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The Significance of Active Evaporative Cooling System in the Shelf Life Enhancement of Vegetables (Red and Green Tomatoes) for Minimizing Post-Harvest Losses

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Abstract

Tomatoes in its natural state remains highly sort after as a result of its domestic relevance in most homes. In a bit to reduce the amount of losses that occurs after harvest, storage amongst many others is seen to be a very germane consideration to enhancing the shelf life of tomatoes. Samples of red tomatoes were gotten from a popular market in omu-aran town, Kwara state, Nigeria and green tomatoes samples were gotten from the green house in Landmark University teaching and research farm, omu-aran, kwara state Nigeria. The samples were stored in an active evaporative cooling system for a period of seven days. A few samples were also placed in the ambient environment of the evaporative cooler to carry out a load-test on the cooler. The emerging result shows that after the seventh day, the red tomatoes and green tomatoes that was stored in cooler had a percentage weight loss of 8.65% and 1.54% respectively. While the red and green tomatoes samples that was stored in the ambient environment had a percentage weight loss of 47.20% and 5.14% respectively. This outcome implies that the evaporative cooler with an average cooling efficiency of 86.01% was able to optimize the shelf life of the red and green tomatoes.

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Keywords: Evaporative Cooler, Refrigeration, Post-harvest Losses, Shelf life.

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1. Introduction

The yearly incurred post-harvest losses in fruits and vegetables in very alarming owing to their perishable nature. Tomatoes is one of the fast deteriorating vegetables and it is found to be very demanding by most residents of every look and crannies of the Nigerian metropolis [1]. These losses occur as a result of several causative factors as discussed below.

1.1 Causes of Post-Harvest Losses

Kader [2] highlighted and elucidated some of the causes of post-harvest losses and they are as follows; Biological, environmental, and socioeconomic factors.

Biological: The causes of deterioration of biological materials or products from a biological perspective is said to include ethylene production, respiration rate, rates of occurrence of compositional changes (in terms of color, flavor, nutritive value and texture), water stress, mechanical injuries, physiological disorders, rooting and sprouting and pathological breakdown.

Environmental: The rate of deterioration biologically depends so many external (environmental) factors, such as, air velocity relative humidity, temperature, sanitation procedures, and atmospheric composition (concentrations of carbon dioxide, oxygen, and ethylene). These causative factors amongst many others have been explicitly discussed by several authors [4-6].

Socio-Economic: Kader [2] further listed the socioeconomic factors causing post-harvest losses as follows; Inadequate Transportation Facilities, Inadequate Marketing Systems, Unavailability of Needed Tools and Equipment, Government Regulations and Legislations, Lack of Information and Poor maintenance of facilities.

1.2 Factors Affecting the Shelf Life of Vegetables

The consideration of some factors is very important as they in a way or two have effect on fruits and vegetables in with regards to shelf life which on the long run could lead to their deterioration. These factors are as follows: Temperature, Relative Humidity, Ambient Condition
Variety and stage of ripening

Temperature is generally expressed as the degree of coldness or hotness of a material be it a biological material or an engineering material. There is a pronounced effect of temperature on the shelf life of agricultural produce.
FAO, [7] discovered to be true that every agricultural produce is susceptible to damage or spoilage whenever there is immense exposure to temperatures with a possibility of increased respiration level. Likewise, it was also seen that there is a significant variance in the temperature tolerance of agricultural products.
Wilson *et al*., [8] proposed that spoilage of garden-fresh produces can occur from physiological breakdown owing to processes of natural ripening, temperature injury, water loss, attack by microorganisms or physical damage. All these factors are influenced by temperature and can all interact. He went further and said that exposure to warm and cold temperatures alternatively may amount to accumulation of moisture on the produces which could increase spoilage. Gravani, [9] discussed his observation that in every -7.7°C (18°F) temperature rise for a given range of (50°F-100°F)/(10°C-37.8°C) as handling of food take place, chemical reaction rate of is doubled approximately. To this end, unnecessary temperatures result in amplified frequency of some constituent food reaction and natural food enzyme.

Relative Humidity has a significant influence as regarding the spoilage of vegetable and fruits owing to the fact it possess direct connection with the atmospheric moisture content that is a determinant of the shelf life being exceeded or not. Bachmann and Earles, [10] disclosed that water loss in produce is directly influenced by the relative humidity of the storage unit. Wilson *et al*., [8] further said that water loss could also imply viable weight loss and decreased profit.
Ambient Condition means the conditions of the environment have a very significant influence in determining how long fruits and vegetables can stay before spoilage and these factors are categorized into relative humidity and temperature.
Variety and Stage Ripening means the respiration of fruits and vegetables cannot be stopped by Post-harvest operations, and if this is not taken into full consideration for control it would result into fruits over-ripening and on

the long run result in quick spoilage. Olosunde, [11] said that the commodities have different storage conditions owing to the stage at which fruits were harvested, with variance compared to the mature green and fully ripened produce in practice.

There is great difference between Coolant and Refrigerant, Chlorofluorocarbons are ideal gases used as refrigerants for refrigerator for enhanced cooling. [12, 21] The continuous use of CFCs as refrigerants has been observed from previous researches to be a germane contribution to the global warming [12, 14]. While the Evaporative Cooing System uses water as its coolant in place of the CFCs refrigerants. Water literarily having a Hydrogen and two molecules of oxygen doesn't have any advert effect on the ozone layer unlike the CFCs that cause depletion (Ashworth, n.d.)

Respiration: The stored produce are biological materials that respires. This means that metabolism still continues even after harvest during storage which result in the release of heat from the produce. Refrigerators do not keep fruits and vegetables for so long because of the CFCs that is used as refrigerants. It makes the stored materials respire more because of the presence of carbon dioxide with a resultant effect on the stored fruits and vegetables by turn its colour to black [15-16]. However, there are needs to carry out research on how to preserved this agricultural product due to that this product is seasonal, which in turn will help to improve the lifecycle of tomatoes and also improve the economics of the country for sustainable development [17-20]. This research work is aim out carrying an evaluation of a locally developed active evaporative cooling system to enhancement the shelf life of vegetables such as red and green tomatoes for minimizing post-harvest losses.

3. Experimental Procedure.

3.1 Materials

The sample materials for this experimental study are red tomatoes and green tomatoes. The red tomatoes were gotten from a market in Omu-aran town, Kwara State, Nigeria. And the green tomatoes were gotten from the green house of the Landmark University farms, Omu-aran, Kwara State.

3.2 Load test of the Evaporative Cooling System

The Cooler was evaluated for performance with red and green tomatoes. The parameters for its evaluation and shelf life enhancement are physiological weight loss, colour changes and vegetable firmness.

3.2.1 Physiological Weight Loss

The red and green samples obtained were weighed using a digital weighing scale to determine the initial weight of the samples before storage, consecutively determine their weights during storage and after storage to fully determine the cumulative weight loss of the samples.

3.2.2 Colour Changes

The colour change of the produce was observed and noted for the tomatoes stored in the ambience and in the cooler. The changes in colour was discovered basically from the physical appearance of the tomato samples.

3.2.3 Vegetable Firmness

The produce was examined to physically observe its texture. The firmness variance was noted upon a successful completion of a seven-day storage both in the ambient and in the cooler.

3.3 Brief Description of the Evaporative Cooling System

The evaporative cooler that was used for this experiment was designed and fabricated using galvanized steel for its external wall, aluminium for its internal wall and both walls were lagged with polyurethane of 25mm thickness. The cooler has two water tanks of 20litres storage capacity each. The evaporative cooling system is an active one because air is set in motion through a suction fan of 38mm swept dept and its mode of water supply and circulation is automated with the aid of floater switch and a 0.5hp pump that syphons water from one storage tank to another through a PVC pipe.

The cooling principle is based on the conversion of sensitive heat to latent heat. The suction fan draws the available air from within its ambience, sets it in motion and then drives the air through a porous jute bag with frame mesh of 1-icnh. As water drips from the storage tank into the jute bag, the driven air evaporated the water from the damp jute bag and concurrently gives a cooling effect inside the cooling chamber

4. Results and Discussion

4.1 Weight Loss.

The stored produce was weighed daily for the seven consecutive days of storage for easy analysis of the storage performance of the cooler through the determination of the weight losses that occurred in the stored biological materials (tomatoes), and this was done through percentage weight estimate. The results of the daily weight loss analysis of the red and green tomatoes are shown in Figure 1 and Figure 2 respectively.

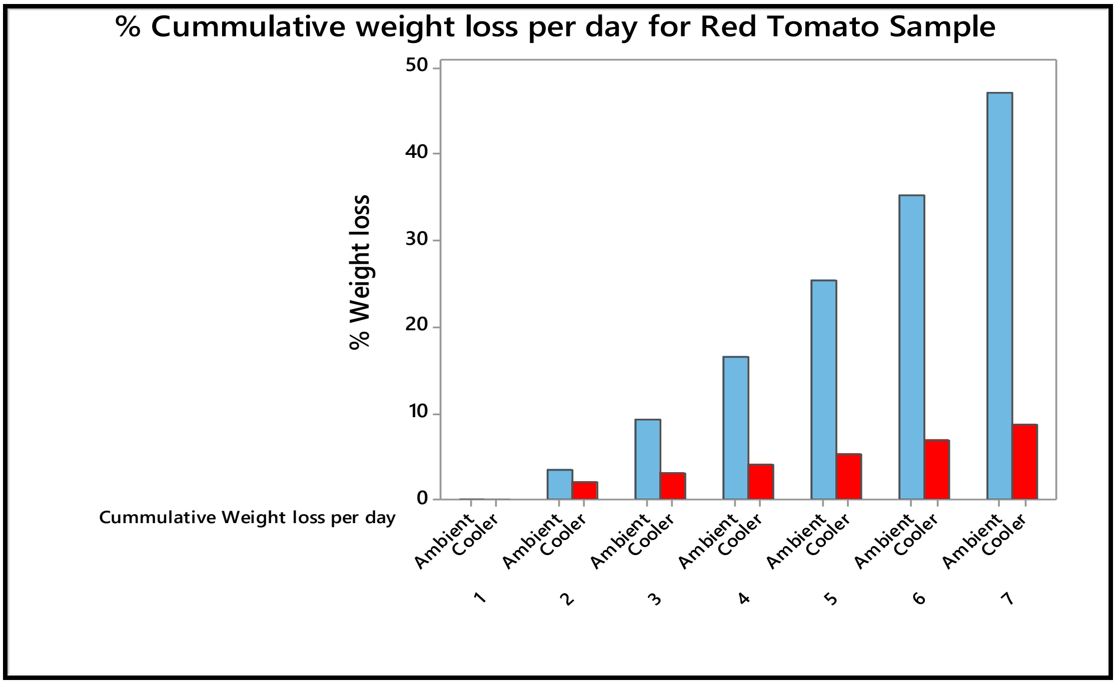

Figure 1: % weight loss of red tomato samples.

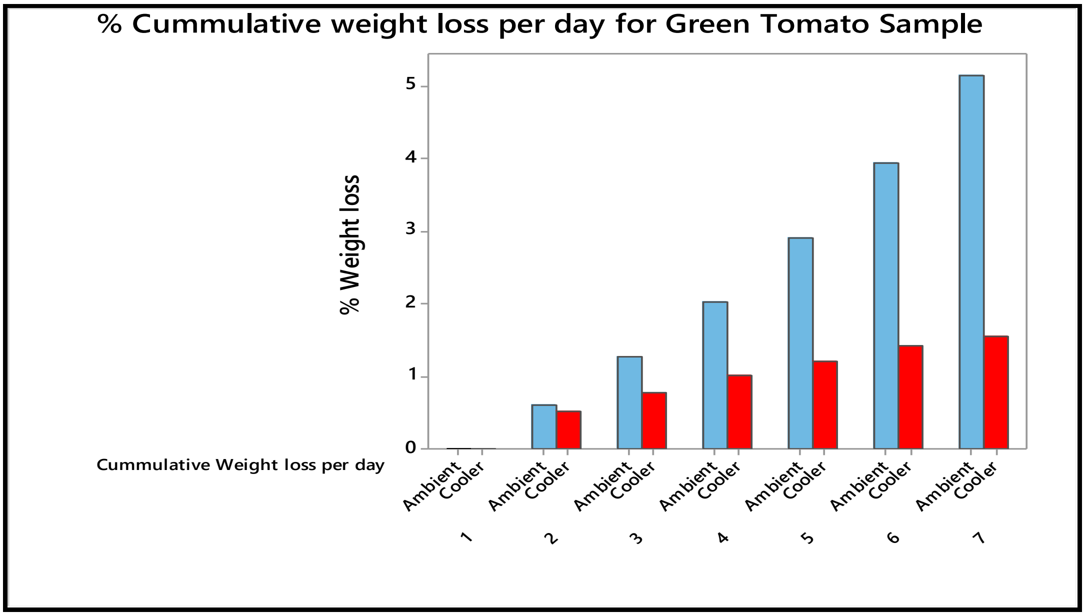

Figure 2: % weight loss of green tomato samples.

4.2 Colour Changes

The initial colour of the produce was bright before storage but during the evaluation process, the colour of the tomatoes stored outside the cooler in the ambience began to change some days after storage. In the ambience, the green tomatoes began to change colour after the fourth day, the red tomatoes became totally red and started getting deteriorated on the third day. After the seven days of evaluation, the red tomatoes kept in the ambience already got deteriorated and was virtually useless and the green tomatoes got ripen. While in the cooler, the red tomatoes stored maintained its colour for the seven days, the green tomatoes were still green in colour but only one slightly got ripen but minimal compared to the samples kept in the ambience as shown in Figure 3 and Figure 4 below.

(a) (b)

Figure 3. Pictorial view of red tomatoes after storage (a) Red Tomatoes in Ambient (b) Red Tomatoes in Cooler

(a) (b)

Figure 4 Pictorial view of green tomatoes after storage (a) Green tomatoes in ambient (b) Green tomatoes in cooler

5 Conclusion

This experimental study has shown that tomatoes can have its shelf life improved and prolonged with the aid of the evaporative cooling technology. The cooler was able to reduce the emission of the ripening hormone from the tomatoes as this inhibited and delayed the rate of further ripening of the stored tomatoes in the evaporative cooling system with relative comparison to the samples stored in the ambience.

Sustainability of the Methodology Adopted

- Evaporative cooling is very cheap and easy to attain. Hence, this will be easily adopted by end users and on the long run become sustainable because the coolant used in this experiment is water which is readily available in abundance to everyone.
- Secondly, the evaporating agent is the natural air that is set in motion by a suction fan. As long as there is free flow of air from the atmosphere, this process will remain sustained and relevant.

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