The Effect of Evaporative Cooling System on the Storage of Citrus (Sweet Orange)

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Abstract.
Postharvest losses have been a very perpetual challenge facing the agricultural industries as most produce get spoilt after harvest owing to poor postharvest handlings. Several attempts have been made to eliminate this challenge ranging from transportation, packaging and storage. The panacea to this problem is still much work in progress. However, a developed cooler with a cooling efficiency of 86.01% which was immensely able to salvage the rapid deterioration challenge of fruits as ascertained through a seven days concurrent storage of sweet oranges in a cooler and ambient. The result shows that the cooler successfully improved the shelf life of the stored produce with about 4% weight loss of the stored citrus compared to the 9% weight loss of the ambient storage.
Keywords; Sweet Orange, Cooler, Shelf life, Ambient Temperature and Relative Humidity.

1. Introduction

In the world today, several countries especially the developing ones are facing a number of postharvest challenges in their citrus industries which has resulted into very immense loss both quality and quantity in perspective leading to rapid profit margin reduction for the industries [1]. The production of citrus in the world is around a metric tonne of 73.3 with the nation of Brazil have the largest production quota contributed to the world's general production output. There has been a significant increase in the production growth of most developing countries, however, there several limitations due to postharvest losses caused by the many handling process that takes place after harvest [2].
FAO statistics in 2009 reported that the global land mass being utilized for citrus cultivation was nine million hectares alongside a cumulative production output of 122.3 million tons, with sweet oranges as the first ranked fruit among all the fruit crops [3].
In 2007, FAO report rated Nigeria as the 9th citrus producing country with annual average production capacity of about 3,325,000 tonnes.

The production of citrus in Nigeria was estimated to be 3.9 million tonnes from a land mass of 0.8 million hectares of land. Three percent of total production capacity of the world citrus output between the year 2000 and 2004 was from Nigeria. This production output ranked Nigeria the ninth country amongst the various top citrus producing countries in the world [4].
In Nigeria, close to 0.93 million tons of citrus fruits production on annual basis is gotten from a given estimate on hectarage of 3 million. Citrus is mostly cultivated in the guinea savannah and

rainforest. The states in Nigeria where citrus is mainly produced are Nassarawa, Benue, Kogi, Osun, Oyo, Ogun, Ebonyi, Taraba, Kaduna, Ekiti, Kwara, Imo, Delta. and Edo,
Citrus production is affected by several factors liken the production practices and climatic conditions [5].
Despite the immense production statistics of citrus fruits both national and globally, there are several challenges facing the postharvest handling processes which result into postharvest losses. The most occurring form of postharvest losses in fruits especially citrus happens as a result of lack or poor orchard maintenance, faulty method of harvesting, produce mishandling, loss of weight and firmness, poor transportation, faulty facilities for storage [6-7]. In developing countries, the effect of postharvest losses is seen to be more severe compared to those of the developed countries. In addition, another constraining factor limiting the improvement in the postharvest challenges is that the percentage of scientific researchers in the developing countries that are involved in researches concerning production are significantly higher than those with research focus on the losses incurred in foods after harvest [8]. With the several causative factors that initiates postharvest losses like storage atmosphere, mechanical injury, genetic factors, initial quality of crop and so on. In a bid to solve this problem, shelf life extension of agricultural produce is a very key technique to be adopted to help enhance effective storage. This would be based of principles such as proper temperature management, humidity regulation [9-10].

Chinenye [11], utilized some locally available materials to develop a clay evaporative cooling system for the storage of fruits and vegetables. At no load test, the system was evaluated based on cooling capacity, evaporative effectiveness and drop in temperature. Tomatoes were stored in it for 19days consecutively prior to the appearance of mould spots and rapid colour change.
Jahun et al., [12], developed an evaporative cooling system with materials that are locally available to store of some grams of hot pepper and fresh tomatoes for eight days consecutively before the deterioration became rapid. The effect of temperature alongside relative humidity on the storage span of vegetables. The evaluation shows that the developed cooler gave an appreciable increase in relative humidity and decrease in temperature compared to the ambient which eventually gave an improved shelf life on the produce stored in the evaporative cooler.
Deoraj et al., [13], also developed a cooler for the preservation of vegetables and fruits. The cooler was able to achieve the fruits and vegetables cold storage requirement of low temperature and high relative humidity. Three pad mediums such as coconut fibre, peak and cedar were used and they gave varying saturation efficiency like53.47%, 63.56% and 64.42% respectively. The cooler was also evaluated with tomatoes.
Zakari et al., [14], developed an evaporative cooling system that is solar powered to improve the shelf life of vegetables. A cooling efficiency of 83% was achieved and the cooler was able to preserve the tomatoes for five day with seemingly negligible change(s) in firmness, color, weight and rotting unlike the tomatoes stored in the ambient.
The above highlighted facts are excerpts from the bank of literature that reveals that efforts of some researchers in trying to solve the postharvest loss problems. The arear of focus has mostly been vegetable storage specifically tomatoes
However, this paper aimed out to study the effect of a locally developed evaporative cooling system on the storage of citrus (sweet orange), in other to determine the significant effects on the sweet orange product for mass storage system.

2. Experimental Procedure

Sweet oranges used for this evaluation were gotten from omu-aran market, kwara state. The evaporative cooler that was used to evaluate the shelf life of the sweet oranges was designed to full specification with alignment with the storage requirement for fruits and vegetables as much as a high relative humidity and low temperature for effective storage. The cooler that was used for this experiment has an inner storage space of 0.45m by 0.425m by 0.85m in dimension. The inner storage is made of aluminium so as to enhance the cooling efficiency of the cooler. The detailed specification of the cooler is recorded in [15].

The evaluation was done for seven days consecutively to determine the effect of the cooler and the available ambient temperature and relative humidity on the storage of the sweet oranges. Weight loss analysis was done with the use of a digital weighing balance to determine the extent and rate of deterioration on the fruit within the cooler and ambient storage.

3. Result Discussion

3.1 Temperature and Relative Humidity

During the no load test the relative humidity of the cooler was as high as 95.70% and the temperature was as low as 22.8^{0}C but when the cooler was loaded with fruits and vegetable, the relative humidity dropped to a range of 86.20% to 93.42% and the temperature rose to the range of 23.9^{0}C to 25.2^{0}C. This was because the sweet oranges that were stored in the cooler are biological material and they respire. This respiration process generated heat and that was what led to the drop and increase in relative humidity and temperature respectively.

3.2 Physiological Weight Loss.

In a bid to determine the efficiency of the cooler on a load storage condition, the cooler was loaded with citrus (sweet orange) and was weighed before the commencement of the storage evaluation. The weight loss analysis was carried out daily for seven days consecutively and the percentage weight loss was determined and presented in figure 2 below. The result shows that the rate of deterioration was rapid with the produce stored under the ambient condition while the cooler had very little weight loss.

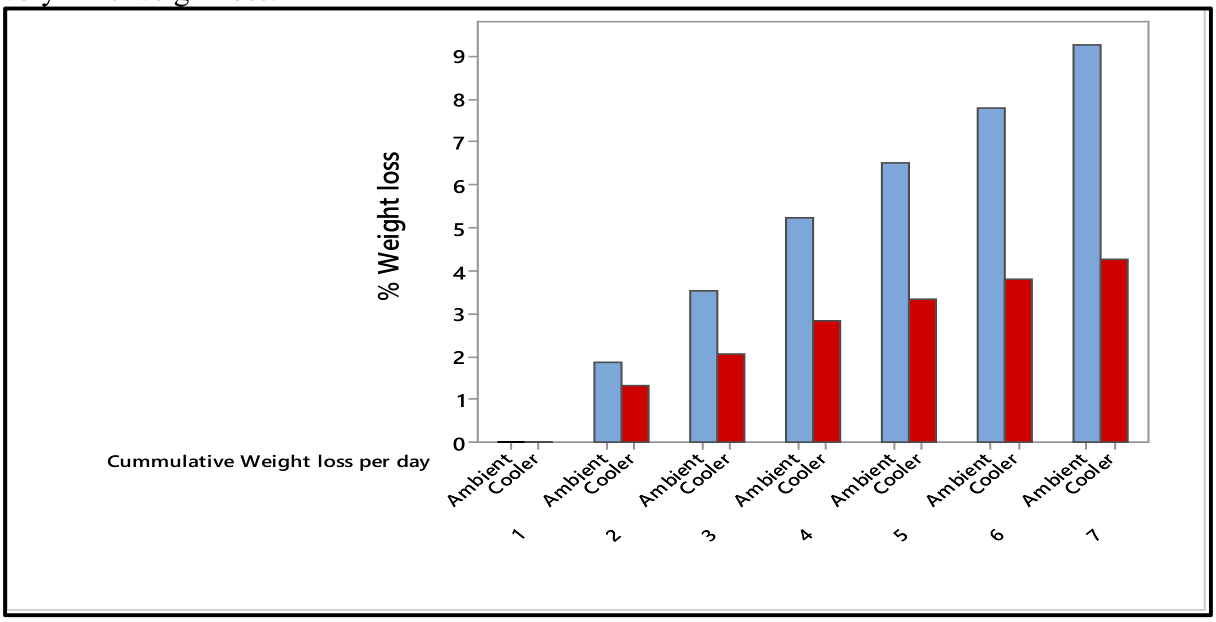

Figure 2: Physiological Weight Loss of Sweet Orange Stored in Ambient and Cooler

3.3 Colour Change

The colour of biological produce places a very germane role to determining the ripening rate alongside the deterioration of the produce. The sweet oranges stored in the ambient had a rapid colour change as shown in figure 3a compare to the cooler storage.

(a) Orange in Ambient (b) Orange in Cooler

Figure 3: Pictorial view of sweet orange after storage

4. Conclusion.

The result if this experiment has conspicuously indicated that the effect of evaporative cooling system on the storage of sweet orange is highly significant with an appreciable percentage difference between the ambient and cooler storage. The cooler is really a very suitable system to help combat the postharvest challenge of storage that occur to most fruits and vegetables after the harvesting of the produce. The relative comparison between the produce stored in the cooler and ambient is on an average percentage weight loss of 4% and 9% respectively. This implies that the ripening hormone had a slow secretion in the cooler storage and a double rate of hormone secretion in the ambient storage. Furthermore, the rate of respiration was very slow in the cooler and relatively faster for the ambient storage which initiates rapid deterioration of the stored produce.

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