DETERIORATION OF CELOSIA (*Celosea argentea*) AND PEPPER (*Capsicum frutescens*) IN A METAL –IN – WALL EVAPORATIVE COOLER

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ABSTRACT

Due to the high rate of deterioration of fruits and vegetables particularly after harvesting in Nigeria, there is need for the development of an efficient storage structure for such highly perishable products. A metal in wall evaporative cooler was evaluated using fresh pepper and celosia to ascertain the optimum period that they could be stored without losing their essential nutritive values. The metal-bin walled evaporative cooling system consists of a brick wall, a cooling chamber (metallic box) and a coarse sand which act as the evaporating medium. The study revealed that there were continuous decrease in the food quality parameters such as ash content from 2.95% to 1.83% for celosia and 1.03% to 0.17% for pepper, fat content decreased from 1.80% to 1.04% for celosia and 1.14% to 0.89% for pepper, carbohydrate content decreased from 4.06% to 0.03% for celosia and 7.88% to 3.66% for pepper, protein content decreased from 4.77% to 4.51% for celosia and 2.61% to 2.05 for pepper and fibre content decreased from 2.73% to 2.49% for celosia and 1.09% to 0.80% for pepper, while the value of moisture content increased from 83.69% to 90.10% for celosia and 86.25% to 92.43% for pepper with increase in storage days. It was discovered that the cooling chamber had an average temperature drop of about 7° C when compared the ambient temperature and an average relative humidity drop of about 4% was experienced throughout the period of the study. The maximum storage days of celosia inside the cooler was 7 days while that of pepper inside the cooler was 10 days for both of them to retain their optimal nutritive value.

1. INTRODUCTION

A significant part of the world agricultural food production is fruits and vegetables, even though their production volumes are small when compared with grains, legumes and tuber crops. They remain important sources of digestible carbohydrates, minerals and vitamins, particularly vitamins A and C. In addition, they provide roughage (indigestible carbohydrates) which is needed for normal healthy digestion (Salunkhe and Kadam 1995). Recent researches have proven that nutrients in fruits and vegetables do more than just prevent deficiency diseases for instance beriberi or rickets, findings reveal that certain vitamins or vitamin precursors in produce, notably vitamin C; beta-carotene as well as polyphenols are powerful antioxidants (Consumer Reports on Health, 1998).

The shelf-life of vegetables is related to some biochemical processes that take place after harvest. Physiological actions such as respiration involves heat emission resulting in temperature increase and consequently accelerates metabolic processes and decay phenomena (Sánchez-Mata *et al*. 2003). Green vegetables have high respiration rate which limits their shelf-life after harvest to a maximum of 1-4 weeks. This is partly attributed to the high metabolic activity of the leaves and in some cases the seeds inside some of the fruits (Wills *et al*. 1999). However, at later stages of ripening, the degradation process increases with the hydrolysis of starch and the consumption of soluble sugars on respiration (Muñoz-Delgado 1985).

As a measure to improve the shelf-life of vegetables, several researchers have recommended the storage of these products at 4-10^{o}C (Wills *et al*. 1999). Modified or controlled atmosphere storage is also a useful technique for extending shelf-life of vegetables, especially for those that deteriorate quickly (Sánchez-Mata *et al*. 2003). Kadder (1997) reported that in general, oxygen level should be kept under 5% to obtain decreased respiration activity and in turn cause reduction of oxidize activities, such as polyphenol-oxidase, ascorbate-oxidase and glycolic-oxidase (Sánchez-Mata *et al*.2003). Low oxygen levels can also induce the suppression of genes that codify maturation associated enzymes, such as cellulose, polygalacturonase, acid invertase, sucrose-phosphate-synthase and amine cyclopropane-1-carboxylate-oxidase (Kanellis *et al*. 1991).

The study is aimed at evaluating the deterioration of celosia and pepper stored inside metal in-wall evaporative cooler and thereby estimating the storage period of the produce.

2. MATERIALS AND METHODS

2.1 Experimental Location

The experiment was carried out using an already designed and constructed metal-in-wall evaporative cooling structure located at the department of Agricultural Engineering, The Federal University of Technology Akure in Akure south local government area, Ondo State, Nigeria which is between the Latitude of 30^o North and Longitude 15^o West. Readings were taken and recorded for both the air conditions inside the evaporaive cooling system and ambient conditions simultaneously. Measurements included temperature using digital thermometer, relative humidity using digital hydrometer, moisture content using standard gravimetric method and air movement using digital anemometer. Deterioration of the stored produce was determined using standard methods of proximate analysis as suggested by AOAC (1990).

2.2 Description of the Structure

The metal bin wall evaporative cooling system consists of a brick wall, a cooling chamber (metallic box) and a coarse sand which act as the evaporating medium due to its wide availability in the area. The dimension of the evaporative cooler is 600mm × 600mm × 600mm while the entire dimension of the whole cooling system is 1500mm × 1100mm × 600mm. The coarse sand used was obtained from river bed. This isometric view of the cooler and the internal features are shown in Figures 1, 2 and 3 respectively. The metallic box was installed into the brick wall while the clearance between the brick wall and the metallic box was filled with the coarse sand above the height of the metallic box. The coarse sand was kept moistened daily, therefore as evaporation takes place through the coarse sand, there is a resultant cooling of the produce stored inside the cooling chamber. The design and construction of the evaporative cooler has been reported by Falayi and Jongbo (2011).

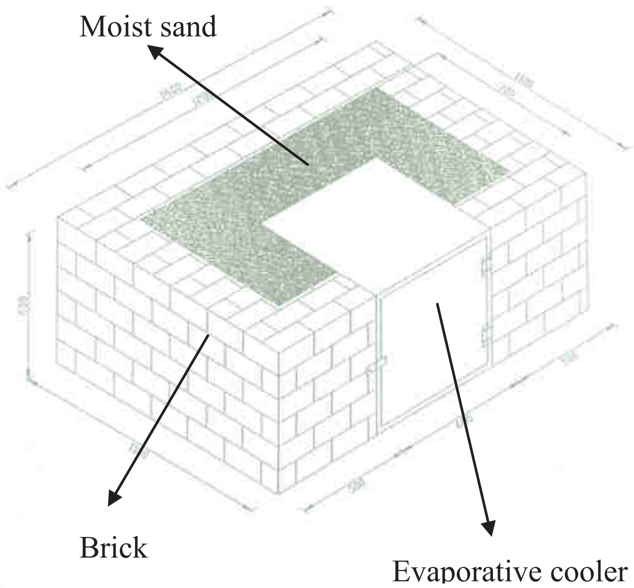

Figure 1. Isometric view of the storage structure

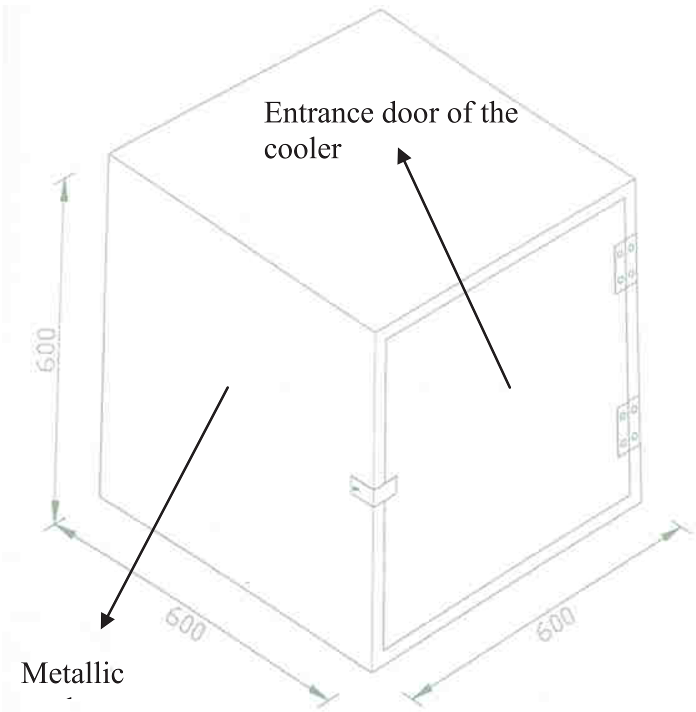

Figure 2. Isometric view of the cooling chamber

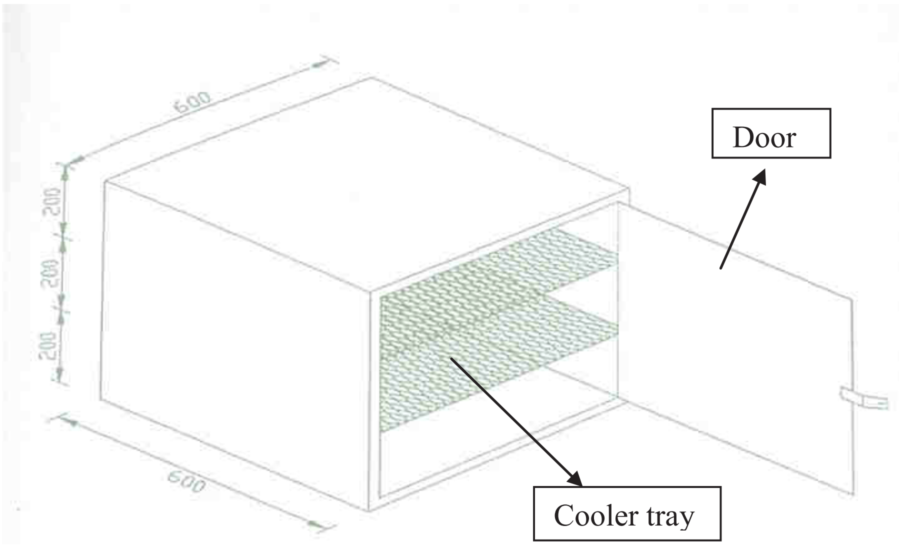

Figure 3. Arrangement of the tray inside the cooling chamber

2.3 Performance Evaluation

Samples of pepper and celosia used for this study were obtained from Agricultural Engineering Farm and Crop Soil and Pest Farm located within Federal University of Technology, Akure. The samples were first assessed for the required nutritional qualities and then prepared and stored in the evaporative cooler. Samples of the vegetables were taken every day and assessed for their nutritional qualities using proximate analysis until the entire samples got deteriorated. Parameters such as Moisture content, Fat content, Ash content, Fibre content, Protein content and Carbohydrate content were assessed using proximate analysis. In addition to the nutritional quality parameters being assessed, the temperature and the relative humidity of the storage system were monitored throughout the storage period. Data obtained from the tests were subjected to appropriate statistical analysis such as analysis of variance (ANOVA), regression analysis and test of significance using Excel software package.

3. RESULTS AND DISCUSSION

3.1 Moisture Content

The results of the average moisture content of the products are as shown in Figure 4. It was observed that moisture content of the stored products in structure increased from 83.69% to 90.10% for celosia while that of pepper increased from 86.25% to 92.43%. The increase in moisture content obviously was as a result of increased relative humidity. This corresponds to the report that moisture content of vegetables on wet basis is between 92.8% and 62.9% % (Javid et al., 2011). Also, according to Anthony and Effiong (1998), the maximum value of moisture content in vegetables is 90% which implied that the maximum storage days of celosia is 20 days while that of pepper is 16 days for the product to maintain adequate moisture content. The regression equations show a high correlation coefficient (R^2=0.92 and 0.95 for celosia and pepper respectively).

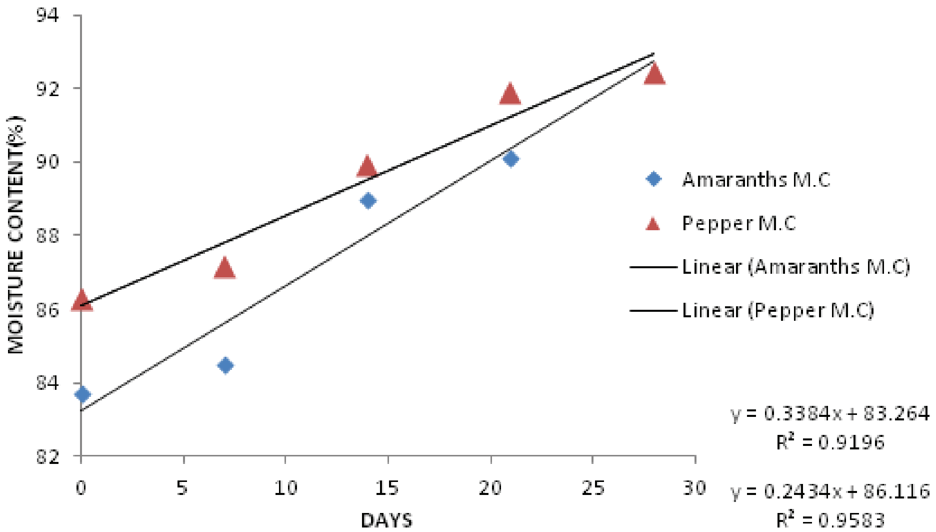

Figure 4. Relationship between moisture content and no of days

3.2 Ash Content

The results of the ash content showed that there was gradual decrease in the ash content as the storage period increased. The ash content decreased from 2.95% to 1.83% for celosia and ash content for pepper deceased from 1.03% to 0.17% which implied that 37.97% of the values of ash content were lost from celosia within three weeks and 83.50% of the values of ash content were lost from pepper. These values are by no means small when one is concerned with nutritional values. Using the recommendation of Anthony and Effiong 1998, the minimum standard for ash content in vegetables is that it must be 30% less from the initial content which are 2.07% for celosia and 0.721% for pepper. It was also reported that the ash content, which is a measure of the mineral content of food, had values ranging from 8.10 - 6.30% (Nnamani et al., 2009). Omale and Ugwu (2011) lately asserted that the ash content of vegetables is between 4.00% to 12.53%. Lockett had also reported high ash content in some green vegetables used by the lactating mother such as bitter leaves, *Veronia colorata* (15.9%) and *Moringa oleifera* (15.1%) (Lockeett *et al*., 2000). From the regression graph of Figure 5, it shows that for both equations of the crops, the maximum storage days of celosia is 15 days while that of pepper is 10 days in terms of ash content. The R^2 value was very high.

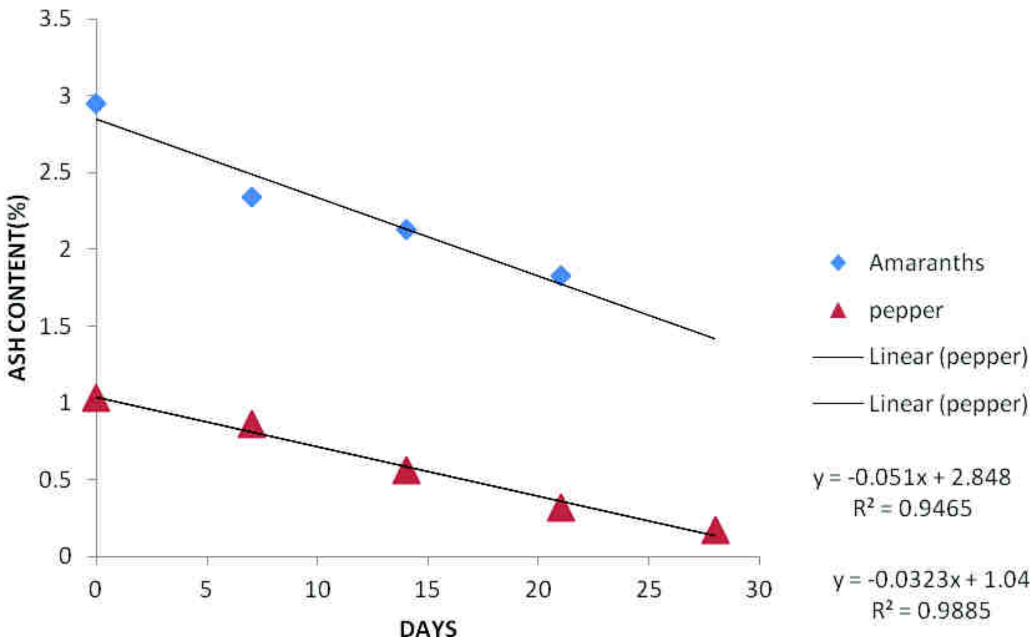

Figure 5. Relationship between ash content and no of days

3.3 Protein Content

The result of the protein content for the products is as shown in Figure 6. Protein content decreased from 4.77% to 4.51% for celosia while pepper decreased 2.61% to 2.05% showing that 5.45% and 21.46% of the values of protein content were lost in celosia and pepper respectively. As the period of storage increases, the protein content of the samples decreases which may be due to the difference in variety and environmental conditions. Nnamani et al. (2009) reported that Crude protein in vegetables had values ranging from 8.74 - 5.12%. He observed further that the amount of protein which is about 75% (when converted) of the total nitrogen in the leafy vegetables is variable, ranging from 5 – 10% of fresh weight or 13 - 30% for dry weight basis. These percentages are higher than the 3 – 8% and 11 – 28% results reported by Oyenuga and Fetuga (1975).

Omale and Ugwu (2011) estimated the crude protein content in some selected vegetables parts to be between 0.04 ± 0.03%and 2.67 ± 0.58%. Nevertheless, the protein contents determined for vegetable samples by Javid et al. (2011) were found to range from 7.8% to 16.9%. According to Anthony and Effiong 1998, the minimum standard for protein content in vegetables is that it must be 30% less from the initial content which are 3.33% for celosia and 1.827% for pepper. From the regression graph of Figure 6, it shows that for both equations of the crops, the maximum storage days of celosia is 122 days while that of pepper is 44 days in terms of protein content. The R^2 value is high.

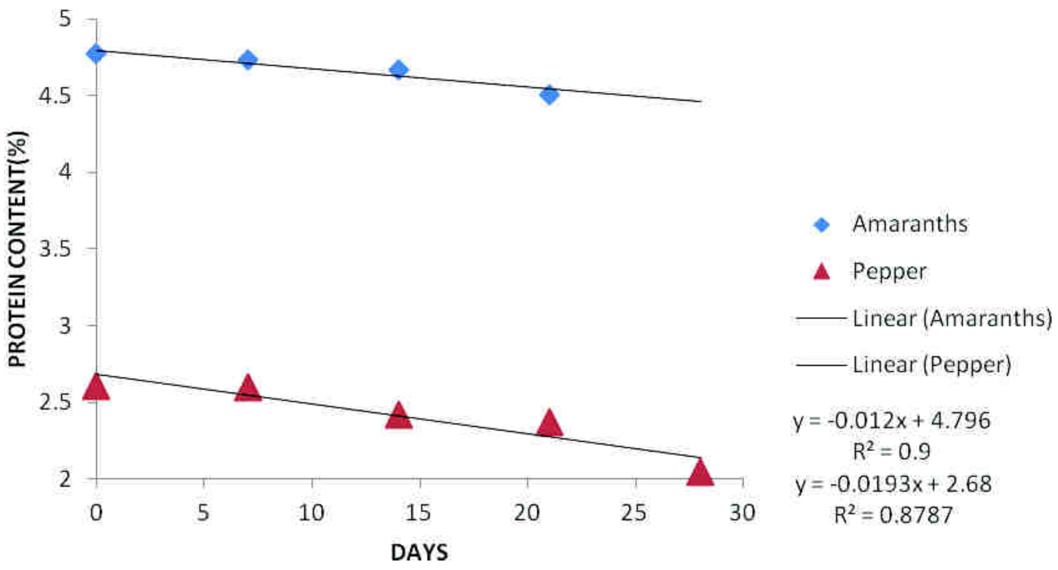

Figure 6. Relationship between protein content and no of days

3.4 Fat Content

Fat content reduced from 1.80% to 1.04% celosia while fat content also decreased from 1.14% to 0.89% for pepper in Figure 7, this shows that 42.22% and 21.93% of the values of fat content were lost in celosia and pepper respectively. As the period of storage increases, the fat content of the samples decreases. Also using Anthony and Effiong 1998, the minimum standard for fat content in vegetables is that it must be 30% less from the initial content which are 1.26% for celosia and 0.728% for pepper but research conducted has also shown the crude fat content of *some vegetables* ranged from 3.50 to 2.10% (Ajayi et al., 2006). From the regression graph of Figure 7, it shows that for both equations of the crops, the maximum storage days of celosia is 18 days while that of pepper is 46 days in terms of fat content. The R^2 value is very high.

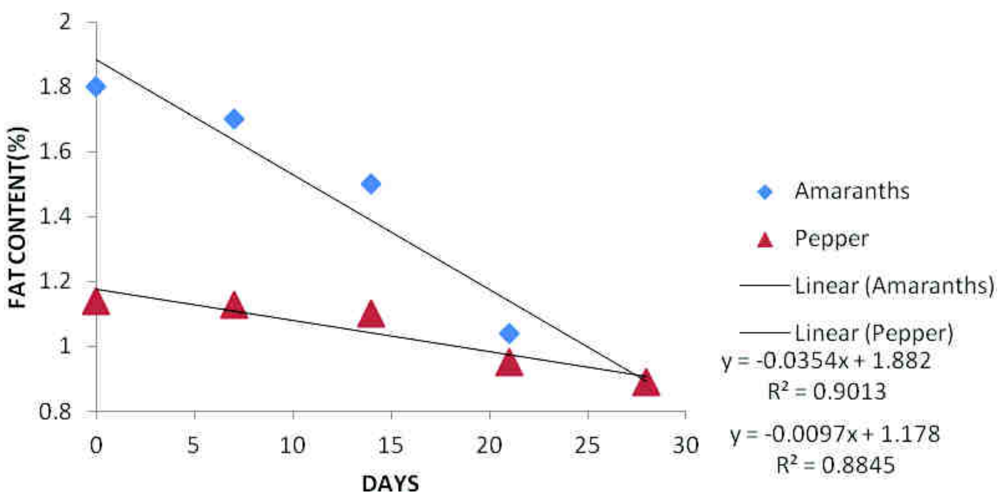

Figure 7. Relationship between fat content and no of days

3.5 Fibre Content

Fibre content of celosia and pepper decreased from 2.73% to 2.49% and 1.09% to 0.80% respectively in Figure 8, which implied that 8.79% and 26.61% of fibre content were lost in celosia and pepper, respectively. The fibre content of the samples decreased with increase in storage period. According to Anthony and Effiong 1998, the minimum standard for fibre content in vegetables is that it must be 30% less from the initial content which are 1.911% for celosia and 0.763% for pepper. Nnamani et al. (2009) reported that the fibre content of leafy vegetables ranges from 2.50 - 4.50%. These exceeded the fibre content of *T. triangulare* (2.0%) *T. occidentalis* (1.7%) and *C. argentea* (1.8%) (Akachukwu and Fawusi, 1995).

Figure 8 shows that for both equations of the crops, the maximum storage days of celosia is 74 days while that of pepper is 28 days in terms of fibre content. The coefficient of correlation (R^2) is very high.

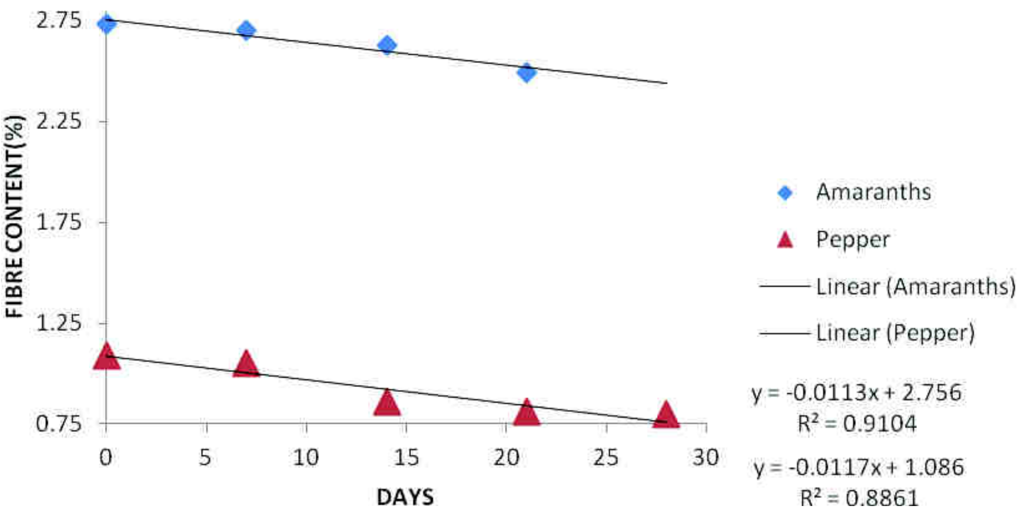

Figure 8. Relationship between fibre content and no of days

3.6 Carbohydrate Content

The carbohydrate content decreased from 4.06% to 0.03% for celosia and 7.88% to 3.66% for pepper as shown in figure 9, showing that 99.26% and 53.55% of the values of carbohydrate content were lost in celosia and pepper, respectively. As the period of storage increases, the carbohydrate content of the samples decreases. Previous research showed that the carbohydrate level of the underutilized indigenous vegetable ranged from 58.94% in *Z. zanthoxyloides* to 66.20% in *A. cissampeloides*. (Nnamani et al. 2009). According to Anthony and Effiong 1998, the minimum standard for protein content in vegetables is that it must be 30% less from the initial content which are 2.842% for celosia and 5.516% for pepper. From the regression graph of Figure 9, it shows that for both equations of the crops, the maximum storage days of celosia is 122 days while that of pepper is 44 days in terms of carbohydrate content. The R^2 value is high.

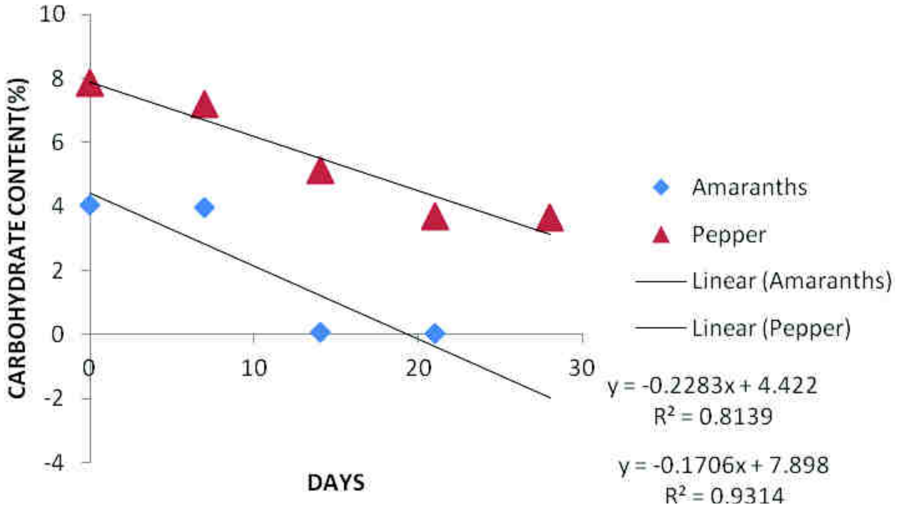

Figure 9. Relationship between carbohydrate content and no of days

3.7 Variation in Temperature and Relative Humidity

Variations in temperature of the evaporative cooling chamber and ambient storage were recorded as shown Figures 10, 11 and 12. The temperature inside the cooling chamber was significantly lower than the ambient temperature. The cooling chamber had an average temperature drop of about 7° C when compared the ambient temperature. As expected, the temperature inside the cooler was lowest in the morning followed by evening temperature, while temperature during the afternoon was highest throughout the period of study as shown in Figure 11. The average relative humidity inside the cool chamber was found to be significantly higher than the outside ambient relative humidity as shown in Figures 13, 14 and 15. A further analysis showed that an average relative humidity drop of about 4% was experienced throughout the period of the study which is similar to the result of Odey *et al* (2005). Also as expected, the relative humidity inside the cooler was highest in the morning period and lowest in the afternoon throughout the period of the study as shown in Figure 14.

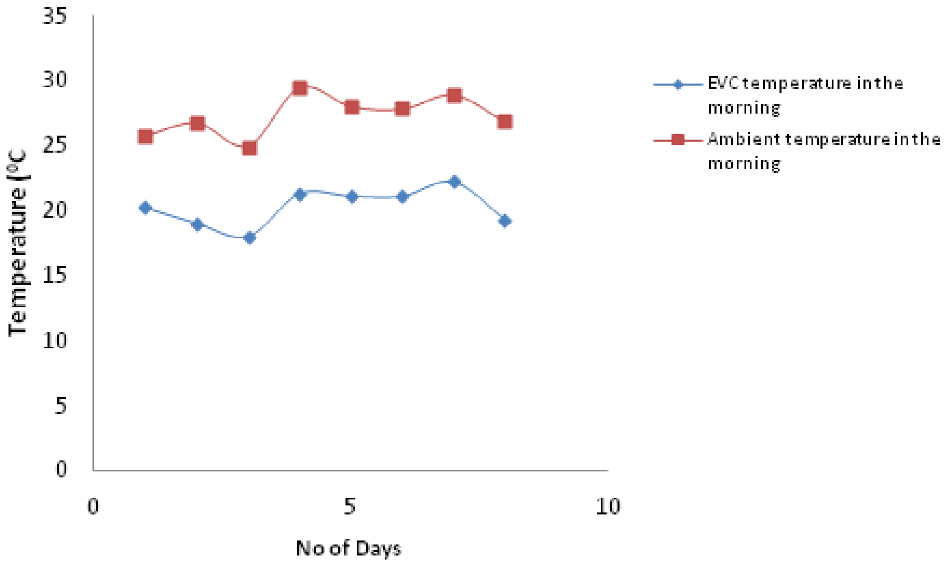

Figure 10. Relationship between temperature inside the cooler and ambient temperature in the morning

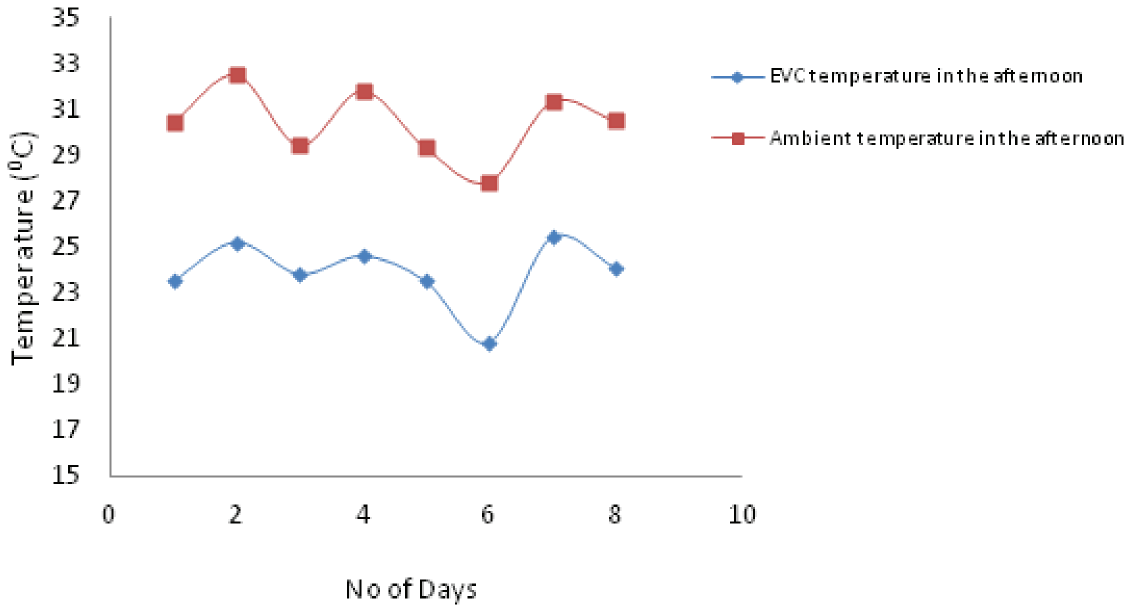

Figure 11. Relationship between temperature inside the cooler and ambient temperature in the afternoon

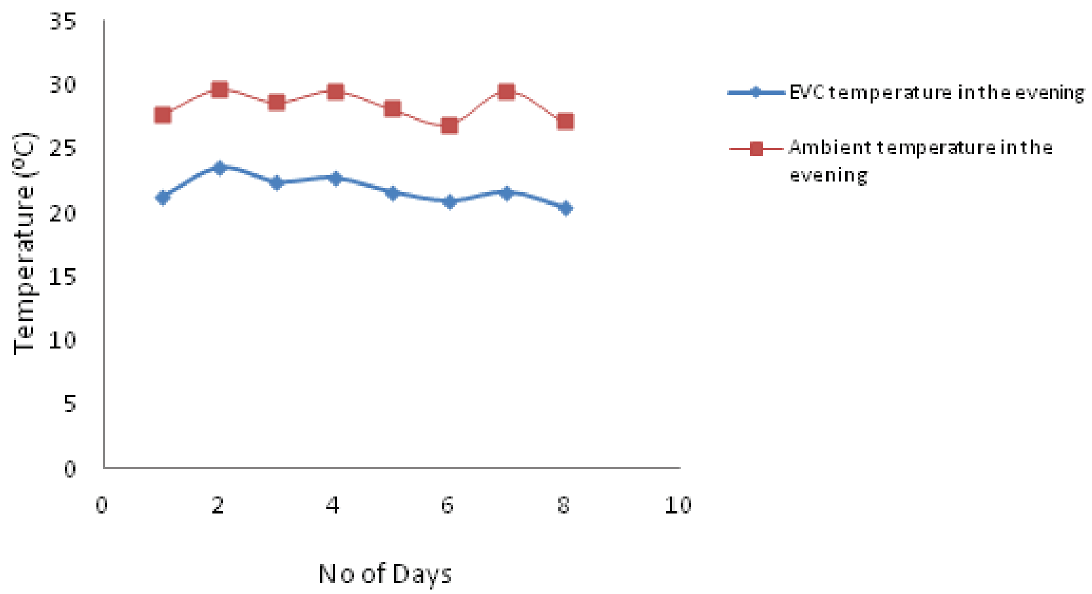

Figure 12. Relationship between temperature inside the cooler and ambient temperature in the evening

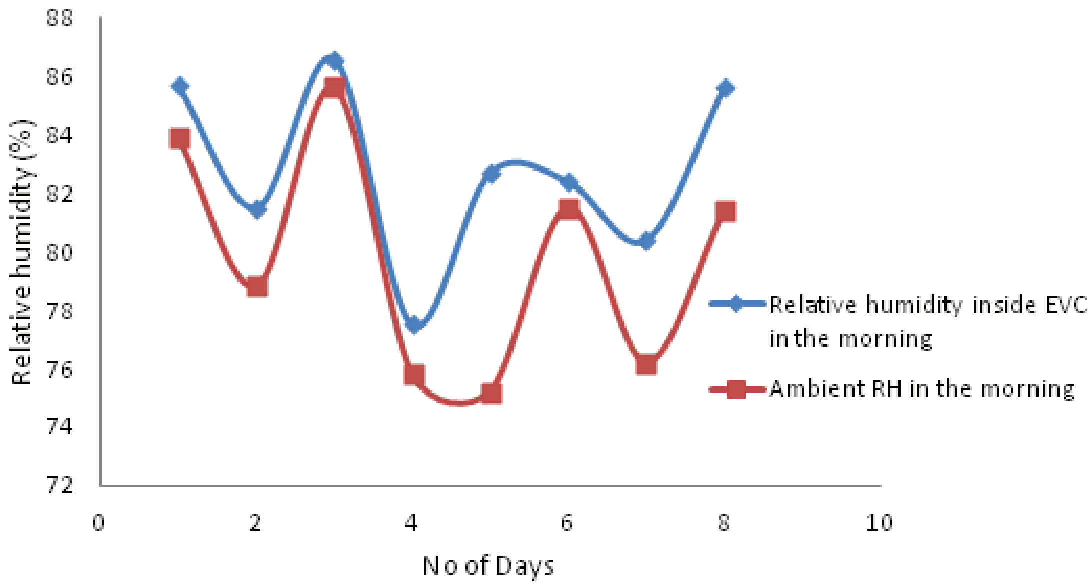

Figure 13. Relationship between relative humidity inside the EVC and ambient relative humidity

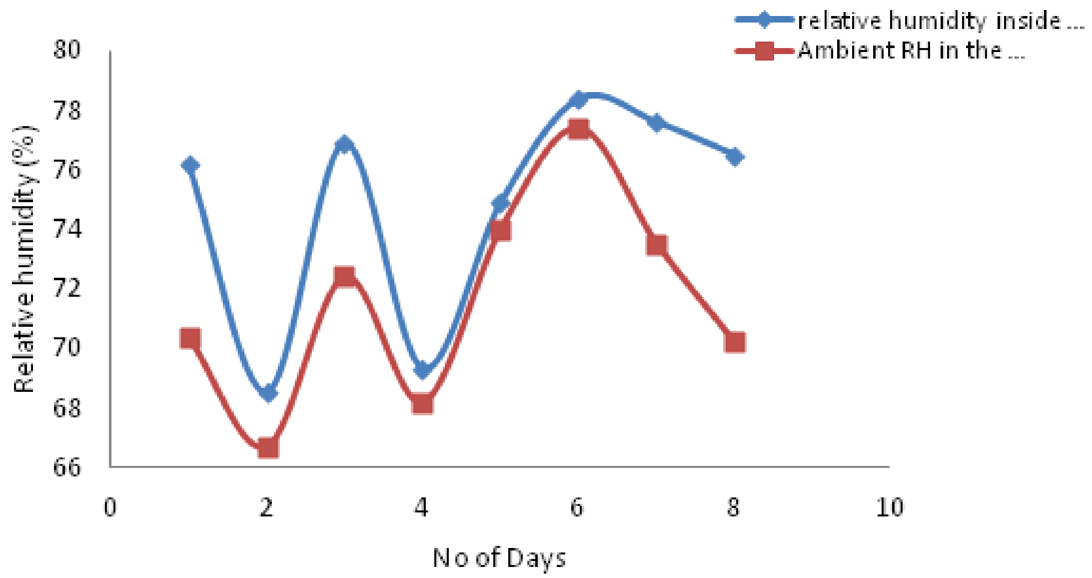

Figure 14. Relationship between relative humidity inside the EVC and ambient

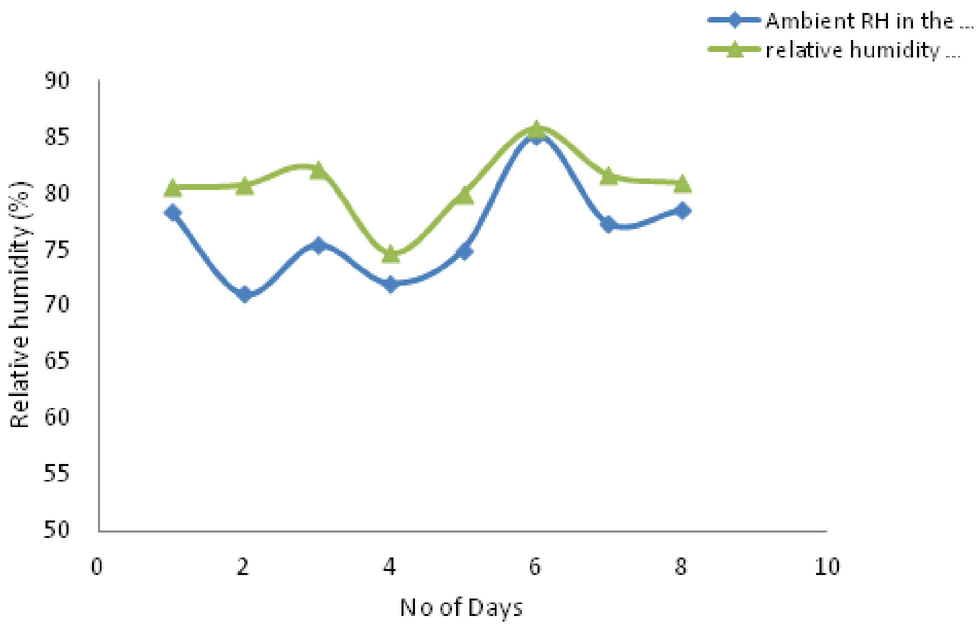

Figure 15. Relationship between the relative humidity inside the EVC ambient

4. CONCLUSION

Important information has been generated on nutrition properties of the samples of Amaranths and pepper during storage inside a metal-in-wall evaporative cooler. Quality parameters such as ash content, protein, fat content, fibre content and carbohydrate content were also evaluated using proximate analysis. It can be concluded that these qualities parameters generally reduce with time during storage in the cooler. The ash content reduced from 2.95% to 1.83% and 1.03% to 0.17% for celosia and pepper respectively. Also, protein content reduced from 9.77 to 4.51 and 2.61 to 2.05% for celosia and pepper respectively. Fat content reduced from 1.80 to 1.04 and 1.14 to 0.89% for celosia and pepper respectively. Fibre content also reduced from 2.73 to 2.49% and 1.09 to 0.80% for celosia and pepper respectively. Carbohydrate content reduced from 4.06 to 0.03% and 7.88 to 3.66%. The maximum storage days were 7 and 10 days for celosia and pepper respectively for both of them to retain their optimal nutritive value. The average temperature and relative humidity drop was about 7^0C and 4% respectively.

The storage structure is very economical since it requires no electrical or mechanical power to run. The storage structure is therefore considered suitable for small scale farmers in the rural areas of Nigeria to alleviate the problems of deterioration of their highly perishable crops and increase their financial benefits.

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