SUITABILITY OF CHARCOAL-CEMENT PASSIVE EVAPORATIVE COOLER FOR BANANA RIPENING

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ABSTRACT

The common banana ripening methods practiced by fruit sellers are application of calcium carbide or 'ethrel'. Ethrel is expensive and therefore the ethylene analogue calcium carbide is commonly used although it contains heavy metals as it is readily available. Therefore a passive evaporative cooler made of charcoal, cement and sand was tested as a ripening chamber for banana as the internal relative humidity and temperature were ideal for banana ripening. The evaporative cooler maintained a high relative humidity of around 90-98% with a 3°C temperature reduction than room temperature during the test period. In the experiment, banana cultivars were allowed to ripen with 1000ppm ethrel and without ethrel, in two evaporative coolers and in two corrugated fibreboard boxes with the same dimensions of the cooler, under room conditions. Fruits from a single hand were subjected to all treatments and four parameters; TSS, peel colour, firmness and weight were tested. There were no significant differences of TSS, peel colour and firmness among four treatments. However for all cultivars, the weight loss was 16-22% for fruits ripened in the boxes while the weight loss was 3 - 6% .for those ripened in the evaporative cooler.

INTRODUCTION

Banana (Musa spp.) is the fourth most important food crop in the world and for commercial purposes banana is harvested at the mature green stage. Therefore banana ripening is very important at commercial enterprises. The most popular methods in large scale ripening are application of ethylene gas in to the ripening room or dipping fruits in ethrel. These operations are relatively expensive in developing countries like Sri Lanka. Therefore, the application of calcium carbide as an ethylene analogue is the most common practice in Sri Lanka although improper application techniques would cause health hazards due to heavy metal contamination (Amerakoon *et.al*., 1999). Temperature and relative humidity (RH) in the ripening chamber are important environmental factors affecting the ripening process and the final quality. Paulyne, (2000) reported that the temperature from 14 – 18 °C and 85 – 95% RH are the optimum conditions for banana ripening. Lebibet et al., (1995) reported that storage of banana at 13 °C and 20 °C will develop full colour in ethylene induced ripening. George and Mwangangi (1994) have reported that low RH (50 – 60%) and relatively a high temperature (22 – 27 °C) are also satisfactory for banana ripening. Passive evaporative cooler, designed to store fruits and vegetables may be an ideal place for fruit ripening as it provides optimum conditions of 90-95% relative humidity and temperature around 16 - 22 °C which are reported as optimum for the quality of ripened banana (Koelet, 1992 and Impianti, 2002).

This experiment was conducted with the objectives of investigating the suitability of evaporative cooler for banana ripening and to evaluate the influence of ripening technique on the quality of ripened banana.

MATERIALS AND METHODS

Construction of the evaporative cooler

Evaporative cooler which was developed by Arumathanthri, in 2002 was made using ground charcoal, cement and sand with a ratio of 3:1:1. The unit consists of two main components; cooling chamber and the water pre-cooling unit (Dharmasena and Elankumar, 1995,

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Figure 01: Evaporative cooling unit

Dharmasena 2001). Outer frame of the cooling chamber (55 x 35 x 35cm) was made using 2mm thick stainless steel strips to make it portable. Walls were made with the mixture of charcoal (350μm), cement and sand. Water was pre cooled using a long necked traditional clay pot (*Grulettu*). A nylon tube was used to convey water from the "*Gurulettu"* to the tubes embedded into the cooling unit. Clay pot was placed on the top of the cooler to create a positive hydraulic gradient. Cooling chamber of the evaporative cooler was used as the banana-ripening chamber. The sliding glass door was covered with a black polythene sheet in order to prevent exposure of direct sunlight onto the banana inside. Two of such evaporative coolers were used for the experiment (Fig.1).

Banana ripening treatments

Three local cultivars of banana; 'Ambul', "*Kolikuttu"* and "*Amban"* were used for the experiment. Each cultivar was subjected to the following four treatments and the experiment was replicated three times. Evaporative cooler without application of ethrel.

a) Evaporative cooler with the application of ethrel.
b) In a closed corrugated paper box with equal dimension as the evaporative cooler, without ethrel, under room temperature.
c) In a closed paper box with the application of ethrel under room temperature.

Four samples from a single hand were subjected to above four treatments at a time in order to ensure the uniformity of the sample. Replication was done with three hands obtained fromthree different bunches of banana from each cultivar. The ethrel treatment was given by dipping fruits in a 1000ppm ethrel solution and the experiment was replicated three times.

Ripening quality evaluation

The experimental design was a Randomize Complete Block Design (RCBD) while considering one hand of banana as a block. Four parameters; peel colour, Total Soluble Solids (TSS), firmness and fruit weight were used to measure the quality of banana. Omoaka (2000) has also mentioned that the above parameters are the potential indicators for banana ripening quality evaluation.Peel colour was measured using a Minolta CR300 colour meter and the Hue angle (ho) of the colour chart wasused as the indicator. It was measured in every 24h time interval. TSS content was measured using a refractometer (PR101). TSS content was measured before the treatments and at 24h intervals after the initiation of ripening. An Instron universal testing machine was used with a 2mm flat end probe to measure the fruit firmness and it was measured before the treatments and at 24h time intervals after the initiation of ripening. Fruit weight was measured using an electronic balance and percentage of remaining weight was calculated based on the initial weight. Temperature and relative humidity were measured using thermocouples and RH sensors connected to a CR 10 data logger.

The effect of different treatments on the quality parameters was compared by plotting graphs and data was statistical analyzed by General Linear Models (GLM) as a three factor factorial experiment.

RESULTS AND DISCUSSION

Temperature and humidity levels in the evaporative cooler

The two passive type evaporative coolers used in the experiment maintained similar environmental conditions. Room temperature fluctuation during the experiment was 20-28 ^{o}C and the relative humidity varied between 60-95%. The internal temperature of the cooler was between 21-27 ^{o}C while maintaining 3 ^{o}C of maximum cooling during daytime and the relative humidity was maintained between 90-98 %. Figure 02 shows the behavior of internal and external relative humidity and Figure 03 shows the behavior of temperature.

Effect of different treatments on Total Soluble Solids (TSS)

In general, TSS increased with ripening due to the conversion of starch into sugar. Behavior of total soluble solids with time for banana cultivars is shown in Figures 04, 05 and 06.

Total soluble solids increased with ripening for all three varieties. There was no considerable difference in final TSS between the samples treated with ethrel and without ethral, kept under the same environmental conditions. For "*Amban"*, initiation of ripening of ethrel untreated samples took place 7 days after the initiation of ripening of ethrel treated samples. Therefore, it is clear that ripening can be induced by application of ethrel for "*Amban"* even in the evaporative cooler.

However, analysis of variance for TSS showed that the treatment effect was not significant on the TSS content when cultivar and time were kept as constants.

Effect of different treatments on peel colour of fruits

Green colour of peel turned into yellow colour with ripening due to break down of chlorophyll. Hue angle of the colour chart decreased from about 120^{o} to about 80^{o} when fruit's colour turns from green to yellow. Figures 7, 8 and 9 show the behavior of Hue angle with time for all the cultivars. Ethrel treated samples started to change their colour within 2-3 days while it was 4 -10 days for ethrel untreated samples. Cultivar "*Amban"* took more time to initiate ripening than other two cultivars without the ripening agent.

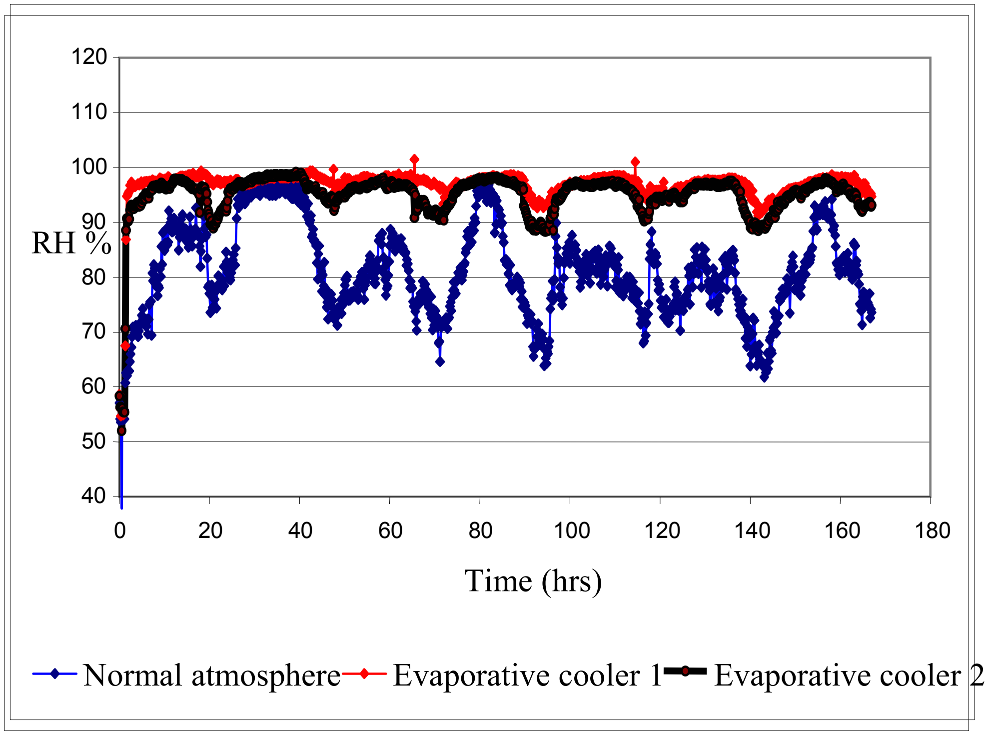

Figure 02: Behavior of internal and external relative humidity

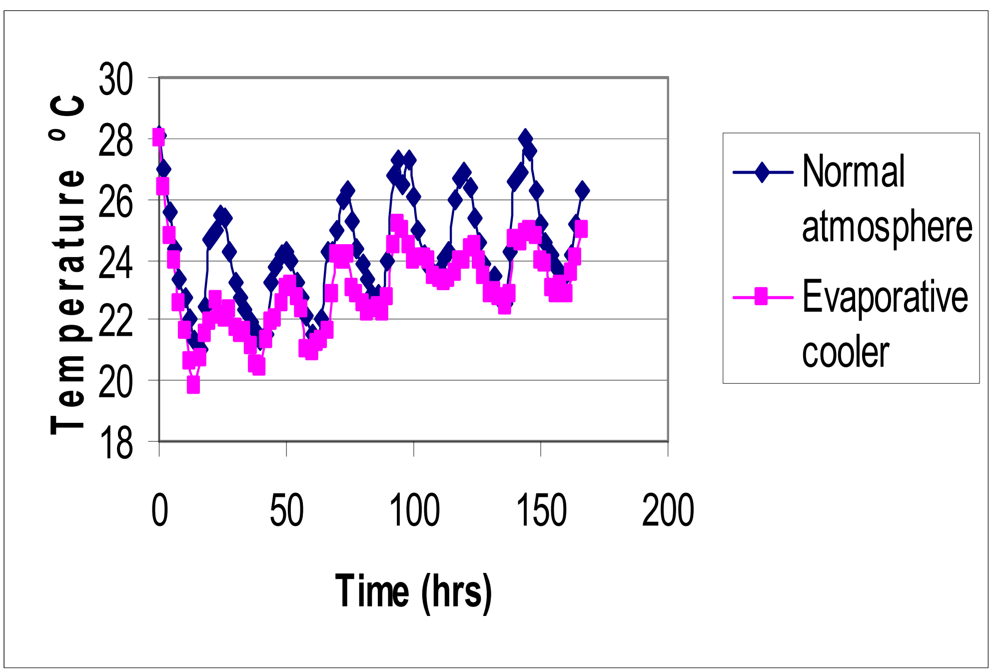

Figure 03: Behavior of internal and external temperatures

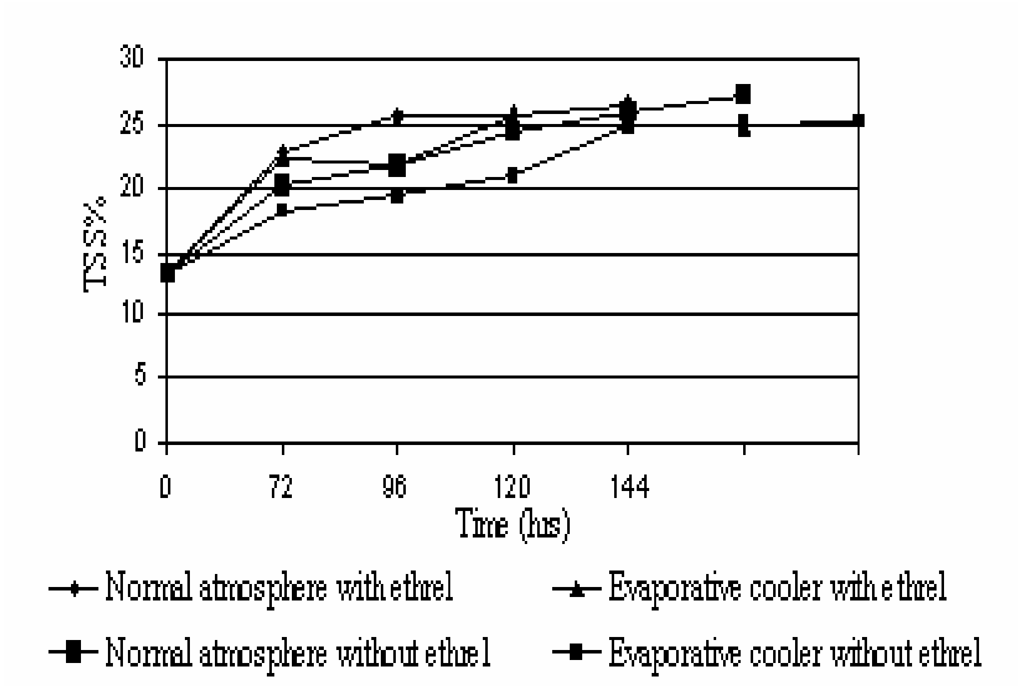

Figure 04: Change in total soluble solids content with ripening time for the cultivar *"Ambu"*.

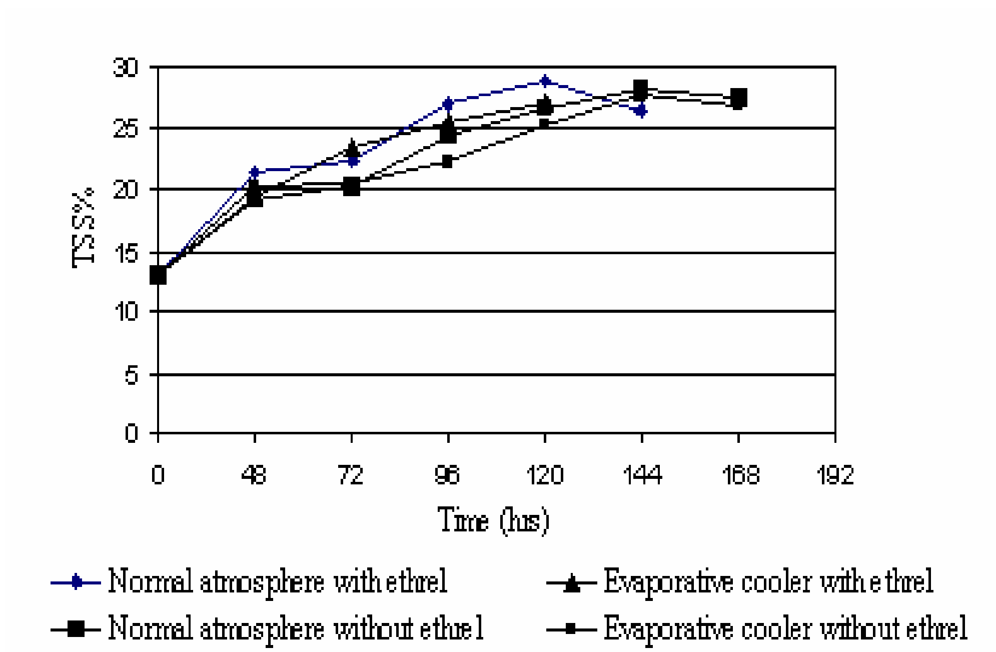

Figure 05: Change in total soluble solids content with ripening time for the cultivar *"Kolikuttu"*.

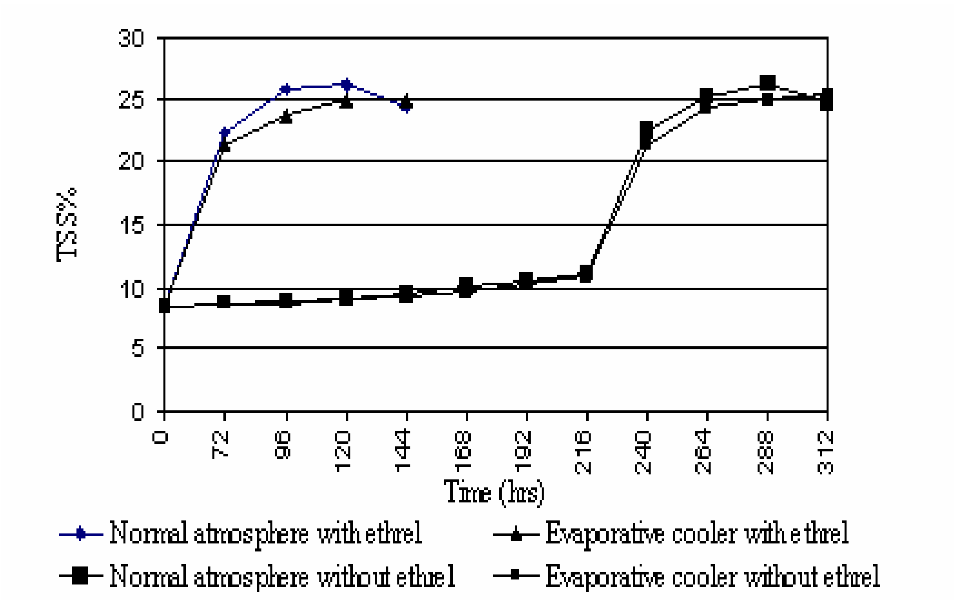

Figure 06: Change in total soluble solids content with ripening time for the cultivar "A*mban*".

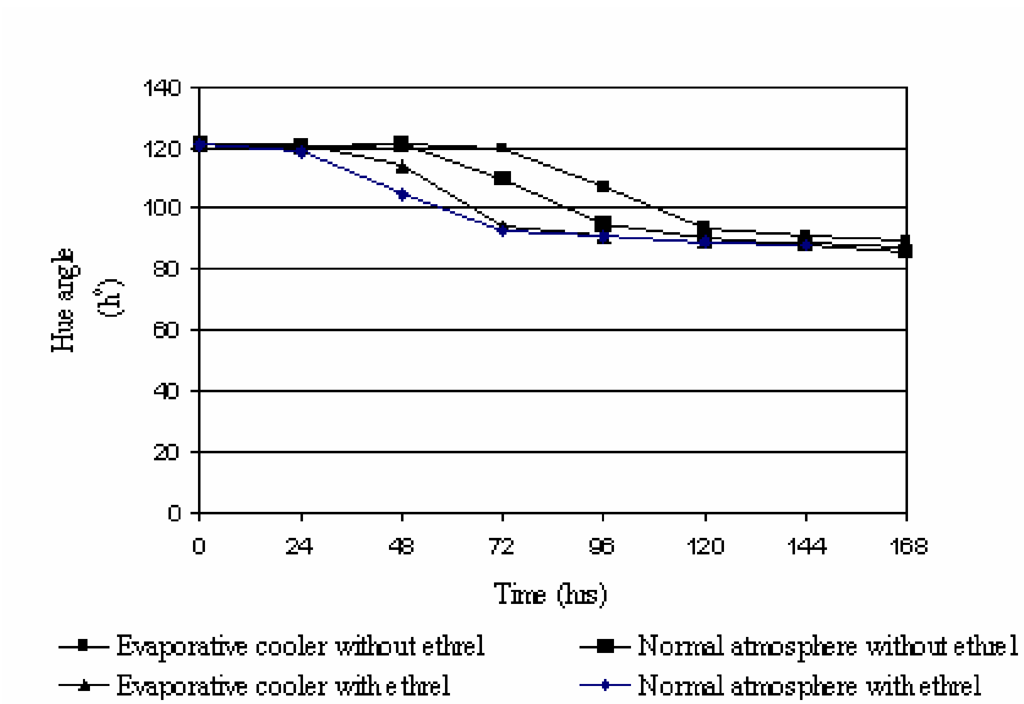

Figure 07: Change of the Hue angle with storage time for the cultivar "*Ambul*":.

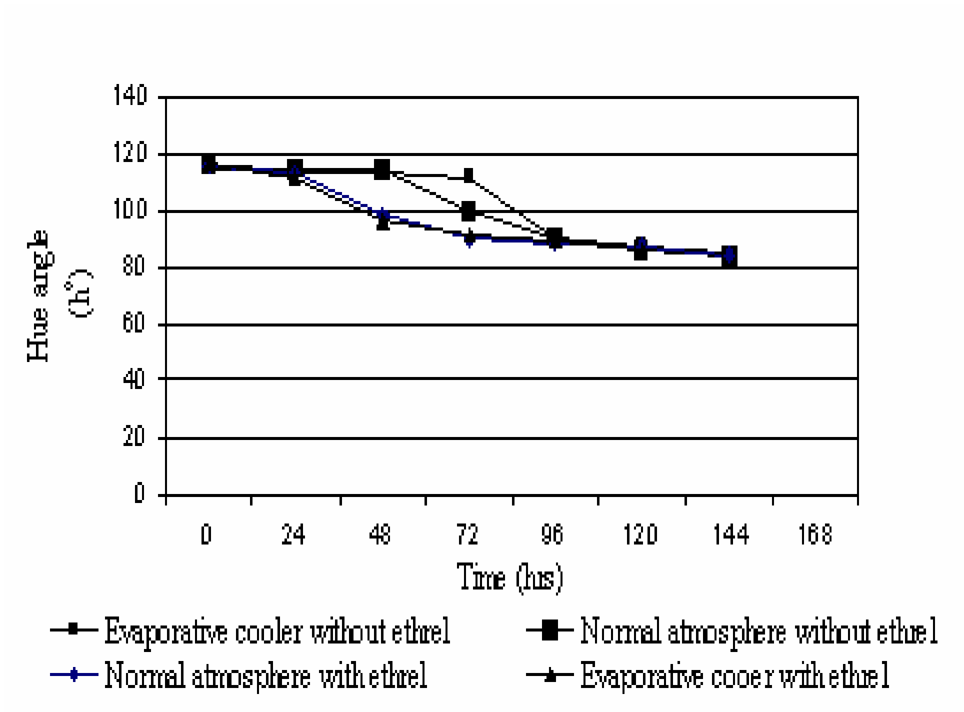

Figure 08: Change of the Hue angle with storage time for the cultivar "*Kolikuttu*".

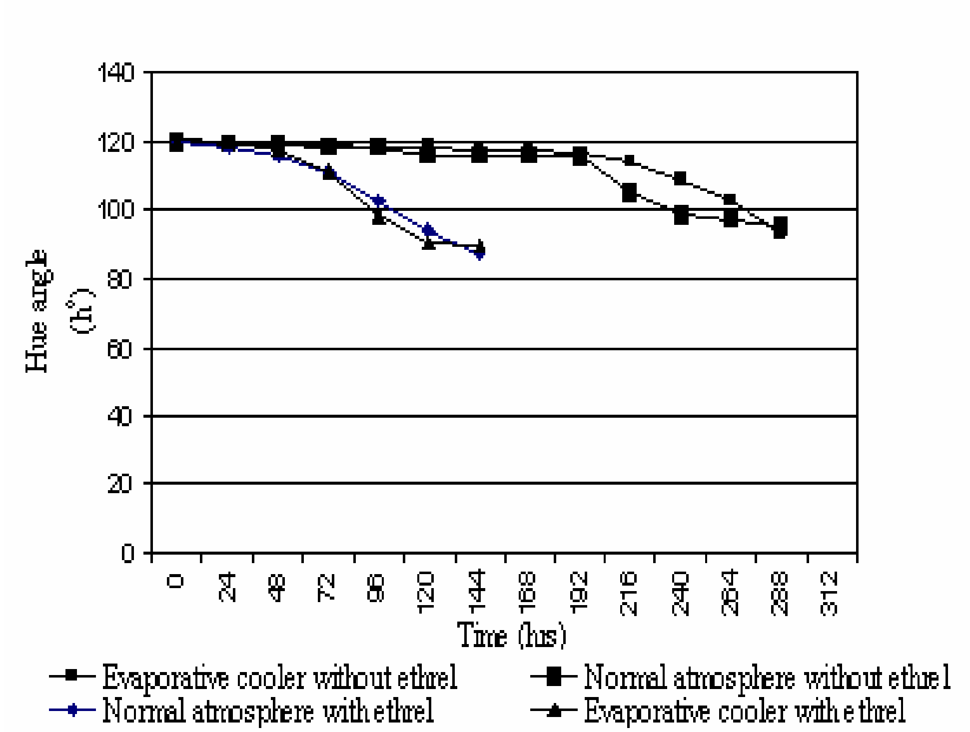

Figure 09: Change of the Hue angle with storage time for the cultivar *"Amban"*.

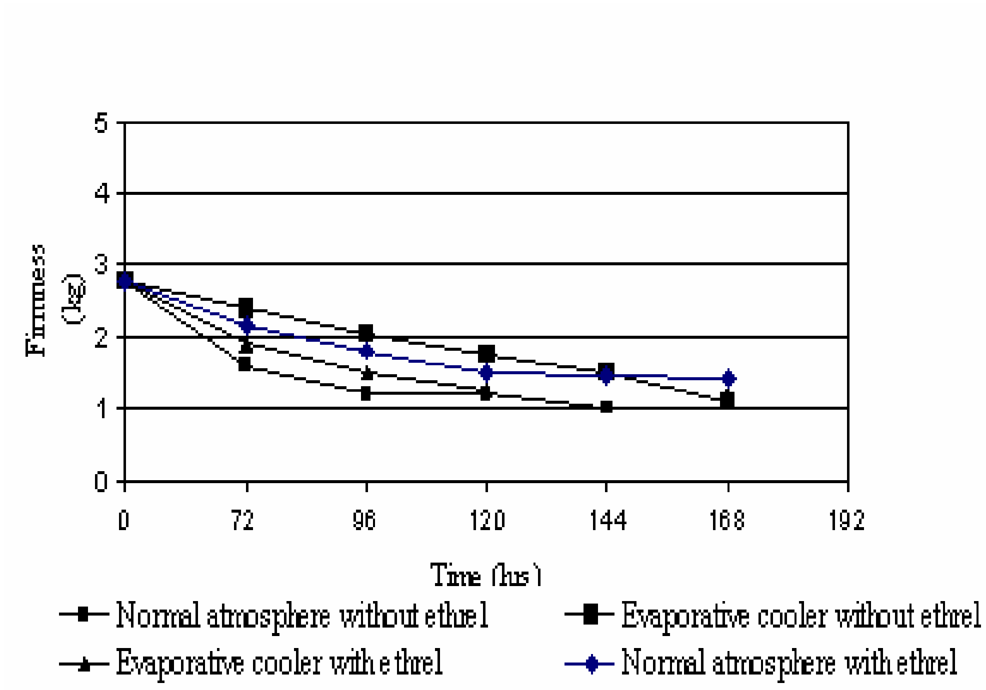

Figure 10: Change of the firmness with storage time for the cultivar *"Ambul"*.

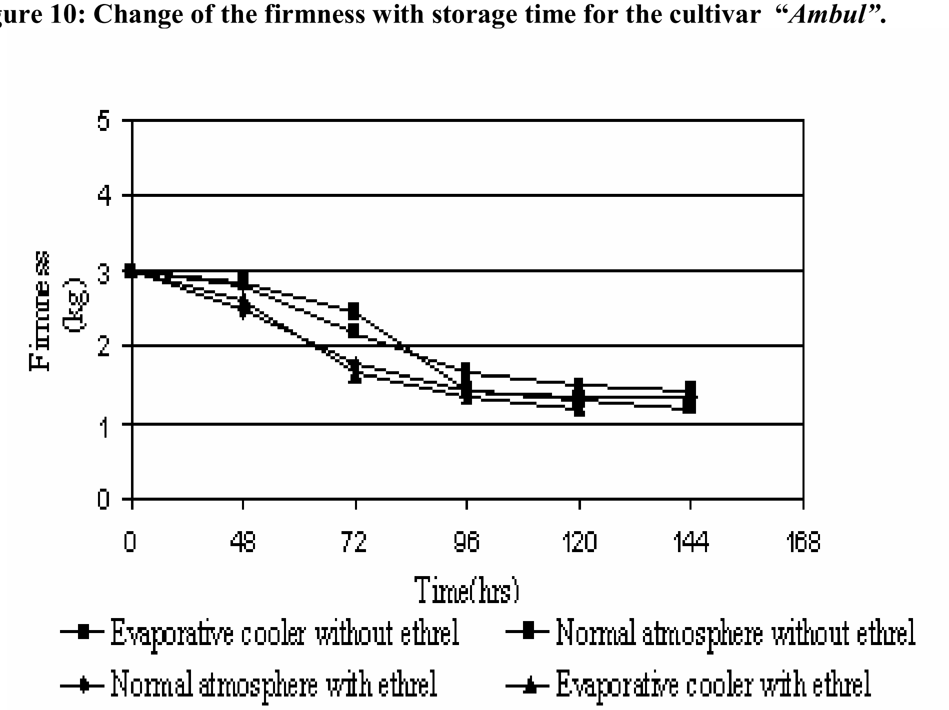

Figure 11: Change of the firmness with storage time for the cultivar *"Kolikuttu"*.

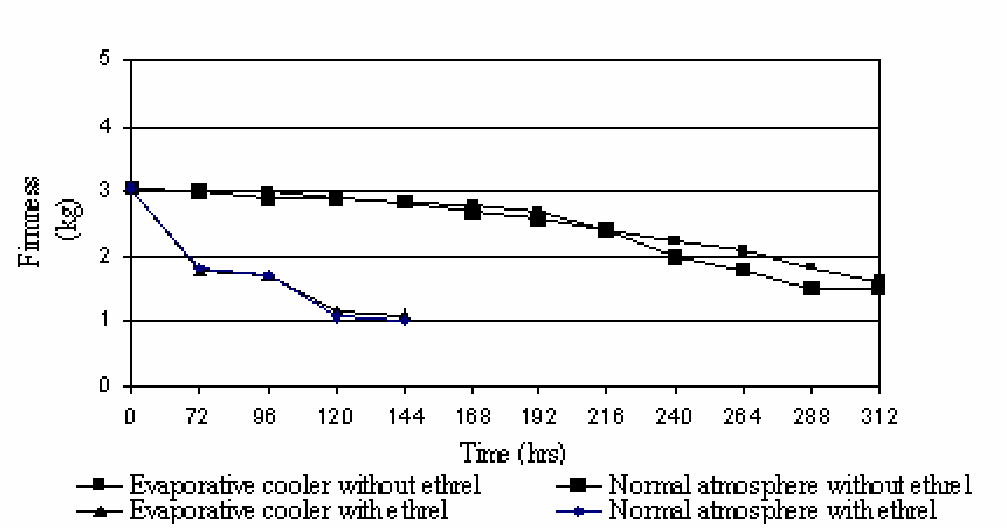

Figure 12: Change of the firmness with storage time for the cultivar "*Amban*".

The treatment effect was not significant for the colour when cultivar and time were kept as constants.

Effect of different treatments on firmness of fruits

Naturally fruit firmness decreases with ripening of fruits due to the biochemical changes of the cellular structure. Figures 10, 11 and 12 illustrate the behavior of firmness with time under different treatments.

According to the analysis of variance, the effect of treatment was not significant but the time effect was significant on the firmness at the probability level of 5%. Treatment means varied only with time. It is clear that the ethrel induce ripening in the cooler as well as in the box and ripening reduces the firmness. This phenomena is well illustrated by the above three graphs.

Effect of different treatments on percentage weight retention

Percentage weight retention was calculated based on the initial weight. In general this value decreased with time. Rate of weight loss in the samples kept under normal atmospheric conditions was higher compared to the samples kept under evaporative cooler. Figures 13, 14 and 15 show the behavior of remaining weight percentage under each treatment for all the cultivars.

The analysis of variance showed that the treatment effect was significant for the parameter remaining percentage weight. Keeping cultivar and time in constant, the treatment mean separation was done. Treatment means for samples kept under normal atmosphere were significantly equal and the treatment means for samples kept under evaporative coolers were also significantly equal for all three cultivars.

However, the samples kept under normal atmosphere showed the highest rate of weight loss (14 - 23%) while the samples kept in evaporative coolers showed the lowest weight loss (3 - 6%). The evaporative cooler significantly reduced the loss (14%) of moisture from fruits. The monitory value of this preservation is about four rupees per kilogram at the selling price of Rs. 30/kg. The cost for construction and running the cooler is only twenty five cents per kilogram. Therefore the technology can easily be exploited at banana ripening centres for optimization of profit.

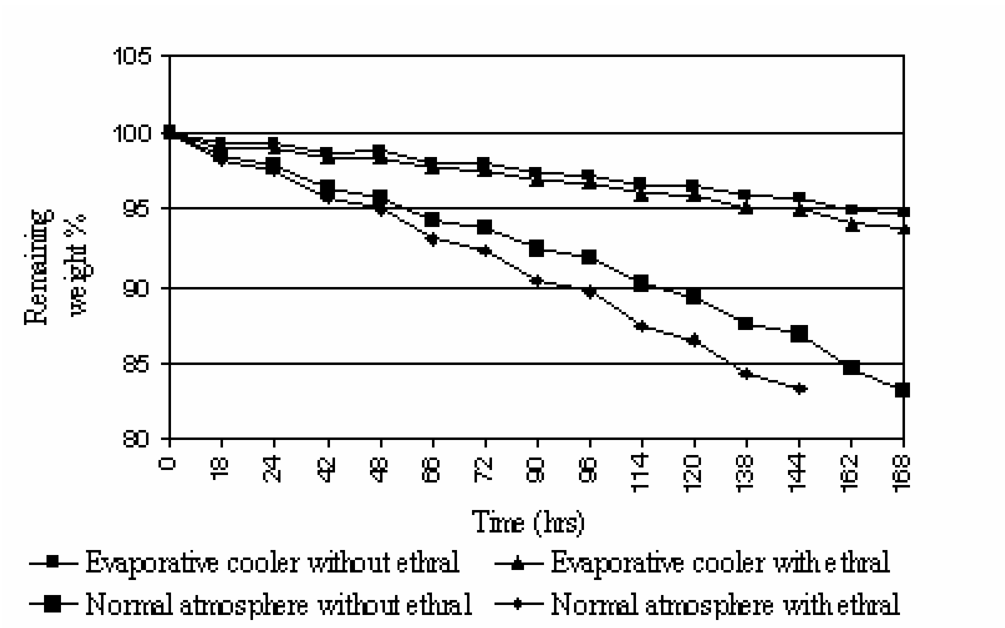

Figure 13: Remaining percentage weight with time for the cultivar 'Ambul'.

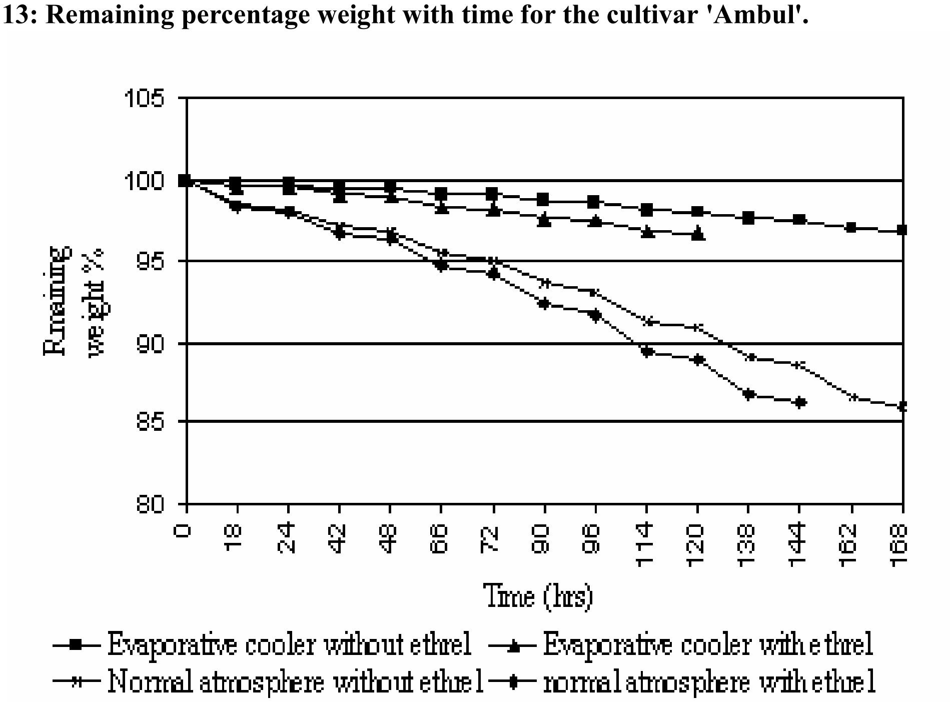

Figure 14: Remaining percentage weight with time for the cultivar "*Kolikuttu*".

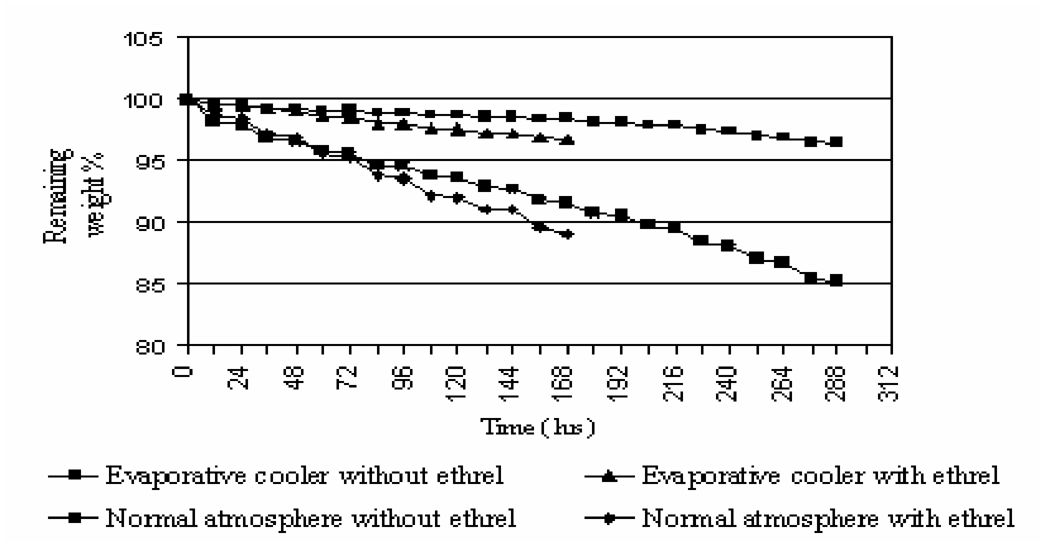

Figure 15: Remaining percentage weight with time for the cultivar *"Amban"*.

CONCLUSIONS

Based on the above results, the following conclusions can be drawn. The charcoal-cement evaporative cooler does not affect the measurable ripening quality parameters of banana but helps to retain the initial weight after ripening. Storage of banana in the evaporative cooler does not delay or accelerate the ripening process with respect to the natural ripening under room conditions. Application of ethrel induces the banana ripening in the evaporative cooler as well as in a box under room conditions. Use of an evaporative cooler for banana ripening is highly profitable as it maintains the required ripening quality while preserving most of its initial weight.

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