Full Length Research Article

Storage Studies of Avocado in Low-Cost Cool Chambers

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ABSTRACT

Avocado (*Persea americana*) is a climacteric fruit. During its storage, high temperatures accelerate postharvest changes, reduce shelf life and increase postharvest losses. Three low cost zero energy cool chambers (ZECC) prepared by using bricks, gunny bags and bamboo mat were used to evaluate the shelf life and storage changes of avocado fruit. It was observed that the average storage temperature in all the three chambers was 6.1 °C less than the ambient temperature, whereas the average relative humidity (RH) of cool chambers ranged from 91.8 % to 93.3% as against 60.29 % RH in ambient storage. Avocado stored well for 12 to 13 days in the cool chambers, whereas under ambient conditions fruit was unmarketable on the 7th day of storage. Statistically significant physiological weight loss (PWL) was recorded under all storage conditions; however, maximum loss was observed at ambient temperature. Harvested avocado had 0.117 % acidity and 7.8^{0} Brix total soluble solids (TSS). During storage both acidity and TSS decreased significantly. However, sugar percentage increased significantly during storage. The pH ranged from 6.01 to 6.58 during storage. Based on the present results it is concluded that under high temperatures and low RH atmospheric conditions, the low-cost cool chambers can best be used for extending shelf life of avocados.

Keywords: Avocado, Bamboo mat, Bricks, Cool Chambers, Gunny bag

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1. INTRODUCTION

Avocado (*Persea americana*) is a highly nutritious fruit known for its health benefits. The fruit is grown in tropical and Mediterranean climates all over the world. Africa contributes about 9% towards world avocado production and the major African avocado producing countries are South Africa, Kenya, Morocco and Zimbabwe (FAO, 2017). In Ethiopia avocado was introduced in Hirna and Wondo Genet by a private orchardist in 1938 (Ettisa, 1999). Due to favorable agro-climatic conditions the cultivation gradually spread to other parts of the country. The annual production of avocado in Ethiopia for the year 2018 was 52389 MT (FAO, 2020). Being a climacteric fruit, its ripening continues even after harvest. The fruit is highly perishable and as such retention of its quality till its final destination is a major concern. Avocado cannot be stored for a long time at ambient storage temperatures as the post-harvest deterioration takes place at a faster rate at high temperatures. Besides the financial losses, the post-harvest losses cause huge nutritional loss and also reduce availability of the fruit. In a country like Ethiopia where a significant percentage of population suffers from nutritional deficiency, the huge post-harvest loss of such nutritionally important fruit is most unwanted.

When avocado reaches the physiological maturation or harvesting stage, it contains almost 80% of water. Being a climacteric fruit, it has high rate of respiration and releases carbon dioxide and ethylene. Thus, after harvest, the live tissues degrade at a high rate and irreversible internal changes take place. These changes are accelerated by high storage temperatures. The post-harvest wastage of fruits and vegetables in some African countries is as high as 30-80% (Kitinoja *et al*., 2010). Avocado being a perishable fruit can suffer greater losses than non-perishable produce. Any physical injury on avocado results in faster fruit deterioration at high ambient temperatures. Reducing storage temperatures and increasing relative humidity (RH) to a desirable level is one of the techniques to extend storage life of the fruit. This principle is also adopted in developing commercial storage infrastructures like cold stores. In developed countries cold stores and controlled atmospheric stores are commercially used for storage of fruits and vegetables. However, such infrastructures need heavy capital investment and the common farmers in developing countries like Ethiopia cannot afford such huge financial investments. Alternate cheap technologies for reducing storage temperatures and increasing relative humidity have been developed and evaluated earlier (Roy,1989; Shah and Girma, 2020) and the results have been encouraging. Zero energy cool chambers have been introduced as low-cost storage chambers. These chambers work on the principle of evaporative cooling and attain lower temperatures and higher relative humidity, thus help in extending shelf life of produce. The Zero Energy Cool Chamber constructed by using bricks (Roy,1989) is one of the storage chambers that have been popularized in some parts of India. Research conducted in Africa (Ambuko, 2017) has also shown success of such chambers for extending shelf life of leafy vegetables. However, in a country like Ethiopia bricks in some avocado producing areas are not available or they are very costly and cannot be affordable by common farmers. Recently Shah and Girma (2020) have reported feasibility of bamboo mat and gunny bags as an alternate option to bricks for construction of Evaporative cool chambers. These construction materials are affordable for common farmers. The present research was conducted to assess feasibility of such chambers for storage of avocado and compare the storage changes and shelf life with the produce stored at ambient storage and Zero Energy Cool Chambers constructed with bricks.

2. MATERIALS AND METHODS

2.1 Experimental site

The research was conducted in the College of Agricultural Sciences, Arba Minch University, Arba Minch, Ethiopia. The laboratory facilities of Chemistry Department, College of Natural Sciences, Arba Minch University were used for conducting analysis of the fruit.

2.2 Storage Chambers

Three storage chambers were developed from three different materials (bricks, bamboo mat and gunny bags) as developed by Shah and Girma (2020). Each chamber was constructed by double walled structures having a gap of 7.5 cms within two walls and had uniform dimensions of 165 cms length, 115 cms width and 70 cms height. The gap (7.5 cms) between the double walled structures of each chamber was filled with saturated moist sand. The sand was kept moist during storage studies of avocado, by sprinkling water on the sand two times daily. Bamboo poles of appropriate length and nails were used for erecting gunny bag and bamboo mat chambers. However, for erecting brick chamber no other material was used. A cover made of bamboo mat having gunny bags stitched on one side was used to cover each chamber so as to maintain temperature and relative humidity in the chambers. All the three chambers were covered under one shed to protect the chambers from rain and heat of sun. The shed was kept open from all sides to ensure free movement of air. Avocado fruit was stored for storage studies in the three chambers as constructed above and at ambient temperature in the laboratory of Horticulture Department, College of Agricultural Science, Arba Minch University.

2.3 Fruit Procurement

The avocado fruit of uniform maturity was procured from the orchard of main campus Arba Minch University, Arba Minch. The uniformity in the maturity was assessed by size, color and texture. The fruit was packed in plastic crates, before storing in the storage chambers and at ambient temperature.

2.4 Storage

The fruit was divided into four uniform lots and stored in four different storage conditions. The four storage conditions used for the studies comprised of three cool chambers (cool chamber made of bricks, cool chamber made of gunny bags and cool chamber made of bamboo mat) and an ambient storage (laboratory).

2.5 Quality Analysis Interval

The fruit was analyzed for various parameters immediately after harvest. This was marked as initial analysis of the fruit. Subsequently, the fruit was analyzed after every three days intervals, till the fruit lost its marketability. Once the fruit turned unmarketable, it was discarded and no further analysis was conducted for such fruit.

2.6 Assessing Marketability of Fruit

The stored avocado fruit was continuously assessed for its marketability during storage. This assessment was based on visual inspection of fruits and the considerations for marketable and unmarketable attributes included freeness from any visible defects like fungal growth, too soft texture, off flavor, decayed pulp and excessive fruit shrinkage. Based on such quality observations the fruit was categorized as marketable or unmarketable.

2.7 Temperature and Relative Humidity

During storage studies wet and dry bulb temperatures were recorded three times a day with an interval of about 3 to 4 hours. Zeal Wet and Dry Bulb Hygrometer (Mason's Type) was used for recording the temperatures. On the basis of these recorded temperatures the daily relative humidity was also recorded from the Table provided for the purpose with the said Hygrometer. Thus, the temperature as well as RH was recorded thrice every day and average daily temperature and relative humidity was worked out from the three observations. On the basis of daily temperatures and relative humidity an average temperature and relative humidity was worked out for the storage period for all storage conditions.

2.8 Physiological Weight Loss

The physiological weight loss (PWL) of stored fruit was measured after every three days intervals till the fruit lost its marketability or spoiled. An electronic balance (ConTECH Model CT 15005 having capacity of 15 Kgs) was used for weighing. The physiological loss in weight (%) was calculated by using formula.

$$\text{PWL, \%} = \frac{\textit{Initial weight} - \textit{weight at the end of storage interval}}{\text{Initial weight}} \times 100$$

2.9 Chemical Analysis

Total soluble solids (TSS) were measured using Abbe refractometer. Acidity (as citric acid), pH and sugars were estimated as per the procedures documented in AOAC (2005).

2.10 Statistical Analysis

Significance tests were conducted using variance analysis for the complete random design (CRD) with SAS 9.1.3 software. Mean values obtained from statistical analysis were used for presenting data. Duncan's Multiple Range Test (Duncan,1955) was also used to compare treatment means. P-values of less than 0.05 was considered significant.

3. RESULTS AND DISCUSSIONS

During fourteen (14) days storage studies, the ambient storage temperatures ranged from 26.3 °C to 31.5 °C, whereas the temperature in the cool chambers ranged from 22 °C to 25.6 °C. As reflected in

Figure 1, the average mean temperatures of all the three cool chambers were 23.4 °C as against average mean temperature of 29.5 °C of ambient storage (control). Thus, a temperature difference of 6.1 °C existed, between ambient storage and cool chambers. The statistical analysis yielded a P-value of < 0.0001 at 5 % level of significance. The lower temperatures in cool chambers can be attributed to evaporative cooling effect of the water. During evaporation water draws energy from its surroundings, which results in a cooling effect. Once air with less humidity passes over wet surface, the water from the surface evaporates and the evaporative cooling takes place. A temperature difference of 1 to 10 °C between cool chamber and ambient storage has also been reported earlier by Ambuko *et al.* (2017). Temperatures in the range of 23.4 to 25.0 °Cwere recorded by Mishra *et al*. (2020) in zero energy cool chambers (ZECC), whereas the corresponding temperatures at ambient storage were 29.31-31.5 °C.

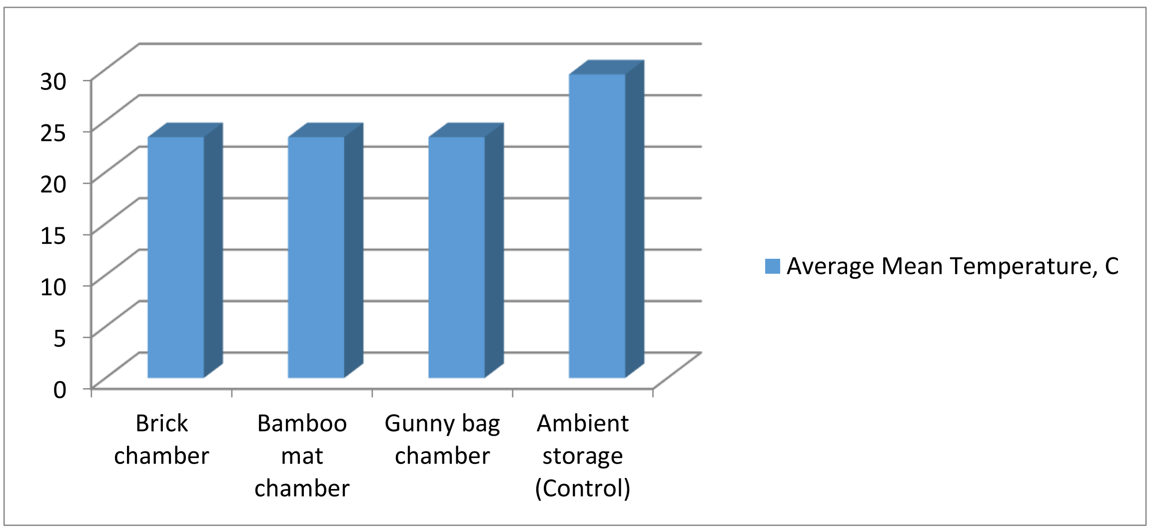

Figure 1: Average mean temperature of different storage chambers

The relative humidity (RH) in cool chambers ranged from 74.3 to 100 % as against 52 to75.7 % in ambient storage (Control). As depicted in Figure 2 the average means relative humidity (RH) for Bricks chamber, Gunny bag chamber and Bamboo mat chamber was 91.8%, 92.8% and 93.3%, respectively whereas the corresponding values of RH for ambient storage was 60.29 %.

Thus, RH in cool chambers was over 1.5 times more than the ambient storage RH. Earlier researchers (Dipran *et al*., 2017; Shah and Girma, 2020) have also reported higher relative humidity in different cool chambers compared to ambient storage conditions.

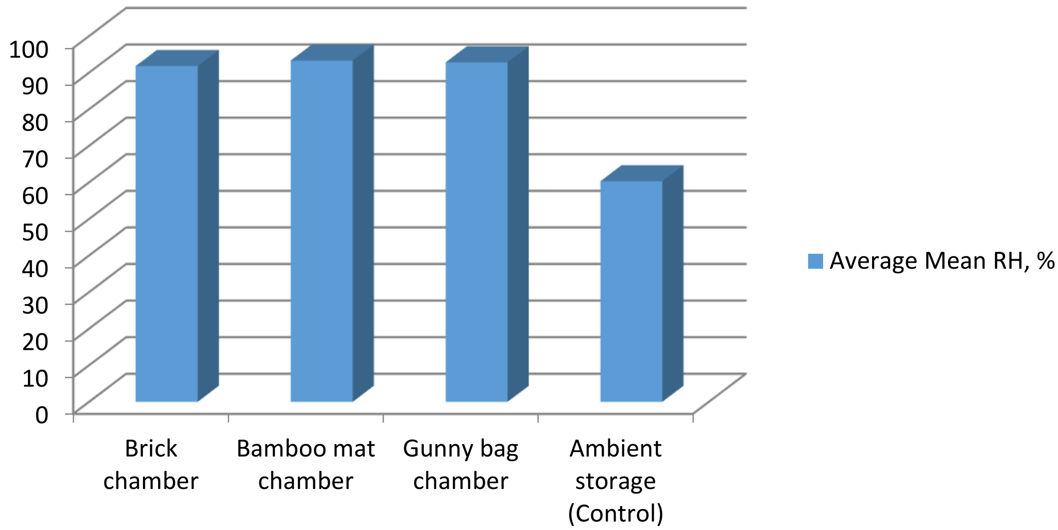

Figure 2: Average relative humidity (RH) of different storage chambers

Avocado stored under ambient conditions lost its marketable attributes on the 7th day of storage and thus the fruit was discarded. No further storage analysis could be conducted for fruit stored at ambient temperatures beyond six (6) days. However, the temperature and RH of the ambient store was continued to be recorded till storage of fruit in Cool chambers. The fruit in Brick cool chamber and Gunny bag cool chamber lost its marketability on the 13th day of storage, whereas avocado stored in Bamboo mat turned unmarketable on 14th day. No storage analysis of stored avocado was conducted after 12 days of storage. The major indicators of spoilage included excessive shrinkage (mostly under ambient storage), decayed pulp, too soft texture and such other reasons.

Table 1: Physiological weight loss, percentage (PWL, %) of Avocado during storage

Storage chamber	Storage period, Day			
	3	6	9	12
	PWL, %	PWL, %	PWL, %	PWL, %
Brick cool chamber	3.430[l]	7.590[i]	12.010[g]	13.100[e]
Bamboo mat cool chamber	4.330[k]	9.880[h]	11.920[g]	13.600[d]
Gunny bag cool chamber	6.040[j]	12.500[f]	15.200[c]	16.900[b]
Ambient storage (Control)	9.830[h]	20.550[a]	--	--

[A,b,c,d,e,f,g,h]Mean values within the same row and/or column followed by the same letter superscripts are not significantly different

Physiological weight loss (PWL) was observed in avocado under all storage conditions, the maximum loss was recorded in ambient storage. Table 1 presents the PWL (%) in avocado and it is noticed that highest loss of 20.55 % was observed just within six days storage at ambient storage temperatures and the corresponding losses for the fruit stored in cool chambers ranged from 7.59 to 12.50%. The PWL of 16.90%, 13.60% and 13.1% was recorded in the fruit stored in Gunny bag chamber, Bamboo mat chamber and Brick chamber respectively on 12th day of storage. The PWL during storage of fruits has also been reported by earlier researchers (Dipran *et al*., 2017; Pila *et al*., 2010). Sundaram (2016) reported PWL of 17.75 to 35.12 % in vegetables at ambient storage as against 10.13 to 15.28% in Zero Energy Cool Chambers.

Avocado stored in different cool chambers and at ambient storage was continuously evaluated for its suitability for marketing. Fruit stored at ambient temperature turned unmarketable on the 7th day of storage, whereas fruit stored in Brick chamber and gunny bag chamber turned unmarketable on the 13th day and the fruit stored in Bamboo mat chamber turned unmarketable on 14th day of storage. Longer storage life in cool chambers can be attributed to lower chamber temperatures and higher relative humidity. Since under ambient conditions the temperatures were higher and relative humidity was low compared to cool chambers so the shelf life was half than those of cool chambers. According to Sun and Zheng (2006) shelf life of fresh produce can be doubled by reducing storage temperatures from 10 to 5 °C. In the present study a temperature difference of 6.1°C was observed and the shelf life increased from 6 days to 12-13 days. The fresh avocado had acidity of 0.117% after harvest. However, the acidity during storage decreased under all storage conditions as reflected in Table 2.

Table 2: Effect of Cool Chambers and Storage Period on Acidity (% age)

Treatment	**Storage period, Days**				
	0	**3**	**6**	**9**	**12**
	Mean, acidity%	**Mean, acidity%**	**Mean, acidity%**	**Mean, acidity%**	**Mean, acidity%**
Brick cool chamber	0.117[a]	0.075[ef]	0.076[ef]	0.076ef	0.076[def]
Bamboo mat cool chamber	0.117[a]	0.071[gh]	0.073[fg]	0.080[bcd]	0.083[b]
Gunny bag cool chamber	0.117[a]	0.081[bc]	0.080[bcd]	0.075[ef]	0.068[h]
Ambient storage (Control)	0.117[a]	0.078[cde]	0.076[ef]	--	--

[a,b,c,d,e,f,g,h]*Mean values within the same row and/or column followed by the same letter superscripts are not significantly different*

Kelbessa (2019) reported that the titratable acidity of avocado fruits during storage ranged from 0.13% to 0.086%. He observed decrease in titratable acidity with increase in storage time. Srinivasa et al. (2002) suggested that the decrease in acidity could be attributed to their utilization in the metabolic process of the fruit. Decrease in acidity of other fruits like papaya during storage has also been reported by the Vyas *et al*. (2014). The pH value of 6.58 was observed in fresh avocado pulp. As presented in Table 3 the pH values ranged between 6.01- 6.58 during storage. Similar results have been reported by Kelbessa (2019) who observed that pH of avocado ranged between 5.5 to 6.7during storage of avocados treated with bee wax and Aloe Vera gel and stored in cool chambers.

Table: 3 Effect of Storage Chambers and Storage Period on pH

Treatment	Storage period, Days 0 Mean, pH	3 Mean, pH	6 Mean, pH	9 Mean, pH	12 Mean, pH
Brick cool chamber	6.580^{a}	6.180^{efgh}	6.290^{cdef}	6.460^{abc}	6.573^{a}
Bamboo mat cool chamber	6.580^{a}	6.230^{defg}	6.310^{bcde}	6.400^{abcd}	6.483^{ab}
Gunny bag cool chamber	6.580^{a}	6.010^{h}	6.090^{gh}	6.186^{efgh}	6.236^{defg}
Ambient storage (Control)	6.580^{a}	6.110^{fgh}	6.300^{cde}	--	--

[a,b,c,d,e,f,g,h]Mean values within the same row and/or column followed by the same letter superscripts are not significantly different

Avocado had total soluble solids (TSS) of 7.8^{0} Brix at the time of harvesting. During storage there was a decline in TSS, though in bamboo mat cool chamber and at ambient storage the TSS initially increased but subsequently it also decreased. Simple sugars and acids are the respiration substrates and as such the longer the time of fruit respiration, the higher consumption of sugars and acids takes place (Tefera, et al., 2008). This may be the reason for the decrease in the total soluble solid content of the fruit during storage. Dirpan *et al*. (2018) observed similar results during storage studies of mango fruit in cool chambers. As presented in Table 4, TSS decreased from initial values of 7.8^{0} B to 5.9^{0}B in Gunny bag cool chamber on 12th day of storage, whereas in Bricks cool chamber and Bamboo mat cool chamber the corresponding values were 6.166^{0} B and 6.7^{0} B, respectively. Earlier researchers (Vinha *et al*., 2013) reported a TSS of 6.68±1.02 in avocado pulp. The present findings fall almost within the range reported by the researchers.

Table 4: Effect of storage chambers and storage period on total soluble solids (^{0}Brix)

Treatment	Storage period, Days				
	0	**3**	**6**	**9**	**12**
	Mean, TSS^{0}B	**Mean, TSS^{0}B**	**Mean, TSS^{0}B**	**Mean, TSS^{0}B**	**Mean, TSS^{0}B**
Brick cool chamber	7.800^c	7.400^d	7.000^{ef}	6.500^h	6.166^i
Bamboo mat cool chamber	7.800^c	8.000^b	7.100^e	6.933^f	6.700^g
Gunny bag cool chamber	7.800^c	7.500^d	7.000^{ef}	6.500^h	5.900^j
Ambient (Control)	7.800^c	9.500^a	7.000^{ef}	--	--

^{a,b,c,d,e,f}Mean values within the same row and/or column followed by the same letter superscripts are not significantly different

Sugar percentage of 0.735 was recorded in freshly harvested avocados (Table 5). Haas avocados are reported to contain 0.3 % sugars only as reported by Dreher and Davenport (2013). As is observed in Table 5, the sugar percentage increased under all the storage conditions, however, in brick cool chamber the sugar percentage decreased beyond 9th day of storage. Dirpan *et al.* (2018) observed increase in sugar content during storage studies of mango and opined that increase in sugar is caused by the degradation of starch into the simple sugar that increases sugar content of fruit during storage. Increase in sugar content during storage of apples has also been reported by some researchers (Ali, 2004).

Table 5: Effect of Storage Chambers and Storage Period on Sugar (%age) of Avocado

Treatment	Storage period, Days				
	0	**3**	**6**	**9**	**12**
	Mean, sugar%	**Mean, sugar%**	**Mean, sugar%**	**Mean, sugar%**	**Mean, sugar%**
Brick cool chamber	0.735^{e}	0.903^{b}	0.910^{b}	0.750^{e}	0.535^{h}
Bamboo mat cool chamber	0.735^{e}	0.810^{c}	0.821^{c}	0.810^{c}	0.810^{c}
Gunny bag cool chamber	0.735^{e}	0.575^{g}	0.603^{f}	0.780^{d}	0.937^{a}
Ambient storage (Control)	0.735^{e}	0.942^{a}	0.903^{b}	--	--

[a,b,c,d,e,f,g]Mean values within the same row and/or column followed by the same letter superscripts are not significantly different

4. CONCLUSIONS

Avocado is a highly perishable fruit. Besides many factors, high storage temperatures accelerate post-harvest changes and reduce its marketable attributes. Since there are no cold storages in the production areas in developing countries, there is a need to explore alternate low-cost technologies for maintaining fruit quality during storage. Low-cost cool chambers constructed with bamboo mat, gunny bags and bricks have yielded encouraging results in reducing storage temperatures by about 6.1°C and in turn have significantly contributed in minimizing storage changes and retaining better marketability percentage of stored fruits. Thus, the present findings revealed that low-cost cool chambers could be successfully used for extending shelf life of fruits like avocado in such areas where ambient temperatures are high and relative humidity of the environment is low. Farmers can use such chambers as farm storages. Besides minimizing post-harvest losses, such infrastructures can help them to have longer time for better negotiations with potential buyers/traders that can result in better financial gains for the farmers.

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Conflict of Interests

The researchers confirm that there is no conflict of interests.

REFERENCES

Ali M A, Raza H, Khan M A, Hussain M (2004). Effects of different periods of ambient storage on chemical composition of apple fruit. *International Journal of Agriculture and Biology:* 1560-8530/2004/06-3-568-571; http://www.ijab.0rg

Ambuko J, Wanjiru F, Chemining‟wa G N, Owino W O, Mwachoni E (2017). Preservation of postharvest quality of leafy Amranth (Amaranthus spp.) vegetables using evaporative cooling. *Hindawi Journal of Food Quality volume* 2017, https://doi.org/10.1155/2017/5303156

AOAC (2005). Official methods of analysis of AOAC International. 18thedition.Association of Official Analytical Chemists International, Maryland 20877-2417 USA.

Dipran A, Sapsal M T, Muhammad A K, Tahir M M, Rahimuddin (2017). Evaluation of temperature and relative humidity on two types of zero energy cool chamber (ZECC) in South Sulawesi, Indonesia. IOP Con. Series: *Earth and Environmental Science*, 14(6):26-33.

Dirpan A, Sapsal M T, Syarifuddin A, Tahir M M, Ali K N Y, Muhammad A K (2018). Quality and Storability of Mango during Zero Energy Cool Chamber (ZECC). *International Journal of Agriculture System*, 6 (2):119-129.

Dreher M L, Davenport A J (2013). Haas avocado composition and potential health effects. *Crit Rev Food Sci Nutr*., 53(7): 738–750.

Duncan D B (1955). New Multiple Range and Multiple F-tests. *Biometrics,* 11: 1-42

FAO (2017). Committee on Commodity Problem. Tropical Fruits Fifth Session. Tropical Fruits Compendium http://www.fao.org/docrep/meeting/022/am481t.pdf

FAO (2020). List of countries by avocado production, from Wikipedia the free encyclopedia. Data for 2018 from "Food and Agriculture Organization Corporate Statistical Database" Retrieved 2020-02-07 en.wikipedia.org/wiki/List_of_countries_by_avocado_production

Kelbessa A G (2019). Physiochemical properties and shelf-life evaluation of avocado fruit (Persea americana) as influenced by storage condition, storage duration and edible coatings. M.Sc.

thesis submitted to Arba Minch University for award of M.Sc. Post-harvest Management during 2019.

Kitinoja L, AlHassan H A, Saran S, Roy S K (2010). Identification of appropriate post-harvest technologies for improving market access and income for small horticultural farmers in Sub-Saharan Africa and South Asia. Invited papers in three parts of the IHC Postharvest Symposium Lisbon, August 23, 2010 (Cited in Wileyonlinelibrary.com DOI 10.1002/ jsfa.4295; January 2011)

Mishra A, Jha S K, Ojha P (2020). Study on Zero Energy Cool Chamber (ZECC) for storage of vegetables. *International Journal of Scientific and Research Publications*, 10 (1): 427-433.

Pila N, Gol N B, Rao T V R (2010). Effect of post-harvest treatments on physicochemical characteristics and shelf life of tomato (Lycopersicon esculentum Mill.) fruits during storage. *American-Eurasian J. Agric. and Environ. Sci*., 9 (5): 470-479.

Roy S K (1989). A low-cost cool chamber: an innovative technology for developing countries (Tropical fruits storage), Johnson GI, (Commonwealth Scientific and Industrial Research Organisation, St Lucia (Australia). Division of Horticulture), Editor. Postharvest handling of tropical fruits. Canberra, A.C.T., *Australia: Australian Centre for International Agricultural Research,* 15(4): 393–5.

Shah G H, Girma G (2020). Developing and Evaluating Low-Cost Storage Chambers for Horticultural Crops. Journal of Environmental Science, Toxicology and Food technology, Volume 14 (6) pp26-33 www.iosrjournals.org

Srinivasa P, Baskaran C R, Ramesh M N, Prashantand K V H, Tharanthan R N (2002). Storage studies of mango packed using biodegradable chitosan film. *Europe Food Research Technology*, 215:504–508.

Sun W, Zheng L (2006). Vacuum cooling technology for the agri-food industry: Past, present and future. *Food engineering*, 77:203- 214

Sundaram, V (2016) Studies on storability of vegetables in zero energy cool chamber. *Agric. Sci. Digest*: 36(3):244-246.

Tefera A, Seyoum T, Woldetsadik K (2008). Effects of disinfection, packaging and evaporatively cooled storage on sugar content of mango. *Journal of Biotechnology*, 7(1): 065–072.

Vinha A F, Moreiral J, Barreira SVP (2013). Physicochemical Parameters, Phytochemical Composition and Antioxidant Activity of the Algarvian Avocado (Persea americana Mill.). *Journal of Agricultural Science*, 5(12): 100-109.

Vyas P B, Gol, N B, Rao T V R (2014). Post-harvest quality maintenance of papaya fruit by using polysaccharide based edible coatings. *International Journal of Fruit Sciences*, 14(1): 81–94.