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KSCOET ZERO ENERGY COOLING CHAMBER

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ABSTRACT

Production pf fruits and vegetables are never a problem in Nigeria but its storage. The production is way beyond enough for production but the usually goes to the gabbage due to its short shelf life. The Zero energy cooling chamber is a zero energy storage facility that is used in the storage of fruits and vegetables using evaporative cooling principle. As the name implies, it does not use any form of energy as energy is expensive in Nigeria using either electrical or fuel as a source of energy. The research took place at the Kogi State College of Education (Technical) Kabba, Kogi State farm. The chamber was constructed to compare the percentage weight loss of fruit (banana) and vegetables in the chamber and at room temperature and as well determine the shelf life of the crops. The cooling was achieved by wetting the seabed sand in between the core of the chamber morning and evening. The vegetables that were used are tomatoes, cayene pepper, scotch bonnet pepper, okro, amaranths and fluted pumpkin. The fruit used for the research was banana. The percentage weight loss for fluted pumpkin which is a common and most used vegetable was 13.42% in the chamber as against 30.37% under room temperature, with a shelf life of 7 and 3 days in the chamber and room temperature respectively. Amaranths had a percentage weight loss of 14.85% in the cooling chamber and 37.54% under room temperature and shelf lives of 4 and 2 days respectively. The shelf life of tomato in the cooling chamber was between 15 to 20 days and 10 days under room temperature. Scotch bunnet; 10 to 18days in the chamber and 9 days under room temperature. Cayenne pepper had The shelf life of between 10-18 days in the chamber and 9-10 days under room temperature. Banana had a percentage weight loss of 1.48% in the chamber and 3.66%under room temperature and shelf lives of 4 and 2 two days in the cooling chamber and under room temperature respectively. The temperatures in the chamber and room (ambient) were recorded at three different time intervals; 8:10am-8:20am, 1:05pm-1:15pm and 6:05pm-6:15pm. It was observed that the average temperature difference between the chamber and the room was 9.5℃.

Keywords: Zero Energy, Percentage weight loss, Average Temperature, Evaporative cooling.

1. INTRODUCTION

Post-harvest loss is a major problem in cultivation of horticultural crops. The amount of effort put into producing these crops does not commiserate the profit. Losses for highly perishable leafy green vegetables have been measured to be as high as 70%-80% in West Africa and losses in fruits to be 50%-70%, especially during the rainy season. It is not unusual to find post-harvest losses reported to average 20% to 50% during the period between harvesting and final retail marketing. This amounts to an enormous waste of seeds and planting materials, land, energy, fertilizers, water, labour and other productive resources.

Roughly about one third of food produced for human consumption is loss or wasted globally, which amounts to about 1.3 billion tons per year (FAO,2010). Moreso, 30 to 40 % of the food crops produced in the world is never consumed as a result of damage, rotting as well as pest and diseases which affect crops after harvest (Meena, et al 2009). As such, post-harvest loss has contributed to food problem in Nigeria.

Nigeria is Africa's second largest producer of tomatoes with over 1.5 million tonnes harvested annually. Globally, Nigeria ranks as the 16th largest tomato producing nation in the world and has the comparative advantage and potential to lead the world in tomato production and exports. The country accounts for 68.4 percent of West Africa's output; 10.79 percent of Africa's and 1.2 per cent of total world production of the crop. Despite this, nearly 50 percent of post-harvest losses occur annually due to poor storage system and poor transportation (Omosomi O., 2017). There is always a glut at the peak of production and scarcity during off season. Reduction of post-harvest losses and quality deterioration are essential in increasing food availability from the existing production. Minimizing this loss has a great significance for food security, economic growth and welfare of the society.

Electricity is erratic in Nigeria and the use of generating set or fuel is far from it as the price of fuel increases by the day. The use of refrigerator or cold room is very expensive as these farmers only have enough to produce for the family and the little left be sold off in the market. When these are used, the cost of production will be so high thus leading to loss after sale as the cost price does not commensurate with cost price.

The term post-harvest losses are defined as "losses that occur after harvest till the produce reaches consumers. It can be quantity as well as qualitative losses. Post-harvest losses are more painful and costlier than pre-harvest in terms of money and labour. Vegetables are highly perishable having moisture content of (80-90%). They are live commodities and continue their life processes like respiration and transpiration even after harvest. When the fruit is attached to the parent plant, water and photosynthates are supplied to it. But losses are not replaced during post-harvest stage and hence the produce depends on its own food reserve and moisture content with the result they perish fast. Water is lost from the product due to transpiration and food reserve depletes by respiration. Water loss or transpiration is a major factor affecting quality of vegetables. In addition to lower saleable weight, loss of water can affect quality in many ways, including wilting, shrivelling, flaccidness, soft texture and loss of nutritional value (Nath A., L.R. Meena, K. Vinod and A.S. Panwar (2018). The rate of water loss, and the impact of this loss, will vary by product. Water loss can be reduced by cooling products, maintaining a high relative humidity in the storage environment, controlling air circulation, and where permitted, the use of surface coatings or plastic film (Chris and Jacqueline, 2012).

Post-harvest loss is more serious as compared to production loss. Reductions of post-harvest losses significantly increase availability of vegetables without bringing additional land into production and without using additional inputs. Although losses cannot be reduced completely, but can be minimised by adoption of modern cultural practices, harvesting, handling, marketing and processing techniques.

Due to the physiological form of fruits and vegetables, they deteriorate easily in transit and storage especially under conditions of high temperature and humidity resulting in heavy losses of these crops (Idah PA., et al., 2007). The main factors that are most consistently related to higher levels of post-harvest losses include rough handling, use of poor quality packages, high post-harvest handling temperatures and delays in marketing (Kitinoja and Al Hassan, 2012; Kitinoja and Cantwell, 2010).

On farm storage is also required to reduce losses in highly perishable fresh horticultural produce. Low-cost, low-energy, environmental friendly cool chambers made from locally available materials and which utilize the principles of evaporative cooling will be developed in response to this problem. This cooling chamber is able to maintain temperatures at 10^0C–15°C below ambient, as well as at a relative humidity of 90 per cent, depending on the season. Fruits and vegetables are stored in plastic crates within the chamber. The shelf life of the fruit and vegetables maintained in the cool chamber was reported to be increased from 3 days at room temperature to 90 days (Anon. 2006).

In tropical areas like Nigeria, tremendous amount of quality deterioration take place immediately after harvest of produce due to lack of on farm storage facilities to overcome this problem, low cost environmental friendly and easy to use storage facilities are to be developed. This does not require electricity. An example of such is the Zero Energy Cooling Chamber. This chambers work on principle of evaporative cooling using locally available materials like brick sand and bamboos. The temperatures in these chambers are less than surrounding atmosphere. These chambers can be used for short term storage of products at the farmer’s field itself.

Therefore, this research was conducted to help farmers and fruits and vegetable sellers to be able to store their produce a little bit longer and so minimise wastage and increase their profit.

Area of Study

This research was carried out at the school’s farm in Egbeda at the academic wing of the Kogi State College of Eduation (Technical), Kabba, Kogi State under Kabba/Bunu Local Government Area of Kogi State, Nigeria. The College is located in the following communities, Gbeleko (administrative department) Egbeda (Academic wing) and Kakun (hostel).

2. MATERIALS AND METHOD

The following materials were used:

- Brick
- Timber
- Bamboo
- Sea bed sand
- Clay
- Hose
- Raffia
- Straw
- Water container
- Plastic crates
- Polyethene

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- Jute bags
- shovel
- Nails
- Twine
- Thermometer
- Electronic weighing scale.

Procedure

Erection of Shade

Soil is dug in eight places for the shade. The timber was then inserted into the dug holes and filled with sand and soil. This was left for a week so that it can solidify. are then put into the hole and allow to solidify. The shed was constructed using bamboo, timber, twine, nails and straw. The area measured 15m x 10m.

Chamber Construction

A flat surface area was then marked for the erection of the chamber. This was spread out and levelled using a shovel. Bricks were laid to make the base of the chamber. Bricks were laid one on top of the other with the aid of clay mortar to bind them together. This outer rectangle measured 2.10.m x 1.38m (Length and breadth) with the height of 0.80m. for inner chamber and 0.60m for the outer chamber. After the first layer, another is laid with a cavity of 0.10m in between with the inner rectangle measuring 1.87m x 1.22m .The cavity was then filled with seabed sand using a shovel.

The plastic crates were then put inside the chamber. The vegetables and fruit were then weighed and put in the individual plastic crates. These were then covered with polyethene bag. Raffia mat was used to cover the top of the chamber followed by a jute bag. The temperature of the chamber was taken thrice a day; morning, afternoon and evening. The vegetables and fruits were weighed once a day. The same amount of vegetables and fruits were also weighed and kept under room temperature. The room temperature and the weight of the vegetables and fruits were taken every day as well. The cavity is wet twice a day; morning and evening for three weeks (22nd November to 13th December 2022).

Fig. 1 Moulded bricks

Fig. 2 Foundation of chamber

Fig. 3 Measurement of the core spacing

Fig. 4 construction of the inner chamber

Fig. 5 Vegetables in crate inside the chamber

Fig. 6 Polyethelene cover

Fig 7 Rafia mat covering the chamber

Fig. 8 The chamber with its shed

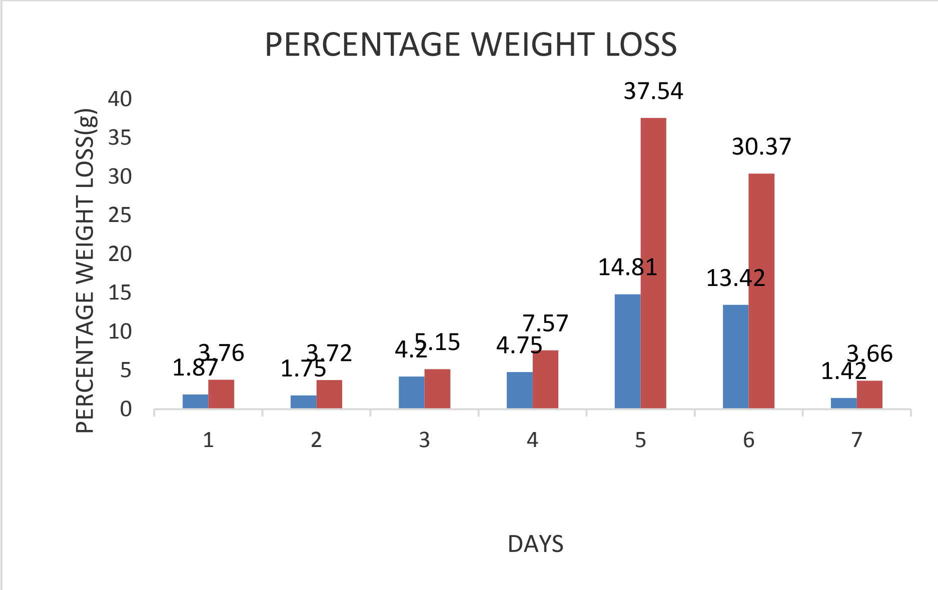
3. RESULTS

Below are data collected over a period of three weeks. The table below showed the percentage weight loss of the vegetables and fruits in the chamber and under room temperature. And the shelf life of the different crops.

Table 1

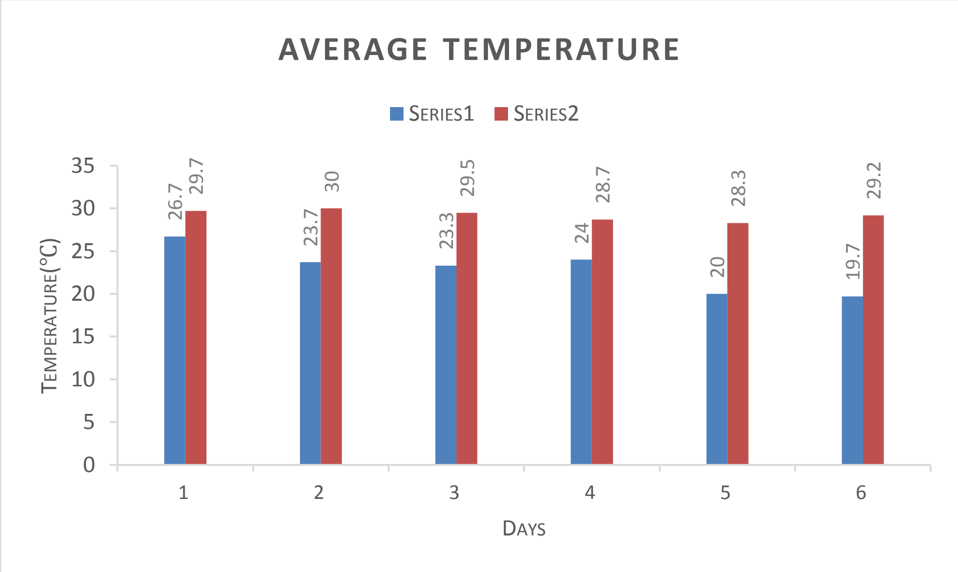
Vegetable/ Fruit	Weight Loss (%)		Shelf life	
	ZECC	Room Temp.	ZECC	Room Temp.
Tomato	1.87	3.76	15-20	7
Scotch bonnet	1.75	3.72	10-18	10
Cayene Pepper	4.20	5.15	10-18	9
Okro	4.75	7.57	7	4
Amaranths	14.85	37.54	4	2
Fluted pumpkin	13.42	30.37	7	3
Ripe Banana	1.48	3.66	4	2

Table 1 shows the percentage weight loss and shelf life inside the chamber and under room temperature. Amaranths had 14.85 % in the chamber and 37.54% under room temperature. Fluted pumpkin had 13.42% in the and 30.37% under room temperature. Okro had 4.75% and 7.57%, Cayene Pepper, 4.20% and 5.15%, tomato, 1,87% and 3.76%, scotch pepper 1.75% and 3.75% and ripe banana had 1.48% and 3.66% inside the chamber and under room temperature. respectively. It was observed that the shelf life of tomato was inside the chamber and under room temperature were between 15 to 20days and 7 days, 10-18 and 10 days for Scotch bonnet, 10-18 days and 9 days for cayenne pepper, 7 days and 4 days for okro, 7 days and 3 days for fluted pumpkin, 4 days and 2 days for both amaranths and ripe banana inside chamber and under room temperature respectively.



Date	Time Interval	Temp in the Chamber (^{0}C)	Room Temp (^{0}C)	Ave. Temp in the Chamber (^{0}C)	Ave Room Temp (^{0}C)
22/11/2022	8:10-8:20	25	26	26.7	29.7
	1:05-1:15	28	32		
	6:05-6:15	27	31		
23/11/2022	8:10-8:20	24	25	23.7	30.0
	1:05-1:15	20	33		
	6:05-6:15	27	32		
24/11/2022	8:10-8:20	24	25.5	23.3	29.5
	1:05-1:15	20	33		
	6:05-6:15	26	30		
25/11/2022	8:10-8:20	20	24	24.0	28.7
	1:05-1:15	27	32		
	6:05-6:15	25	30		
26/11/2022	8:10-8:20	20	23	20.0	28.3
	1:05-1:15	15	33		
	6:05-6:15	25	29		
27/11/2022	8:10-8:20	23	28	19.7	29.2
	1:05-1:15	15	35		
	6:05-6:15	21.1	24.5		

The table above showed the average temperature in the chamber and room temperature. The data was taken for six days from the 6th of December 2022 to 11th December, 2022. The average temperature for the 6th of Dec. was 26.7℃ and 29.7℃, 24.0℃ and 28.7℃ in the 9th, 23.7℃ and 30.0℃ for the 7th, 23.3 ℃ and 29.5℃ for the 8th, 20.0℃ and 28.3℃ for the 10th and 19.7℃ and 29.2℃ for the 11th of Dec. 2022 respectively.



4. CONCLUSION

The research showed that percentage weight loss for banana and the vegetables showed a significant difference between those in the chamber and those under room temperature. The crops in the cooling chamber had low weight loss and longer shelf lives The temperature in the chamber were lower in the chamber compared to under room temperature and the outside temperature as well. Fluted pumpkin (Ugu) showed the lowest weight loss and tomato had a longest shelf life of 20 days. The temperature difference between the chamber and room temperature was an average of 9.5℃. The experiment had a temperature difference of 18℃ and 20℃ on the 26th and 27th November, 2022 between 1:05pm and 1:15pm in the chamber and outside the chamber. This is to say that there will be reduction in glut, farmers and traders of fruits and vegetables will have more profits should they adopt the use of the storage facility.

5. RECOMMENDATIONS

It is therefore recommended that farmers be encouraged to adopt this storage facility by assisting them with on farm training by way of extension as the materials needed for the construction of the cooling chamber are readily available in the community. Some farmers and traders were involved in the research work. One of their complaint was how to get the crate and the cost. Some mentioned that they are expensive but were told that they could use other cheaper ones. Some also said they would need supervision during the construction. The research was carried out during the dry season and cooler part of the year (Hammattan); with a characteristic low temperature in the morning and a higher temperature during the day with high evaporation rate. I recommend that this research be carried out during the raining season when the relative humidy is high and the rate of deterioration high as well.

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