

*Research Article*

**Effect of packaging materials on some nutritional qualities of fruit and vegetables stored in a passive evaporative cooler**

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**Abstract:** A study was conducted to assess the effect of packaging materials on some nutritional qualities of fruit and vegetables (garden egg, banana and tomatoes) stored in a passive evaporative cooler. The fruit and vegetables were stored inside a perforated plastic container and sisal sack before placement inside an evaporative cooler. The results obtained were compared with that of the control wherein the produce was stored inside the cooler without any packaging material. The shelf life and qualities of the stored produce in the perforated plastic container were much longer and higher than the produce inside the sisal sack and control. The average temperatures of 24°C, 24.35°C, 24.80°C, 28.82°C and relative humidity of 88.87%, 88.68%, 86.67% and 69.41% were recorded for the perforated plastic container, control, sisal sack and the ambient respectively. Also, the packaging of produce inside the perforated plastic container retained the highest amount of vitamin C content (13.1%) for all stored produce than the control and the sisal sack (12.5% and 11.7% respectively). Overall, the data obtained in this study indicates that the perforated plastic container provided the best storage medium.

**Keywords:** packaging material, vitamin C, temperature, relative humidity, post-harvest, Nigeria, storage, cooling, appropriate technology

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## Introduction

Temperature and relative humidity are the most important environmental factors which influence the deterioration rate of harvested perishable crops such as fruit and vegetables. Fruit and vegetables can maintain an independent existence when detached from the tree or vine. The length of storage is a function of composition, resistance to attack by microorganisms, the external conditions of temperature and the gasses in the environment [1].

The best technical method of preserving perishable crops is through the use of refrigeration, which supplies low temperature and high relative humidity for perishable crops. Refrigeration involves mechanical components, electricity and/or other forms of energy input. However, because refrigerator systems are rather complex, energy intensive, expensive to purchase and also difficult to operate and maintain, their application for fresh perishable crop storage is not feasible under the prevailing socio-economic conditions of the rural remote areas in Nigeria. This therefore necessitates the need for the development of an alternative, inexpensive and easy to operate cooling system without electricity for preserving various perishable crops produced by small scale farmers.

Tomatoes (*Lycopersicon esculentum*) have many common names including love apple (English), tomate (French) and tomati (Yoruba). Cultivars may be determinate or indeterminate in growth, variable in size, colour, shape, flavour, vitamin content and degree of resistance to leaf and root diseases [2]. Several important changes occur in the structure of tomatoes during ripening, such as synthesis of pigments, production of flavour and aroma compounds [3]. An increase has been reported in ascorbic acid content of tomatoes during their ripening [4]. The metabolism of tomatoes continues even after their detachment from the plant when the fruit have reached their red stage. They continue to ripen and finally deteriorate to a point where they become valueless [5].

To extend the shelf life of fruit and vegetables, their respiratory metabolism is slowed by low-temperature storage or storage in a high carbon dioxide atmosphere [6]. Storage of tomatoes and other products of tropical or subtropical origin at below critical temperatures predisposes them to chilling injury [3,5]. Storage of tomatoes at temperatures below 13°C has been reported to have a significant effect on tomato flavour, even before any visual symptoms are seen [7]. It has also been observed that when the light-red tomatoes were stored below 13°C, they were significantly lower in ripe aroma and flavour, and higher in off-flavour, compared to tomatoes stored at 20°C [8]. A slight accumulation of ascorbic acid was observed during storage of tomatoes [6]. The presence of flavonoids in tomato cells may have helped to maintain the ascorbic acid content [9]. Toor and Savage [10] 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. Other studies have also shown that the

post-harvest storage of light-red tomatoes does not have any deleterious effect on the total ascorbic acid content of tomatoes [11].

Banana is a staple food of many tribes in a number of African nations, including Nigeria, and it occurs in many varieties. The family comprises about 30 species of wild and cultivated types. However, the most common are *Musa sapientum* and *Musa cavendishi*. The former grows to a height of 5 to 6 metres and it is characterized by the compactness of the branch; while the latter is the dwarf type which grows to a height of between 150 and 240cm.

Garden egg is a fruit of the tropical region and it occurs in two varieties namely *Solanum incantum* L. and *Solanum meleongena* L. Two main cultivars of the fruit are known; one has a sweet taste and the other a bitter taste. Garden egg cannot be expected to keep satisfactorily in storage for more than 10 days. Chilling injury has been noted at temperature of 4°C or lower in 4 – 8 days [12].

Most fruit and vegetables have a very limited life after harvest if held at normal harvesting temperature [13]. Post-harvest cooling rapidly removes field heat allowing for a longer storage period. In addition to helping maintain quality, post-harvest cooling also provides marketing flexibility, allowing the grower to sell produce at the most appropriate time [14]. Having cooling and storage facilities makes it possible to market the produce for a longer period after harvest. This can be an advantage to growers who supply restaurants and grocery stores; or to small growers who want to assemble truckload lots for shipment. Post-harvest cooling is essential to delivering produce of the highest possible quality to the consumer. The present study is aimed at achieving this purpose. Although the evaporative cooler may not be as efficient as the refrigerator, it is hoped that it will be found extremely useful in the rural areas considering their socio-economic status.

## **Materials and Methods**

### ***Collection of fresh fruit and vegetables***

Ninety (90) pieces each of mature fresh garden egg, banana and tomato were harvested from a farm located at Chanchanga area, Minna, Nigeria and used in the study. The fruit and vegetables were divided into three (3) lots of thirty (30) and packaged in a perforated plastic container (PPC), sisal sack (SS) and the third group, which served as the control (C), was stored in the designed and constructed passive evaporative cooler without any packaging material. The garden eggs, bananas and tomatoes were stored for 10, 14 and 12 days respectively according to the recommended storage period for fruit and vegetables by NSPRI [15]. The perforated plastic container and the sisal sack were chosen because of their ease of loading and unloading, ease of transportation and resistance to breakage and moisture.

### ***Determination of temperature and relative humidity***

The temperature and relative humidity of the fruit and vegetables stored in the different packaging materials were measured daily and compared with the ambient using a digital

thermometer and a relative humidity measuring instrument (Testo 625 Compact instrument).

#### ***Determination of percentage decay, moisture content and vitamin C content***

The fruit and vegetable produce in each of the storage systems were observed daily for any decay. The rotten samples were removed from the rest and cut into two or more pieces to ensure rotting had really set in. The percentage decay was calculated at the end of the storage period. The moisture content of the stored produce was determined daily according to the method described by AOAC [16], while the vitamin C content was determined based on the method of Eitenmiller and Landen [17].

#### ***Statistical analysis***

The experiment was designed based on a 3 x 3 factorial in a complete randomized design of 3 replicates. The effect of perforated plastic container (PPC), sisal sack (SS) and control (C) on decay, moisture content and vitamin C content of the stored fruit and vegetables was analyzed using ANOVA at  $p \leq 0.05$  and the significant effects further evaluated by the use of F-LSD at  $p \leq 0.05$ .

### **Results and Discussion**

#### ***Temperature and Relative Humidity of Stored Fruit and Vegetables***

The effect of temperature on the fruit and vegetables stored inside the different packaging materials in the system is presented in Figures 1 to 3, while that of the relative humidity is presented in Figures 4 to 6. The temperature in the evaporative cooler is lower than that obtained for the ambient for all the produce stored in the two packaging materials and the control (Figures 1 to 3) while the relative humidity is observed to be higher (Figures 4 to 6). This is an indication of the effectiveness of the packaging materials and the evaporative cooler.

The effectiveness of the packaging materials inside the evaporative cooling system for storing perishables is expected to be proportional to both temperature drop and relative humidity rise achieved in their respective storage chamber. The three systems recorded lower temperature and higher relative humidity values as compared with those of the ambient (Figures 1 to 6). This may be attributed to the cooling effect of the evaporative cooler. Wetting of the jute pads and the evaporation of water in the soil also helped in reducing the temperature [18]. The produce inside the perforated plastic container provided the lowest temperature. This may be attributable to the plastic nature of the material which is a poor conductor of heat. Hence, it reduces the amount of heat that has direct contact with the produce. The produce inside the sisal sack gave the highest temperature due to the heat generated in the sack, followed by those stored in the control. The higher temperature recorded for produce stored in the control system when compared with the perforated plastic may be due to the direct contact of the produce with the galvanized sheet which has very high conducting properties.

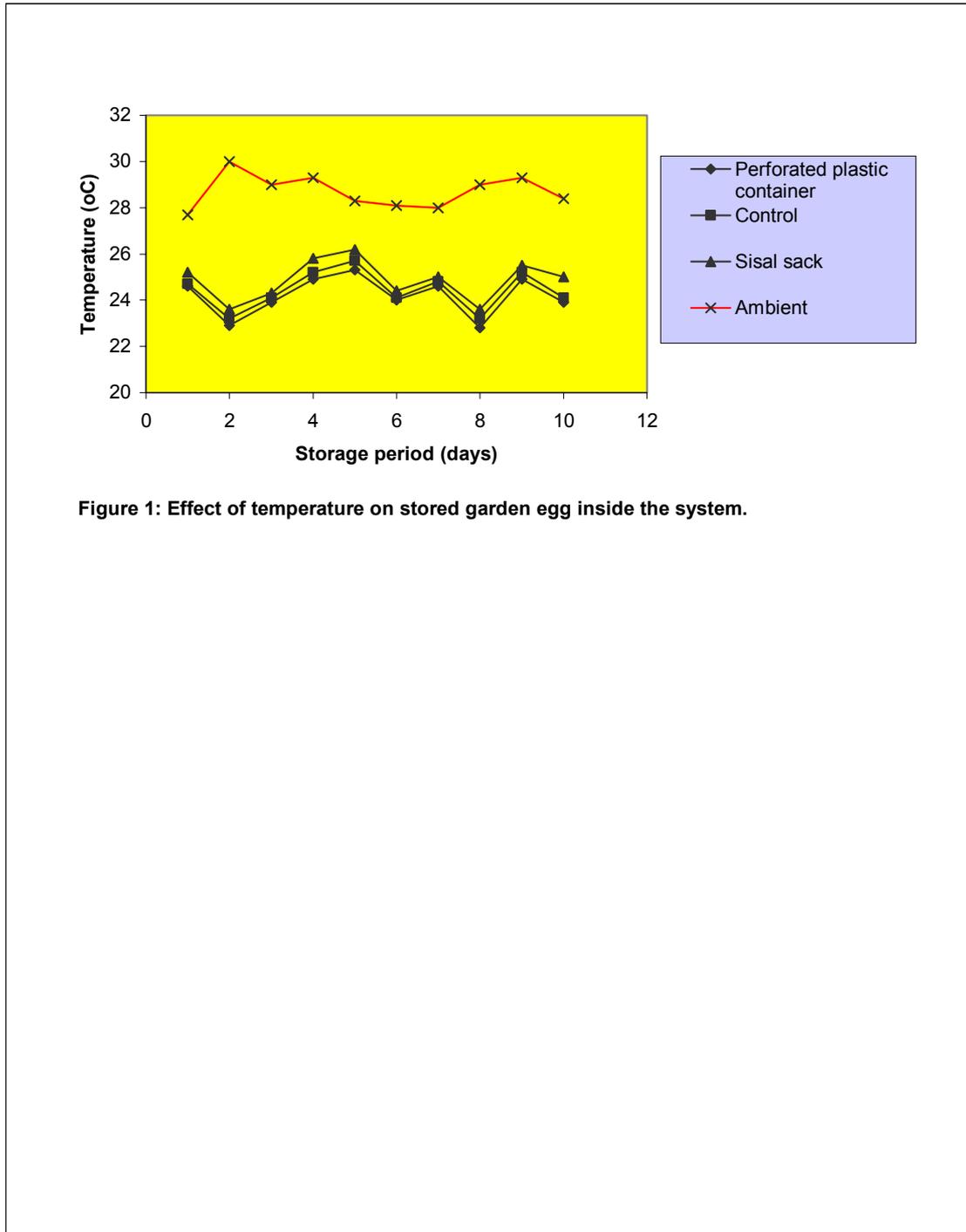


Figure 1: Effect of temperature on stored garden egg inside the system.

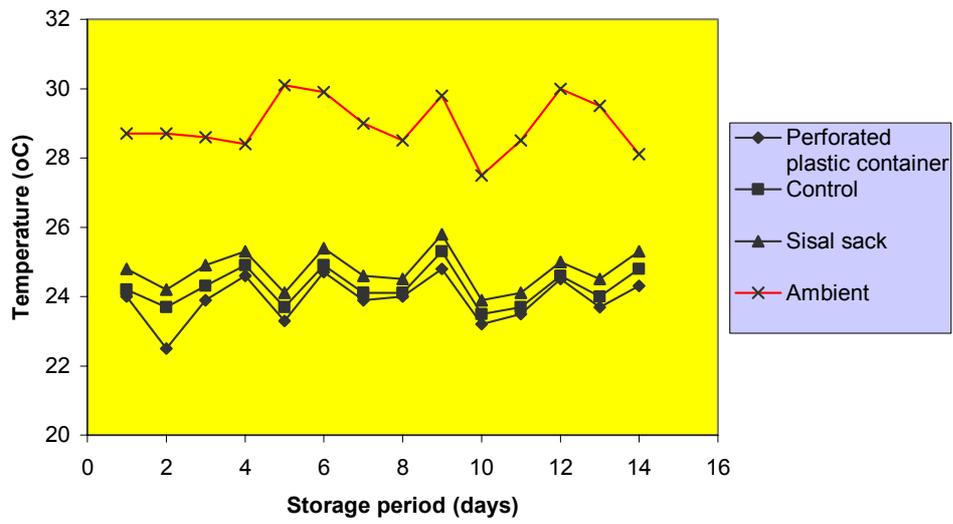


Figure 2: Effect of temperature on stored banana inside the system.

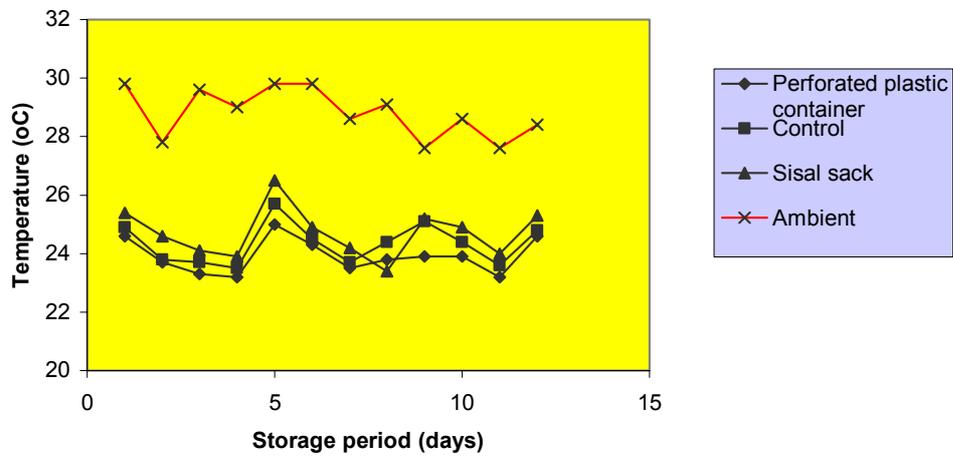


Figure 3: Effect of temperature on stored tomato inside the system.

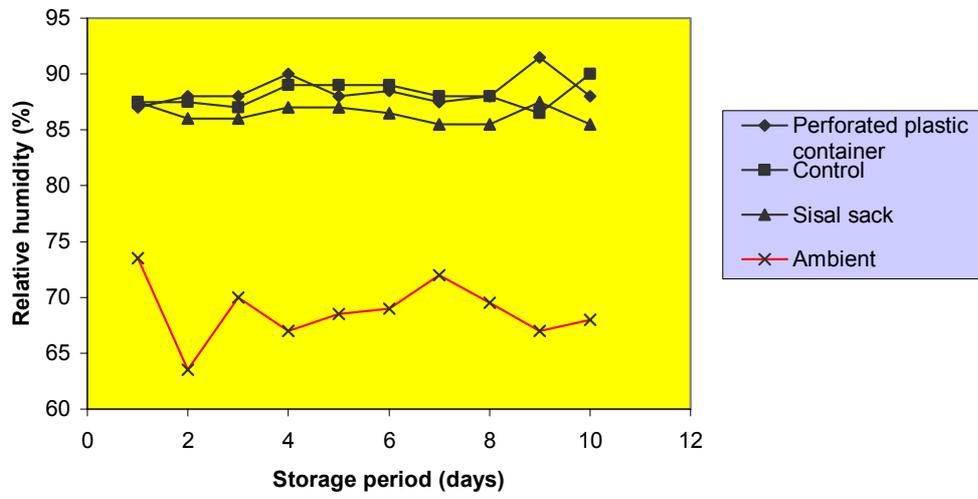


Figure 4: Effect of relative humidity on stored garden egg inside the system.

***Percentage Decay of Stored Fruit and Vegetables***

The data obtained with respect to percentage decay of fruit and vegetables stored inside the packaging materials in the evaporative cooler at the end of storage period is as presented in Table 1. The incidence of decay was observed as spot rotting and the main cause of termination of shelf life of the stored fruit and vegetables inside the system. The produce stored inside the perforated plastic container showed the least amount of decay, followed by those inside the control and the highest decay was observed in the produce stored in the sisal sack. This observation may be attributed to the higher temperature recorded in the sisal sack compared to the other packaging materials (Figures 1 to 3). The perforated plastic container minimized decay while maintaining good appearance for all stored produce unlike those inside the sisal sack and the control system. This may be due to the very low temperature recorded in the perforated plastic container. Low temperature reduces respiration and keeps moisture loss low.

***Moisture Content and Vitamin C Content of Stored Fruit and Vegetables***

The moisture content and vitamin C content of the fruit and vegetables stored inside the different packaging materials in the system is presented in Table 1. The difference in the moisture content of the system could be attributed to the differences in relative humidity and temperature of the storage environment. The produce either lost or gained moisture in relation to either increase or decrease in temperature and relative humidity. The relative humidity of the system is very high and the temperature is low, thus accounting for the gain in moisture by the fruit stored in this system. The low moisture content in some fruit and vegetables in the system indicates higher respiration rate because as they continue to respire under storage, they tend to lose more water [13]. The low moisture content of the produce in the perforated plastic container indicates higher respiration rate.

**Table 1: Percentage decay, moisture content and vitamin C content of fruit and vegetables stored inside the passive evaporative cooler.**

<b>Packaging Materials</b>	<b>Fruit/ Vegetable</b>	<b>Vitamin C</b>	<b>Percentage Decay</b>	<b>Moisture Content</b>
Perforated Plastic Container	Garden egg	0.168	1.25	85.38
	Banana	0.056	0.00	69.99
	Tomato	0.170	5.00	95.07
Sisal sack	Garden egg	0.159	6.25	87.59
	Banana	0.049	21.40	74.05
	Tomato	0.142	17.50	95.30
Control	Garden egg	0.165	1.25	87.34
	Banana	0.051	14.20	72.45
	Tomato	0.158	12.50	95.20

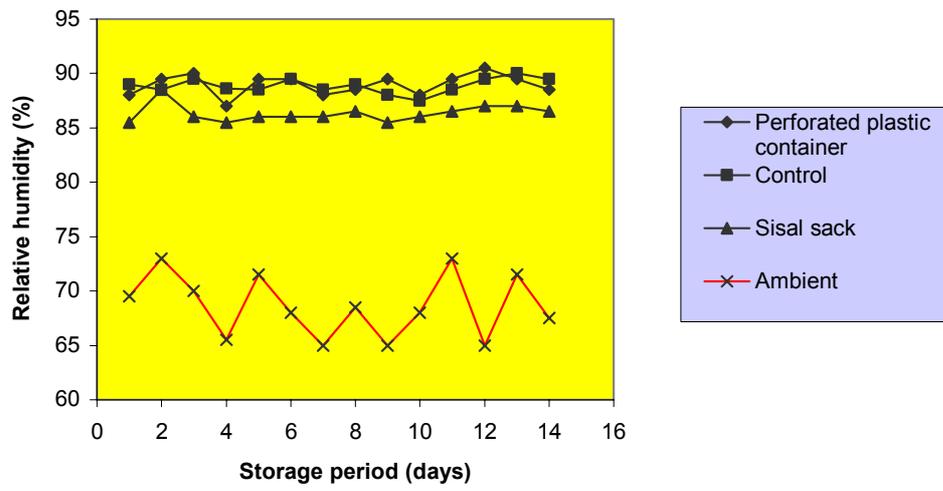


Figure 5: Effect of relative humidity on stored banana inside the system.

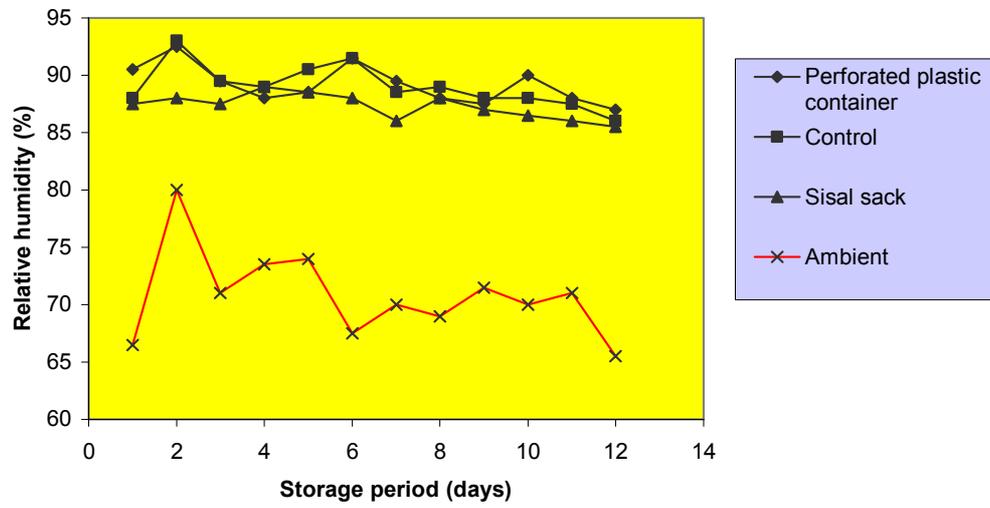


Figure 6: Effect of relative humidity on stored tomato inside the system.

The vitamin C content of the fruit and vegetables stored inside the different packaging materials in the system is also presented in Table 1. The higher level of vitamin C content of fruit and vegetables stored inside the perforated plastic container may be attributed to the lower temperature which tends to slow down the metabolism (including respiration) and eventually reduce the extent of microbial activities as well as the chemical reactions taking place inside the system.

### Conclusion

This study has shown the effectiveness of a low cost, simplified and energy-free cold storage system constructed for perishable fruit and vegetables thus making it appropriate for rural and small-scale storage of fruit and vegetables. Furthermore, the storage of fruit and vegetables inside the perforated plastic container extended the shelf life and retained the nutritional qualities of the stored produce better than the sisal sack and ordinary storage in the cooling chamber.

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