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PROPERTIES OF (*PARINARI CURATELLIFOLIA) (HACHA* OR *CHAKATA*) FRUITS FROM DIFFERENT PARTS OF HARARE, ZIMBABWE

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ABSTRACT

In most African countries, people in rural areas collect edible wild fruits that include (*Parinari curatellifolia*) for direct consumption or processing into food products especially during periods of food shortage. *Parinari curatellifolia* is a miombo woodland tree that bears green to grey oval shaped fruit that turns yellowish to brown when ripe. The purpose of the study was to determine the properties of *Parinari curatellifolia* fruit from Amby, Waterfalls and Acadia in Harare. The parameters evaluated include locations of fruit collection, diameter and mass, proportion of pulp, skin and stone in the fruit, moisture, mineral ash and minerals namely magnesium, iron, manganese, copper and phosphorous. Latitude and longitude positions of the trees locations were approximately E 30 ^{o} and S 17 ^{o}, respectively. The heights of the sites above sea level ranged from 1477 to 1528m. Diameters and masses of fruit from the three sites were significantly different ($p<0.05$). Moisture content of the fruit ranged from 66 to 74%. The mean pulp content was 56±5% for individual fruit units and 50±1% for bulk samples from the sampling sites. Fruit from Acadia had the highest pulp content of 60±4%. The proportion of skins and seed stones in the fruit ranged from 8 to 12.5% and 26 to 36%, respectively. Similarly as for diameters and masses, the skin, pulp and stone content of fruits from the three sites were significantly different ($P< 0.05$). Fruit from Amby had the highest mineral ash, potassium and calcium contents, which were 4.0±0.1, 1.5±0.1 and 0.5±0.1%, respectively. The highest levels of copper and iron were obtained in Acadia and were 0.5±0.1 and 0.8±0.2, respectively. There were no significant differences for mineral ash, P, Mg, Ca, Fe, Mn and Cu content of pulp for fruits from the three sites ($P>0.05$). The pulp level that was more than 50% of the fruit makes the fruit a potential raw material for food processing. The minerals in the fruit provide a source of nutrients for consumers of prepared food.

Key words: *Parinari curatellifolia*, fruit, pulp, food

INTRODUCTION

Wild fruits are important because of their use as food or medicines and potential for generating income [1]. Across sub-Saharan Africa, a wide variety of indigenous fruit trees are valuable to diets and incomes of local communities particularly during times of potential household food insecurity [2,3]. For example, food shortages caused by economic problems and drought experienced in the year 2008 in Zimbabwe led members of the rural communities to consume *Parinari curatellifolia* fruit [4]. The fruit saved many families from starvation as the food shortage was severe during the stated period [4].

Parinari curatellifolia is a miombo woodland tree of the family *Chrysobalanaceae* that grows in tropical Africa from Senegal to Kenya with the highest concentration in Zimbabwe and the lowveld region of South Africa [5, 6, 7]. The tree is found in open woodland, wooded grassland and savannah in areas with a mean annual rainfall of 400-2300 mm, a mean temperature of 10-30^oC and altitudes of 1100-1900 m [7]. *Parinari curatellifolia* fruit tree is an evergreen spreading tree that grows to a height of up to 20 m with erect branches and a dense rounded crown [8].

The fruits are oval in shape, with grey scales and skin colour ranging from yellow to reddish brown [8]. Some consumers believe that the pulp has a pleasant sweet taste and rate *Parinari curatellifollia* fruit as one of the best African wild fruits [9]. However, consumers dislike the smell of *Parinari curatellifolia* fruit [10]. Blending of *Parinari curatellifolia* with other fruits during product processing helped to reduce excessive smell of the fruit, which was disliked by some consumers [10]. The pulp around the seed stone may be eaten raw and may be used to make juice and jam [8, 11]. The pulp from the fruit can be sun dried and stored as reserve food. The seed kernel has high oil content that is edible and can be extracted [7, 11]. The oil is used for cooking or in paint and varnish [9].

The objective of this research was to determine the fruit size, pulp yield and mineral ash of fruit from selected sites with the aim of assessing the feasibility of producing food products using the local fruit.

MATERIALS AND METHODS

Collection of *Parinari curatellifolia* fruit

Fully ripened *Parinari curatellifolia* fruit was picked from the ground at locations in the Amby (AY), Waterfalls (WF) and Acadia (AC) areas of Harare. Unripe and ripening fruit was picked from the trees. Overripe, bruised and rotting fruit was excluded. The fruit was collected into polyethene bags that had holes in order to allow for free circulation of air. Measurement of the fruit was carried out while it was fresh. Excess fruit was stored at -10^oC until required.

Fruit from each site was collected from different trees. At site AY, the trees were located in homesteads. Five of the trees at the site had fruit while the rest did not bear any fruit. In three of the trees, ripe, unripe and ripening fruit was collected as the trees had low lying branches. The other two trees had their lowest branches at about 8 to 10 metres above the ground and the yield of fruit was low. Hence, only ripe fruit was picked from the ground for each of the two trees. A total of 8 kg of fruit was collected from trees at site AY.

At site WF, three trees had fruit while the rest were at flowering stage. Two trees had a high yield of fruit while the third tree had low yield. Ripe fruit was picked from the ground while unripe and ripening fruit was obtained with the aid of a long stick to get them to the ground. Six kilogrammes and eight hundred grammes of fruit was collected from site WF. Only fruit that was not damaged or bruised was collected. The basis for selection of trees was the availability of fruit in the trees. During the season concerned, the yield of fruit per tree was generally low and some trees did not bear fruit.

For site AC, fruit was collected from four trees. The rest of the trees nearby did not bear fruit while others were flowering. Ripe, unripe and ripening fruit was collected from each of three trees that had low lying branches. Only ripe fruit was collected from the ground under a tree whose branches were about 5 to 8 metres above the ground. Unripe and ripening fruit was not collected from the same tree as the branches were positioned too high to access the fruit. The fruit collected from trees at site AC weighed 7.4 kg.

Fruit from each location was thoroughly mixed to form a composite sample. The sample obtained for each site was considered representative of fruit from the different trees.

Positions of fruit collection

Germin GPS V Clan TCE KS USA GPS equipment was used to measure the altitude, longitude and latitude positions of the sampling locations [12].

Diameter and mass of fruit

Thirty fruits from each location were randomly picked for the measurement of long and short axis diameter using vernier calipers. The fruit used was sufficiently firm to withstand the grip of the vernier calipers used to measure diameters. Overripe fruit, which was deformed on measurement of diameters was not used to ensure accuracy.

Only two measurements of diameter were taken for each unit of fruit. The geometry of the fruit allowed for accurate measurement of long and short axis diameters using vernier calipers. To enhance reliability of results, measurements were made on 30 units of fruit per site.

The mass of individual fruits was measured using a Sartorious BP 2215 analytical balance. A sample size of 30 fruit units per site was used in the measurement of diameter and masses. It was important to determine the properties of the fruit when it was as fresh as possible. Hence, the analysis of the samples was commenced on the same day the fruit was collected for the purpose of making accurate measurements.

Proportion of pulp, skin and stone in fruit

Twenty one fruits per site consisting of 7 each, of ripe, unripe and ripening fruit were used. The 21 fruits used were a quantity that could be sustainably processed and analysed while still fresh. Skins of the fruits were removed by scraping and placed in separate pre-weighed plastic cups for each fruit. As much of the pulp as possible was scraped off using a stainless steel scalpel and forceps. Removal of pulp from the fruit units particularly the ripe ones was difficult as the pulp had a slurry texture. The slurry texture caused it to stick to surfaces of the scraping knife or scalpel. The mass of the skins, pulp and stone was measured for each fruit and the proportion of each component calculated for each fruit. Alternatively, twenty one fruits were weighed in bulk, the skins, pulp and stone separated, and the proportion of each component calculated.

Moisture content of fruit and fruit pulp

Moisture content was determined by AOAC method 920.151 [13] and the method described by Galfar and others [14]. Samples of fruit and pulp were dried in an oven at 105^oC to constant mass. Moisture content was calculated as the difference between the mass of the fresh sample and that of the dried samples [13, 14]. For each site, ten fruits comprising 3 unripe, 3 ripening and 4 ripe units were used. Before the determination of moisture, the pulp was thoroughly mixed to enhance homogeneity and weighed in triplicate, each of mass of 1.2g. The replicate samples obtained from the homogenized pulp were considered representative of the fruit used.

Mineral ash content of fruit pulp and skin sample

Mineral ash was determined by AOAC method 923.03 [13] and methods described by Galfar and others [14] and Armarteifio and Mosase [15].The moist pulp and skins from separately peeled fruits were combined with those from the bulk sample and mixed thoroughly. Five grams of pulp in triplicate were dried to constant weight in an oven at 105^oC [13, 14], heated until charred using a Bunsen burner and transferred to a muffle furnace at 600^oC and heated until a white ash formed [13, 15]. Ash content of the pulp was determined on a dry weight basis.

Metals and phosphorous in the mineral ash of fruit pulp and skin sample

Calcium and potassium in the ash were determined by flame atomic emission spectrophotometry (Shimadzu Corp., Tokyo Japan, Model AA 6701) [16,17]. Magnesium, iron, manganese and copper were determined by flame atomic absorption spectrophotometry (Shimadzu Corporation, Tokyo Japan, Model AA 6701) [18].

Phosphorous was determined as phosphate using the vanadate phosphomolybdate UV-Visible Spectrophotometric (Shimadzu Corporation, Tokyo Japan, Model UV-3101PC) method where orthophosphate reacts with vanadate molybdate reagent to form a yellow-orange complex whose absorbance was measured at 420 nm [16].

Statistical analysis of data

Statistical analysis of data was done using Graph Pad Prism 4 software package. The significance of difference among parameters measured in fruits from the three sites was determined using one way analysis of variance (ANOVA). Where ANOVA revealed a P value <0.05, the significance of differences between parameters measured for any two sites was assessed by post hoc- paired t-test.

RESULTS

Positions of fruit collection

Latitude and longitude positions of the trees locations were approximately E 30 ^{o} and S 17 ^{o}, respectively. The heights of the sites above sea level were 1528, 1486 and 1477m (Table 1).

Diameter and masses of the fruits

As shown in Table 2, there was great variability in the size of the fruit even for fruit collected at the same site. The diameters and masses of fruits were significantly different among the three sites ($P<0.05$). Further analysis of the data showed that the diameters and masses of fruits from any two sites were significantly different ($P<0.05$).

Proportion of skin, pulp and stone in fruit

For each sampling site, the pulp constituted the largest portion of the fruit followed by the stone and skin (Table 2). The proportion of pulp from individual fruit units ranged from 54±6 to 60±4% for the sampling sites. The amounts of pulp from a bulk fruit sample from the same sites were 51.1, 48.9 and 50.1% for AY, WF and AC, respectively. Seed stones constituted 26 to 36% of the fruit. The proportion of skins in the fruit ranged from 8 to 12.5%. The means of percentages of skin, pulp and stone of fruits from the three sites were significantly different ($P< 0.05$).

There were no significant differences between the means of percentages of pulp of fruit from sites AY and WF ($P>0.05$). The means of percentages of pulp of fruit from AY and AC were significantly different ($P<0.05$). Similarly as for fruit from AY and AC, the means of percentages of pulp of fruit from AC and WF were significantly different.

The means of percentages of skins of fruit from AY and WF were significantly different ($P<0.05$). Means of percentages of skins of fruit from AY and AC were also significantly different ($P<0.05$). There were no significant differences between the means of percentages of skins of fruit from AC and WF ($P>0.05$).

There were no significant differences between the means of percentages of stones of fruit from AY and WF ($P>0.05$). However, the means of percentages of stones of fruit from AY and AC were significantly different ($P<0.05$). Similarly as for fruit from AY and AC, the means of percentages of stones of fruit from AC and WF were significantly different.

Moisture content of fruit and fruit pulp

The moisture content of intact fruit from the sites ranged from 37±3 to 51±1% (Table 2). Moisture content of the fruit pulp ranged from 66±1 to 74±2% (Table 3). Means of moisture content of intact fruits and pulp were significantly different for fruits from the three sites ($P<0.05$). The means of moisture content of fruit from any two sites were significantly different ($P<0.05$). Similarly as for intact fruit, the means for moisture content of fruit pulp from any two sites were significantly different ($P<0.05$).

Mineral ash, K, Mg, Ca, Cu, Fe, Mn and P of fruit pulp

The ash content of pulp of fruit from the sites varied from 3.4±0.3 to 4.0±0.1. The fruit pulps contained potassium (0.9-1.5%), magnesium (0.1-0.2%), calcium (0.3-0.5%), copper (0.2-0.5%), iron (0.5-0.8%) and manganese (0.1-0.2%). Phosphorous was detected at 0.2% level in samples from the three sampling sites. No significant differences were obtained for means of mineral ash, Mg, Ca, Fe, Mn, Cu and P of pulp for fruits from the three sites ($P>0.05$). The means of K for pulp of fruits from the sites were significantly different ($P<0.05$). The levels of K of fruit from AY and WF were significantly different ($P<0.05$). No significant differences were obtained between means of levels of K of fruit from AY and AC ($P>0.05$). Similarly as for fruit from AY and AC, no significant differences were found between the means of levels of K of fruit from AC and WF.

DISCUSSION

Positions of fruit collection

Typical altitudes for areas in which the trees grow range from 1100 to 1900 m [19] and were comparable to altitudes for sites from which fruit were collected. Longitude and latitude coordinates measured locate the positions or locations from which fruits where collected. The GPS signal receiver is an important tool in identifying the exact locations from which fruits are collected.

Diameter and masses of the fruits

Short axis diameters of the fruit, which ranged from 2.1±0.3 to 2.7±0.2 cm, were similar to previously measured values which were 2.5 to 4 cm [20]. Long axis diameters, which ranged from 2.2±0.3 to 3.0±0.6 cm, were fairly close to literature values of 3 to 5 cm [20]. The variation in masses of *Parinari curatellifolia* fruit from different sites is similar to that in masses of Cornelian cherry fruit collected from different parts of Konya in Turkey [21]. The differences in masses and diameters of fruit from the three sites may arise from possible differences in composition of soils on which the trees grow. The trees at the three sites may belong to different varieties of *Parinari curatellifolia* species. The possible difference in varieties may have resulted in different diameters and masses of fruit from the sites.

Proportion of skin, pulp and stone in fruit

The pulp constituted the largest portion of the fruit followed by the stone and skin. Palmyra palm, a fruit found in Cameroon had a pulp yield of 35.22 to 38.60% [22],

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which was lower than that for *Parinari curatellifolia*, which ranged from 48.9 to 60%. Palmyra palm fruit is a potential raw material for processed foods examples of which are enriched flours, wines, jam and candy products [22]. The proportion of pulp obtained, which was above 50% makes *Parinari curatellifolia* fruit a potentially useful raw material for food processing. The pulp content from individual fruit units was higher than that from the bulk sample for each sampling site. Differences in pulp content of the samples may have arisen from errors in the bulk sample preparation, which may be higher than individual fruit pulp extraction. The percentage for skin, pulp and stone for each sampling site added to a value less than 100%. The possible cause of the discrepancy is pulp lost as it stuck to scraping knife or scalpel and holding forceps. Skins of *Parinari curatellifolia* which constituted 8 to 12.5% of the fruit were similar to Palmyra palm peelings which represented 11.5 to 12% of the fruit [22]. The observed differences in percentages of pulp, skin and stones for fruit from the three sites may be caused by differences in sizes and masses of fruit among the sites.

Moisture content of fruit and fruit pulp

The moisture content of the fruit pulp from the sites (66-74%) were in a similar range to literature values (64.8-66.8%) [23, 24, 25]. Measurement of moisture content is important in establishing appropriate storage conditions to prevent deterioration of food caused by microorganisms [26]. Parameters whose magnitudes were based on fresh weight basis as outlined in Table.1 had significantly different means ($P<0.05$). The differences may be caused by possible losses or gain of moisture by fresh fruit or pulp.

Mineral ash, K, Mg, Ca, Cu, Fe, Mn and P of fruit pulp

The ash content (3.4 to 4.0%) of pulp of fruit from the three sites was higher than 1.8% reported by Saka and Msonthi [24]. The differences could arise from differences in the environmental conditions under which the fruit trees grew. The closeness of the means of ash, phosphorous, magnesium, calcium, iron, manganese and copper content of the pulp (where $p>0.05$) may imply that fruit from different sites take up almost the same levels of the minerals. Differences in the means of potassium (where $p<0.05$) points to inconsistencies in the uptake of the element by the fruits. Other workers in Malawi and West Africa indicated that wild fruits including *Parinari curatellifolia* provide a source of trace minerals for consumers [25, 24, 27, 28]. Calcium, magnesium, iron and phosphorous levels in pulp from the samples were much higher than those measured by other workers [23, 24]. Differences in the mineral levels may be caused by differences in soil types and climate in which the fruits grew. The levels of potassium measured in pulp from the sampling points were within the range observed by other researchers [23]. Most parameters measured on a dry weight basis had comparable means ($P>0.05$). The general consistency may be caused by minimum changes in the weight of dried samples.

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CONCLUSION AND RECOMMENDATIONS

The pulp of the fruit of ripe *Parinari curatellifolia* constituted over 50% of the intact fruit and makes the fruit a useful raw material for food processing or preparation. Detection of K, Mg, Ca, Cu, Fe, Mn and P in the pulp makes *Parinari curatellifolia* fruit a potential source of minerals in the prepared foods. The skin, which could be used, comprised about 12%. The seed stone, in which is contained the kernel and which will not be used formed about 30% of the fruit. The potential of *Parinari curatellifolia* fruit as a raw material for food products implies that members of communities in areas where the trees grow should avoid cutting down the trees and refrain from starting veld fires which destroy vegetation.

A further study on fruit from different regions will reveal properties of fruit from different parts of the country.

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Table 1: Measurement of position of places where fruit was collected

Parameter	Sampling site		
	AY	WF	AC
Longitude	S 17° 50′ 06.4′′	S 17° 53′ 38.0′′	S 17° 50′ 49.9′′
Latitude	E 031° 07′ 14.9′′	E 031° 03′ 19.3′′	E 031° 03′ 57.9′′
Altitude (m)	1528	1477	1486

AY = Amby, WF= Waterfalls and AC= Acadia.

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Table 2: Measurements for fresh *Parinari curatellifolia* fruits from Amby (AY), Waterfalls (WF) and Acadia (AC) in Harare

Parameter	Sampling site		
	AY	WF	AC
Short axis diameter(cm) n=30*	2.1±0.3	2.5±0.2	2.7±0.2
Long axis diameter(cm) n=30*	2.2±0.3	3.0±0.6	3.0±0.3
Average mass of fruit(g) n=30*	14.0±3.0	21.0±4.0	23.0±3.0
Proportion of skins(%) n=21*	11.0±2.0	8.0±1.0	9.0±2.0
Proportion of pulp(%) n=21*	54.0±6.0	56.0±3.0	60.0±4.0
Proportion of stone(%) n=21*	32.0±4.0	32.0±6.0	26.0±2.0
Total percentage for skin, pulp and stone. n=21	97.0	96.0	95.0
Proportion of skin from bulk sample(%) n=21	12.5	11.2	12.1
Proportion of pulp from bulk sample(%) n=21	51.1	48.9	50.1
Proportion of stone from bulk sample(%) n=21	31.2	36.1	29.8
Total percentage for skin, pulp and stone from bulk sample. n=21	94.8	96.2	91.5
Moisture of fruit (%) n=10*	51.0±1.0	40.0±2.0	37.0±3.0

For determinations of Long axis diameter of fruit where n=30 to Moisture of fruit where n=10, n represents the number of fruit units used in the experiments. All values are reported on a fresh weight basis. Results are expressed as $\bar{x} \pm \sigma$ where $\bar{x}$ is the mean and σ is the standard deviation of the mean of replicate measurements. For all measurements bearing asterisk *, means for the sites are significantly different (P<0.05).

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Table 3: Triplicate measurements for moisture, mineral ash, K, Ca, Mg, Cu, Fe, Mn and P content (%) in combined pulp and skin sample of *Parinari curatellifolia* fruit from Amby (AY), Waterfalls (WF) and Acadia (AC)

Parameter	Sampling site		
	AY	WF	AC
Moisture content	66.0±1.0	72.0±4.0	74.0±2.0
Mineral ash	4.0±0.1	3.7±0.5	3.4±0.3
K	1.5±0.1	0.9±0.1	1.1±0.3
Mg	0.1±0	0.2±0	0.2±0.1
Ca	0.5±0.1	0.4±0.1	0.3±0.1
Cu	0.2±0	0.4±0.2	0.5±0.1
Fe	0.7±0.2	0.5±0.1	0.8±0.2
Mn	0.1±0	0.1±0	0.2±0
P	0.2±0	0.2±0	0.2±0

Results are expressed as $\bar{x} \pm \sigma$ where $\bar{x}$ is the mean and σ is the standard deviation of the mean of replicate measurements. Moisture content was measured on a fresh weight basis. Mineral ash, K, Mg, Ca, Cu, Fe, Mn and P were measured on a dry weight basis. For moisture content and K, the means were significantly different ($P<0.05$). For mineral ash, Mg, Ca, Cu, Fe, Mn and P, the means of results from the three sites are not significantly different ($P> 0.05$).

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