

Effect of Maturity Stage Analysis on Post Harvest Physicochemical Characteristics and Mineral contents of Papaya (Carica papaya) Fruit grown in Horo Guduru Wollega Zone, Shambu, Ethiopia

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Abstract
Papaya is a power house of nutrients and is available throughout the year. Maturity at harvest is very important to composition and quality of papaya. The objective of this research was to analyze the effect of maturity stage on post harvest physicochemical characteristics and mineral contents of papaya fruit grown in Horo Guduru Wollega Zone, Shambu, Ethiopia. The treatment consisted of papaya fruit samples at different stages with three levels (Ripe, Medium Ripe, and Unripe Papaya). The proximate composition of papaya were ranged from 17.68 to 18.06% for moisture, 0.78 to 3.03% for ash, 0.63 to 2.27% for fat, 5.39 to 6.68% for protein, 7.80 to 9.16% for crude fiber and 58.10 to 67.30% for carbohydrate. The firmness ranged from 4.40 to 6.40 kg/cm^2, 5.39 to 5.48 for PH, 6.03 to 10.22 ^{o}brix for total soluble solid and 15.08 to 23.50 for total sugars. The mineral contents were ranged from 1670 to 2006 mg/100g for phosphorous, 122.03 to 279.35 mg/100g for calcium and 32.37 to 44.39 mg/100g for ascorbic acids. Papaya fruit have high proximate composition, mineral contents and ascorbic acids in the three treatments for this study. Therefore, it is recommended to use ripe and medium ripe papaya fruit since it contains plenty of proximate composition and mineral. Furthermore, further research should be carried out by using this fruit for different food product development.
Keywords: Papaya, maturity stage, mineral and physicochemical characteristics

1. INTRODUCTION

Papaya is a powerhouse of nutrients and is available throughout the year. It is a rich source of threes powerful antioxidant vitamin C, vitamin A and Vitamin E; the minerals, magnesium and potassium; the B vitamin pantothenic acid and folate and fiber. In addition to all this, is contains a digestive enzyme-papaintha effectively treats causes of trauma, allergies and sports injuries. All the nutrients of papaya as a whole improve cardiovascular system, protect against heart diseases, heart attacks, strokes and prevent colon cancer. The fruit is an excellent source of beta carotene that prevents damage caused by free radicals that may cause some forms of cancer (Aravind *et al*, 2013)

Papaya helps in the digestion of proteins as it is a rich source of proteolytic enzymes. Even papain-a digestive enzyme found in papaya is extracted, dried as a powder and used as an aid in digestion. It contributes to a healthy immune system by increasing your resistance to coughs and colds because of its vitamin A and C contents. Papaya included in your diet ensures a good supply of vitamin A and C essential for maintaining a good health.

Postharvest papaya fruit quality can be affected by many factors including genetic, environmental, pre- and postharvest factors (Tadesse *et al*, 2012). Maturity stage at harvest is very determinant factor for different post harvest quality attributes of papaya fruit such as soluble solid, sugar, acidity, pH colour and firmness both in fresh market and processed papaya.

Sweetness of papaya is mainly dependent upon the levels of total sugars; reducing sugars like glucose and non-reducing sugars like sucrose. Sucrose is mostly due to level of titratable acidity (TA) like citric acid. Sourness which is related to the level of organic acid usually masks sweetness and will be affected by maturity stage at harvest (Borji *et al*, 2012). The changes of maturity stage can affect the post harvest performance and fruit quality of papaya (Garcia *et al*, 2005). In addition to chemical composition, texture is also very important quality attribute of papaya fruits.

Maturity at harvest is very important to composition and quality of papaya. It determines the way in which papayas are handled, transported and marketed and their storage life and quality (Kader *et al*, 1985). Harvesting depends up on the purpose; therefore maturity standard should correlate the quality of the fruit when ripe. Typical and advanced mature-green papaya will usually attain a much better flavor at the table-ripe stage than those picked at the immature or partially mature stages. Immature fruits are more subjected to shriveling and mechanical damage, and inferior quality when ripe. Any fruit picked either too early or too late in its season is more susceptible physiological disorder and has shorter than fruit picked at proper maturity stage (Kader, 1994). Fruit firmness is related to the susceptibility of papaya fruit to physical damage during harvest and storage that depends on maturity stage.

Maturity stage at harvest is one of the most important factors as it can directly affect changes of the fruit quality, particularly the chemical quality characteristics, color, firmness and the post harvest quality of papaya for fresh market and different processed papaya products. Harvesting papayas at proper level of maturity is essential for good quality produce. Therefore, the choice of optimum fruit picking time plays a key role in having papayas with better quality, longer marketability and shelf life of fruits. Information regarding the effect of fruit maturity stage on postharvest quality papaya is scare in the study area. Hence the objective of this work is:

1.1 General Objective:

- The general objectives of these research is to analyze effect of maturity stage on post harvest physicochemical characteristics and mineral contents of papaya (carica papaya) fruit grown in Horo Guduru Wollega Zone, Shambu, Ethiopia

1.1.1 Specific objectives

- To identify the optimum harvesting maturity resulting in better quality and longer marketability of ripe papaya.
- To study the proximate composition of papaya fruit
- To study the mineral and vitamins content of papaya

2. MATERIALS AND METHODS

2.1 Experimental Site

This experiment was conducted in Wollega University Shambu Campus, Department of Food Science and Nutrition, Faculty of Agriculture, Shambu, Ethiopia. The mean minimum and maximum temperature inside the laboratory was 24^{o}C to 26^{o}C respectively with relative humidity of 70%.

2.2 Experimental Materials

The papaya samples representing the same farmers' variety were obtained from local produce farm in Fincha Sugar Factory. Representative samples were randomly taken from plot of land by excluding bruised, diseased, mottled and damaged one for analysis of physicochemical characteristics, minerals and some vitamins between the treatments. The papayas were freshly hand harvested from the field at different maturity stages based on their surface color. After harvesting, the papaya fruit were hand washed to remove field heat, soil and also to reduce microbial populations on the surface; sorted into three classes according to their maturity stage: ripe, medium ripe and unripe papaya. Approximately equal amounts of fruit were used for each class of maturity stages. Analytical grade chemical reagents were used for the analysis of all quality characteristics of papaya fruit.

2.3 Treatments and experimental design

The treatment consisted of papaya fruit samples at different maturity stages with three levels (ripe, medium ripe, unripe papaya). Fruits were randomly selected from each maturity stage for the determination of firmness and skin color. The other fraction of papaya fruit from each maturity stage was used in extraction of juice for chemical analysis including pH, titratable acidity, total soluble solid, total sugar content, proximate compositions like protein, fat, crude fiber, moisture, ash, carbohydrate and some minerals like phosphorous, calcium, iron and vitamin acids among the vitamins in three replications.

2.4 Sample preparation

After equilibrating freshly harvested papaya fruit samples of different maturity stages to room condition of temperature and pressure, fruit from each treatment were randomly selected, washed with water and cut into pieces, then juice was extracted with fruit juicer and filtered to exclude precipitates and analyzed as per the procedure developed by official methods.

2.5 Data collected

2.5.0 Physicochemical Analysis

Moisture content determination was carried out using the gravimetric method as described by AOAC, 1990. The protein content determination was carried out by micro-kjeldahl method as reported by Bari et al (2006). The solvent extraction gravimetric method as described by Kirk and Sawyer (1998) was used for the determination of fat. Crude fiber content was determined by the method James (1995). Carbohydrate was determined according to James (1995). The dry ash extraction method as described by James (1995) was used for the determination of minerals. Vitamin C or ascorbic acid in the samples was determined according to methods adopted by Kirk and Sawyer (1998).

The following parameters were determined on fresh juice of all papaya fruit juice of all papaya fruit juice samples as response variables.

2.5.1 PH and Titratable Acidity

The pH of the papaya juice was determined by the method described by (Rangana 1979). The fruits were chopped into small pieces, mashed by an electrical blender for 10 minutes and papaya juice was prepared using waring blender (NEW HARTFORD, CONN, USA). Then the pH meter was standardized with pH 4.0 and 7.0 buffer solutions. After standardization, 10 mL of papaya juice was added in to 50 mL beaker and then the pH of each juice sample was measured by using Microcomputer pH meter (pH-Vision, model 6071, Taiwan) with a glass electrode.

Titratable acidity of papaya juice was measured following the method developed by (Rangana 1979). The fruits were chopped into small pieces and added in to an electric blender. Five mL of papaya juice was diluted to 95 mL of distilled water. The titratable acidity of papaya juice was estimated by titrating 5 mL of the papaya juice against 0.1N NaOH solution using phenolphthalein indicator until the end point is reached. The acid content of the fruit sample was calculated based on the volume of 0.1 N NaOH used for neutralizing the acid content in the sample and multiplying by a correction factor of 0.064 to estimate titratable acidity as percentage of citric acid. The titratable acidity was calculated using the following equation:

$$\text{Percentage of acid} = \frac{\text{ml of NaOH} \times \text{N (NaOH)}0.0064 \times 100}{\text{ml juice sample}}$$

Where 1ml 0.1M NaOH is equivalent to 0.0064g citric acid.

2.5.2 Total soluble solid (TSS)

A total soluble solid (TSS in °Brix) of the papaya juice was measured by the method described by (Rangana 1979). Papaya juice was prepared by blending papaya fruit using waring blender (NEW HARTFORD, CONN, USA) for 10 minutes. Five mL of the juice was taken and centrifuged using (CL Centrifuge, AUG/78, USA) at 5000rpm. The clear supernatant (1-2 mL) was taken and filtered using a syringe fitted with a 0.45 µm pore diameter filter, and two drops of the filtrate were then carefully applied on the refractometer using plastic dropper and the reading was obtained directly as percentage soluble solids concentration (ºBrix range 0 -95% at 22 °C) using bench-top scale based Abbe- refractometer (Fisher Scientific, Japan).

2.5.3 Determination of sugar content

A common colorimetric procedure for the analysis of the total sugar determination in fruit juice; the Anthrone method was used. The reducing sugar content was estimated by determining the volume of unknown sugar solution of papaya pulp required for complete reduction of standard Fehling"s solution Fehling H. (1849) using titration method.

2.5.4 Firmness

The method developed by Kitinoja L *et al* (2005) was used for the measurement of fruit firmness. Texture analyzer"TA-XTPlus" (No 40555, Stable Micro Systems, Godalming, England) with flat head stainless-steel cylindrical probe of diameter 2 mm was used for the measurement of papaya fruit firmness. The start of penetration test was the contact of the probe and papaya surface and finished when the probe penetrated the tissues to depth of 8 mm with the probe speed of 1 mm s-1. The point where the needle stopped was recorded as the value for the fruit firmness in kg cm-^{2}. Each papaya was punctured three times around the equatorial area and mean value was reported.

2.6 Proximate Composition

The moisture content, crude fat (ether extract) content, crude protein (N×6.25), crude fiber and total ash were determined using AOAC (2000) official methods of 925.09, 4.5.01, 979.09, 962.09 and 923.03 respectively. Total carbohydrate content was calculated by differences as (100-% protein + % fat + % ash + % moisture). All the results were expressed as g/100 g of dry matter of potato flour.

2.7 Data Analysis

SAS version 9.1 software package was used to make analysis of variance and mean separation. All measurements were conducted in triplicates and the means were reported. The means of each response variables were subjected to analysis of variance (ANOVA), and mean separation was performed by using least significance difference (LSD) at the $p< 0.05$ level to determine the significance if any, between the treatment means.

3. RESULTS AND DISCUSSIONS

Papaya fruits of different maturity stage were subjected to the analyses of various physicochemical quality characteristics. The important quality characteristics that determine the flavor, keeping quality and market related quality attribute of papaya such as pH, TA, TSS, sugar level, color and firmness were determined. The proximate composition which includes moisture, ash, protein, crude fiber and carbohydrate and also the mineral contents of the treatment of papaya which includes calcium, iron, phosphorous and ascorbic acid were also determined.

The proximate compositions of the three treatment of papaya are presented in Table 1.There were no significance differences between the treatments of papaya for moisture contents. The highest (18.06%) and the lowest (17.68%) values of the fruit moisture samples were recorded in medium ripe and fully ripe papaya fruit samples respectively (Table 1). The moisture content result were lower than the moisture content reported by chukwuka *et al.* (2013) who have carried out their research on biochemical properties in peel, pulp and seeds of papaya.

The ash content of papaya fruit showed significantly (*P<0.05*) different between medium ripe and unripe papaya fruit samples. There was no significant difference between fully ripe and medium ripe papaya samples. The highest (3.03%) and lowest (0.78%) were recorded in unripe and fully ripe papaya fruit samples respectively. The ash value obtained in this finding was lower than the value reported by chukwuka *et al.* (2013) on evaluation of nutritional components of papaya at different stages of ripening with value of (4.84%). But it was higher than the value reported by Bharati and Yashodhara (2014) who have done on biochemical properties in peel, pulp and seeds of papaya with value of (0.49%).

The fat content of the three treatment of papaya was significantly (*P<0.05*) different from each other with highest value recorded in ripe papaya with value of (2.27%) and the lowest were recorded in unripe papaya samples with value of (0.63%). The fat content value was similar with the value obtained by chukwuka *et al.* (2013) who has reported the value to be ranged from (0.23 to 5.10%). But this finding was lower the value reported by Karuna and Vijaya (2014) on nutritive assessment of different plant parts of papaya with value of (44.40%).

The protein content obtained from the three treatment of papaya was significantly (*P<0.05*) different from each other. The highest were recorded in unripe papaya sample with the value of (6.68%) and the lowest was recorded in ripe papaya sample with value of (5.39%). The finding was similar with Bharati and Yashodhara (2014) on their report of biochemical properties of peel, Pulp and seeds of papaya with value ranged from (5.03 to 10.75%) and lower than the value reported by Karuna and Vijaya (2014).

Table 1: Proximate Composition of Papaya

Sample code	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude Fiber (%)	Carbohydrate (%)
RP	17.68+0.29[a]	0.78+0.19[b]	2.27+0.02[a]	5.39+0.18[c]	7.80+0.11[c]	67.30+0.36[a]
MP	18.06+0.47[a]	0.82+0.13[b]	1.56+0.03[b]	6.41+0.09[b]	8.60+0.04[b]	62.66+0.39[b]
UP	17.76+0.24[a]	3.03+0.04[a]	0.63+0.02[c]	6.68+0.10[a]	9.16+0.06[a]	58.10+0.32[c]
CV	1.98	8.97	1.47	2.14	0.88	0.57
LSD	0.71	0.28	0.04	0.26	0.15	0.72

CV= Coefficient of variation; LSD=least significance deference; RP=Ripe papaya; MP=Medium Ripe; UP=Unripe papaya.

The crude fiber contents were significantly (*P<0.05*) different among each other. The highest was obtained in unripe papaya with value of (9.16%) and the lowest were recorded in ripe papaya sample. As the ripeness of papaya increases, the crude fiber decreases from this investigation. This is similar with the work of chukwuka *et al.* (2013) on evaluation of nutritional components of papaya at different stages of ripening with value ranged from (6.18 to 11.62%). They have showed also that as the ripeness of papaya increases, the crude fibers decreases and vice versa. But the crude fiber obtained is lower than the value reported by Karuna and Vijaya (2014).

Carbohydrate content of the treatment was significantly (P<0.05) different from each other. The highest (67.30%) and the lowest (58.10%) was recorded in fully ripe and unripe papaya fruit samples. From the result obtained, the carbohydrate content increases as the ripeness of papaya increased. The carbohydrate result obtained in this finding was higher than the value reported by chukwuka *et al.* (2013) in which they reported the value from (9.65 to 18.47%). This finding is higher than the value reported by Karuna and Vijaya (2014).

Table 2. Mean value of physicochemical properties of papaya fruit at different maturity stage

Treatment	Firmness (Kg/cm^2)	PH	TA (%)	TSS(^{o}Brix)	TS (%)
RP	4.40+0.01[c]	5.39 +0.02[a]	0.01+0.00[a]	10.22+0.13[a]	18.06+0.01[a]
MR	5.34+0.02[b]	5.45+0.01[a]	0.01+0.00[ab]	8.63+0.09[b]	23.50+0.06[b]
UP	6.40+0.02[a]	5.48+0.08[a]	0.01+0.01[b]	6.03+0.03[c]	15.08+0.01[c]
CV	0.34	1.58	9.95	1.56	0.34
LSD	0.04	0.17	0.002	0.32	0.13

Where, CV= Coefficient of variation; LSD=least significance deference; RP=Ripe papaya; MP=Medium Ripe; UP=Unripe papaya; TA = Titrable acidity; TSS = Total Soluble Solids; TS = Total sugar

The data indicated that firmness of papaya fruit was significantly (P<0.05) influenced by maturity stage at harvest. The highest value (6.40 kg/cm^2) was reported in unripe papaya fruit while the lowest value (4.40 kg/cm^2) was reported in full ripe papaya (Table 2). Firmness decreased notably with advance in maturity stage of papaya fruit. Similar result was recorded by (Tilahun A, 2013) who reported that firmness of tomato fruit decreased with maturity stage at harvest. Mahmood *et al*.2013 also reported that the firmness significantly decreased with progress of fruit maturation at harvest stage on their study of changes in physiological characteristics of Kiwifruit harvested at different maturity stages. Fruit firmness is an indication of the level of softening of the fruit that can be affected by maturity stage at harvest. The decrease in fruit firmness with advance in maturity stage may be related to the degradation of polysaccharides.

The pH value of papaya fruit does not varied significantly (P<0.05) in different maturity stages. The minimum (5.39) and maximum (5.48) pH values of the fruit sample were recorded in fully ripe and unripe papaya fruit samples respectively. The pH of result obtained was similar with the work of Jain *et al*.2011 who reported on quality of guava and papaya fruit as influenced by blending ratio and storage period. The result obtained is similar with work reported by Claudia *et al.* (2014) on chemical characterization of the flour of peel and seed from two papaya cultivars.

The titrable acidity of ripe papaya and medium ripe papaya was not significantly different whereas, the unripe papaya sample was significantly different from ripe and not significantly different for the medium ripe papaya. This result was lower than the value reported by Tilahun A (2013) on the study of the effect of maturity stage on the postharvest biochemical quality characteristics of tomato fruit.

Total soluble solids (TSS) content of papaya fruit ranged from (6.03 to 10.22) ^{o}Brix in this study (Table 2). The highest value (10.22 ^{o}Brix) of TSS was recorded in medium ripe papaya fruit where as the lowest value (6.03 ^{o}Brix) was recorded in unripe papaya fruit. It was noted that, maturity stage at harvest has significantly (P<0.05) affected the total soluble solid content of the fruit. The increase in total soluble solid content id due to the hydrolytic change in starch and conversion of starch to sugar, which is an important index of ripening process in fruits (Arthey and Ashurst, 2005).

Total sugar contents of the three levels of papaya were varied significantly (P<0.05) in fruit of different maturity stages. Total sugar content of papaya fruit ranged from 15.08 to 23.50%. The highest (23.50%) and lowest total sugar content (15.08%) was recorded in medium ripe papaya and unripe papaya fruit sample respectively. The remarkable increase in total sugars observed during the repining phase may be attributed to the increase in starch hydrolysis or sugar conversion. The total sugar content of this study was higher than the value reported by Tilahun A (2013) on their postharvest biochemical quality characteristics of tomato fruit.

Minerals and Vitamins

The ascorbic acid content of papaya fruit varied significantly (P<0.05) in fruits of different maturity stages. The minimum (32.37mg/100g) and maximum (44.39mg/100g) ascorbic acid of the samples were recorded in unripe and medium ripe papaya fruit samples. The ascorbic acid content of the three treatments of papaya were lower than the value reported by chukwuka *et al.* (2013) on their evaluation of nutritional components of papaya at different maturity stages of ripening with value ranged from (112 to 150.12 mg/100g).

The Iron content of the three levels of papaya samples does not show any significant (P<0.05) different among themselves. The result obtained between treatments was almost the same value. The iron content obtained in this finding was lower than the value reported by Claudia *et al*. (2014) with (3.02mg/100g) and similar with work reported by Bharathi and Yashodhara (2014) on their study of biochemical properties in peel, pulp and seeds of *carica papaya* on which the value ranged from (0.16 to 3.7mg/100g).

Table 3. Mean value of some minerals and ascorbic acids mg/100g.

Treatment	AA (mg/100g)	Fe (mg/100g)	Ca (mg/100g)	P (mg/100g)
RP	36.59+0.10^{a}	1.91+0.01^{a}	260.46+0.17^{c}	1881.93+0.07^{c}
MR	44.39+0.03^{b}	1.91+0.01^{a}	122.03+0.12^{b}	1670.09+0.21^{b}
UP	32.37+0.02^{c}	1.92+0.01^{a}	279.35+0.06^{a}	2006.20+0.22^{a}
CV	0.29	0.63	0.09	0.02
LSD	0.23	0.02	0.43	0.63

CV= Coefficient of variation; LSD=least significance deference; RP=Ripe papaya; MP=Medium Ripe; UP=Unripe papaya; AA = Ascorbic Acid; Fe = Iron; Ca = Calcium; and P = Phosphorous

The calcium content of the papaya treatment was significantly different (P<0.05) among themselves. The highest calcium content was recorded in unripe papaya fruit samples with value of (279.35mg/100g) and the lowest were recorded in medium ripe papaya samples with the value of (122.03mg/100g). The value of calcium were lower than the value reported by Claudia *et al*. (2014) on which they have done on chemical characterization of the flour of peel and seed from two papaya cultivars and higher than the value reported by Karuna and Vajiya (2014).

The phosphorous content of the three levels of papaya were significantly (P<0.05) different with highest values of (2006.20mg/100g) for unripe papaya samples and the lowest value of (1670.09mg/100g) for medium ripe papaya sample. The phosphorous result was higher than the value reported by Chukwuka *et al*. (2013) and Claudia *et al.* (2014) in which their value ranged from (3.10 to 9.48mg/100g) and (526.9 to 547.50mg/100g) respectively.

4. CONCLUSION

This study has shown the physicochemical composition, mineral contents and some vitamins of papaya at different maturity stages (Ripe, Medium Ripe and Unripe papaya). On the approximate composition of papaya fruit, as maturity increases the protein, carbohydrate and fat contents increases, where as the ash and crude fiber content decreases. The result showed also that there are appreciable mineral contents in the three treatments of papaya fruit. The firmness of the fruit decreases as the maturity increases and total soluble solids increases as maturity increases. Generally, papaya fruit have high proximate composition, mineral contents and ascorbic acids in the three treatments for this study. Therefore, it is recommended to use ripe and medium ripe papaya fruit since it contains plenty of proximate composition and mineral. Furthermore, further research should be carried out by using this fruit for different food product development.

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