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Preservation of Tomatoes in a Brick-Walled Evaporative Cooler

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Abstract

A double-walled evaporative cooler built of bricks with the interspaces filled with wet riverbed sand was tested for storage of tomato fruits (non-wrapped and wrapped in perforated and imperforated polyethylene bags). The temperature in the storage chamber was at 16-19 °C and 83-96% RH as compared to the ambient at 20-36oC and 34-70% RH. The evaporative cooler performed better than the ambient by reducing mean weight loss and decay in fruits by 53.7 and 41.2%, respectively. The shelf life of unpackaged tomatoes was 13 days in evaporative cooler as compared to 5 days under ambient conditions. Fruits stored in cooler were rated higher in sensory quality than those in the ambient. Perforated PE bags significantly reduced weight loss and decay in the stored tomatoes, thereby increasing shelf life to 20 days in the evaporative cooler and 13 days under ambient conditions. Tomatoes sealed in imperforated polyethylene bags had shorter shelf life of 7 and 9 days, under ambient and evaporative cooler respectively. The increase in shelf life of tomatoes in the cooler was attributed to lower temperature and higher relative humidity (RH) in the storage chamber. The study demonstrated that shelf life of tomatoes can be extended by the use of evaporative cooler.

INTRODUCTION

In Nigeria, problem of preservation of fresh tomatoes is assuming an alarming proportion. In view of the magnitude of postharvest losses encountered, a suitable process of prolonging the shelf life would considerably increase the availability of fresh fruits for consumption. Small to medium scale storage of the fruits is also a corollary to the so much desired development of rural processing in the country. What is required is an effective storage method that is adaptable by the small scale producers of the vegetable. In view of the high cost of electric power demand for operating mechanical refrigeration, the system is not yet acceptable to the numerous rural and small-scale producers.

Researchers working on fruits and vegetable storage in developing countries of the tropics have found some evaporative cooling systems effective in extending shelf life of perishable crops. In particular, Acedo (1997) in Philippines and Pal et al. (1997) in India have applied simple evaporative coolers to extend shelf life of fresh tomatoes and kinnow mandarins respectively. In Nigeria, a simple and low-cost evaporative cooler (Babarinsa, 2006) has also been effectively applied for storing carrots (Babarinsa et al., 1997) and plantains (Babarinsa et al., 2000). In all these cases, the effectiveness of the non-mechanical evaporative cooler lies in the generation of beneficial atmosphere of reduced temperature and elevated relative humidity in the storage chamber.

With or without a cooling operation, the shelf life of some tropical fruits and vegetables had been reportedly extended when packaged in polyethylene (PE) bags (Babarinsa, 2000 and Babarinsa et al., 2001). Polyethylene (PE) bags produce modified atmospheres of reduced oxygen and increased carbon dioxide concentrations which improve the condition of fruit and vegetables under storage. This study investigates the effectiveness of a brick-walled evaporative cooler in extending the shelf life of fresh tomatoes under the semi arid condition of Kano, Nigeria.

MATERIALS AND METHODS

Physiologically mature tomatoes, Roma variety, were harvested at the breaker point (just turning from green) stage from a market garden at the outskirt of Kano.750 wholesome fruits of fairly uniform size were washed and pre-cooled overnight in an air-conditioned room at 21±1 °C. The fruits were divided

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into five lots of 150 fruits and packaged in three ways: (1) unpacked but held in paper-lined raffia basket (2) packaged in perforated polyethylene (PE) bags 0.08mm thick and (3) packaged in imperforated polyethylene (PE) bags of the same thickness. Each PE bag was of dimension 30cm x 15cm, perforation consisted of 20 uniformly spaced holes of diameter 2.0 mm.

The packaged and unpacked tomatoes were stored under two conditions as obtained in: (1) ambient (20-36oC and 34-70% RH and (2) brick-wall evaporative cooler described by Babarinsa (2006) (16-19 °C and 83-96% RH). Each storage unit consists of five PE bags of fruits or equivalent quantity in each unpacked units. Temperature and relative humidity in the cooling chamber and ambient were measured with minimum-maximum (glass) thermometers and hair hygrometers located within and outside the chamber. Stored fruits were monitored at intervals of 4 days to note changes in weight and sensory attributes. Fruit weight was measured with a top loading, electronic Mettler balance to an accuracy of 0.01g.

Sensory evaluation of fruit for firmness, flavour, colour and general appearance was made by a panel of 15 trained and experienced assessor of ten male and 5 female, aged between 21 and 40 years. Samples were presented randomly for rating on a hedonic scale ranging from a score of 5 for “like extremely” to a score of 1 for “dislike extremely”. Peel colour, which serves as ripening index was rated from a colour index of 1 = mature green to a colour index of 5 = full red.

Incidence of decay was determined as the number of diseased fruits as % of the total. The numerical scores for each sample were analyzed by analysis of variance (ANOVA) technique to determine significant differences among samples. The shelf life of fruits was terminated in consideration of spoilage parameters: decay, shrivelling and softening. The end point of shelf life was taken as either 15% weight loss, 20% decay or sensory score of 3 for firmness, appearance and flavour.

RESULTS AND DISCUSSION

Weight loss in stored tomatoes

The cumulative weight loss of tomato fruits was increased with duration of storage and was influenced by the method of packaging and storage condition (Table 1). Generally, physiological weight loss in fruits was high under ambient conditions while this was reduced significantly (P=0.05) in fruits stored in the evaporative cooler. Packaging in PE bags had additive effects. Fruits packaged in PE bags held inside cooler (PE+C) showed the lowest weight loss during storage. Unpacked fruits held at ambient exhibited the highest weight loss and shrivelled rapidly. Although equivalent fruits in perforated PE wilted eventually, the prevention of early shrivelling was apparent up to 10 days of storage

The exposure of fruits to high temperature and relatively low relative humidity at the ambient might have favoured the high weight loss of 31.3% recorded. However when the unpacked fruits were

Table 1:

Weight loss, decay, and shelf life of tomatoes stored in ambient and evaporative cooler. Means followed by the same letter in each column do not differ significantly at P=0.05

Storage Environment	Packaging	Weight loss (%)			Decayed fruits (%)			Shelf life (days)	Cause of shelf life termination
		Day 5	Day 10	Day 15	Day 5	Day 10	Day 15		
Ambient	Unpacked	14.3d	22.4d	31.3d	0	14a	24c	5a	Shriveling
	Perforated PE	8.1c	14.6c	22.8c	0	8b	14a	13c	Shriveling
	Imperforated PE	3.1b	4.4a	6.2a	0.5	22d	32c	7ab	Decay
	Mean	11.8	13.8	20.1	0.17	14.7	23.3	8.3	
Evaporative cooler	Unpacked	6.2c	9.2b	10.5b	0	10bc	16ab	13c	Decay
	Perforated PE	4.1b	7.2b	12.1b	0	7c	10ab	20	Decay
	Imperforated PE	1.8a	3.7a	5.4a	0	14a	18b	9b	Decay
	Mean	4.0	6.7	9.3	0	10,3	13.7	13	

Table 2:

Peel colour and flavour of tomatoes stored in ambient and evaporative cooler

Storage Environment	Packaging	Peel colour			Flavor		
		Day 5	Day 10	Day 15	Day 5	Day 10	Day 15
Ambient	Unpacked	2.7	3.6	-	5.0	3,9	-
	Perforated PE	2.0	3.1	5.0	5.0	3.8	3.1
	Imperforated PE	1.2	2.8	3.6	5.0	2.6	n.d
Evaporative cooler	Unpacked	2.6	3.6	5.0	5.0	4.3	3.8
	Perforated PE	1.8	2.5	3.6	5.0	4.4	4.3
	Imperforated PE	1.2	2.1	2.8	5.0	3.9	n.d

stored in evaporative cooler the loss in weight was reduced to 10.5%. This weight loss was reduced further to 5.4% in fruits packaged in sealed PE bags. In general the evaporative cooler reduced weight loss by 66.5%, 46.9% and 12.9% in fruits unpackaged, perforated PE packaged and perforated PE packaged respectively.

The lower temperature and high relative humidity obtained inside the cooling chamber presumably reduced the rate of moisture loss due to reduced respiration and transpiration. The cooler has earlier been reported to considerably reduce postharvest weight loss in carrots (Babarinsa et al., 1997), oranges (Babarinsa, 2000) and plantains (Babarinsa et al., 2000). This is most likely because the relative humidity of above 85% required for storing tomatoes for weight loss prevention (Gull, 1990) is adequately met in the cooler.

Ripening in stored tomatoes

Ripening was slowed down in fruits held in PE bags, especially in imperforated PE. Unpacked fruits rapidly ripened, attaining a mean peel score of 3 (considered as the threshold of edible stage) within 7 days in both ambient and cooler. Score 5 (fully ripeness) was attained before 15 days. This observation supports the finding of Srinivasa et al. (2006) and Passam et al. (2006) that modified atmospheres resulting from the enclosure of tomatoes in polyethylene or other forms of plastic packaging may delay fruit ripening and prolong storage life.

In the cooler, fruit ripened more uniformly to a bright red colour than in the ambient. The temperature obtained in the cooling chamber was very close to the recommended ripening temperatures of 18-21 °C for tomatoes as given by Harvey (1986). This author considered temperatures above 24 °C too warm, causing abnormal ripening and accelerated deterioration in the fruits. This seems to explain the abnormal ripening pattern and rapid deterioration in the ambient with temperatures frequently remaining above 24 °C.

The incidence of decay was significantly affected by packaging method and condition of storage as shown in Table 1. The stored fruits packaged in imperforated PE suffered the highest incidence of decay, which occurred as early as day 5 of storage under ambient conditions and leading to a high loss of 32% of fruits after 15 days as compared to 14% and 24% in perforated bags and unpacked fruits respectively.

In the cooler rotting does not set in until after 10 days. On the other hand, perforated PE reduced the incidence of decay in both ambient and cooling chamber. In general the evaporative cooler reduced decay by 33.3%, 28.6% and 43.8% in fruits unpackaged, perforated PE packaged and perforated PE packaged respectively. There is the possibility that holding the fruits in perforated PE reduced suffocation caused by accumulation of carbon dioxide.

Moisture condensation was a major problem in tomatoes packaged in sealed PE bags at ambient. This resulted in rotting in both ambient and cooling chamber. The condensation of moisture of moisture, which occurred inside the PE bags started after 4 days probably due to temperature fluctuation and initiated rotting under the ambient condition. Fruits packaged in imperforated PE, regardless of storage places, incurred the highest incidence of decay during storage. The incidence of decay was lower with fruits stored in evaporative cooler. The overall results suggested that fruits packaged in sealed PE bags for storage should be removed for airing before the onset of softening or sign of rotting. Alternatively, such bags should be perforated.

Shelf life evaluation

Shelf life termination in stored tomatoes was caused by either shriveling (due to desiccation) or deterioration by decay (Table 1). The storage life of tomatoes was longest in the evaporative cooler in combination with perforated polyethylene bags where the fresh fruits were kept for over 20 days. However, in the evaporative cooler, unpackaged fresh tomatoes and tomatoes held in sealed imperforated PE kept for 13 days and 9 days respectively. Under ambient conditions, comparable lots of stored fruits kept for shorter shelf life.

This result confirmed the earlier findings of Vanndy et al. (2007) that the storage life of unpackaged fresh tomatoes was longer in an evaporative cooler than storage life under ambient conditions. They also observed that, in combination with sealed but perforated polyethylene bags, the fresh tomatoes were kept longer both in the evaporative cooler and under ambient conditions. The benefits of perforating PE in both storage environments appear to derive from the inhibiting potentials for the prevention of desiccation and rotting.

Table 3: Appearance and firmness of tomatoes stored in ambient and evaporative cooler

Storage Environment	Packaging	Appearance			Firmness		
		Day 5	Day 10	Day 15	Day 5	Day 10	Day 15
Ambient	Unpacked	4.8	4.1	-	5.0	4..3	-
	Perforated PE	5.0	4.1	3.2	4.3	3.2	2.7
	Imperforated PE	5.0	3.9	2.3	4.8	3.2	2.4
Evaporative cooler	Unpacked	5.0	5.0	5.0	4.2	3.8	3.2
	Perforated PE	5.0	5.0	4.2	4.6	4.0	3.6
	Imperforated PE	5.0	4.8	4.7	.4.8	3.8	3.2

Sensory evaluation

Results of sensory analyses indicated that tomatoes packaged in perforated PE bags were most acceptable to panelists on the basis of sensory quality (Table 2 and 3). Those in imperforated bags held in ambient were least acceptable, particularly due to softening at ambient (Table 3). Kantola and Helen (2001) found that the good sensory quality of organically grown tomatoes stored for 3 weeks at 11±1°C in perforated LDPE apparently reflects the level of O_2 within the containers. Muratore et al. (2005) showed that the quality characteristics (vitamin C, carotenoids) of plum tomato could be preserved satisfactorily in modified atmospheres produced by enclosure of fruit in biodegradable or polyolefin films only when the O_2 permeability of the film was sufficient to prevent anaerobic respiration. Fruit enclosed in low-density polyethylene showed better colour retention and firmness in relation to the control (fruit held in air). The noticeable loss of firmness accompanying change in colour (hence ripening) has been attributed to a reduction in thickness of cell walls and the adhesion between adjacent cells (Hobson, 1982). Mondal et al. (2006) reported that when tomatoes are enclosed in polyethylene and stored at 25 °C they are more resistant to oxidative stress than unenclosed fruit stored at the same temperature. On the other hand, Kapotis et al. (2004) attributed the reduced rate of fruit softening in low oxygen levels (in modified atmospheres) to inhibition of polygalacturonase activity.

CONCLUSION

This study showed that the evaporative cooler is an effective simple technology for extending the shelf life of fresh tomatoes under semi-arid condition. There were additive effects of storage in cooler and PE packaging in extending shelf life. With the identification of fruit decay as the major limiting factor to fruit shelf life in the tested evaporative cooler, it becomes paramount that the use of the cooler be in combination with an appropriate fungicidal treatment.

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