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COMPARISON OF BAGGED TOMATO STORAGE CHARACTERISTICS UNDER TWO DIFFERENT EVAPORATIVE PAD MATERIALS

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Abstract

Tomatoes are important in the agricultural sector as they serve as raw materials for the production of value added products. The aim of this study was to compare bagged tomato (tomato in sealed Ziploc bags storage characteristics using two evaporative pad materials (charcoal and river sand). River sand and charcoal were used as cooling pads with storage under ambient conditions being the third treatment (control). Each treatment had two replicates. Temperature, Relative humidity, Cooling efficiency, Weight, Firmness and Colour assessment were determined throughout the test period and the results were subjected to Analysis of Variance [ANOVA]. Means were separated using DMRT at 5 percent level of significance. Result from storing bagged fresh tomatoes under both media showed that a cooling chamber filled with charcoal as absorbent material with uninterrupted water supply performed best in the storing of tomato fruit when compared to tomatoes stored under ambient conditions or with river sand as evaporative media. It is therefore recommended that further studies should vary the use of different absorbent materials with respect to availability, cost, and durability among others. Comparison can also be further made between tomato storage under bagged and unbagged conditions.

Keywords: evaporative cooling, tomato storage, low cost storage structure, fruits and vegetable preservation.

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1. Introduction

Evaporative cooling is the process by which the temperature of a substance is reduced due to the cooling effect from the evaporation of water. The conversion of sensible heat to latent heat causes a decrease in the ambient temperature as the evaporated water provides useful cooling. This cooling effect has been used on various scales from small scale cooling to large industrial applications [1]. Evaporative cooling occurs when air that is not too humid, passes over a wet surface. Hence the faster the rate of evaporation, the greater the cooling. The efficiency of an evaporative cooler depends on the humidity of the surrounding air [2], and the type of evaporative pads used. Evaporative systems take advantage of the reduction in temperature resulting from the evaporation of mostly water to air [3].

Consequently in developing countries there is an interest in simple, low-cost alternatives, many of which depend on evaporative cooling which is simple and does not require any power supply [4]. To alleviate environmental degradation, the need for energy-efficient and eco-friendly systems for building cooling becomes essential. Hence, the importance of devices for controlling indoor temperatures is increasing [5]. Evaporative cooling, a typical passive cooling technique, could meet the energy demand and global climatic issues [6]. Deterioration of fresh tomatoes during storage depends partly on temperature. This is because temperature is the most important environmental factor in the post-harvest life of tomato fruit. Heat stress can also affect fruit quality of tomatoes by altering physical properties such as size and color, nutritional composition and sensorial attributes [7]. One way to slow down deterioration and thus increase the length of time tomatoes can be stored, is by lowering the temperature to an appropriate level. It is essential that tomatoes are not damaged during harvest and that they are kept clean. This is because damaged and bruised tomatoes have much shorter storage lives and very poor appearance after storage. The author of [8] stated that keeping products at their lowest safe temperature (0 °C for temperate crops or 10–12 °C for chilling-sensitive crops) will increase storage life by lowering respiration rate, decreasing sensitivity to ethylene gas and reducing water loss. Refrigerated cold stores are the best method of preserving vegetables but they are expensive. Fresh tomatoes have also been suggested to be stored in sealed air tight bags in the refrigerator or freezer [9].

Evaporative pads can be made from locally available materials such as river sand, saw dust, charcoal etc., and help to keep products fresh for a while in an environmentally friendly way with no pollution. However, it requires constant water supply to wet the pads, for optimum performance.

Fruits and vegetable farmers do not get enough value for their labour due to weak storage infrastructure, poor transportation, and the perishable nature of these crops often results in substantial economic losses. Local fruit and vegetable farmers often sell as much as they can when the produce is still fresh. Once produce loses its freshness, they are forced to sell it at lower prices or give away for free. During this post-harvest glut, the loss is considerable and often some of the produce will have to be fed to animals or allowed to rot. According to [10, 11], the damage that occurs in fruits and vegetables is primarily due to loss of moisture, change in physical composition and pathological attack. There is therefore a need to store bagged tomatoes (which have been proven to keep them fresh longer) under optimum conditions to reduce perishability, increase shelf life and maintain market value. Evaporative cooling has been used to store tomatoes successfully using various evaporative pad materials, with varying results. With all year round demand for tomatoes, a cost effective evaporative pad material is essential for tomato storage. Hence, this study aimed at evaluating and comparing the performance of two evaporative pad materials (river sand, charcoal) on stored fresh bagged tomatoes.

The aim of this study is to compare bagged tomato (tomato in sealed Ziploc bags storage characteristics using two evaporative pad materials (charcoal and river sand).

2. Materials and Methods

The project was carried out at Crop Production Technology's Experimental plot, Federal College of Forestry, Ibadan (Nigeria). The college is situated at Jericho Hill, Ibadan North West Local Government Area of Oyo state. The area lies between latitude 7°54′ N and longitude 3°34′ E. The annual rainfall range is from 1400–1500 mm. The average temperature is about 32 °C with average humidity of 80–85 %, with two distinct seasons of wet (April to October) and dry (November-March) [12].

The following steps were carried out in the course of the work:

1. The existing evaporative cooler [10] was refurbished and fit with a source of constant water supply.

2. The cooling pads/evaporative media (River sand and Charcoal): River sand was collected from a flowing stream and Charcoal was procured from the market. Both pad materials were filled into the designated evaporative cooling chamber cavities designed for the pad materials. Each storage chamber in the evaporative cooler has dimensions of 74×24 cm and a depth of 40 cm. The total volume of the evaporative cooler is 1.72 m^3 and the structure can store 206.83 kg of tomatoes [11].

3. Performance evaluation: Both cooling pads were evaluated using bagged tomatoes as a test crop. The following parameters were assessed; Chamber temperatures and humidity values were taken five times daily (7 am, 10 am, 1 pm, 4 pm, 7 pm) with the aid of a thermometer and hygrometer respectively. Tomato weight was taken every two days to determine weight loss with the use of sensitive scale. Firmness was assessed at two day intervals to determine the loss in firmness (three different weights: 30, 60, and 100 g, were placed on randomly selected tomatoes and the level of depression/distortion in the circumference was measured in cm with a rope and ruler).

Other calculations included those for: Cooling efficiency and Physiological weight loss (as used by [11]).

Statistical analysis**:** Data obtained was subjected to analysis of variance [ANOVA]. Significant means were separated using DMRT at 5 % level of significance.

3. Results and Discussions

The effect of temperature on tomato storage using different absorbent materials is presented in **Table 1**. There was significant difference among the treatments in all the days except on days 1, 4, 6, 7 and 12. The highest mean temperature was recorded under ambient conditions on all the days of storage. The least mean temperature was recorded in charcoal storage in all the days except on days 5, 6, 13, and 14. This corresponds with [13], who stated that keeping fruit and vegetables at their lowest safe temperature will increase storage life. Hence, tomatoes stored using charcoal as absorbent material reached the lowest temperature in all the days.

Table 1

Effect of absorbent material on mean daily temperature of the storage chamber

Day	RS	CH	CO
1	26.00a	25.90a	27.00a
2	26.00a	25.50a	27.30b
3	26.10a	26.00a	27.20b
4	26.40a	26.40a	27.60a
5	26.60a	27.10ab	28.00b
6	26.70a	26.80a	28.00a
7	27.30a	27.20a	28.60a
8	27.00a	27.00a	28.20b
9	27.00a	26.80a	28.40b
10	27.00a	26.90a	28.00b
11	26.10a	26.00a	27.20b
12	25.50a	25.40a	26.20a
13	26.80a	27.00a	28.40b
14	25.50a	26.10a	28.00b

Note: means with the same alphabet in the same column are not significantly different at 5 % level of significance; RS – River sand; CH – Charcoal; and CO – Ambient conditions

The effect of relative humidity on tomato storage using different absorbent materials is presented in **Table 2**. There was no significant difference among the treatments in all the days except on days 6 and 14. The highest mean humidity was recorded in Charcoal on all the days except on days 4, 7, 8, 9, and 11 while the least mean was recorded under ambient conditions on all the days except on days 1, 7, 8, 10, and 11. In [14] reported that high relative humidity increases the shelf life of fresh fruit and vegetables. This implies that charcoal as an absorbent materials performed better in tomatoes storage in term of humidity.

Table 2

Effect of absorbent material on mean daily humidity of the storage chamber

Day	RS	CH	CO
1	86.20a	88.70a	87.40a
2	87.80a	88.40a	80.40a
3	87.80a	89.60a	87.60a
4	89.00a	89.00a	89.00a
5	88.10a	89.00a	84.60a
6	90.60b	90.70b	87.60a
7	88.20a	87.30a	89.40a
8	88.10a	87.20a	88.40a
9	88.01a	87.40a	83.00a
10	85.80a	87.40a	86.20a
11	89.40a	89.20a	91.00a
12	89.30a	89.30a	87.00a
13	87.40a	88.10a	83.00a
14	89.70b	90.30b	83.70a

Note: means with the same alphabet in the same column are not significantly different at 5 % level of significance; RS – River sand; CH – Charcoal; and CO – Ambient conditions

Table 3 shows that there was no significant difference in the treatments in all the days except on days 2, 4, and 14. It reveals that Charcoal stored bagged tomatoes had the highest final mean weight of 220.00 g followed by River sand stored bagged tomatoes with mean weight of 190.01 g. Tomatoes stored under ambient conditions lost the most amount of moisture during storage, followed by those under river sand storage, then charcoal storage. This corresponds with the premise that fruit generally loses weight during storage. Charcoal therefore performed favorably in terms of bagged tomato weight loss during storage.

Table 3

Effect of absorbent materials on the weight of stored bagged tomato

Treatment	Initial	Days							% weight loss
		2	4	6	8	10	12	14	
RS	473.50a	463.00a	414.00b	337.50a	230.10a	220.00a	205.10a	190.01b	59.8 %
CH	488.00a	478.00b	422.50b	330.50a	260.20a	240.10a	228.20a	220.00b	54.9 %
CO	465.00a	364.00a	282.50a	240.50a	190.01a	160.00a	142.08a	130.09a	72.02 %

Note: means with the same alphabet in the same column are not significantly different at 5 % level of significance; RS – River sand; CH – Charcoal; and CO – Ambient conditions

There was no significant difference in the treatment in all the days except on days 5 and 14 (**Table 4**). The highest mean of cooling efficiency was recorded in Charcoal storage on day 9 (72.06 %) and the least was under ambient condition with the value of 35.01 % on day 12. Therefore, charcoal as absorbent material performed better in the cooling of bagged tomatoes.

Table 5 shows the compression test results of tomatoes for all three treatments, under three different weights, over the course of 8 days. At day 8, under compression by 100 g weights, it was recorded that charcoal stored tomatoes showed the least compression range (11.00 cm), followed by river sand tomatoes (4.00 cm). Tomatoes stored under ambient conditions had no readings as they were flattened from day 6 of storage. This implies that tomatoes stored under charcoal evaporative cooling kept firm for a longer period than the other two treatments.

Table 4

Comparison of cooling efficiencies of charcoal, river sand, and ambient conditions on bagged tomatoes

Day	RS	CH	CO
1	64.33a	70.26a	63.32a
2	43.83a	55.17a	63.32a
3	51.67a	58.34a	70.00a
4	62.62a	62.62a	46.68a
5	65.95b	67.38b	40.76a
6	55.92a	52.58a	47.62a
7	64.12a	66.34a	49.50a
8	72.06a	65.01a	58.74a
9	65.01a	72.06a	58.74a
10	40.20a	43.00a	35.45a
11	48.34a	53.32a	40.84a
12	36.67a	40.00a	35.01a
13	49.46a	67.22a	49.46a
14	65.95b	67.38b	40.76a

Note: means with the same alphabet in the same column are not significantly different at 5 % level of significance; RS – River sand; CH – Charcoal; and CO – Ambient conditions

Table 5

Effect of absorbent materials on the firmness of stored tomato

Treatment	Weight, g	Days							
		2		4		6		8	
		I.R.	F.R.	I.R.	F.R.	I.R.	F.R.	I.R.	F.R.
River sand	30	11.00a	11.00a	12.00a	11.75a	11.00a	11.00a	8.00b	8.00b
	60	11.00a	11.00a	12.00a	12.00a	11.00a	10.50b	8.00b	7.00b
	100	11.00a	11.00a	12.00a	11.95b	10.50a	8.50b	7.00b	4.00b
Charcoal	30	11.50a	11.50a	13.00a	13.00a	16.50b	16.50b	13.50b	13.50b
	60	11.50a	11.50a	13.00a	13.00a	16.50b	16.50b	13.50b	13.00c
	100	11.50a	11.50a	13.00a	13.00b	16.50b	16.50b	13.00c	11.00c
Control	30	8.00a	8.00a	6.00a	6.00a	0.00a	0.00a	0.00a	0.00a
	60	8.00a	8.00a	6.00a	5.00a	0.00a	0.00a	0.00a	0.00a
	100	8.00a	8.00a	5.00a	4.00a	0.00a	0.00a	0.00a	0.00a

Note: I.R. – Initial Reading (cm); F.R. – Final Reading (cm); means with the same alphabet in the same column are not significantly different at 5 % level of significance

Tomatoes stored under ambient conditions showed the most drastic color changes. On the 3rd day, the tomatoes changed from a bright reddish color, to pale red, and later turned black. The tomatoes stored in the cooling chamber still retained their colour with little significant changes within the test period, but spoilage of samples in the cooling chamber were noticed on the 10th day of the test period. The color change observed was based on the physical appearance of the tomatoes and supports the work [1].

Charcoal absorbed more water than river sand (**Table 6**). This implies that charcoal is a better evaporative media than river sand.

Table 6

Absorption rate of river sand and charcoal as evaporative media

Parameter	Weight, g	Amount of water absorbed, l/h
River Sand	400	11.7
Charcoal	400	16.7

From the results, it was concluded that a cooling chamber filled with charcoal as absorbent material with uninterrupted water supply performed best in the storage of bagged tomato fruit which helps in extending the fruit's shelf life when compared to tomatoes stored under ambient conditions or with river sand as evaporative media. Using charcoal as an evaporative pad promotes low temperatures and high humidity for stored tomatoes, resulting in higher cooling efficiencies, lower weight loss, and firmer stored tomatoes during the storage period.

Study limitations included our inability to store tomatoes longer than 14 days before total spoilage. The storage was also carried out during dry season hence bagged tomato storage characteristics in rainy and harmattan seasons were not explored. It should be noted that findings are solely limited to bagged tomato storage in a block evaporative cooling facility under river sand and charcoal as cooling pads, in South West Nigeria, during dry season. Further studies can explore bagged tomato storage characteristics under different weather conditions, in other parts of the country, and under other different evaporative pad media.

This study compared bagged tomato storage characteristics under different two evaporative pad materials in an evaporative cooler. Based on the results from this experiment it is therefore recommended that further studies should vary the use of different absorbent materials with respect to availability, cost, and durability among others.

4. Conclusions

In the course of the research, we have shown that a cooling chamber filled with charcoal as absorbent material with uninterrupted water supply performed best in the storage of tomato fruit when compared to tomatoes stored under ambient conditions or with river sand as evaporative media. This is seen with charcoal having the highest mean humidity and temperature readings on more than 50 % of the total storage period. Charcoal stored bagged tomatoes also had the highest final mean weight of 220.00 g followed by River sand stored bagged tomatoes with mean weight of 190.01 g. This is because tomatoes stored under charcoal evaporative media lost the least amount of moisture during the storage process. Charcoal also absorbed more water than river sand (70 %), showing that it is a better absorbent material than river sand. More work can be done to further improve the storage characteristics of such indigenous evaporative structures to help farmers who may not be able to afford more expensive cold storage systems for tomatoes.

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