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Physico-Chemical Assessment of Herb Treated Sweet Oranges (*Citrus sinensis*) Osberk stored in Evaporative Cooler

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ABSTRACT--- ***Large quantities of oranges produced in Nigeria are wasted during post-harvest handling and storage which result in nutritional and economic losses. Therefore there is a need to understand the physico chemical properties, handling and storage of oranges to minimize these losses. Hand-plucked matured green sweet oranges were dipped in 15% aqueous extracts of Thymus vulgaris (Thyme), Allium sativum (Garlic), Eugenia aromatica (Clove) and Cymbopogon citratus (Lemon grass). The pre-storage treated oranges were stored inside evaporative coolers. The oranges treated with C.citratus and A.sativum stored for thirty five days while oranges treated with E. aromatica and T. vulgaris stored for fifty two days. Control (untreated) oranges stored for only seven days. Chemical parameters monitored weekly were pH, ash content, total soluble solids, titratable acidity, total reducing sugar and vitamin C. The study revealed that local herbs and condiments can safely be used to preserve sweet oranges after harvesting. Data obtained were subjected to analysis of variance and least significant difference (LSD) (P>0.05) was used for mean separation. There was no effect of the pre-storage treatments on the physico chemical analyses (P≥0.05). There was no significant difference in the results of analyses of the treated oranges stored in the evaporative cooler. This study revealed that local herbs and condiments can be safely used to preserve sweet oranges after harvesting.***

Keywords--- Thyme, Garlic, Eugenia clove, Lemon grass extracts, Proximate analyses.

1. INTRODUCTION

Nigeria produces a wide variety of tropical fruits including citrus, mango, papaya, guava, pineapple, banana, water melon and a variety of indigenous fruits including Africa star apple, hug plum, native pear and wild mango. The growth and production of crops in Nigeria is seasonal. Most crops are being grown in the rainy season. Raiyemo *et al.,* (2013) reported that about 930,000 tons of citrus fruits are produced annually from an estimated three hectares of land. Therefore food crops are abundant at the time of harvest but scarce a few months later. Post-harvest losses are defined as many changes in the quality of the product after harvest, that decrease its value (Fallik and Porat, 2009). Post-harvest losses are as high as 30% - 50% for vegetables, fruits and some other crops (Taiwo, 2007). Nigeria produces diverse fruits and vegetables on a seasonal and simultaneous harvesting often leads to gluts. Overcoming gluts necessitates the preservation of fruits and vegetables. Both quantitative and qualitative losses occur in fruits and vegetables between harvest and consumption (Adekalu, 2014). Fruits and vegetables are cheap sources of Vitamins C, A, and E, essential minerals, antioxidants and other phyto nutrients (Kordylas, 1990). Most horticultural produce are classed as perishables. Therefore, long term storage is necessary not only to extend shelf life, marketing period but also availability of fresh fruits throughout the year. To achieve this, post-harvest research is of great significance in minimizing the post-harvest losses through new long-life varieties, suitable cultivation methods, and optimum harvesting indices, storage recommendations, pre-cooling, refrigerated transports and careful handling. Fungicides, pesticides and waxing are imported from Europe and United States of America. These chemicals are expensive and their availability is low. About 70% of farmers in Nigeria lack the technical knowledge on their applications and there is no awareness either (Adekalu, 2014). Recent research studies have shown that these preservatives or pesticides are carcinogenic (Adekalu, 2014). The inappropriate use of synthetic chemicals may lead to human and environmental risks and promote crop resistance (New Agriculturist, 2003). Crops like *A. sativum, T. vulgaris, C. citratus* and *E. aromatica* are proven spices, edible, and being flavour enhancer; have shown notable concentration of antimicrobial and antioxidants for the past centuries (Hutchinson

and Dalziel, 1984; Willie Jones, 2011; Adekalu, 2009 Solgi and Ghorbanpour, 2014). Their major active components are Thymol, Eugenol, Allicin and Citronella respectively. They are all proven antimicrobial, and hence, reduce disease incidence when used in association with aqueous extracts or essential oils to treat fruits (Sivakumar and Baustistan, 2014). Since fruits and vegetables are main crop in horticulture and are consumed freshly, their postharvest condition are therefore of immense important. The control of fungal decay involves use of fungicides namely prochloraz, guazatine, imazalil, thiabendazole and pyrimethanil which are used to treat fruits such as mango, avocado, and citrus. These are applied by passing freshly harvested fruits through large volume dip solutions. Aderele-Ayo (2015) published a report on human reproduction, which showed that those who eat high amounts of fruits and vegetables with high levels of pesticide residues have a 49% incidence of lower sperm count. This finding has important implications on human health. In most developing countries, including Nigeria, refrigeration is costly to procure and sustain while the cost of most tropical fruits and vegetables are relatively low. In such situations, it is necessary to employ a cheaper means of storage especially at the retailer and small scale processing level. Evaporative cooler storage is the alternative to refrigerators since electricity is irregular in the rural areas of Nigeria. Proper temperature management can be an effective tool in ensuring that the produce remains in good condition throughout storage and transportation (Adekalu, 2014). Babarinsa and Nwangwa (1988) designed and constructed two evaporative cooler storage systems, viz: Tin in Pot (A) and Pot in Pot (B). They reported that evaporative cooler works on the principle of cooling as a result of evaporation of water from surface of the cooler. The main objective of this research is to assess the physico chemical properties of the different pre-storage treated oranges with botanical extracts.

2. MATERIALS AND METHODS

Materials: Oranges, plastic crates, spices, bowls, burners, potable waters.
Preparation of extracts: Herbs and spices which have been proven to be antimicrobials and antioxidants were purchased from the local market and used. They included. *Thymus vulgaris* (thyme), *Eugenia aromatica* (clove), *Allium sativum* (garlic), *Cymbopogon citratus* (lemon grass). Boiled water extract containing 15% concentrations of each powered spices were prepared.
Application of Extracts: The mature green fruit of sweet oranges (Breaker State) were dipped into the prepared warm extract of each of the finely grounded spices and then rolled in for five minutes. The treated fruits were then placed inside the plastic crates to drain and air dried. After the fruits were dried they were then placed inside the evaporative coolers. Three replicates of each treatment were laid out. A thermo hydrograph was used to measure the relative humidity and temperature in the evaporative cooler structure and environment (ambient) while a thermometer was used for measuring the temperature in the coolers (Pot in Pot and Tin in Pot). The experimental designs were a randomized block design involving 5 spice treatments x 3 concentrations x harvesting methods.
The effect of pre-storage treatment, on the proximate analyses and storability of sweet oranges, stored at ambient and evaporative coolers were evaluated.

Data on the proximate analyses were collected on a weekly interval until deterioration sets in between 35 - 52days. Temperature of the ambient and evaporative coolers was monitored. The pH determination was carried out as described by AOAC (1990). Total titratable acidity was done following the procedures described by Pearson (1976). Total soluble sugars were determined by the use of hand refractometer. Organoleptic test was done following the procedures described by Ladapo (2000). Ash content determined as described by Adekalu *et al* (2011) while Vitamin C (Ascorbic acid) content in treated fruits was determined by AOAC (1990). Total reducing sugar determination was by the method described by McCaseady (1971).

3. RESULTS AND DISCUSSION

Table 1: Organoleptic tests for Different Herb Treated Stored Sweet Oranges.

Pre-storage treatment	Number of Days			Period of storage (Days)				
	7	14	21	28	35	42	49	52
Aqueous Thyme extract	5	5	5	5	5	5	5	4
Eugenia Extract	5	5	5	5	5	5	5	4
Lemon grass	5	5	5	4	4	-	-	-
Garlic Extract	5	5	5	4	4	-	-	-

Scale value for Test: Tasteless 1, Poor 2, Fair 3, Good 4, Very Good 5.

From the result of organoleptic tests on herb treated oranges presented in Table 1**,** it can be inferred that all the factors that aid post-harvest deterioration have been either reduced or controlled due to the effect of aqueous extracts of thyme, clove, lemon grass and garlic used as pre- storage treatments on experimental oranges. This is in agreement with the findings reported by Assous *et al.*, (2013) on nectar prepared with lemon grass. Quality evaluation consists of measurement of appearance, texture, flavour, nutritive value and safety of the produce. According to Laminkanra (2013), flavour and aroma are based on either chemical analyses or sensory evaluation.

Table 2: Temperature Ranges and Relative humidity values obtained during the Trials

	Ambient 27 - 30°C	Tempt (°C) Week 1	Week 5
Portable A		22 - 26°C	22 - 25°C
Portable B		25 - 27°C	25 - 27°C

Relative humidity value (%)

week 1	week 2	week 5
60-70%	50-100%	55-80%

Reference Thermo hydrograph (graph)

The evaporative cooler, temperature is lower than the ambient (Table 2). The cooler served as zero energy cooling chambers. This is in agreement to Babarinsa and Nwangwa, (2000); Paudal (2002) they reported that evaporative coolers internal temperatures are lower than ambient environment. Relative humidity is another important factor responsible for the deterioration in fruits and vegetables. Internal temperature in cooler A was about 2-3°C lower than cooler B. The temperature of ambient was between 4-7°C higher than that of cooler A and B.

pH of the treated oranges stored in cooler.

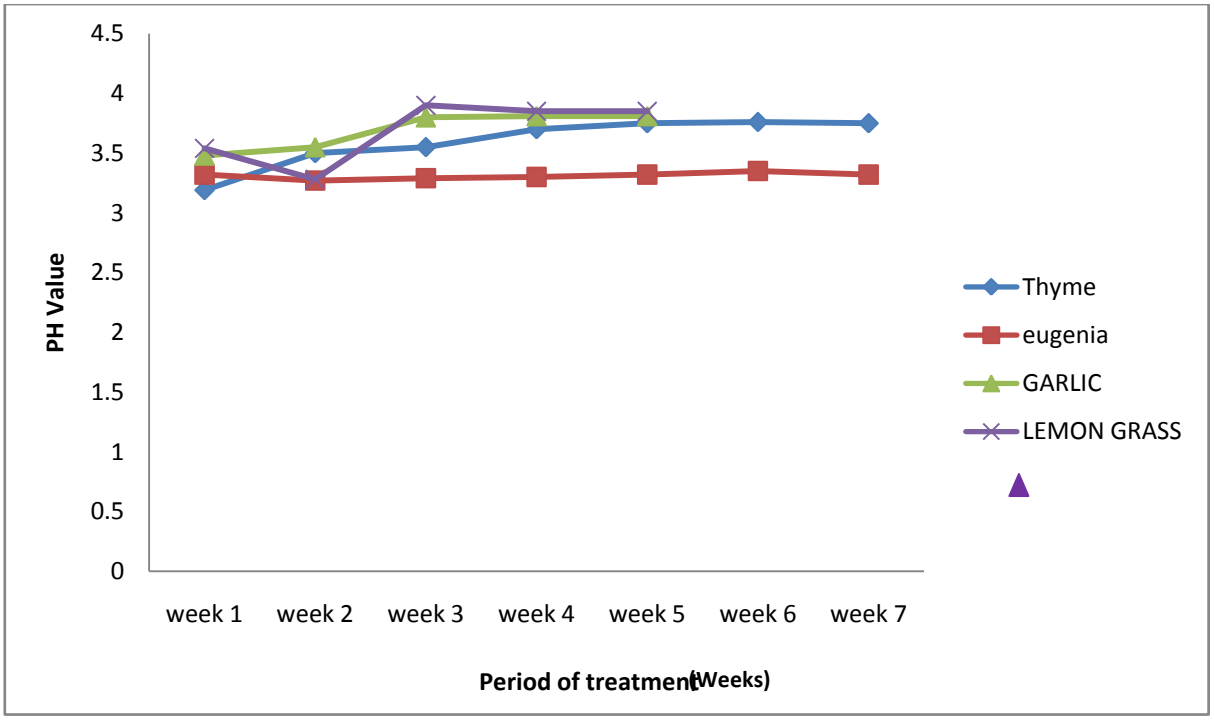

Figure 1: pH Value of aqueous extracts of different herbs treated oranges stored in evaporative cooler over seven weeks.

A slight steady increase in the pH level of herb treated oranges is shown in figure 1. Garlic extracts and lemon grass extract treatment were stored for thirty–five days (five weeks) while Thyme and Eugenia clove stored were for fifty-two weeks (seven weeks). No significant difference in the pH of the herb treated oranges ($P \leq 0.05$) was observed. The observable little increase in the pH could be due to the presence of alkaline elements that enhanced the ripening of oranges, hence, making it nutritionally suitable for consumption. According to Kumar *et al.*, 2011, pH of fruits is the major factor that influences the composition of sweet oranges at the time of harvesting. Rahman (2001) reported the importance of pH on food stability and food preservation. He observed that microorganism would not grow at low pH values. It can be concluded that pH also affects many functional properties such as colour, flavour and texture of fruits. In addition, the stability of vitamins depends on pH of the medium under acidic or alkaline condition.

Titratable acidity (TTA) of herb treated oranges Figure 2.

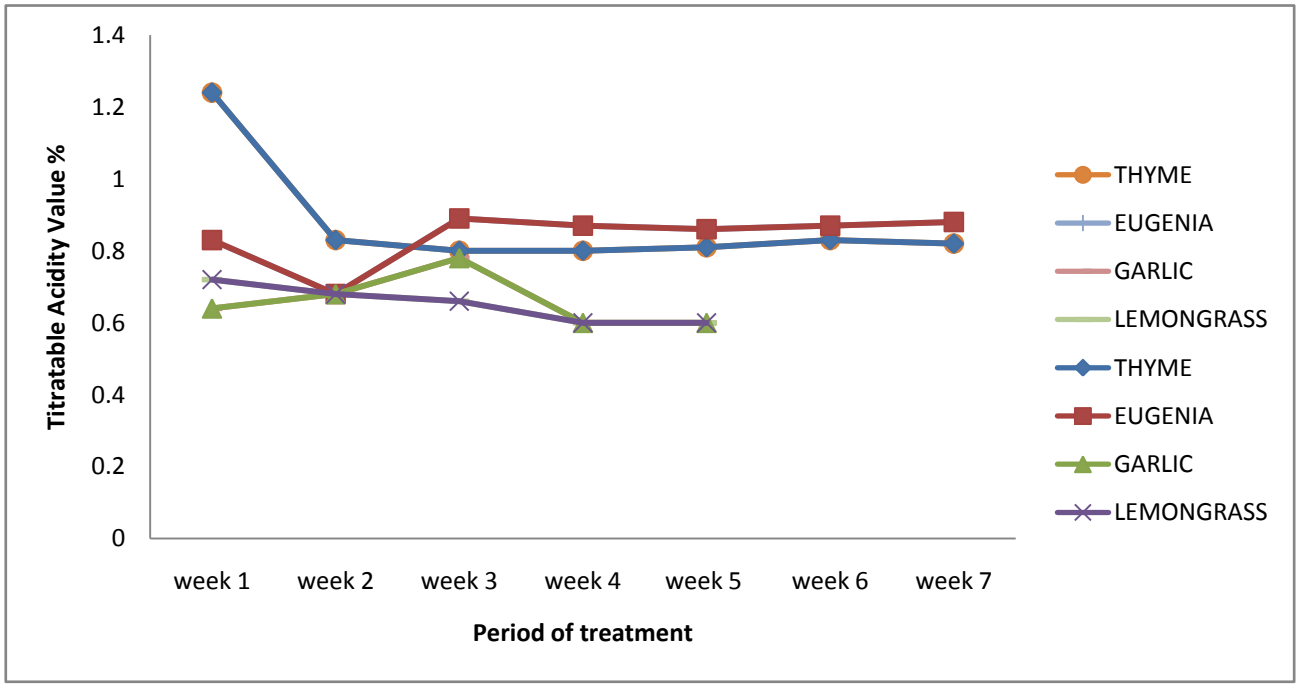

Figure 2: Titratable acidity value (%) of aqueous extract treated oranges stored in Evaporated Cooler A over seven weeks

A slight decrease of TTA values was observed in garlic and lemongrass extract treated oranges while increase was observed in thyme and Eugenia extracts treatments. In many fruits, acidity decreased progressively as the fruit matures on the tree. Radovanoic *et al.*, (1986) reported that titratable acidity vary in wine depending on grapes variety, while ripeness degree depended on grapes variety, type of soil, phyto- sanitary condition of grapes and agro-technical measure and way of process. Low TTA content was observed not to be high during storage. Tartaric, malic and citric acid are products of fermentation with high acid content. (Frazier and Westhoff, 1992). Titratable acidity and pH have also been used to assess the sugar to acidity ratio in some fresh cut fruits (Laminkanra, 2013). Total soluble sugars of herb treated sweet oranges stored in evaporative coolers ranged between 8° to 10°Brix. The increase was significant ($P \geq 0.05$). This could be attributed to the breakdown of polysaccharide into smaller units of disaccharide and the hydrolysis of starch into simple sugars like glucose and fructose (Jafar and Fatemi, 2012).

Total Reducing Sugars

The status of total reducing sugars (TRS) of herb treated sweet oranges stored in evaporative cooler expressed as mg/100 is shown in Figure 3. A stable and slight decrease in the TRS was recorded for all the treatments. The decrease in TRS was probably due to enzymatic conversion of starch and pectin by amylase enzyme present in the oranges (Adekalu *et al.*, 2011) According to Moneruzzman (2008), palatability of fruits depends on total soluble sugars and acidity ratio increased the gradually during storage time.

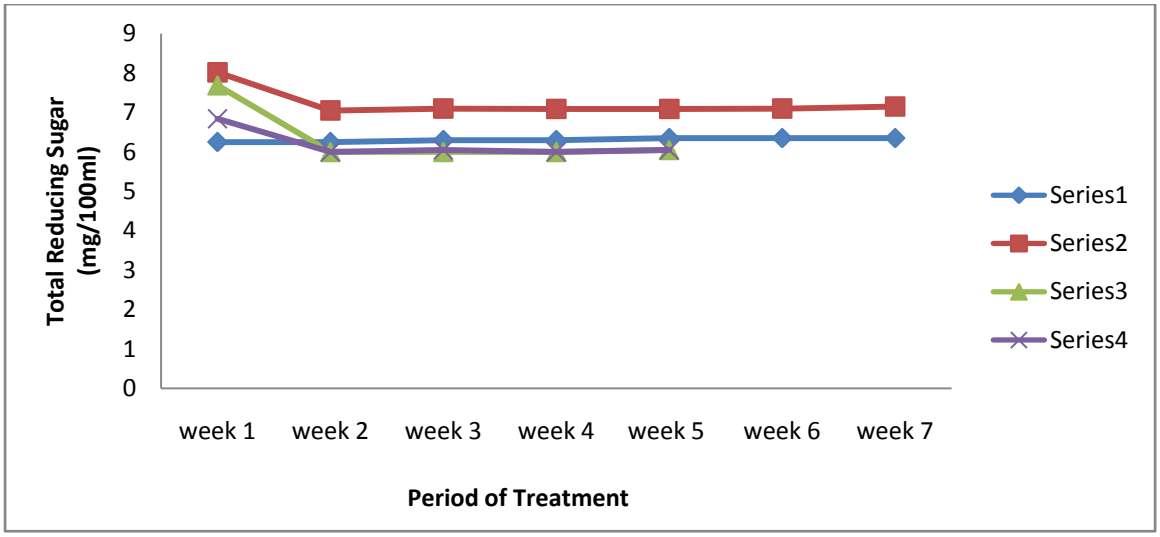

Figure 3: Total reducing sugar of herb treated oranges stored in (mg/100ml) Cooler over seven weeks.

Ash Content

Ash content (%) of the herb treated oranges stored in evaporative cooler is shown Figure 4.

A significant increase in ash content was recorded in all the four treatments. A high Ash content implies that there is a high quantity of inorganic compounds. The increase was however not significant (P≤0.05). The increase might be due to the release of minerals ions from the treated oranges because of the acidic nature. This is in agreement with Adekalu *et al.*, (2011) report, that, significant increase in P, K, Ca, Mg Fe, and Na were observed in banana mineral analyses. All the four herbs/ spices used are known good sources of Vitamins C, A, E, K and B. They are also good sources of inorganic minerals like calcium, iron, manganese, magnesium, copper, phosphorus, selenium and other phyto-nutrients (Dharini *et al.*, (2014); Anonymous, 2004). Since time immemorial, they have been recognised in almost all cultures for their medicinal, culinary properties, anti-fungal and anti-bacterial application.

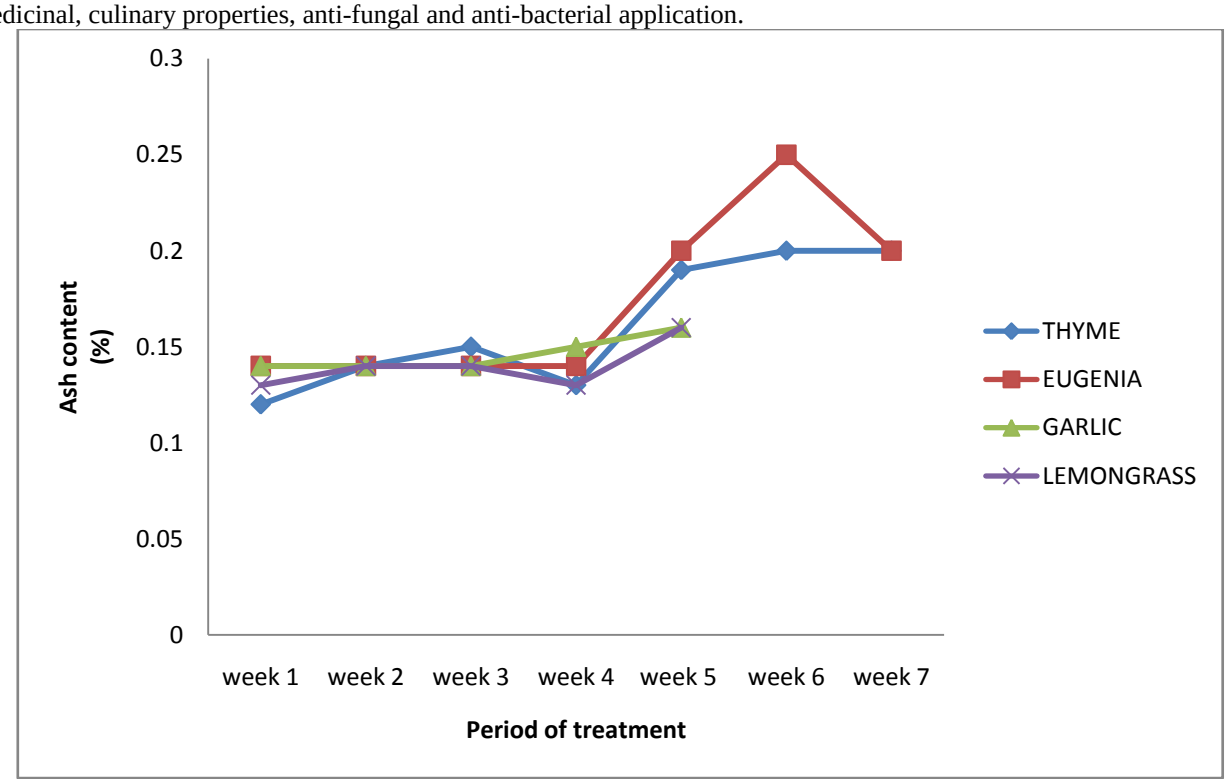

Figure 4: Ash Content (%) of Herb Treated Oranges Stored in evaporative Coolers A over seven weeks

Vitamin C content

A steady increase in Vitamin C was reported in Eugenia, garlic and lemon grass extracts treatments while a decrease in Vitamin C content was observed in thyme extract treatment as shown in figure 5. Untreated oranges which serve as control stored for only a week and recorded an increase in Vitamin C content.

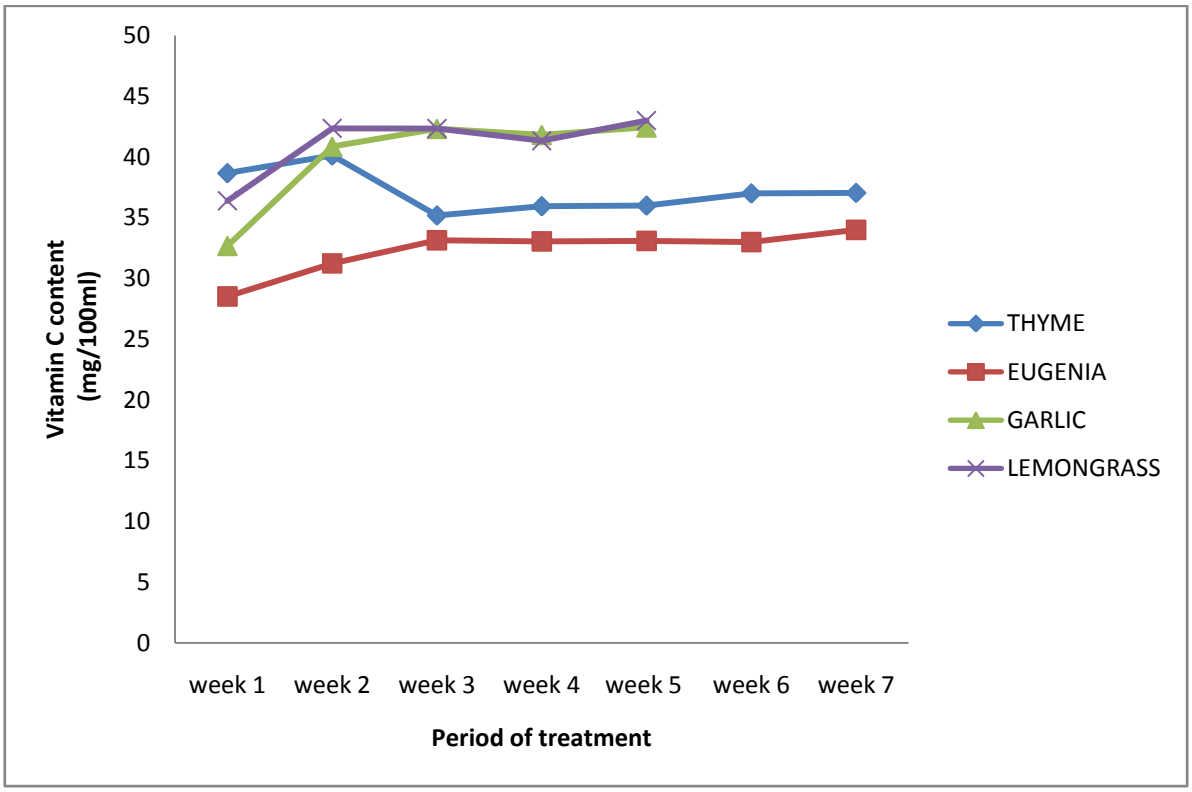

Figure 5: Vitamin C content of herb treated oranges stored in evaporative cooler over a seven weeks period.

Vitamin C is an unstable substance and is readily decomposed by inappropriate storage conditions such as light, heat, presence of water and diseases. The L-ascorbic acid (AA) is the main active form of Vitamin C and it is irreversibly oxidized due to biological activity (Aranha *et al.*, 2000). The treated oranges were still marketable and edible at the end of the trials. The chemical parameters were still acceptable unlike the result of Afolabi (2009) and Rana *et al*., (1992).

Prevention of pathogenic and spoilage microorganism in fruits and crop produce are usually achieved by using chemical preservatives but they are responsible for many carcinogenic and tetratogenic attributes as well as residual toxicity, and with growing concern of microorganism such as *Penicillium digitatum* and *P. italicum* resistance toward conventional preservatives (Nychas, 1995). Moreover, fungicide residues present on the fruit surface pose serious threat to consumers and environment. This has prompted the development of non hazardous approaches. Natural preservatives which either reduce or eliminate toxic pack house effluents while still maintaining pathogen control be extremely valuable. At present the application of chemical agents remains the primary method of choice for the management of post harvest diseases. The strategies adopted here, usually take the form of pre and /or postharvest sprays dip or drench treatments and fumigation. Pathogenic resistance to commonly use fungicides has become major issue. Integration of waxes and fungicides are popular in developed countries (Triparthi *et al*., 2008). Some vegetarians and other individuals are hesitant in patronizing green groceries where waxed fruits are sold. They are sceptical about consuming such vegetables for fear of ingesting chemical residues (Onwuzulu *et al.*, 1992.). Few research studies have been done in wax treatment/ coating in Nigeria the technology was not adopted by local farmers. Personal communication with NSPRI Extension staff (2008), reported that, vegetables farmers use banned Methyl bromide Trade name Gammalin since it controls Cocoa diseases. This has led to the innovative alternative measures ("Green alternative") to control post harvest diseases. Use of herbs/spices provides a more friendly and consumer acceptable substitute for synthetic fungicides (Mari *et al.*, 2010). Plants produce an array of secondary metabolites which in many cases have been found to be biologically active and a rich source of antimicrobial, alleoparthic, antioxidants and bio-regulatory properties (Tripathi *et al*., 2008)

Some research scientists have reported the use of essential oils extracted from some spices namely garlic, cinnamon, thyme, Eugenia and lemongrass (Solgi and Ghorbanpour, 2014; Obagwu and Korsten, 2003; Sivakumar and Baustistan, 2014; Tajkarimi, 2010; Panhwar, 2006). Temperature management/control is the main postharvest factor required for

maintaining concentration of Vitamin C synthesised from sugars supplied through photosynthesis. The tin in pot cooler temperature was cooler than ambient. The zero energy coolers cooling effect also extended the shelf life of the herb treated oranges. The herbs/ spices are available, extend shelf life and lower cost which can lead to less waste, more profit for the farmers, marketers and lower prices for consumers. Shelf life of all the treatments was between five and seven weeks. This result is in agreement with Babarinsa and Nwangwa 1988; Aror (1992), they reported that oranges stored for between five and seven weeks in evaporative coolers. The pre-storage treatments, use of herbs, spices/ botanicals did not markedly alter the nutritional attributes but rather appeared promising as it has a preservative property. Fundamental function of food crop is to provide our bodies with energy in form of calories, nutrients like protein, vitamins, minerals and dietary fibre which are more important in maintaining health. Tens and even hundreds of chemicals compounds contribute to the aroma and flavour of fresh squeezed oranges (Shewlft, 2009).
This research is a breakthrough and information of value addition which can improve to post-harvest handling and storage of sweet oranges. Botanicals could therefore have advantages over synthetic fungicides as cost effective and environmentally sustainable alternative in treating, preserving or protecting fruits. This research breakthrough is a great achievement for available local and cost effective treatments for reduction of post-harvest losses and extension of shelf life of sweet oranges.

4. CONCLUSION

The findings of this study are breakthrough which in no small measure lead to reduction of post-harvest losses of *Citrus sinensis* (Osberk). The use of simple zero energy cost methods such as evaporative coolers for either small marketers or growers of *C. sinensis*, is vital for loss reduction in fruits preservation. The fruits and vegetables sector have a vital role in farm income enhancement, poverty alleviation, food security and sustainable agriculture especially in developing countries. The postharvest losses of sweet oranges will reduce if the four investigated pre storage treatments (thyme, eugenia, garlic and lemon grass extracts) are utilized.

5. RECOMMENDATIONS

Recommendations include the following: Use of 15% or1500pm botanical/spice extract. These are cost effective and available. Zero energy cost chamber to be subsidized by the government. Considerable research and training will be required to reduce the high levels of post-harvest losses in fruits and vegetables.

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