PHYSICAL AND CHEMICAL COMPOSITION OF STORAGE-RIPENED PAPAYA (*CARICA PAPAYA* L.) FRUITS OF EASTERN TANZANIA

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ABSTRACT

*The proximate composition (ash, titratable acidity, crude fat, crude fibre, moisture and sugars), soluble solids, ascorbic acid, polyphenol oxidase activity, macro-nutrients and heavy metal contents of storage-ripened papaya (*Carica papaya L.*) fruits from Mbezi, Dar es Salaam, Tanzania were determined. The determinations were repeated for early, middle and late-season papaya fruits. The fruits were always harvested at the mature green stage and allowed to ripen during room temperature storage. The results showed that papaya fruits had high moisture content (>85.5%), low acidity (<0.18% c.a.), low crude fat (0.10 g/100 g-edible portion), moderate crude fibre (1.45 g/100 g-edible portion), high ascorbic acid content (>84.5 mg/100 g-fw), moderate total sugars (>13.0%) and soluble solids (>12.9%) content. Early-season fruits had the highest polyphenol oxidase (PPO) activity while late-season fruits had the lowest PPO activity. During storage-ripening the PPO activity in the papaya fruit decreased. Of the determined macro-nutrients (Ca, K, Mg, Na), potassium content (420 mg/100 g-fw) was the highest. Heavy metals content was very low in the papaya fruits. Variations in moisture content, reducing sugars, total sugars, soluble solids, titratable acidity, ascorbic acid content and PPO activity were observed during the season and during the ripening period.*

INTRODUCTION

Papaya (*Carica papaya* L.) is an important fruit in Tanzania as it is a good source of vitamins, dietary fibre and minerals and provides flavor, aroma and texture to the pleasure of eating. Fully ripened papaya fruits are usually eaten fresh as the enzymes in the fruit produce calm, soothing feelings in the stomach. Papaya is known for its fine and natural laxative virtue which aids digestion. Papaya fruits are rich in enzymes called papain and chymopapain that break down the proteins from the food a person eats into amino acids and therefore helps digestion. The anti-inflammatory properties and high antioxidant content of papaya is known to prevent cholesterol oxidation and can be used in preventative treatments against strokes, heart attacks, diabetic, heart disease and blood pressure (Eno et al., 2000). Nutritionally, papaya is a good source of calcium and an excellent source of vitamins A and C (Nakasone and Paull 1998).

Physico-chemical characteristics are important qualitative indexes of any fruit for fresh consumption (Zaman *et al*. 2006). Such characteristics are yet to be reported for *Carica papaya* of Tanzania. The proximate composition (ash, acidity, crude fat, crude fibre, sugars and moisture), ascorbic acid, soluble solids, polyphenol oxidase (PPO) activity and mineral elements present in storage-ripened papaya fruits from Mbezi, Dar es Salaam, were determined.

Concern about metal toxicity has provoked considerable research in the analysis of food and food products (Robinson et al., 1989) since foods provide a direct dietary input of the metals. The physical and chemical characteristics and levels of inorganic elements in green leafy vegetables of Tanzania (Raja *et al*. 1997, Othman 2001) and some fruits (Mamiro *et al*. 2007, Saka *et al*. 2007) have been reported. However information appears to be rather limited on many other fruits from Tanzania. Plants that are grown near motor ways have been shown to accumulate heavy metals especially lead (Luilo and Othman 2003). Foliar sprays, irrigation practices and environmental pollution may easily cause contamination of fruits. This study describes the physico-chemical characteristics of papaya (*Carica papaya* L.) fruits from Mbezi in Dar es Salaam, Tanzania.

MATERIALS AND METHODS

Samples

Mature green papaya (*Carica papaya* L.) fruits that did not have any visual signs of bruises, cuts, blackening or infestation were harvested from papaya trees and selected as samples for the study. The fruits were allowed to ripen during room temperature storage.

Sample collection

Samples of papaya fruits were collected from Mbezi area in Dar es Salaam. The fruits were picked from trees in batches of five for the appropriate determination and transported to the laboratory for further studies. The determinations were done on arrival and at intervals of two days from the day of harvest. Sample collection was repeated during the early, middle and late season of the papaya fruit.

Analytical methods

Moisture

The moisture determination was conducted as prescribed by AOAC (1990) for fruits. Moisture content was determined by heating 2.0 g of each sample to a constant weight in a crucible placed in an air oven maintained at 105 ^{o}C for 5 hr. Fruits from early, middle and late (papaya) seasons were analyzed on harvest and after every two days interval during the storage ripening period.

Titratable acidity

Minced fresh fruit sample (10 g) were mixed with 200 cm^3 distilled water and boiled for 1 hour, cooled and the mixture then filtered. The filtrate (10 cm^3) was titrated with 0.1 M NaOH up to pH 8.1 measured with pH meter. The results were expressed as % citric acid (% c.a., g citric acid/100 g-fw) (Ranganna 1977).

Crude fat

The dried sample in a thimble was covered with fat free cotton and kept in a soxhlet apparatus. The flask was filled with 150 cm^3 petroleum ether and extraction done for 16 hours or longer on a water bath. The sample was then dried at 100 ^{o}C in an oven for 1 hour, cooled to room temperature and weighed. The difference in the weights gave the fat-soluble material present in the sample. Determinations were conducted in triplicate and the average value was recorded (Ranganna, 1977).

Crude fibre

Crude fibre was determined from the residue remaining after the crude fat determination. Boiling sulphuric acid (200 cm^3) was added to the 2 g of the residue in a digestion flask and heated for 30 minutes. The wetted material was then filtered and washed thoroughly with boiling water until the washings were no longer acidic. NaOH solution was added to the washed material and the mixture boiled under reflux for 30 minutes. The material was then filtered and washed thoroughly with water followed by 15 cm^3 of alcohol. The contents were dried at 110 ^{o}C to constant weight, cooled in a desiccator and weighed. The material was then ashed in the muffle furnace at a dull-red heat at 450 ^{o}C for 20 minutes then cooled and weighed. The loss in weight represented the crude fibre content (Ranganna 1977).

Sugars

Total and reducing sugars, sucrose and total soluble solids contents were determined following the procedures of AOAC (1990).

Ash

The sample (5 g) was kept in a muffle furnace and ashed at a temperature not exceeding 525 °C for 6 hours. The ash was then cooled in a desiccator and weighed. The ash content was recorded as g per 100 g fresh weight (g/100 g-fw), (AOAC, 1990).

Ascorbic acid
Ascorbic acid content was obtained by using the titration method involving 2,6-dichloroindophenol (Method 967.21 of AOAC, 1990).

Polyphenol oxidase (PPO) activity
PPO activity was assayed by a spectrophotometric procedure (Dincer *et al.* 2002, Colak *et al.* 2005). The activity was determined by using 4-methylcatechol (4-MC) as substrate for the triplicate extracts and measuring the increase in absorbance at 494 nm. The buffer used to provide the required pH range was a 0.05 M phosphate (pH 6.0 and 7.0) solution.

Determination of metals
Sample preparation
Fresh fruit juice (20 cm^3) was put in a 100 cm^3 volumetric flask and 10 cm^3 of conc. HCl was added and the solution was made up to volume with distilled water. The resulting mixture was centrifuged. Appropriate dilution was done for elements present at high concentrations (McHard *et al.* 1976).

Atomic Absorption Spectrophotometry (AAS)
The above treated fruit juice sample solution was aspirated into the AAS instrument after all necessary set up, standardization and calibration procedures had been completed. All determinations of metals were performed with a Perkin Elmer model AAnalyst 300 Atomic Absorption Spectrophotometer (Perkin-Elmer 1994). All determinations were performed at the laboratory of the Chemistry Department, University of Dar es Salaam.

RESULTS AND DISCUSSION
The experimental results on proximate composition components (moisture, acidity, reducing sugars, total sugars, total soluble solids) and ascorbic acid content of papaya (*Carica papaya* L.) fruit are reported in Table 1. The results on determinations of ash, crude fat and crude fibre content are reported in Table 2.

Moisture
The moisture content of papaya fruit of Tanzania was always higher than 85.5% throughout the season. The moisture content increased significantly with season. Late season fruits had the highest moisture content while early season fruits had the lowest content. Moisture content also increased during ripening under normal room temperature conditions especially with early season fruit. The juiciest fruits were the late season fully ripened fruits. Such high moisture papaya fruits have also been reported in Nigeria (Akaniwor and Arachie 2002) and India (Zaman *et al.* 2006).

Titratable acidity
The observed titratable acidity values for papaya fruit over the season are presented in Table 1. Early season papaya fruits had the highest titratable acidity while late season fruits exhibited the lowest titratable acidity content. During ripening of the papaya fruit there was a decrease in titratable acidity. Such a decrease in acidity during ripening of papaya has been reported (Moya-León *et al.* 2004, Bron and Jocomino 2006). Such decrease in titratable acidity was also noted during the ripening of oranges (*Chen et al.* 1992) and Kinnow (citrus) fruits (Nagar 1994).

Sugars
The reducing sugars and total sugars content of the papaya fruit increased during the ripening process (Table 1) while the sucrose content decreased during this period. Such observation has been reported for Hawaiian papaya by Jones and Kubota (1940) and for Indian papaya by Zaman *et al.* (2006). The papaya fruit also shows a seasonal variation in sugar content. The highest total sugars content were in early season papaya fruits while the lowest were in late season fruits.

Table 1; Proximate composition (moisture, acidity, reducing sugars, total sugars, soluble solids) and ascorbic acid content of papaya (*Carica papaya* L.) fruit of Dar es Salaam

Period of season	Storage-ripening days				
	0	**2**	**4**	**6**	**8**
	Percent moisture (% moisture ± 0.24 [Av. Dev.])				
Early	85.90	86.04	86.15	86.26	86.45
Middle	86.95	87.04	87.10	87.14	87.17
Late	**87.37**	**87.45**	**87.50**	**87.56**	**87.62**
	Percent titratable acidity (as citric acid) (%c.a. ± 0.02 [Av. Dev.])				
Early	0.18	0.15	0.10	0.10	0.09
Middle	0.15	0.10	0.10	0.09	0.09
Late	0.10	0.10	0.09	0.08	0.08
	Percent reducing sugars (% sugar ± 0.14 [Av. Dev.])				
Early	10.94	11.31	12.25	12.58	12.91
Middle	11.04	11.42	12.03	12.46	12.80
Late	11.17	11.50	11.94	12.34	12.70
	Percent total sugars (% sugar ± 0.17 [Av. Dev.])				
Early	13.14	13.36	13.49	13.58	13.63
Middle	13.05	13.12	13.23	13.46	13.57
Late	12.97	13.10	13.24	13.31	13.50
	Percent soluble solids (% SS ± 0.15 [Av. Dev.])				
Early	13.26	13.42	13.53	13.58	13.62
Middle	12.98	13.11	13.24	13.40	13.49
Late	12.94	13.05	13.14	13.25	13.36
	Ascorbic acid content (mg/100 g-fw ± 0.28 [Av. Dev.])				
Early	84.51	84.10	83.92	83.83	83.78
Middle	85.13	84.86	84.61	84.52	84.35
Late	85.85	85.54	85.30	85.19	85.02

Soluble solids

The soluble solids content of the Tanzanian papaya fruits increased during the ripening process (Table 1). Similar results have been reported by Bron and Jocomino (2006) for Brazilian papaya fruits. The papaya fruit also exhibited a seasonal variation in soluble solids content. Higher soluble solids amounts were in early season fruits while the lowest amounts were in late season fruits.

Ascorbic acid

Late season papaya fruits had the highest content of ascorbic acid whereas early-season fruits had the lowest values during the season (Table 1). The ascorbic acid content in the fruits decreased significantly during the ripening storage period similar to observations of Aydin and Kadioglu (2001) for ripening medlar (*Mespilus germanica* L.) fruits.

Table 2: Ash, crude fat and crude fibre, and sucrose content in papaya (*Carica papaya* L.) fruit of Dar es Salaam

Attribute	Content
Ash (g/100 g-fw)	0.42 ± 0.03
Crude fat (g/100 g-fw)	0.10 ± 0.04
Crude fibre (g/100 g-fw)	1.45 ± 0.01
Percent sucrose (range)	2.2 – 7.5 (± 0.3)

Ash
The average ash content of the papaya fruit during the season was 0.42 g/100 g-fw. No significant variation in ash content was observed for early, middle and late season papaya fruits. During normal storage ripening at room temperature the ash content decreased with ripeness of the fruit i.e. 0.42 (at harvest) to 0.29 g/100 g-fw after 8 days of storage-ripening. A similar trend was observed by Adetuyi *et al.* (2008) for Nigerian Papaya.

Crude fat
The crude fat content of papaya fruit from Dar es Salaam was quite low, lower than values reported for Nigerian papaya (Oloyede and Adeboye 2005, Adetuyi *et al.* 2008) but within the range reported for American papaya (Morton 1987). The low levels of crude fat in these fruits indicate that they are not good sources of energy (Samson, 1986).

Crude fibre
The crude fibre content of the papaya fruit was similar to contents reported for papaya from Nigeria (Oloyede and Adebooye 2005, Adetuyi *et al.* 2008) and higher than content of Indian papaya (Ramulu and Rao 2003). There was no variation during the season for crude fat and crude fibre contents of the papaya fruit. Fibre helps to maintain the health of the gastrointestinal tract, but in excess it may bind trace elements, leading to deficiencies in iron and zinc in the body (Siddhuraju *et al.* 1996).

Polyphenol oxidase (PPO*)*
The PPO activity in the papaya fruit showed systematic variations during storage ripening as well as within the season (Figure 1). At harvest time the early season papaya fruits had the highest PPO activity level while the late season fruits had the lowest. During storage-ripening the PPO activity levels decreased with days of storage. Similar observation has been reported for pear fruits by Ziyan and Pekyardimci (2004) and for melon fruit (Chisari *et al.* 2008).

Macro-nutrients and heavy metals
The average amounts of calcium, magnesium, sodium and potassium observed in the papaya fruits are presented in Table 3. Of these elements, potassium was found to be the predominant element followed by magnesium. The potassium content of the fruits herein reported were equivalent to the potassium contents (150.0 – 280.0 mg/100 g-fw) of other edible fruits in East Africa as reported by West et al. (1988). The Ca, Mg and Na levels found in Dar es Salaam papaya were of similar magnitude to levels in Nigerian papaya reported by Oloyede and Adebooye (2005). The magnesium and calcium levels were higher than levels reported for Galician fruits by Romero-Rodriguez ***et al.*** (1994). The sodium levels were low but within the range of 2.7-8.9 mg/100 g-fw found in Galician passion fruits as reported by Romero-Rodriguez *et al.* (1994).

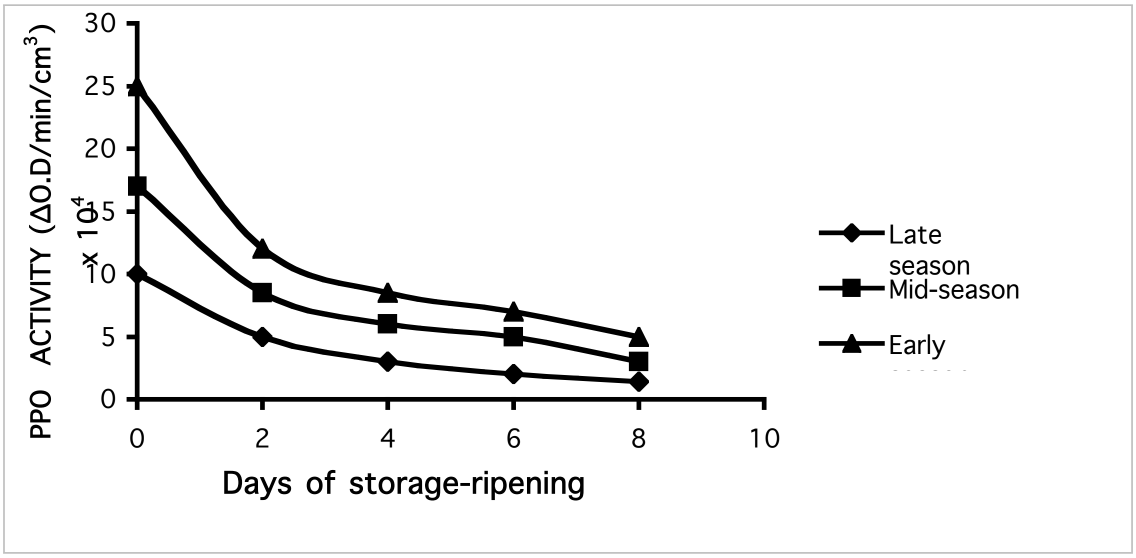

Figure 1: Polyphenol oxidase (PPO) activity in papaya fruit during room temperature storage ripening

Table 3: **Mineral elements and heavy metal content in papaya (*Carica papaya* L.) fruit of Dar es Salaam**

Mineral element	Content (mg/100 g-fw)
Calcium	21.44 ± 0.74
Magnesium	38.48 ± 0.52
Sodium	3.26 ± 0.03
Potassium	420.7 ± 3.6
Heavy metal	
Cadmium	<0.0005
Copper	0.02 ± 0.01
Chromium	<0.005
Iron	0.21 ± 0.02
Lead	<0.0005
Manganese	0.13 ± 0.03
Nickel	<0.005
Zinc	0.12 ± 0.01

The heavy metals levels observed in papaya fruit by this study are summarized in Table 3. For manganese, the levels were similar to 0.021 – 0.574 mg/100 g-fw reported for human foods by Hunt *et al*. (1991) and 0.02 – 0.39 mg/100 g-fw by Ellen *et al.* (1990). Romero-Rodriguez *et al*. (1994) reported a level of 0.08 – 0.2 mg/100 g-fw. The amounts found were lower than the level of manganese of 2 – 5 mg/100 g-fw per day required as the Recommended Daily Intake (RDI) (Ellen et al., 1990).

The levels of copper found in Dar es Salaam papaya were similar to levels (0.02-0.2 mg/100 g-fw) reported for Galician passion fruits by Romero-Rodriguez *et al.* (1994) and 0.034 – 0.23 mg-Cu/100 g-fw for some Netherland fruits (Ellen *et al.* 1990). The levels of iron in Dar es Salaam papaya fruits were but within the range of 0.07 – 0.37 mg/100 g-fw reported by Hunt *et al.* (1991). When the zinc levels found were compared to the FAO and WHO permissible level of Zn in foods (6 mg/100 g-fw), the papaya fruits had levels well below the permissible level. However, the levels of Zn in the papaya fruits from Tanzania were generally higher than those reported by Hunt *et al.* (1991) and within the range reported by Romero-Rodriguez *et al.* (1994) for passion fruits from Spain. Cadmium, chromium, lead and nickel in the papaya fruits were below detection levels. However, Ellen *et al.* (1990) reported a range of 10-29 μg-Pb /kg and 2-9 μg-Cd /kg in some edible fruits from the Neterlands.

CONCLUSION

The physical and chemical composition of storage-ripened, early, middle and late-season papaya (*Carica papaya* L.) fruit from Mbezi, Dar es Salaam, Tanzania were determined. The proximate composition (ash, titratable acidity, crude fat, crude fibre, moisture and sugars), soluble solids, ascorbic acid, polyphenol oxidase activity, macro-nutrients and heavy metal contents of storage-ripened papaya fruits were obtained. The papaya fruit had high moisture content (>85.5%), low acidity (<0.18% c.a.), low crude fat (0.10 g/100 g-edible portion), moderate crude fibre (1.45 g/100 g-edible portion), high ascorbic acid content (>84.5 mg/100 g-fw), moderate total sugars (>13.0%) and soluble solids (>12.9%) content. Early-season fruits had the highest polyphenol oxidase (PPO) activity while late-season fruits had the lowest PPO activity. Potassium content (420 mg/100 g-fw) was high while heavy metal contents were very low. Seasonal variations in moisture content, reducing sugars, total sugars, soluble solids, titratable acidity, ascorbic acid content and PPO activity were observed.

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