time, it is recommended that storage of tomatoes should be done in the wall-in-wall (10cm) and tin-in-pot (10cm) structures using salt solution as wetting media so as to control the growth of fungi thereby improving the quality of the stored produce.

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