

## Packaging Material Affects Quality Attributes and Ripening Period of Avocado (*Persea americana*) Fruit

Tigist Nardos and Tolawak Wakgari

Jimma University College of Agriculture and Veterinary Medicine, P. O. Box 307, Jimma Ethiopia

**Abstract:** The quality of avocados is comprised of a number of physical, chemical and sensory characteristics that change at each stage of the maturation process. The outstanding compositional feature is the high fat content, which varies significantly between different cultivars. Shelf life is defined as the period in which a product should maintain a predetermined level of quality under specified storage conditions. The objective of this study was to determine the effect of different packaging materials on ripening period and quality attributes of avocado fruit. The study was conducted from October 2015 to December 2015. A randomized complete design was employed with three replications to arrange the experimental units in the lab. The packaging materials were Poly sheet, carton with poly sheet, wooden box with straw, sack and open air as a control. Local avocado variety was obtained from Ela Dal farm, southwest of Ethiopia to be used in the experiment. The results showed that avocado fruits in stored in poly sheet and carton with poly sheet low percentage weight loss, less firmness loss and highest TSS, TA, Acid to Sugar ratio, pH, Self life, ripening period value, storage temperature, relative humidity, pulp weight and dry weight. Even though poly sheet and carton with poly sheet packaging materials took longer period for ripening. These packaging materials were best storage material to Producers, traders or consumers may use the technology in order to get good quality avocado fruit at the end of ripening period.

**Key words:** Avocado • Packaging materials • Quality • Ripening period • Shelf life

### INTRODUCTION

The avocado (*Persea americana*) is a fruit with a high nutritive value and an unusual composition. The outstanding compositional feature is the high fat content, which varies significantly between different cultivars. Shelf life is defined as the period in which a product should maintain a predetermined level of quality under specified storage conditions [1]. Avocado is highly perishable compared to other produce. While fruit are often stored for 4 weeks, it is a challenge to commercially store fruit for 6 weeks with a relatively short storage life. Low temperature storage is utilized to extend its shelf life, but it induces chilling injury (CI) symptoms, expressed as pulp browning, as well as external damage [2].

When avocado reaches the physiological maturation point (harvest point), it contains almost 80% of water. It is a climacteric fruit with high respiration rates and releases carbon dioxide and ethylene. This means that after harvest, the live tissues degrade at a high rate,

together with accelerated internal and irreversible changes. Avocado can dehydrate at the relatively high environmental temperatures and the mechanical injuries during handling will stimulate higher and faster fruit decay. Sometimes, physiological disorders in the post-harvest stage are originated in nutritional imbalances of the trees. Orchards should have a balanced nutrition and the fruit should be handled carefully, in order to increase post-harvest life and preserve quality [3].

Ethylene has the potential to induce over ripening accelerate quality loss and increase susceptibility to pathogens during storage of fresh commodities [4]. The effect of ethylene on avocados can be identified as flesh softening, color change and development of distinct aromas [4, 5]. Ethylene formation in avocados have thus appeared to be independent of high temperatures, while at 40°C this process seems to be inhibited [6].

The quality of avocados is comprised of a number of physical, chemical and sensory characteristics that change at each stage of the maturation process.

The physical quality parameters which are of concern to customers are the texture of the avocado and appearance which is essentially the color and presence of defects [7].

The chemical quality parameters are also of importance as these are closely related to both the physical and sensory appeal of the avocado. Some of the chemical parameters include pH, Total Soluble Solids (TSS) Titratable Acid (TA), moisture content, oil content and dry matter content. The degree of change of these parameters depends on the harvest time, maturity, cultivar and storage conditions [7]. Avocados continue respiring after harvest, which initiates the ripening process almost immediately due to their climacteric characteristic of high respiration rates. The duration of complete avocado ripening can take five to seven days at 25°C [8].

Texture can be quantified as the resistance to an applied force experienced by the produce [7] and is a significant indicator of avocado quality and of concern to the consumer [7, 9]. Avocados undergo drastic changes in texture [9, 10]. According to Chen *et al.* [11] and Hofman *et al.* [12] the oil content is a key component in the texture of avocados and which identified as contributing to the smoothness.

Storage temperature, oxygen and carbon dioxide concentrations and wounding directly affect the texture [7]. Identification of horticultural maturity is often difficult to determine in avocados as changes in external appearance are sometimes not easily distinguishable [13]. Therefore other maturity determination techniques (chemical properties) are required. The chemical properties of avocados discussed within this section are titratable acid, dry matter content and total soluble solids. Acidity is associated with both sweetness and sourness of fruit. According to Maftoonazad and Ramaswamy [7] both pectin-based coated and non-coated avocados, an increase in the titratable acidity was more apparent at higher storage temperatures.

An extended maturation stage of avocados allows for more oil accumulation and dry matter content, however, the risk of increased disease is introduced. Maturity standards are being used by avocado producing countries to avoid marketing of low quality immature fruit. The standards adopted are the Californian minimum dry matter of 20.8% for 'Hass' or a slightly higher minimum dry matter content of approximately 25% to decrease disorders during storage [14]. An oil content of 8% has been reported by Ozdemir and Topuz [15] to be acceptable for marketing of avocados. Villa-Rodriguez *et al.* [8] found that the dry matter had increased from 31.65% to 36.52% over eight days at 15 °C and thereafter decreased to

32.91% on day 12. Hofman *et al.* [12] stated that the percent oil content and dry matter are not suitable indicators of avocado maturity in late-harvested 'Hass' due to inconsistent changes later in harvested fruit. No distinct relation could be found between the effect of varying temperature and relative humidity on the percent dry matter and oil content of avocados during storage [12].

In Ethiopia modern packagings as well as ripening facilities are almost non-existing; it is imperative to make investigation that can easily be affordable to the local avocado grower. Therefore, it is timely to determine the magnitude of variation in quality attributes and ripening periods of avocado fruits stored at different packaging materials. Furthermore, consumers would also be able to choose the quality they need based on the physical characteristics of the fruits. These physical characteristics of the fruits depend on the packaging materials that used to ripening. Therefore, the objectives of the study was to determine the effect of different packaging materials on ripening period and quality attributes of avocado fruit.

## MATERIALS AND METHODS

**Study Area:** The study was conducted in post harvest physiology laboratories of Jimma University College of Agriculture and Veterinary Medicine.

**Experimental Material and Treatments:** A non-damaged and fresh Avocado fruits were collected from Ela Dal farm and used as a test material. Twelve avocado fruits were used per treatment for both non-destructive and destructive measurements. Five types of packaging materials (Poly sheet, carton with poly sheet, wooden box with straw, sack and open air) were used. The experiment was had five treatments (avocado stored in poly sheet, carton with poly sheet, wooden box with straw, sack and open air) with three replications in a completely randomized design (CRD) arrangement. During chemical analysis in the laboratory twelve measurements were made in order to see the variation on quality parameters among the treatments. Every data was taken within four day intervals.

### Parameters to be taken

**Firmness (g):** The firmness of the fruits was measured by using texture analyzer (TA.XT.plus). The firmness was determined by the maximum force exerted to compress the avocado fruit down to 5mm at 10mm/sec. speed from lowering the probe until it touches the avocado skin.

**Weight Loss of the Fruits:** The initial weight of the treated and a control fruit was taken before storing at different packaging materials. Then the weights of the fruits were recorded after storing at those packaging materials at four day interval. Hence, the sum of the weight loss was taken as the four days interval gives total weight loss, which was converted to percentage weight loss using the following formula:

$$\text{Percent weight loss} = \frac{\text{Initial weight of avocado (g)} - \text{weight after interval (g)}}{\text{Initial weight of avocado (g)}} \times 100$$

**Total soluble solids (TSS):** Avocado fruit juice was extracted using juice extractor and total soluble solid from extracted samples were determined by using a digital or a hand refractometer.

**Titrateable Acidity (TA):** The titrateable acidity of the fruits samples were determined by taking a certain amount of fruit juice and titrated with 0.1N NaOH solution to pH 8.1±0.05 and results were reported as percent citric acid.

**Sugar /Acidity Ratio (SAR):** To determine the sugar to acid ratio the sugar (TSS) concentration in °Brix was divided by percentage acid:

$$\text{The sugar acid ratio} = \frac{\text{°Brix value}}{\text{Percentage acid}}$$

**pH Value:** pH Value of avocado juice was measured by pH meter.

**Dry Mater Content:** Exocarp (peel) and seed part of the fruit was separated from mesocarp (fresh part) and the mesocarp was dried at 80°C for 24 hours until moisture became zero percent to get dry mater content of the fruit.

**Pulp (Fresh Part) Weight:** The weight of Mesocarp of the fruit was measured by using sensitive balance.

**Ripening Period:** The data on ripening period was taken in days from the day of packing to the day of ripening where more than 90-95% fruits ripened. Ripening period was judged on the basis of change of peel and when the total soluble solid (TSS) approaches the standard value.

**Temperature and Relative Humidity (RH):** The temperature and Relative humidity of the packaging material and the ripening room were recorded on daily basis using hygrometer during the whole experimental period and average values was used for analysis.

**Shelf Life:** Shelf life of the fruit was recorded in days at 30% spoilage level.

**Data Analysis:** All data were analyzed by using GenStat statistical package 14<sup>th</sup> Edition [16] Analysis of variance was used to determine variation among the treatments for the variables recorded.

## RESULTS AND DISCUSSION

**Firmness and Weight Loss of Avocado Fruits During Storage:** On average, the poly sheet and carton with poly sheet stored fruit (Fig.1A) did not soften sufficiently till day 12 compared with the fruits stored in wooden box with straw, sack and open air. However, the firmness of the control and fruit soared in different packaging materials was show more or less the same redaction at the day 16 (Fig.1A). The control fruit (stored in open air) was show more firmness redaction than the fruit stored in different packaging materials (Fig.1A).

During 16 days of experiment, fruits lost about 0.2% their initial weight (Fig.1B). The highest percentage of weight loss was observed in the fruits stored in open air than the fruits stored in the polysheet, carton with polysheet, wooden box with straw and sack (Fig.1B). Moreover, the fruit stored in polysheet and carton with polysheet was registered less weight loss than the other treatments (Fig.1B). Weight loss mainly consists of water loss through transpiration and carbon loss through gas exchange [17]. The probable reason for low percentage weight loss and less firmness loss exhibited in stored in polysheet and carton with poly sheet might be due to there was relatively lower air circulation into and out of the polysheet which resulted in higher relative humidity that in turn allowed in lower respiration rate. Slow respiration rate implies low energy exhaustion that which keeps the weight loss to the minimum and firmness to maximum [18].

**Total Soluble Solid (TSS), Titrateable Acidity (TA), Acid to Sugar Ratio and pH of Avocado Fruits During Storage:** In the present study, the TSS content of the avocado juice stored in different packaging materials varied significantly ( $P < 0.05$ ) (Table.1). According to Lu [19] TSS is an important quality factors for attributes for many fresh fruits because solids include the soluble sugars sucrose, glucose and fructose as well as acids. Increase of TSS in fruit probably due to the hydrolysis of starch to

soluble sugars such as glucose, sucrose and fructose [20]. During fruit ripening and softening process, starch is broken down to the simple soluble sugars and also the amount of soluble pectin will increase, leading to fruit softening [21].

The results for the TA experiments are shown in Table 1. Avocado juice TA of all the fruits stored over a period of 16 days, in different packaging materials showed significant ( $P \leq 0.05$ ) variation. Titratable Acidity (TA) decrease in total acidity and increase in total sugars and TSS during storage at room temperature was also reported recently by Policegoudra and Aradhya [22] in mangoes. It has been suggested that during storage, fruits utilize organic acids for metabolic activities and this results in a decrease in the TA content during the storage periods. Various organic acids have been reported in fruits and in the pomegranate; these include citric, malic, acetic, fumaric, tartaric and lactic acids although the main acid accounting for titratable acidity in fruits is citric acid [23]. They reported the decrease in acidity coincided with an increase in sugar concentration in the pomegranate fruits. Kulkarni and Aradhya [24] suggested that a slow decrease in acidity, concomitant with increased TSS and total sugar content, is an intrinsic process during ripening of fruits to impart the flavor.

As can be seen in Table 1 the pH of the avocado fruit juice stored at different packaging materials throughout the experimental storage period was within the narrow range of pH 6.489 – pH 7.173. In other studies reported, fruit pH changes have been in 4.2 to 4.4 during storage in peaches [25], 3.0 to 3.5 in citrus fruits [26] and 4.0 in tomatoes [27]. In peaches, citrus and tomato fruits more dominant acid is citric acid. However, in avocado fruits tartaric acid is more dominant acid. Therefore, the range of pH of avocado fruits is higher than the above mentioned fruits that reported by different authors.

Besides, ASR of avocado fruit stored in different packaging materials showed significant ( $P \leq 0.05$ ) aversion among the treatments. These happen in this quality parameter because of the variation of TSS and TA of avocado fruits stored in different packaging material. Generally, in this experiment the results showed that fruits stored in poly sheet and carton with poly sheet contained the highest TSS, TA, Acid to Sugar ratio and pH value than the fruits store in wooden box with straw, sack and open air. This might be due to there was relatively lower air circulation into and out of the polysheet which resulted in higher relative humidity that in turn allowed in

lower respiration rate. Slow respiration rate implies low energy exhaustion that which keeps more TSS, TA, ASR and pH of the fruits during storage period.

#### **Shelf Life, Reining Period, Temperature and Relative Humidity of Avocado Fruits During Storage:**

In this experiment a significant ( $P \leq 0.05$ ) difference was observed among avocado fruits stored in poly sheet, carton with poly sheet, wooden box with straw, sack and open air in their Self life, ripening period, storage temperature and Relative humidity (Table 2). The fruits stored in poly sheet and carton with poly sheet packaging materials scored the highest self life and ripening period in days and also registered the highest storage temperature and relative humidity than the fruits stored in wooden box with straw, sack and open air (Table2). According to Hopkins [28], simple polysheet bag is adequate to extend storage life and ripening period about a week at warm ambient temperature compared to other packaging materials. The highest relative humidity exhibited in the polysheet might be responsible for the extended storage life and ripening period recorded by slowing down rate of respiration. Besides, the highest values were scored in storage temperature and relative humidity on the fruit stored in polysheet and polysheet with carton, might be due to the fact that there was relatively lower air circulation in and out of the polysheet compared the fruits stored in wooden box with straw, sack and open air which in turn resulted in higher relative humidity and temperature in polysheet and polysheet with carton.

#### **Pulp Weight and Day Weight of Avocado Fruits During Storage:**

In this study there was variation among the storage materials in their pulp weight of the fruits during 16 days of storage (Fig. 2). The fruits stored in polysheet and carton with polysheet scored the highest pulp weight than the fruits stored in wooden box with straw, sack and open air (Fig. 2). As we motioned before there was higher relative humidity in polysheet and carton with polysheet storage materials that in turn allowed in lower respiration rate. Slow respiration rate implies low energy exhaustion that which keeps the pulp weight to the maximum. Moreover, small version was observed among the fruits stored in different packaging material in their dry matters content, Even though, there was no statistical difference among the fruits stored in different packaging materials, the fruits stored in polysheet and carton with polysheet scored a bit higher dry weight than the fruits stored in wooden box with straw, sack and open air.

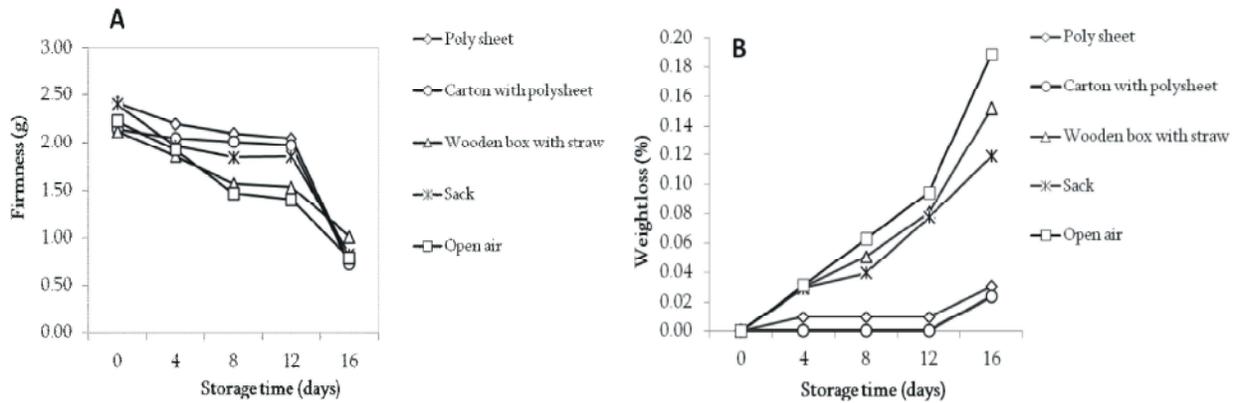


Fig. 1: Firmness (A) and weight loss (B) of avocado fruits stored in different packaging materials for 16 days at room temperature. Data are means  $\pm$  SE

Table 1: Total soluble solid, titratable acidity, acid to sugar ratio and pH of avocado fruits stored in different packaging materials at room temperature for 16 days

Packaging materials	Parameters			
	TSS ( $^{\circ}$ Brix)	TA (%)	ASR	pH
Poly sheet	3.633	0.1075	0.0345	7.078
Carton with polysheet	3.893	0.1126	0.0357	7.173
Wooden box with straw	3.613	0.0851	0.0245	6.816
Sack	3.473	0.0963	0.0330	6.489
Open air	3.393	0.0988	0.0269	6.823
LSD (0.05)	0.4980	0.02453	0.01479	0.1286

TSS = Total Soluble Solid, TA= Titratable Acid, pH= power of Hydrogen, Acid to Sugar Ratio (ASR)

Table 2: Shelf life, ripening period, temperature and relative humidity of avocado fruits stored in different packaging materials at room temperature for 16 days

Packaging materials	Parameters			
	SL (days)	RP(days)	T $^{\circ}$ ( $^{\circ}$ C)	RH (%)
Poly sheet	16.00	12.33	23.647	84.07
Carton with polysheet	13.67	11.33	23.727	85.47
Wooden box with straw	9.00	7.33	23.640	75.99
Sack	10.67	9.00	23.500	71.74
Open air	12.00	9.67	23.260	69.73
LSD (0.05)	0.729	0.972	0.2515	2.440

P= Ripening Period, SL=Shelf Life, T $^{\circ}$ =Temperature and RH=Relative Humidity

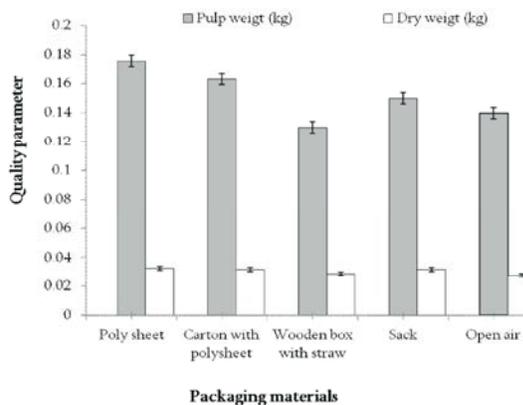


Fig. 2: Pulp weight and dry mater content of avocado fruits stored in different packaging materials for 16 days at room temperature. Data are means  $\pm$  SE

## CONCLUSION

This study confirmed that avocado fruits stored in polysheet and carton with polysheet showed a significant difference on some quality parameters such as TSS, TA, Acid to Sugar ratio, pH, Self life, ripening period value, storage temperature, relative humidity and, the result showed that avocado fruits in stored in these packaging materials low percentage weight loss, less firmness loss.

Besides, there was no statistical difference among in pulp weight and dry weight quality parameters the fruits stored in different packaging materials, However, the fruits stored in polysheet and carton with polysheet scored a bit higher dry weight than the fruits stored in wooden box with straw, sack and open a

Even though, ripening period value showed a significant difference among the treatments in the fruits stored in polysheet and carton with polysheet it took longer periods for ripening compared with the fruits stored in wooden box with straw, sack and open air.

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