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AUTOMATED ELECTRONIC EVAPORATIVE COOLER FOR FRUITS AND VEGETABLES PRESERVATION

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ABSTRACT

Horticultural products such as fruits and vegetables are highly perishable in nature; thus, maintaining the optimal air conditions inside the storage helps extending their shelf life. However, commercially available cool storages can give chilling injuries to the commodities which its quality, color, texture and freshness are often sacrifice. Hence, the proponents aimed to develop an automated electronic evaporative cooler in prolonging and preserving the freshness and quality of fruits and vegetables.

The study was designed to evaluate the effectiveness of the electronic evaporative cooler for fruits and vegetables preservation through (a) percentage weight loss, (b) visual quality, (c) degree of shriveling, and (d) determining the expectancy life of the commodities. To evaluate the performance of cooler, (a) calibration of the system, (b) evaporative cooling efficiency, and (c) monitoring of air conditions in terms of temperature and relative humidity were first done to attain its end goal.

The study focused on construction of an automated electronic evaporative cooler in which temperature and humidity were kept under control as associated by the standard temperature requirement of a specific fruit or vegetable. The system was inputted with required temperature of particular fruits and vegetables; then equipped with temperature and humidity sensors, water circulation system, DC fans which were all connected to a microcontroller that provided the appropriate action or output.

From various tests conducted, for reliability, the cooler had evaporative cooling efficiency of 85.5263% during 12 p.m. to 6 p.m. of the day. The cooler also indicated a temperature drop range of 1.40 to 3.40 ˚C and a relative humidity rise range of 9.30 to 20.30%.

Moreover, the study also revealed that commodities placed inside the cooler had average percentage weight loss of about 2.50% to 5.50% while those exposed in ambient environment with about 4.50% to 10.30%. Through evaluation done by five vendors, the commodities inside the cooler were considered as field fresh without defects while those in ambient environment were mostly evaluated as with serious defects and had reached the limit of usability in terms of visual quality. Meanwhile, in terms of degree of shriveling, most of commodities inside the cooler showed no signs of shriveling, wilting or dryness compared to those in ambient environment which most were considered with evident but not serious shriveling. More so, using regression method, the proponents projected a trend line to determine expectancy life of the commodities and it was found out that tomatoes and bananas in ambient environment can reduce a five-percent weight after 78 and 42 hours respectively compared to commodities placed inside the cooler.

Therefore, the proponents concluded that commodities stored inside the cooler showed better conditions in terms of percentage weight loss, visual quality and degree of shriveling compared to those exposed outside the cooler. Furthermore, the study proved that the use of electronic evaporative cooler can prolong the shelf life of the commodities

KEYWORDS: evaporative cooling, shelf life, horticultural products, fruits and vegetables preservation, shriveling, visual quality.

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I. INTRODUCTION

The fruit and vegetable market demands for fresh and good quality products even after the post-harvest period. Thus, appropriate way of storage and preservation is required.

Cooling is the most traditional way of preserving agricultural products such as vegetables and fruits. It is also the most common means of keeping the quality and freshness of the farm produce. However, appropriate storage and treatment for a particular commodity is not taken into considerations.

Vegetables and fruits sold in public markets are mostly imported from other provinces; since these farm produce are being transported, it is inevitable for these produce to acquire physical damage due to shipping that contributes in losing their freshness. Once these commodities are distributed to local resellers and merchandisers who have no other precise means of storing and preserving than cooling, produce still obtain physical damages which affect its quality and quantity.

Ambient temperature and relative humidity are main parameters to be considered in proper storage and preservation of fruits and vegetables. With this, these parameters should be monitored with accuracy and maintained its necessary values for specific commodity to preserve the freshness and to prolong the shelf life.

Cooling by means of evaporation will provide a low cost and effective way of preserving the freshness and prolonging the shelf life of fruits and vegetables as it reduces the temperature and increases the relative humidity inside the storage. In line with this, evaporative cooling is introduced to maintain the quality of products and to lessen the problems related to increasing number of rejected products due to improper storage.

The proponents decided to design and develop an automated electronic evaporative cooler that can control and monitor temperature and humidity which can lead to proper product storage and preservation. Thus, increasing the shelf life and good quality of horticultural produce will be achieved.

The study primarily aims to design and develop an automated electronic evaporative cooler for fruits and vegetable preservation.

Specifically, the study aims to: (1) determine the effectiveness of using electronic evaporative cooler for fruits and vegetables preservation; (2) determine weight loss of the commodities inside the cooler compared to those exposed in ambient environment; and (3) evaluate visual quality conditions and degree of shriveling of the commodities inside the cooler compared to those exposed in ambient environment.

II. SIGNIFICANCE OF THE STUDY

Horticultural produce are stored at lower temperature because of their highly perishable nature. In order to extend shelf life of fruits and vegetables they need to be properly stored. The essence of storage is of great importance because not all crops in general will be used immediately after harvest. More so, they lose moisture through respiration which can be seen as shriveling or witting that leads to the reduction of quality and quantity reduction. That is why measures of preserving the produce before exceeding its shelf life are of great importance.

Therefore, in order to reduce deteriorations and enhance the shelf life, there is a need to address the preservation and storage of fruits and vegetables and understand the importance of such methods.

Evaporative cooling is an adiabatic cooling process whereby the air takes moisture which is cooled while passing through a wet pad or across a wet surface show that evaporative cooled storage is more efficient than mechanical refrigeration system (Thompson JF and RF Kasmire). During evaporation, there is a simultaneous heat and mass transfer. The heat in the air is utilized to evaporate the water which changes from liquid form to vapor and results to a drop in temperature, and rise in relative humidity of air.

Thus, the development of a simple, efficient and economical means of preserving fruits and vegetables would be a good alternative to keep the quality and to extend the shelf life of these commodities, while maintaining the taste and nutritional properties, furthermore, to decrease the wastage of commodities by preventing decay or spoilage.

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III. METHODOLOGY

The project was based on the principle of evaporative cooling (see Figure 1) and was made electronically automated for convenience and efficiency. Figure 2 shows the theoretical framework of the study including the devices that were utilized in the system.

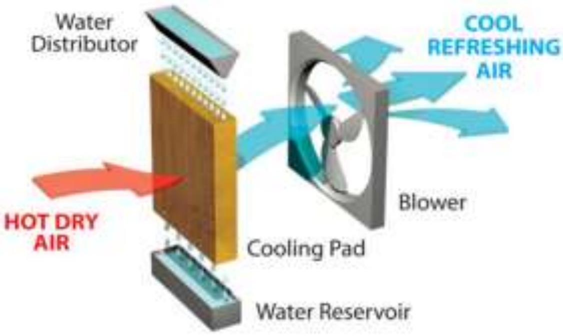

Figure 1 Principle of Evaporative Cooling

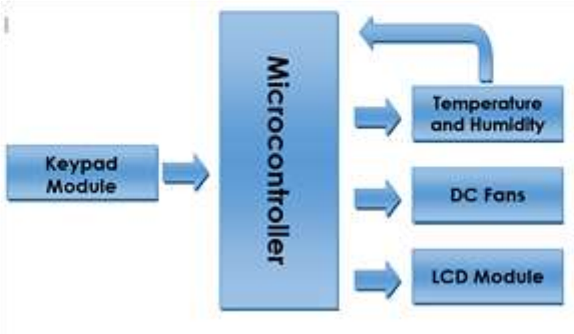

Figure 2 Theoretical Framework

Figure 3 Developed Automated Electronic Evaporative Cooler

A temperature sensor is a device, typically, a thermocouple or RTD that provides temperature measurement through an electrical signal. While a humidity sensor senses relative humidity. This means that it measures both air temperature and moisture. Temperature and humidity sensors were used to measure the level of ambient temperature and relative humidity inside and outside the evaporative cooler.

A four-by-four (4x4) keypad module is a basic 16-button keypad for user input. The buttons are setup in a matrix format. It allows a microcontroller to scan the eight output pins to identify which of the 16 buttons is being pressed. It is used with the system to allow users to choose their preferred commodity to be stored inside the cooler.

Direct Current (DC) fans were also attached to the cooler. It is used to support the evaporation process in providing the cooling air inside the cooler.

Liquid crystal display (LCD) modules were utilized to display the current status of the system. A four-by-twenty (4x20) type of LCD was installed for each compartment indicating the commodity inside, real time temperature and humidity status and speed of the fan. On the other hand, two-by-sixteen (2x16) type was used to display the temperature and humidity of the ambient environment.

A microcontroller is a compact microcomputer designed to govern the operation of embedded systems in motor vehicles, robots, office machines, complex medical devices, mobile radio transceivers, vending machines, home appliances, and various other devices. It acts as the brain of the whole system. All other devices were connected to it so that operation of the device would be done simultaneously.

The constructed evaporative cooler would be powered up using 220V just like a typical home appliance.

As a result of all the processes in the system, temperature and humidity were controlled and maintained according to the specified temperature and humidity levels.

IV. TEST RESULTS

1. Monitoring of Air Conditions

The air conditions inside the cooler in terms of temperature and relative humidity were monitored within 72 hours.

Table 1 shows the summary of the air conditions during the testing conducted on tomato and banana samples. This indicates the temperature and humidity that the evaporative cooler absorbs and produces in two separated testing procedure.

It indicates that the cooler can improve the air conditions in terms of temperature and relative humidity with respect to the ambient environment after underwent process of evaporative cooling. The cooler has the ability to decrease the temperature and increase the relative humidity inside the cooler passing through the cooling pad.

Table 1 Air conditions During the Laboratory Testing

PARAMETER	AMBIENT	ELECTRONIC EVAPORATIVE COOLER	
		TOMATO TESTING	BANANA TESTING
Temperature Range, °C	24.80 - 30.80	23.20 - 27.60	22.60 - 27.40
Temperature Drop Range, °C	-	1.40 - 3.40	1.40 - 3.40
Relative Humidity Range, %	62.50 - 87.90	73.80 - 98.40	79.30 - 99.80
Relative Humidity Rise Range, %	-	9.30 - 19.30	9.50 - 20.30

2. Product Quality Evaluation

2.1. Percentage Weight Loss

The following figures indicate the increasing average percentage weight loss of the samples during the 72-hour testing inside and outside the evaporative cooler. Based on the data, samples in Set Up B have greater increase in percentage weight loss after the testing procedure with 4.7641% for small tomatoes, 4.7777% for medium tomatoes, 4.4603% for large tomatoes, and 10.3114% for bananas compared to Set Up A with 3.5717%, 2.9292%, 2.5001%, and 5.5216%, respectively. This only proves that the evaporative cooler has reduced the rate of the weight loss among the samples.

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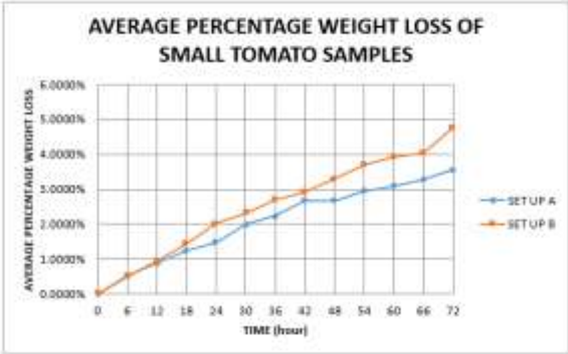

Figure 1 Average Percentage Weight Loss of Small Tomato Samples

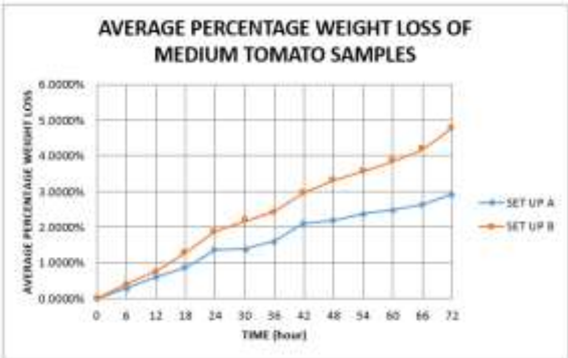

Figure 2 Average Percentage Weight Loss of Medium Tomato Samples

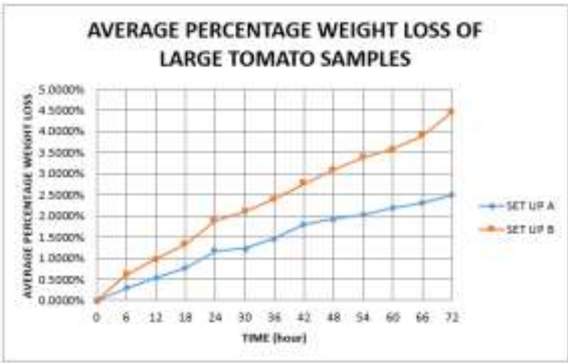

Figure 3 Average Percentage Weight Loss of Large Tomato Samples

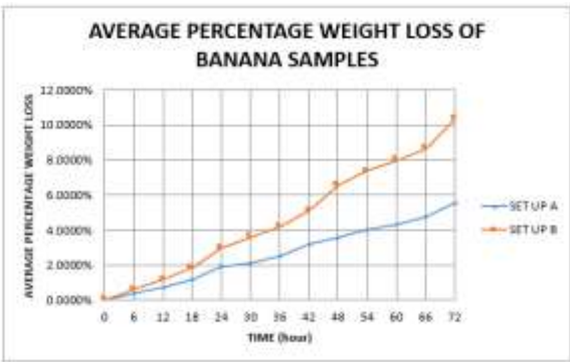

Figure 4 Average Percentage Weight Loss of Banana Samples

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2.2. Visual Quality

Visual quality of each sample was evaluated through the use of the rating chart below as basis of evaluation (see Table 2). To gather reliable data on this part of the study, evaluation was conducted with the aid of five (5) fruit and vegetable vendors from Balanga City Public Market.

The data obtained from the result of evaluation were analyzed using the central tendency which is mode, to represent each set up or group on the graph.

Table 2 Visual Quality Rating

VISUAL QUALITY RATING	
SCORE	DESCRIPTION
9	EXCELLENT: Field fresh, no defects
7	GOOD: Minor defects
5	FAIR: Moderate defects, limit of salability
3	POOR: Serious defects, limit of usability
1	VERY POOR: Non-usable under usual conditions

Source: Kader, 2010 Fresh Produce Quality Parameters

The following figures show the visual quality condition of the samples in both set ups within 72 hours of testing. As indicated, set ups placed inside the cooler maintained its overall quality as rated by most of evaluators as “Excellent” which considered as field fresh and no defects. Meanwhile, the set ups of tomato samples exposed in ambient environment decreased its quality as the samples were evaluated as “Poor” with serious defects and have reached the limit of usability after the testing procedure and bananas rated as “Very Poor” which are no longer usable.

Figure 5 Visual Quality Rating per Set Up of Small Tomato Samples

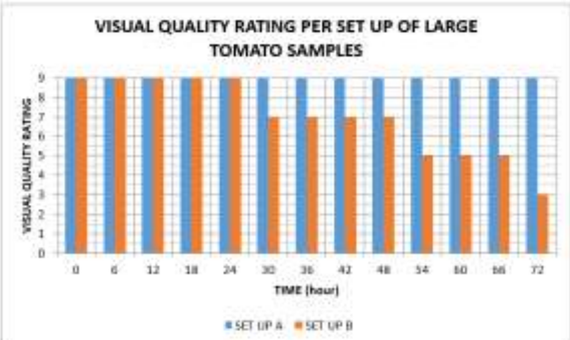

Figure 6 Visual Quality Rating per Set Up of Medium Tomato Samples

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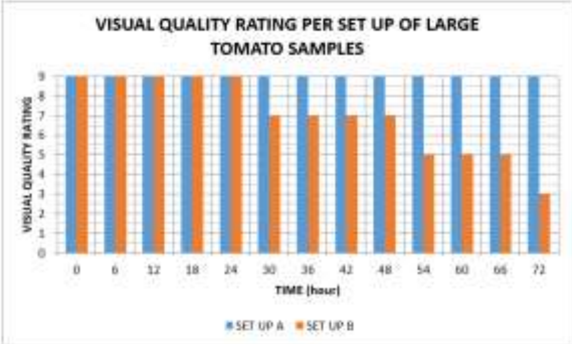

Figure 7 Visual Quality Rating per Set Up of Large Tomato Samples

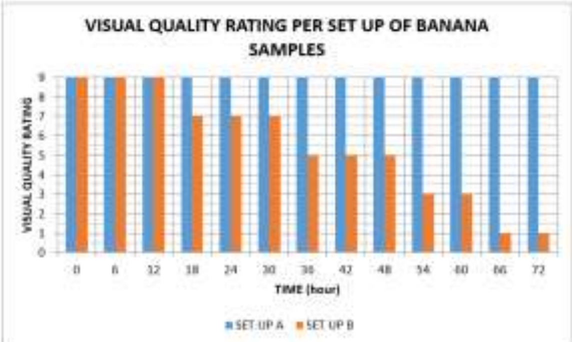

Figure 8 Visual Quality Rating per Set Up of Banana Samples

2.3. Degree of Shriveling

Degree of Shriveling of each sample was evaluated through the use of the rating chart below as basis of evaluation (see Table 3). To gather reliable data on this part of the study, evaluation was conducted with the aid of five (5) fruit and vegetable vendors from Balanga City Public Market.

The data obtained from the result of evaluation were analyzed using the central tendency which is mode, to represent each set up or group on the graph.

Table 3 Degree of Shriveling

DEGREE OF SHRIVELING	
SCORE	**DESCRIPTION**
1	Field fresh, no signs of shriveling, wilting or dryness
2	Minor signs of shriveling, wilting or dryness
3	Shriveling, wilting or dryness evident but not serious
4	Severely wilted and dry

The following figures show the degree of shriveling of the samples in both set ups within 72 hours of testing. As indicated, the set ups placed inside the cooler maintained its freshness and does not show any sign of wilting or dryness as rated by most of evaluators. Meanwhile, the set up exposed in ambient environment decreased its freshness as the samples were evaluated with evident but not serious shriveling, wilting or dryness after the testing procedure.

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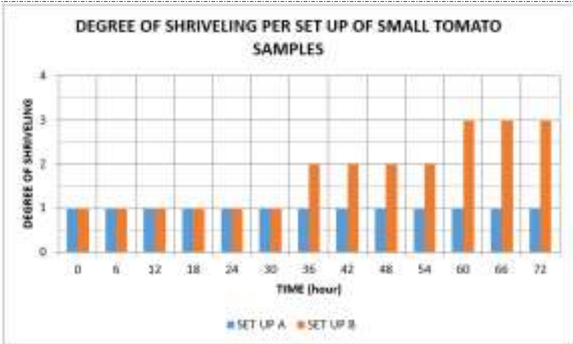

Figure 9 Degree of Shriveling per Set Up of Small Tomato Samples

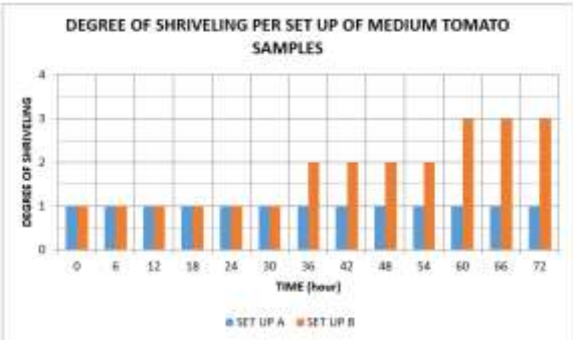

Figure 10 Degree of Shriveling per Set Up of Medium Tomato Samples

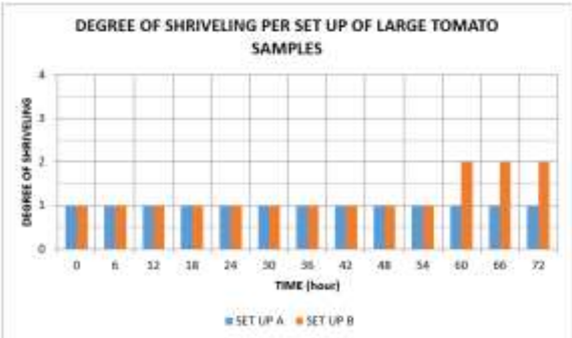

Figure 11 Degree of Shriveling per Set Up of Large Tomato Samples

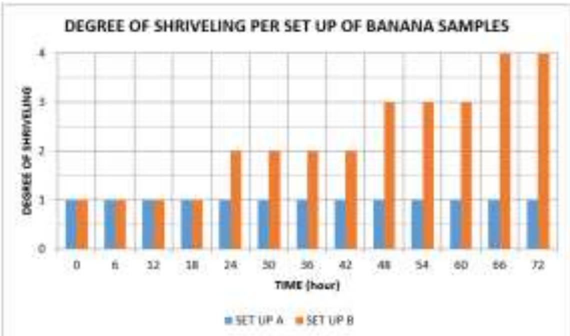

Figure 12 Degree of Shriveling per Set Up of Banana Samples

3. Expectancy Life

After the 72-hour testing procedure, the proponents projected a trend line to determine the weight reduction of the commodities for 168 hours by using First-Order Polynomial Regression Method since the weight loss is linearly declining as time passed by. The data obtained in the testing procedure were used in this method.

Using the derived linear equation for each set up of the commodities, the following tables and figures are generated. These show the relationship of percentage weight loss with respect to time. These also indicate the possible percentage weight loss of the bananas and tomatoes every six (6) hours.

Hence, the following are the linear equations for each set up of tomatoes and bananas which were derived from the regression method:

%W=0.003191+0.000479t (Equation 1)
%W=0.002584+0.000623t (Equation 2)
%W=0.001649+0.000399t (Equation 3)
%W=0.001038+0.0006452t (Equation 4)
%W=0.001610+0.000344t (Equation 5)
%W=0.002718+0.000575t (Equation 6)
%W=-0.000847+0.000753t (Equation 7)
%W=-0.004596+0.001414t (Equation 8)

This part of the study was used to determine the time when the samples will reach its limit in terms of percentage weight loss. According to FAO, when the harvested produce losses 5 or 10 percent of its fresh weight, it begins to wilt and soon becomes unusable.

However, the proponents are not concluding that the percentage weight loss is always linear in nature. This method in determining the projection on expectancy life is limited only in this study and the proponents are not encouraging anyone that this is the best way to conclude the shelf life of the commodities.

The following graphs and analysis are the data obtained from the projected trend line using the equations derived from the regression method:

Figure 13 Data Trend for Time Vs. Average Percentage Weight Loss of Small Tomato Samples

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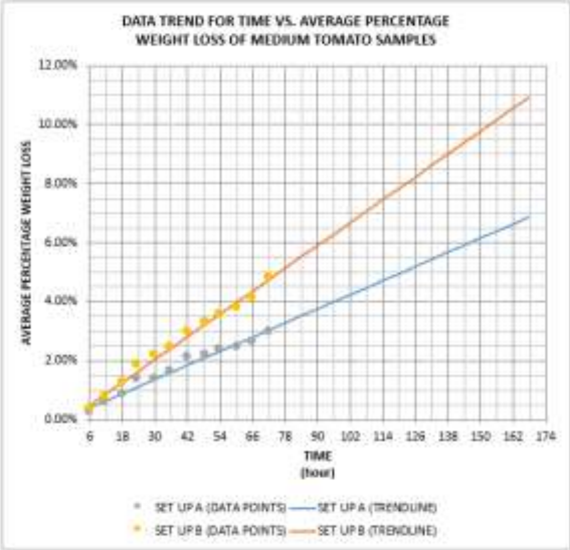

Figure 14 Data Trend for Time Vs. Average Percentage Weight Loss of Medium Tomato Samples

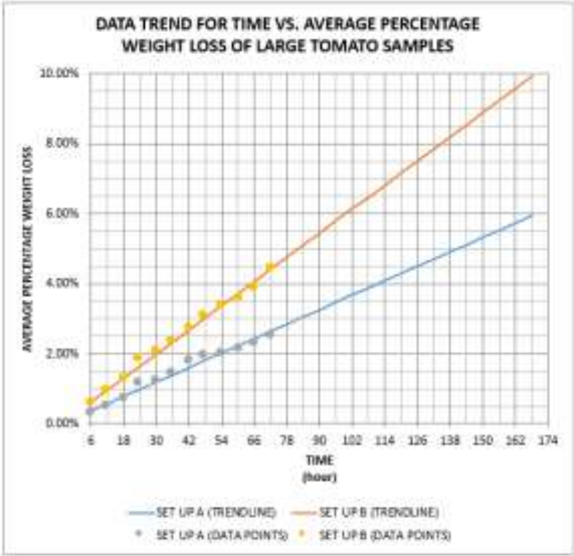

Figure 15 Data Trend for Time Vs. Average Percentage Weight Loss of Large Tomato Samples

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Figure 16 Data Trend for Time Vs. Average Percentage Weight Loss of Banana Samples

The following figures show the linear relationship of time and average percentage weight loss of samples in both set ups within the 72-hour testing procedure. The projected trend line determines the difference of the two set ups. As the graph indicated, the percentage weight loss of Set Up B has greater inclination over 168 hours with 10.73% for compared to Set Up A with 8.36% for small tomato samples; 10.94% compared to 6.87% for medium tomato samples; 9.93% compared to 5.95% for large tomato samples; and 23.30% compared to 12.56% for banana samples, respectively.

V. CONCLUSIONS

Based on various data and results of the study, the proponents concluded the following:

1. Commodities stored inside the evaporative cooler show better conditions in terms of weight, visual quality and degree of shriveling compared to those exposed outside the cooler.
2. The study proved that the use of electronic evaporative cooler can prolong the shelf life of a particular commodity than exposing the commodity in ambient environment.

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