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Chemical Composition of Mango (*Mangifera Indica* L) Fruit as Influence by Postharvest Treatments in Arba Minch, Southern Ethiopia

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Abstract: *Mango is one of the important fruit in the tropical and subtropical regions. The experiment was carried out to investigate effect of storage condition, packaging material and storage period on chemical composition of mango fruits. The experimental treatments were two types of storage conditions namely ambient temperature and pusa zero energy cool chamber, two types of packaging materials namely plastic and wooden crates and five levels of storage period namely 0, 3, 6, 9 & 12 days that arranged in Complete Randomized Design (CRD) with three replications. The data obtained was analyzed by using SAS (version 9.1) statistical procedure and means were compared by using Duncan's Multiple Range Test (DMRT). The fruits were analyzed for their proximate composition, titratable acidity and total soluble solids. The highest moisture content (97.26% in wet wt), crude fiber (0.72%), ash content (1.76%), carbohydrate content (95.36%) and energy content (384.56 Kcal) were observed in mango fruits that stored at cool chamber whereas the least results were obtained in mango fruits that stored at ambient temperature for different storage periods. Moreover, the highest crude fat (0.93%), crude protein (0.59 %), titratable acidity (1.55%), total soluble solid (13.33 brix^o) and pH (5.17) were observed in mango fruits that stored at ambient temperature while the least results were obtained in mango fruits that stored at cool chamber. It can be concluded that increase in storage period increases the chemical compositions in stored mango fruits. However, increase in storage period decreased fruits acidity, TSS, protein and fat at both storage conditions. Besides, Pusa zero energy cool chamber was exhibited better chemical composition of the stored mango fruits than that of mango stored at room temperature. Further studies are required on assessment of postharvest factors that causes postharvest loss of mango fruit at postharvest chain.*

Keywords*: Chemical composition, mango fruit, packaging material and storage condition*

I. Background and Justification

1.1 Background of the Study

Mango (*Mangifera indica* L.) is one of the important fruit in the tropical and subtropical regions. It is a good source of nutrients, particularly vitamins A and C and dietary fibre (Pal,1998). Flavour, volatiles, texture, chemical constituents and appearance of flesh colour are the key components that contribute to a high quality fresh mango and in the acceptance of the fruit by the consumer.

The world production of mango was 31.7 million tons in 2009 and was estimated to be 34.4 million tons in 2010 [1]. Total fruit production in Ethiopia is about 500 thousand tones. Fruits have significant importance with a potential for domestic and export markets and industrial processing in Ethiopia. The main fruits produced and exported are banana, citrus fruits, mango, avocado, papaya and grape fruits (Zeberga, 2010). 'In Ethiopia mango is produced mainly in-west and east of Oromia, SNNPR, Benishangul and Amhara [2]. Mango production in Ethiopia is in fluctuated conditions, because of occurrence of diseases, lack of proper management and also weather conditions [3]. More than 47 thousand hectares of land is under fruit crops in Ethiopia. Mangoes contributed about 12.61% of the area allocated for fruit production and took up 12.78% of fruit production in comparison to other fruits growing in the country and the annual consumption of mango by the processing plant at full production capacity is 8.6 tones which is only 1.8% of the current production of mango [4]. However, less than 2% of the produce is exported [5]. But, according to CSA (2013) cropping season mangoes contributed about 14.21% of the area of land allocated for fruit production and holds 14.55% of quintals of fruits produced in the country [6]. Mango is the largest produced tropical fruit next to Banana in Gamo Gofa Zone in Southern Ethiopia. Production of mango at Arba Minch Zuria Woreda, which is one the Woredas in Gamo Gofa zone is 126,800qt and total area coverage is 634 ha [7].

Most of the horticultural crops including fruits and vegetables begin to deteriorate shortly after harvest. Refrigerated cool storage is considered to be the best method of storing fruits and vegetables. However, this method

is not only highly energy intensive but also involves huge capital investment which is not affordable for small scale farmers. The present trend in the world is to develop a simple low cost cooling system for storage of fruits and vegetables. In order to overcome the problem of on farm storage, low cost and environment friendly Pusa Zero Energy Cool Chambers have been developed. The greatest importance of this low cost cooling technology lies in the fact that it does not require any electricity or power to operate and all the materials required to make the cool chamber are available locally, easily and cheaply. Even an unskilled person can install it at any site, as it does not require any specialized skill. Most of the raw materials used in cool chamber are also re-us sable. The cool chamber can reduce the temperature by 10-15^0 C of ambient temperature and maintain high relative humidity of above 90% throughout the year that can increase the shelf life and retain the quality of fresh horticultural produces.

Mango being a highly perishable fruit possesses a very short shelf life and reach to respiration peak of ripening process on 3rd or 4th day after harvesting at ambient temperature [8]. The shelf life of mango varies among its varieties depending on storage conditions. It ranges from 4 to 8 days at room temperature and 2-3 weeks in cold storage at 13ºC [9]. This short period seriously limits the long distance commercial transport of this fruit [10]. Usually after harvesting, the ripening process in mature green mango takes 9-12 days [11]. Due to improper handling, inadequate storage, lack of packaging and lack of harvest technical knowledge, producers and traders faced about 20 to 30% losses [14]. Spoilage of mango due to end rot and anthracnose limit its storage potential and the shelf life is decided on the bases of spoilage (10%) during storage. The loss of water from fruit is due to skin evaporation (transpiration) and to some extent respiration. When the fruit looses weight, shriveling will occur and the appearances will deteriorate thus reducing its postharvest quality [8]. Even though the country is experiencing such a huge loss of fruit, very little emphasis has been given to post-harvest handling of perishable produces. Therefore, the main objective of the present study was to investigate the influence of postharvest treatments on chemical composition of mango fruits.

II. Research Methodology

2.1. Experimental Site

The experiment was conducted at Arba Minch University/ AMU/ Department of Chemistry and Horticulture Laboratories in 2014/15. Pusa zero-energy cool chamber was constructed at AMU Kulfo Campus. Arba Minch University found in Arba Minch town which is geographically located at 6° 2' N latitude and 37° 33' E longitude, far about 500 km from Addis Ababa, the capital city of Ethiopia and at an altitude of about 1200 m.a.s.l. Its annual average temperature and annual rainfall is 29°C and 900 mm, respectively.

2.2. Experimental Materials

Green matured but unripe good quality mango fruits of the same size were purchased from *Lante 'Kebele'* local farm near Arba Minch town and brought to the laboratory of Horticulture Department College of Agricultural Sciences, Arba Minch University. The mango fruits were washed with cold tape water in order to remove field heat and dried with muslin cloth. The fruits were stored at ambient average temperature (29°C with 70% RH) and in pusa zero cool chambers (18°C with 90% RH) to determine their proximate composition, titratable acidity and total soluble solid.

2.3. Experimental Design and Treatments

The trial was laid out in completely randomized design (CRD) with three replications in factorial experimental combinations (Table 1). The treatments were two types of storage condition (ambient temperature and pusa zero energy cool chamber), two types of packaging materials (plastic and wooden crates) and five different storage periods (0, 3, 6, 9 &12 days).

Table 1. Experimental layout

Factors (postharvest treatments)				
[1]Storage periods (days)	[2]Pusa zero energy cool chamber		[2]Room temperature (RT)	
	[3]Wooden crate	[3]Plastic crate	[3]Wooden crate	[3]Plastic crate
0	Cc*Wb@0	Cc*Pb@0	RT*Wb@0	RT*Pb@0
3	Cc*Wb@3	Cc*Pb@3	RT*Wb@3	RT*Pb@3
6	Cc*Wb@6	Cc*Pb@6	RT*Wb@6	RT*Pb@6
9	Cc*Wb@9	Cc*Pb@9	RT*Wb@9	RT*Pb@9
12	Cc*Wb@12	Cc*Pb@12	RT*Wb@12	RT*Pb@12

Where: PC; Plastic Crate and WC; Wooden crate, Cc; Pusa Zero Energy Cool Chamber, three Factors of Postharvest Treatments such as [1]Storage Periods, [2] Storage Conditions and [3] Packaging Materials

2.4. Construction of Pusa Zero Energy Cool Chamber (PZECC)

Construction of pusa zero-energy cool chamber followed the standard set as per [15]. A rectangle shape floor measuring 200 ×150 cm was made with bricks. Over this, a double wall was erected to a height of 100 cm leaving a gap of 7.5 cm between the double walls. The walls were drenched with water. Wet fine river sand was filled in the 7.5 cm gap between walls. A bamboo frame (200 ×150 cm) was made to cover the chamber. A thatched shed was constructed over the chamber in order to protect it from direct sun or rain. During the experimental period, the sand between the walls, bricks and top cover of the chamber were kept moist with varied quantities of water through drip system with plastic pipes and micro tubes connected to an overhead water source. The stored mango fruits were evaluated every three days' intervals.

Figure 1. Pusa Zero Energy Cool Chamber (Picture)

2.5. Data Collection

Chemical composition laboratory analysis of all parameters was conducted at Chemistry lab, Arba Minch University. The data of proximate compositions, titratable acidity and total soluble solid of mango fruits were determined. During experiment two mango fruit were taken randomly from each treatment within an interval of 3 days for 12 days of storage period at room temperature and Pusa zero energy cool chamber (PZECC). The procedure of all parameters was described in detail as follows: -

2.5.1. Chemical Composition of Mango Fruit

Moisture Content

The moisture content was determined according to AOAC method [16]. The sample was taken in a flat-bottom dish (pre-weighed); keep overnight in an oven at 100 to 110°C and weighed. The loss in weight was regarded as a measure of moisture content, and was calculated by the following formula:

$$\text{Moisture}\,(\%) = \frac{\text{weight of fresh sample} - \text{weight of dry sample}}{\text{weight of fresh sample}} \times 100$$

Ash Content

For the determination of ash content, method of AOAC [16] was followed. According to the method, 10 g of each sample was weighed in a silica crucible. The crucible was heated in a muffle furnace for about 4 to 5 hours at 525°C. It was cooled in desiccators and weighed. To ensure completion of ashing, it was reheated again in the furnace for half an hour more, cooled and weighed. This was repeated consequently till the weight became constant (ash became white or grayish white). Weight of ash give the ash content and was calculated by the following formula.

$$\text{Ash}\,(\%) = \frac{\text{weight of after ashing}}{\text{weight of fresh sample taken}} \times 100$$

Crude Fat Content

Crude fat was determined by Mojonnier tube AOAC method [16]. The fat content was determined gravimetrically after extraction with diethyl ether ($C_4H_{10}O$) (ethoxyethane) and petroleum ether (C_6H_{14}) from an ammonia alcoholic solution of the sample. About 10 g of sample was taken into a Mojonnier tube, and then 1 ml of 0.880 ammonia with 10 ml ethanol (C_2H_5OH) was added, mixed well and cooled. Next, 25 ml diethyl ether was added, then the tube was stoppered and shaken vigorously, after which 25 ml petroleum ether was added and the tube was left to be stand for 1 hr. The extraction was repeated three times using a mixture of 5 ml ethanol, 25 ml diethyl ether and 25 ml petroleum ether also added the extraction to the distillation flask. Distilled off the solvents, dried the flask for 1 hr at 100°C and reweighed. The percentage fat content of the sample was calculated by the following formula which give the difference in the weight of the original flask and the flask plus extracted fat represent the weight of fat present in the original sample.

$$\text{Fat content}\,(\%) = \frac{W2 - W1}{W3} \times 100$$

Where*:* W1 is the weight of empty flask (g); W2 represent the weight of flask + fat (g) and W3 is the weight of sample taken (g).

Crude Fiber Content

The crude fiber content fruit sample was analyzed as described in AOAC method [16] No 32-10. About 2g sample was transferred to 600 ml beaker. After digestion with 1.25 % sulfuric acid it was washed with distilled water and then digested by 1.25 % sodium hydroxide. It was then filtered in coarse porosity 75-76 µm crucible in an apparatus at a vacuum of about 25 mm. The residue left after refluxing was washed again with 1.25% sulfuric acid near boiling point. This residue was then dried at 110 ^{0}C for one hour, cooled in desiccators (Nalgene Model 5317-0120) and then it was weighed (W_1). After ashing at 550*°C,* it was cooled in desiccators (Nalgene Model 5317-0120) and weight again (W_2). The total crude fiber was expressed in percentage as follows:

$$\text{Crude Fiber}\,(\%) = \frac{W1 - W2}{W3} \times 100$$

Where: W_s is the weight of sample, W_1 is the dried sample and W_2 is the dried ashed sample.

Crude Protein (N X 6.25)

Total nitrogen of the mango fruit sample was determined by micro-Kjeldahi method according to AOAC method [16] No. 925-09 using Automatic digestion and distillation systems (Model UDK-142, Europe). Protein nitrogen was transformed to ammonium sulfate by hot digestion of the dry sample with concentrated sulfuric acid in the presence of a catalyst, (1 g of mixture (Na_2SO_4) mixed with anhydrous $CuSO_4$ in 10:1). Ammonia was liberated from the sulfate by distillation in the presence of sodium hydroxide (40%) and driven into a known volume of boric acid solution. From the ammonium borate formed the amount of ammonium ion attached to borate was titrated with standardized about 0.1 M HCL. The percent of protein was estimated from percent of nitrogen as follows:

$$\text{Nitrogen}\,(\%) = \frac{V_{HCL}\ \text{in L} \times N_{HCL}\,(\text{ca.}0.1) \times 14}{\text{sample weight on drymatter basis}} \times 100$$

Where: V is volume of HCL in liter consumed to the end point of titration, N is the normality of HCL used (often 0.1N) and 14.00 is the molecular weight of nitrogen. The percent of nitrogen is converted to percent of protein by using appropriate conversion factor (% Protein = % N x 6.25). Urea was used as control in the analysis.

Carbohydrate

Carbohydrate content of mango fruit sample was determined by subtracting the above proximate composition values from 100 using the following formula:

$$C(\%) = 100 - (\%M + \%A + \%F + \%FB + \%P)$$

Where: C (%), % M, % P, % F, % Fb and % A are percentage of carbohydrate, moisture content, protein, fat, fiber and ash content respectively.

Energy Value in Kilocalorie

Energy was calculated as described by Osborne and Voogt using the Atwater factors [17]: 1g of carbohydrates (C) provides (4 kcal), 1g of protein (P) provides (4 kcal) and 1g fat (F) provides (9 kcal).

$$\text{Energy (kcal/100g)} = [9 \times \text{fat (\%)} + 4 \times \text{carbohydrate (\%)} + 4 \times \text{protein (\%)}]$$

Total Soluble Solids (TSS)

The total soluble solids (TSS) levels of the fruit were determined according to AOAC method [18] by using hand refractometer. An appropriate quantity of sample of each product was placed on the prism-plate of the refractometer and the reading appearing on the screen was directly recorded as total soluble solids. Results were expressed in Brix^{o}.

pH Value

The pH of mango fruit juice was recorded according Anonymous [19] method No. 981. 12b by using digital pH meter (Model: Knick 646). The pH meter was standardized with the help of a standard buffer solution prior to measurement.

Titratable Acidity (TA)

The mango juice was titrated with 0.1M NaOH and the results are expressed in terms of percentage citric acid. It was calculated by following [20] formula:

$$\text{TA}(\%) = \frac{\text{Nb} \times \text{Vb} \times \text{Ea} \times \text{d.f.} \times 100}{\text{Vs}}$$

Where: Nb = normality of the base, Vb = volume of the base, Ea= mill equivalent weight of citric acid, VS= volume of sample, d. f. = dilution factor.

2.6. Statistical Analysis

Significance tests were made by using analysis of variance (ANOVA) for complete randomized design with factorial arrangement according to [21]. ANOVA was carried out by using SAS (version 9.1) statistical procedure. Comparisons of the treatment means were done using Duncan's multiple range tests at $p \leq 0.01$.

III. Results and Discussions

3.1. Moisture Contents

Moisture content data were showed statistically highly significant ($P<0.01$) difference among treatments (Table 2&3). The results indicated that the highest moisture content of 97.26 and 97.22% (wet basis) was recorded in mango fruits stored in wooden and plastic crate at cool chamber for 12 days, respectively, whereas the lowest moisture content (85.85) was observed in plastic crate for 6 days. Samples at room temperature showed low moisture content 80.80% stored in plastic crates for 3 days. The moisture content variations in stored mango fruits may be due to difference in storage conditions. At high temperature the moisture content of the mango samples greatly reduced. This hypothesis was verified by [22] that reported storage temperature affects the moisture content of fruits during storage.

3.2. Crude Fat and Ash

There was a significant difference observed for crude fat among the treatments. Initial values of fat content in mango samples were 0.93 %. However, during storage, fat contents decreased gradually and reached (0.24%) in mango fruits stored in wooden crate at cool chamber for 12 days. The low content of fat may be enhanced the storage life of the food products due to the lowered chance of rancid flavor development. The observation was supported by [23] who reported slight changes in proximate chemical composition such as protein and crude fats during storage.

There was no considerable significant different in ash content of mango fruits among all treatments at both open air and cool chamber. At the initial stage, the ash content in mango sample were 0.16% and this remained the same even after 9 days' storage at both storage conditions. Hence, it is stated that there was not a considerable increase or decrease in ash content. Ash is the inorganic residue remaining after the water and organic matter and could not be decreased during storage [24].

3.3. Crude Protein and Fiber

Significant difference (P<0.01) was noted in crude protein content of dried pulp of mango fruits among treatments (Table 2&3). The highest crude protein (0.58 & 0.59%) were observed for mango fruits stored in plastic and wooden crates at room temperature for 3 & 0 days respectively, whereas the least crude protein (0.08%) was recorded for fruits stored in wooden crate at cool chamber for 12 days. A decrease in protein content observed during storage is in agreement with the findings made in several fruits by [10]. Tressel *et al* (1975) also reported an increase in the amounts of some proteins and enzymes [25]. Described a dramatic increase in protein, reflecting the enzyme required for storage [26]. Conversely, there was no considerable effect on crude fiber content of fruit among all treatments (Table 2&3).

3.4. Carbohydrate and Energy

The interaction effect of storage condition, packaging material and storage duration demonstrated highly significant (p<0.01) differences regarding total carbohydrate and metabolic energy (Table 2&3). The highest carbohydrate (95.36 %) was determined in wooden and plastics crates stored mango fruit at cool chamber for 12 days. The minimum carbohydrate (77.90 %) was observed for fruit stored in plastic crate at ambient temperature for 3 days. Results indicated that sugars in stored fruits could be increased during storage; however, increase of sugars may be rapid at high temperature than low temperature. Mango fruits were showed slightly significant among treatments for energy. The results indicate that the highest metabolic energy of 384.14 Kcal was recorded in mango fruit stored in plastic crate at cool chamber for 12 days followed by mango fruit of 383.94 Kcal stored in wooden crate at cool chamber for same days; whereas fruits under room temperature showed low metabolic energy content of 320.27 Kcal during storage in plastic crate for 3 days.

Table 2. Effect of room temperature, packaging material and storage period on proximate composition of mango fruit

Treatments	Moisture %	Fiber %	Protein %	Ash %	Fat %	CHO (%)	Energy (kcal)
RT*Pb@0	84.67±2.34^{ab}	0.29±0.19^{a}	0.42±0.08^{ab}	1.14±0.17^{a}	0.72±0.01^{d}	82.11±2.56^{ab}	336.55±10.08^{ab}
RT*Pb@3	80.80±2.99^{b}	0.31±0.05^{a}	0.58±0.27^{a}	1.30±0.35^{a}	0.70±0.00^{d}	77.90±3.24^{b}	320.27±13.40^{b}
RT*Pb@6	81.12±3.43^{b}	0.29±0.06^{a}	0.31±0.01^{bc}	1.32±0.39^{a}	0.375±0.01^{e}	78.44±3.73^{b}	321.81±14.94^{b}
RT*Pb@9	84.04±3.39^{ab}	0.26±0.12^{a}	0.15±0.02^{c}	1.18±0.26^{a}	0.89±0.03^{b}	81.58±3.18^{ab}	334.89±12.95^{ab}
RT*Wb@0	87.33±0.77^{a}	0.19±0.01^{a}	0.59±0.09^{a}	1.07±0.04^{a}	0.71±0.01^{d}	84.78±0.76^{a}	347.82±2.98^{a}
RT*Wb@3	84.92±0.39^{ab}	0.23±0.15^{a}	0.48±0.13^{ab}	1.46±0.23^{a}	0.70±0.00^{d}	82.04±0.53^{ab}	336.40±2.62^{ab}
RT*Wb@6	86.09±1.14^{ab}	0.25±0.02^{a}	0.42±0.07^{ab}	1.43±0.14^{a}	0.75±0.01^{c}	83.23±1.06^{a}	341.39±4.00^{a}
RT*Wb@9	86.50±0.35^{a}	0.24±0.05^{a}	0.15±0.03^{c}	1.32±0.28^{a}	0.93±0.03^{a}	83.87±0.58^{a}	344.39±2.33^{a}
Mean	84.43±2.95	0.26±0.09	0.39±0.19	1.28±0.25	0.77±0.09	81.74±3.04	335.44±12.30
CV (%)	2.64	38.84	30.26	20.03	2.13	2.85	2.81

Mean within the same column with different alphabet are significantly (p<0.01) different. RT: Room Temperature *: interaction effects, Pb: plastic crate box, Wb: wooden crate box, @: at storage periods (0-12 days) and CV: Coefficient Variance

Table 3. Effect of cool chamber, packaging material and storage period on proximate composition of mango fruit

Treatments	Moisture %	Fiber%	Protein%	Fat%	Ash%	CHO (%)	Energy (kcal)
PZECC*Pb@0	87.92±4.07^{b}	0.72±0.10^{a}	0.52±0.09^{a}	0.48±0.05^{ab}	1.55±0.24^{ab}	84.65±4.28^{b}	344.97±17.47^{b}
PZECC*Pb@3	86.67±2.08^{b}	0.56±0.16^{ab}	0.49±0.10^{a}	0.58±0.01^{ab}	1.31±0.26^{ab}	83.73±1.91^{b}	342.09±7.97^{b}
PZECC*Pb@6	85.85±0.55^{b}	0.48±0.08^{b}	0.33±0.03^{ab}	0.61±0.01^{a}	1.53±0.10^{ab}	82.90±0.69^{b}	338.42±2.74^{b}
PZECC*Pb@9	88.97±1.68^{b}	0.45±0.02^{b}	0.22±0.03^{bc}	0.72±0.02^{a}	1.35±0.15^{ab}	86.23±1.50^{b}	352.28±6.21^{b}
PZECC*Pb@12	97.22±4.81^{a}	0.22±0.28^{c}	0.15±0.13^{bc}	0.47±0.41^{ab}	1.55±0.30^{ab}	94.83±5.62^{a}	384.14±20.44^{a}
PZECC*Wb@0	86.25±1.23^{b}	0.53±0.03^{ab}	0.50±0.16^{a}	0.47±0.06^{ab}	1.42±0.31^{ab}	83.33±0.97^{b}	339.56±4.11^{b}
PZECC*Wb@3	86.26±1.14^{b}	0.54±0.03^{ab}	0.50±0.14^{a}	0.58±0.01^{ab}	1.01±0.44^{b}	83.64±1.12^{b}	341.72±4.95^{b}
PZECC*Wb@6	87.22±2.88^{b}	0.49±0.04^{b}	0.48±0.05^{a}	0.59±0.03^{ab}	1.19±0.33^{b}	84.47±3.07^{b}	345.13±12.26^{b}
PZECC*Wb@9	88.80±0.68^{b}	0.49±0.08^{b}	0.23±0.02^{bc}	0.72±0.01^{a}	1.76±0.33^{a}	85.60±0.55^{b}	349.78±2.30^{b}
PZECC*Wb@12	97.26±4.75^{a}	0.06±0.10^{c}	0.08±0.14^{c}	0.24±0.42^{ab}	1.52±0.15^{ab}	95.36±5.35^{a}	383.94±17.08^{a}
Mean	89.24±4.82	0.45±0.20	0.35±0.18	0.55±0.21	1.42±0.31	86.47±5.18	352.20±19.24
CV (%)	3.19	25.96	29.33	34.13	19.78	3.60	3.26

Mean within the same column with different alphabet are significantly (p<0.01) different. PZECC: Pussa Zero Energy Cool Chamber, *: interaction effects, Pb: plastic crate box, Wb: wooden crate box, @: at storage periods (0-12 days) and CV: Coefficient Variance

3.5. Total Soluble Solids

The interaction effect of storage condition, packaging material and storage period on total soluble solids of mango fruits was highly significant (P<0.05) (Figure 2&3). The highest total soluble solids (13.33%) were determined in mango stored under room temperature for6 days, followed by mango (2.33 %) stored in plastic crate at cool chamber for 12 days. The total soluble solids of mango fruit decreased gradually with increasing the storage periods. These results revealed that time and temperature are equally responsible for physicochemical changes of fruits and the major changes occur when fruits are stored for long time at high temperature. For instance, [27] reported that seven hybrid varieties of green mature mangoes underwent a series of physicochemical changes and major changes were observed in TSS (19.0%) when stored at 18 to 34°C.

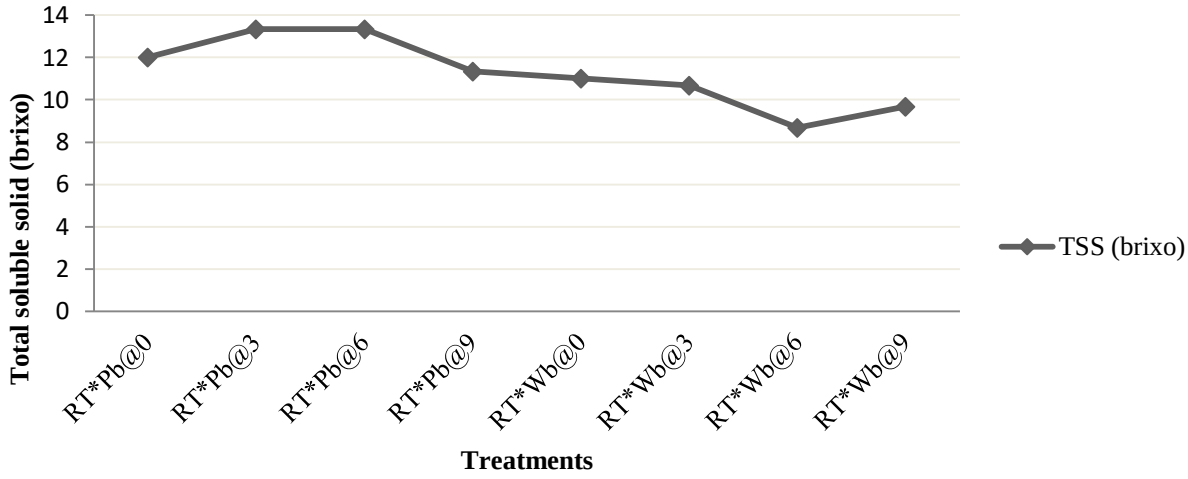

Figure 2. Effect of ambient temperature, packaging material and storage period on titratable acidity and total soluble solid of mango fruit. Mean within the same column with different alphabet are significantly (p<0.01) different. RT: Room Temperature, *: interaction effects, Pb: plastic box, Wb: wooden box, @: at storage periods (0-12 days)

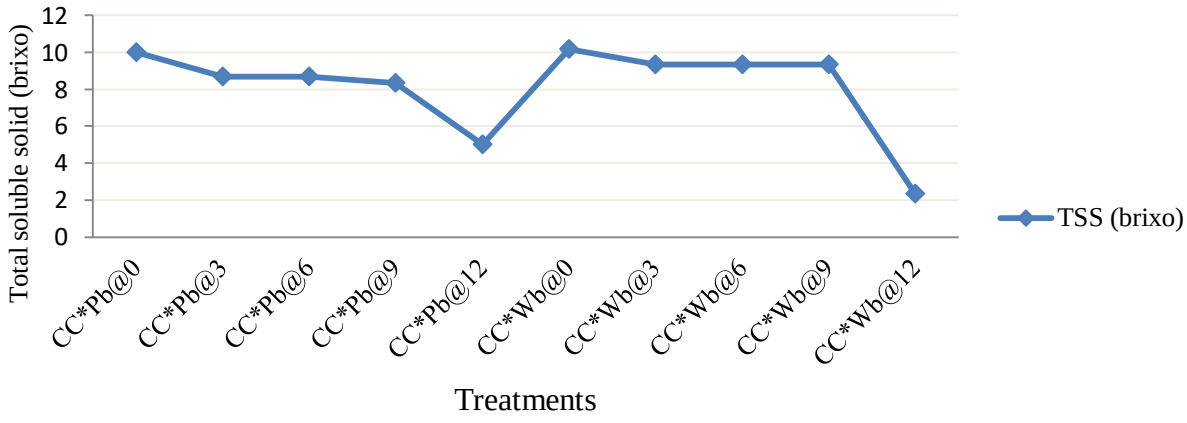

Figure 3. Effect of cool chamber, packaging material and storage time on titratable acidity and total soluble solid of mango fruit. Mean within the same column with different alphabet are significantly (p<0.01) different. CC: Cool Chamber, *: interaction effects, Pb: plastic box, Wb: wooden box, @: at storage periods (0-12 days)

3.6. pH and Titratable Acidity (%)

The interaction effect of storage condition, packaging material and storage period on of pH and titratable acidity (%) of mango fruits was significant (P<0.01) (Figures 4&5). The highest titratable acidity (1.55 %) was observed in mango juices that stored in plastic crate at ambient temperature during 3rd storage days, followed by

samples that stored in wooden crate at cool chamber for 12 days with 0.09 %. Conversely, the highest mean value of pH (5.24) was obtained for mango juice that stored in plastic crate at open air for 9th days whereas the least (1.60) was recorded for samples that stored in wooden crate at cool chamber for 12 days. pH increased and the titratable acidity of mango juice decreased along with increased storage time in both storage conditions. The results of this study further indicated that increasing time and temperature decrease the acidity in stored mangoes. The increase in pH may be due to the breakup of acids with respiration during storage [28] and the higher levels of titratable acidity in the fruits that stored at cool chamber, may be due to protective O_2 barrier or reduction of O_2 supply to the fruit surface which inhibited respiration rate [29]. The acidity of the fruit is an important character to determine its quality and acceptability.

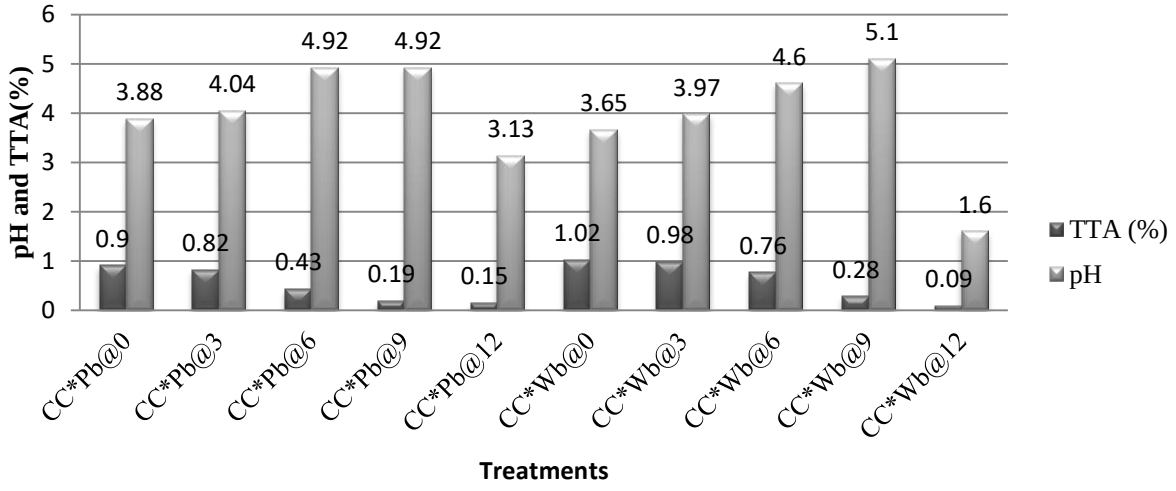

Figure 4. Effect of cool chamber, packaging material and storage time on titratable acidity and total soluble solid of mango fruit. Mean within the same column with different alphabet are significantly ($p<0.01$) different. CC: Cool Chamber, *: interaction effects, Pb: plastic box, Wb: wooden box, @: at storage periods (0-12 days)

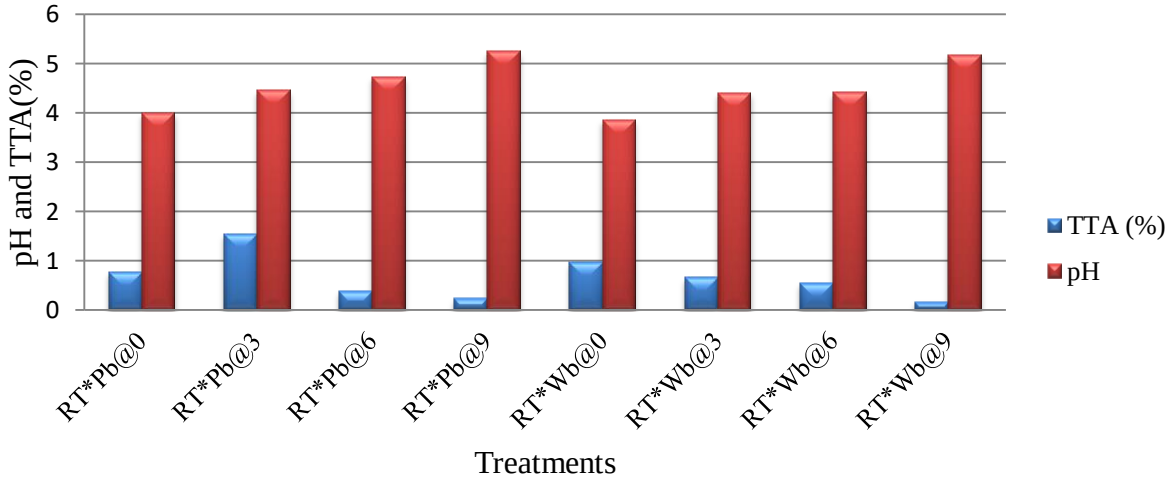

Figure 5. Effect of room temperature, packaging material and storage time on titratable acidity and total soluble solid of mango fruit. Mean within the same column with different alphabet are significantly ($p<0.01$) different. RT: Room Temperature, *: interaction effects, Pb: plastic box, Wb: wooden box, @: at storage periods (0-12 days).

IV. Conclusions and Recommendation

In conclusion, chemical composition of mango fruit as influenced by storage condition, packaging material and storage period were analyzed. To this end, the cool chamber was exhibited the best quality when compare to mango fruit that stored in open air. Accordingly, the highest moisture (97.26% in wet weight), crude fiber (0.72%), ash (1.76%), carbohydrate (95.36%) and energy content (384.56 Kcal) were observed in mango fruits that stored at cool chamber whereas the least results were obtained in fruits that stored at room temperature for different storage periods. However, the highest crude fat (0.93%), crude protein (0.59 %), titratable acidity (1.55%), total soluble solid (13.33 brix^{o}) and pH (5.17) were observed in mango fruits that stored at room temperature whereas the least results were obtained for fruits that stored at cool chamber for various storage period. Thus, minimizing post-harvest losses and increasing consumer's acceptability by maintaining quality parameters for long storage duration. of mango fruits. It can be concluded that cool chamber + plastic crate +storage period up to 12 days were most suitable combination for mango fruits to achieve of better quality and improved post-harvest quality whereas the mango fruit that stored under open air was stayed safely for about four days under Arba Minch condition. Further studies are required on assessment of postharvest factors that causes postharvest loss of mango fruit at postharvest chains.

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