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Full Length Research Paper

Physiochemical and nutritional characterization of *Vitex payos* (Lour.) Merr. (Verbenaceae): An indigenous fruit tree of Eastern Africa

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In the dry areas, indigenous fruits become important staples when cereals harvested are inadequate to support populations. Farmers in these areas have identified many of the handicaps in domestication but there is still need for inputs from the food industry into identification of the desirable traits and characteristics of potentially novel food. The purpose of this study was to assess the nutrient content of one edible wild fruit, *Vitex payos* that has been identified as a top priority species among the inhabitants of drylands of Kenya for domestication. The proximate, minerals and vitamin content were determined. Results showed that the fruit did contain useful quantities of potassium, manganese, phosphorus and vitamin C. Besides, sodium, magnesium and calcium were also present in minute quantities.

Key words: *Vitex payos*, indigenous fruits, dry lands, nutrients, proximate, Kenya.

INTRODUCTION

Utilization of indigenous fruits is limited in drylands of East and Central Africa (ECA) where they are abundantly available because of scarce knowledge on their nutritional values, postharvest handling (Swai and Kimata, 2005) and lack of appreciation of the quantities available. There is dearth of information on fruit processing and value addition activities by fruit gatherers and traders; yet processing and value addition activities could serve to: (i) ensure continued availability of these fruits to the consumers even in off-season periods; (ii) improve demand and prices of these fruits as a result of good and attractive packaging; and iii) reduce the bulkiness of fruits and hence ease the transportation and storage of the products. One such resource in the drylands of Kenya is *Vitex payos* (Lour.) Merr fruit, which most subsistence farmers collect for food consumption and for subsistence sale in local markets during the fruit ripening seasons. *V. payos* is an indigenous undomesticated fruit tree that grows on farms and fallows in drylands of Eastern, Coastal and Central regions of Kenya. The fruits of *V. payos* are available between April and July during dry season. The pulp is black and mealy, though it does not stain; it is sticky and covers a fine hairy endocarp, which normally possesses four chambers containing the seed.

The endocarp is hard and requires mechanical strength to break and release seed (Mbabu and Wekesa, 2004;

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Mbora et al., 2008). The mealy pulp is usually consumed fresh, but could be used to process by-products such as jam and juice (Mbabu and Wekesa, 2004; Swai and Kimata, 2005). Pulp and nut mass are the two major constituents of the fruits of *V. payos*.

Fruits are good sources of minerals and vitamins, essential for human health (Saka and Msonthi, 1994). They have nutritional value that could provide the necessary body requirements (Beentje 1994; Mbabu and Wekesa, 2004; Ondachi, 2002; Saka, 1995; Mbora et al., 2008; Maundu et al., 1999). While these authors observed the richness of *Vitex payos* in vitamin C, Palgrave (2002) pointed out that these fruits had no vitamin C. This study was therefore carried out to evaluate the physico-chemical characteristics of *V. payos* fruits from the drylands of Kenya. The objective of this study was to determine the physical and nutritional composition of fruit pulp. The null hypothesis was that *V. payos* fruit pulp does not possess any valuable nutrients.

MATERIALS AND METHODS

Fruit characteristics

Pulp and nut mass are the two major constituents of fruits (Leakey et al., 2002, 2005). In *V. payos*, the important component is the pulp, which is the edible portion. Ten ripe fruits were randomly collected below 10 trees in Kitui and Mwingi districts, the two areas where fruits are consumed as snacks and also sold in local markets. The length and width of the fruits were measured to the nearest 0.1 mm. The fruit skin and pulp were removed at the widest diameter and length of the fruit and the nut measured for length and diameter to the nearest 0.1 mm. Assuming fruit and nut had cylindrical shape, their volumes were calculated using the formula:

$$\text{Volume} = \tfrac{1}{4}(\pi d^2 l);$$

where d is fruit/nut diameter; l is length and $\pi = 3.14$ (Foster, 2008), even though some fruits had irregular shapes. The volumes of individual fruits were computed and compared between the two districts and between individual trees.

To assess variation between fruits at different heights in the canopy, 15 ripe fruits were collected from each of the lower, middle and upper third portion of the entire canopy from 18 trees in Kitui. This was done to determine the anecdote farmers held that fruits from different parts of the canopy differed in size. Length and width of individual fruits were measured to the nearest 0.1 mm and weight to the nearest 0.1 g. The 15 fruits from every canopy layer were mixed and divided into three random subgroups of five fruits each. Each batch of five fruits had all the pulp scrapped together with the skin and weighed (fresh weight). Pulp was dried in an oven at 105°C for 12 h, weighed after cooling and expressed as percent of the fresh pulp weight. To estimate the number of fruits per kilogram, batches of 200 ripe fruits were collected from 15 randomly selected trees in Kitui. The fruits were mixed thoroughly and divided into batches of close to 1000 g and fruits in each counted.

Chemical composition of fruit pulp

Ripe fruits were collected from five random trees in Gitumbi village, Mbeere district, where fresh ripe fruits were available for immediate transport to the UK. The fruits were frozen and transported to the laboratory. The pulp was scrapped from the fruit immediately and chilled to 0°C. The frozen pulp was stored until the time of analyses. To prepare the samples for analysis, they were thawed and oven-dried at 70°C for 24 h, ground, and sieved at 200 µM. Samples were analyzed for proximate, mineral and vitamin content in the laboratory of the School of the Environment, Natural Resources and Geography, Bangor University, UK. The proximate included protein, fat, ash, total dietary fibre, carbohydrate and energy, while minerals were macronutrients: calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K) and sodium (Na) and micronutrients: iron (Fe), zinc (Zn) and Manganese (Mn). Vitamins analysed were both water-soluble; ascorbic acid (vitamin C), thiamine (B1), niacin (B3) and pyridoxine (B6), and fat soluble ones; α-tocopherol (vitamin E), phylloquinone (vitamin K) and β-carotene (provitamin A). The laboratory analytical methods used are described as follows.

Protein

The protein content of pulp samples was obtained by measuring nitrogen (N) content of the samples following the Kjeldahl method using a Kjeltec 2300 analyser unit (FOSS, Denmark). In brief, 200 mg of pulp sample were digested by adding 4 ml of H_2SO_4 (98%) and 2 digestive tablets, and warmed for 4 h at 30°C. The resultant nitrogen was converted into $(NH_4)_2SO_4$, which on distillation with NaOH released NH_3 in the form of ammonium ions (NH_4^+) which bonded to the SO_4^{2-} ions of the acid. After the digestion, sample solutions were placed in the Kjeltec analyser unit to determine their N content. The realised N content was multiplied by 6.25 to obtain the protein content in samples.

Fat content

The fat content was determined directly by extracting the fruit pulp with petroleum ether using Soxtec Avanti 2050 system (Foss, Denmark). Five grams of pulp sample were placed in a porous thimble, which was lodged into an extraction aluminium cup containing 80 ml of petroleum ether as a solvent and the fat was extracted by the Soxtec system. After the extraction, tubes were placed in an oven at 102°C to evaporate the remaining solvent and dry the sample. The residue in round bottom flask after solvent removal represented the fat content of the sample. Extracted fat was weighed and divided by the sample weight (5 g) to obtain the fat content ($g\ g^{-1}$).

Ash content

Two grams of pulp sample was put into crucible and weight was recorded and placed in a furnace at 600°C for 12 h. When samples were burnt, water and volatile substances were vaporized while organic substances were oxidised in the presence of oxygen. After samples were cooled, ash was weighed and the content ($g\ g^{-1}$) was calculated by dividing ash weight by the original weight of the sample.

Total dietary fibre

Dietary fibre includes polysaccharides, oligosaccharides, lignin and associated plant substances that are resistant to digestion in humans (McCleary, 2003). Therefore, dietary fibre content determination consists of the removal of digestible substances of the pulp samples and weighing the rest. To assess dietary fibre content, 1 g of pulp sample was used after fat extraction. Each

sample was dissolved in 50 ml of phosphate (pH 6), after which 0.1 ml of amylase was added and the solution was incubated at 95°C for 15 min to catalyze the hydrolysis of starch into glucose. After the incubation, the solution was cooled to room temperature and its pH was adjusted to 7.5 by adding NaOH (0.275 N). Then 0.1 ml of protease was added to the solution and placed in a water bath at 60°C for 30 min to solubilise protein. At the end of this second incubation, the solution was cooled at room temperature and the pH adjusted between 4 and 4.6 by adding HCl (0.325 M). Then, 0.1 ml of Amyloglucosidase was added to the solution, which was placed again in a water bath at 60°C for 30 min to remove glycogen. By the end of this third incubation, 4 volumes of ethanol (95%) were added and the solution kept overnight at room temperature to cool. After complete precipitation, the solution was filtered and rinsed with ethanol (95%) and acetone, to extract dietary fibre. Finally, the dietary fibre was dried at 70°C in an oven overnight and then weighed to obtain the fraction of the original sample (g g^{-1}).

Carbohydrate content

Total digestible carbohydrate content was estimated by difference; its content was assessed based on the assumption that samples are constituted of ash, dietary fibre, fat, protein and digestible carbohydrate. So, when the contents of protein, fat, ash and dietary fibre are known for 1 g of sample, carbohydrate content could be calculated according to the following formula:

Carbohydrate content (g g^{-1}) = 1 - (ash content + dietary fibre content + fat content + protein content)

The calorific value calculated as kilo Joules per gram (kJ g^{-1}) of fruit pulp was determined by multiplying the carbohydrate, fibre, protein and fat contents (in grams) by 17, 8, 17 and 37 respectively (FAO, 2003).

Water-soluble vitamins

All vitamins were determined in a Varian Prostar HPLC (Varian Analytical Instruments, Walnut Creek, CA, USA) with a Phenomenex HyperClone 250 x 4.60 5-micron C18 column (Phenomenex, Torrance, CA, USA). Calibration was done by comparing with standards (Sigma-Aldrich, Saint Louis, MO, USA). All water-soluble vitamins were determined using a mobile phase of 90:10 100 mM pH 2.2 phosphate buffer (50 mM NaH_2PO_4; 50 mM H_3PO_4) with 0.8 mM sodium 1-octanesulphonate: acetonitrile. Vitamin C (ascorbic acid) was determined at a flow rate of 1.0 ml min^{-1} and absorbance measured at 240 nm. Vitamins B1 (thiamine), B3 (niacin), and B6 (pyridoxine) were determined at a flow rate of 0.8 ml min^{-1} and absorbance measured at 270 nm. Samples were extracted by maceration in 100 mM phosphate buffer at a ratio of 1 to 2 g FW to 10 ml buffer and filtered to 0.2 µM before injection.

Fat-soluble vitamins

All fat-soluble vitamins were determined using a mobile phase of 50:50 methanol:acetonitrile. The total run duration was 20 min. Flow rate was 1.5 ml min^{-1} and absorbance was measured at 210 nm for the first 7.5 min whilst vitamin E (α-tocopherol) was eluted. Flow rate was 1.5 ml min^{-1} and absorbance was measured at 254 nm for the period 7.5 to 11 min whilst vitamin K (phylloquinone) was eluted. From 11 to 20 min, flow rate was 2.0 ml min^{-1} and absorbance measured at 450 nm whilst β-carotene was eluted. Samples were extracted by maceration in cyclohexane at a ratio of *ca.* 4 g fresh weight (FW) to 50 ml cyclohexane. Volume was reduced to *ca.* 1 ml by freeze-drying before analysis.

Determination of Ca, Na and K contents

Flame photometry was used to determine Ca, Na and K contents in the pulp samples. The flame photometer (model 410) measured the light of a specific wavelength emitted when a solution of a particular element was burnt. The amount of light emitted is directly proportional to the element concentration in the solution. To prepare aqueous solutions of samples, 2 g of sample were burnt at 450°C in a furnace overnight to remove the carbon. The samples were then dissolved into 10 ml of hydrochloric acid (HCl) of 12 M concentration. The solution obtained was diluted to 10 times for K and Na and 80 times for Ca by adding distilled water. Seven standard solutions at concentrations of 0, 5, 10, 30, 50, 70 and 100 mg L^{-1} were prepared for each element (Na, Ca and K). The standards and the sample solutions were read by the flame photometer. A regression equation was derived between standard solutions and the readings of the flame photometer and the equation was used to obtain the concentration of elements in sample solutions (mg L^{-1}). Using the dilution rates, the elements content in dry samples was calculated (g g^{-1}).

Phosphorus content

Phosphorus content was determined using the colorimetric method (Ames, 1966). This method is based on the principle that phosphate ions react with ammonium molybdate to give a blue complex that has an intense absorption band at 820 nm, when reduced by ascorbic acid. The complex absorbance is proportional to phosphate concentration in the original solution and was measured using a spectrophotometer (BioTek, model PowerWave XS). Eighty times concentration solutions of fruit pulp samples were obtained as shown above. Six standard solutions (0, 10, 30, 50, 70 and 100 mg L^{-1}) of the PO_4 ions were used to determine the relation between the spectrophotometer readings with phosphate concentrations. In brief, 80 µl of sample and standard solutions were placed in a 96 wells plate, then 180 µl of Ames reagent were added at 30 second intervals and finally 30 µl of ascorbic acid (10%) were added in each well of the plate. The absorbance of the solutions was read by the spectrophotometer after 15 min at an interval of 30 s until the last well of the plate.

Regression equation between the concentration of standard solutions and the readings of the spectrophotometer was used to obtain the phosphate concentration (mg L^{-1}) in sample solutions and then the content (g g^{-1}) in dry samples was calculated using the dilution rate.

Determination of Mg, Fe, Mn and Zn content

An atomic absorption photometer (VARIAN, model SpectrAA 220FS) was used to assess Fe, Mg, Mn and Zn contents in fruit pulp samples. The principle is that each element when burnt emits a specific wavelength light whose intensity is proportional to the amount of element in the solution. Six concentrations of each element were used as standards to calibrate the photometer. Sample solutions were prepared as earlier described. Ten (10) times concentration solution was used for Fe, Mn and Zn while a ninety times (90) concentration was used for Mg. Assay tubes each containing 50 ml of sample solution were placed on a 60 wells support where the first well was a tube of water and after each five (5) sample tubes, a drift solution was intercalated to control the photometer readings accuracy. The absorbance of solutions was read by the atomic absorption photometer and expressed as elements concentration (mg L^{-1}) according to the calibration done with standard solutions. The content in dry matter (g g^{-1}) was obtained by applying the dilution rates with regard to each element solution.

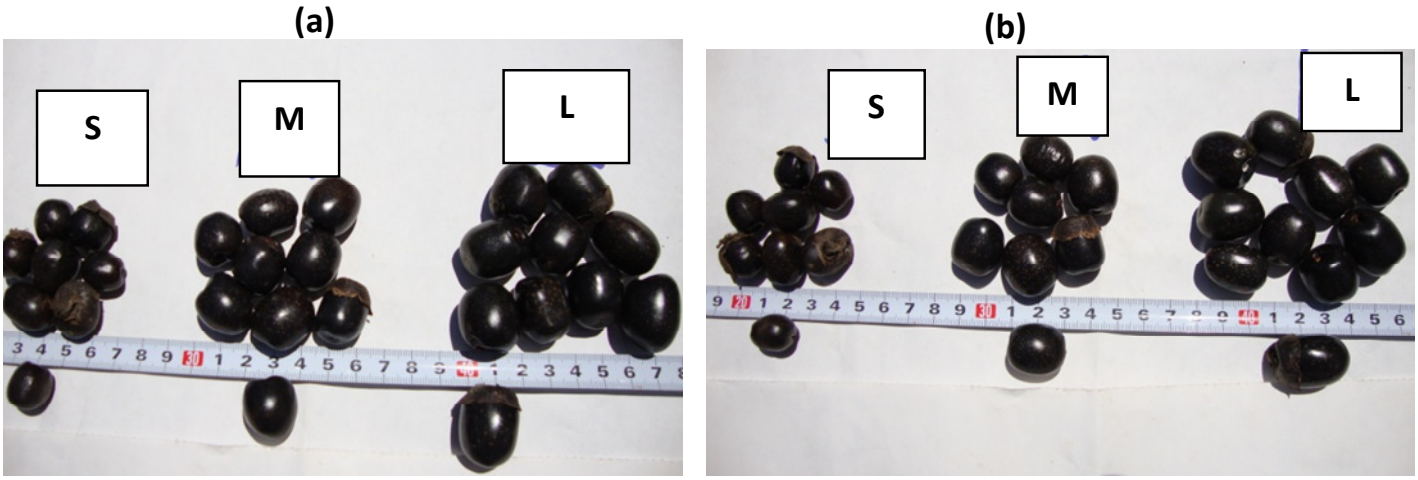

Figure 1. *Vitex payos* ripe fruits showing three size width (a) and length-wise (b). S, small; M, medium; L, large fruits.

Table 1. Mean, standard error of the mean (±SEM) and range of individual fruit length, width and weight in Kitui, Kenya.

Parameter	Minimum	Maximum	Mean±SEM
Fruit wt (g)	1.3	17.7	5.1 ± 0.1
Fruit width (mm)	11.0	28.7	17.7 ± 0.1
Fruit length (mm)	13.8	30.6	21.6 ± 0.1
Fruit pulp volume (cm^3)	0.90	9.84	3.70 ± 0.13

Analysis of data

Fruit characteristics

The fruit parameters were compared between Kitui and Mwingi districts using Mann Whitney test (unequal variance), while 1-way analysis of variance (ANOVA) was used to compare different canopy levels, respectively (Dancey and Reidy, 2007).

Chemical composition

The average content of proximate, minerals and vitamin of *Vitex payos* fruit pulp were calculated from four samples with Excel for Windows 2007.

RESULTS

Fruit characteristics

There were 203 ± 5 (n = 13) fruits for every one-kilogram of fruits. Fruit length and width ranged between 13.8 to 30.6 mm (mean 21.6 ± 0.1 mm) and 11.0 to 28.7 mm (mean 17.7 ± 0.1 mm), respectively, n = 804, (Figure 1), while mean weights and pulp volume were 5.1 ± 0.1 g and 3.70 ± 1.89 cm^3, respectively (Table 1). The pulp volumes of individual fruits from different districts were not significantly different. Length, width and weight of fruits from different canopy levels were not also statistically different. These fruit parameters, including the pulp volume, however, differed significantly among individual trees, $p < 0.001$ with wide range between tree with lowest and highest values (Table 1). The average fruit length among individual trees ranged from 16.5 ± 0.2 (tree no. 14) to 27.53 ± 0.3 mm, (tree no. 6) while average fruit width ranged between 14.4 ± 0.2 to 22.6 ± 0.4 mm for the same trees. Fruit average weight among individual trees ranged from 2.4 ± 0.1 to 10.5 ± 0.4 g. The lowest and highest values of the three parameters were from two trees. However, the order of trees between the two extremes varied from one parameter to the other.

Fruit pulp was the major component with a mean weight of 2.84 ± 0.04 g which represent 57.7 ± 0.5% of total fruit weight. Pulp weights of fruits from different parts of tree canopy were not significantly different. However, like fruit weight, fresh pulp weights also differed significantly between individual trees ($F = 217.434$, $p < 0.001$) ranging from 1.23 to 5.02 g. Furthermore, the moisture content in fresh ripe fruit pulp varied from 54.9 to 91.3%, with a mean of 68.4 ± 0.4%. This was however influenced by the ripeness of individual fruits. Mean dry pulp weight was 0.88 ± 0.03 g and ranged between 0.28 and 1.76 g per fruit. Figure 2 shows six potential groups

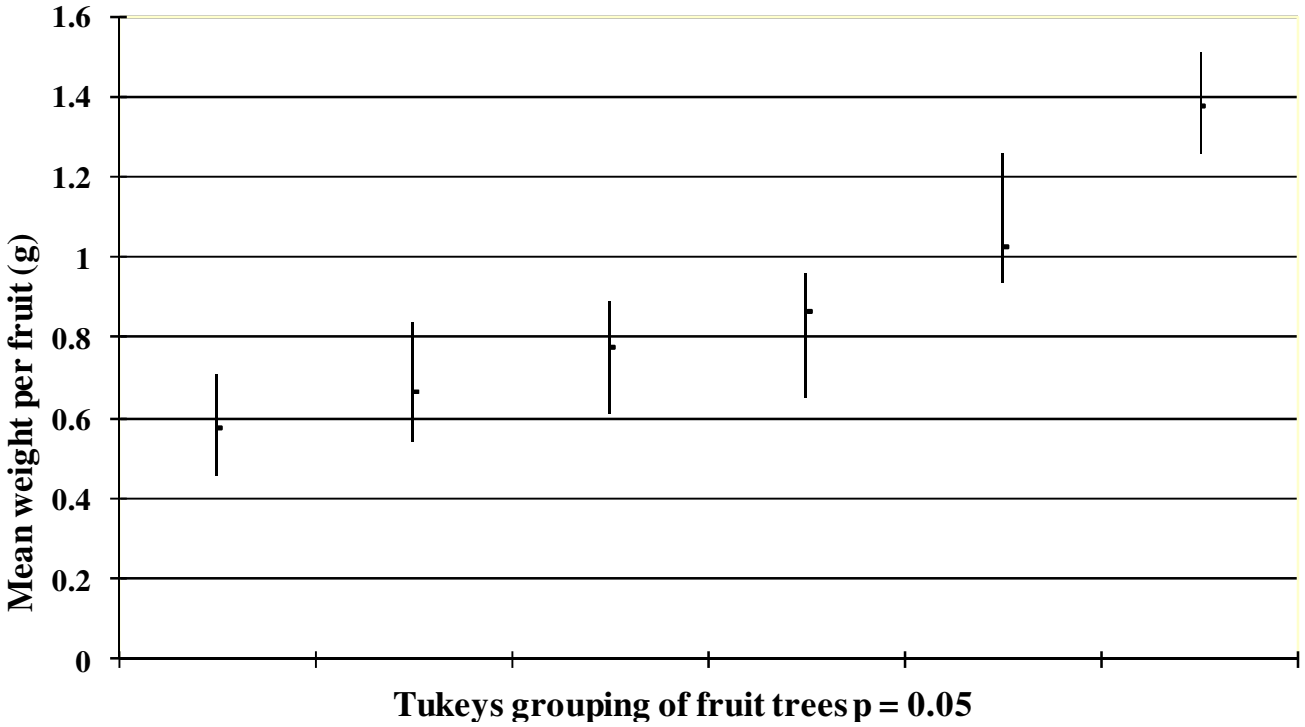

Figure 2. Tukey's test comparison for mean dry fruit pulp weight for individual trees.

Table 2. Proximate and vitamin composition of *Vitex payos* pulp.

Proximate	Mean ± sem (g 100 g^{-1} DW) (n = 4)	Vitamin	Mean ± SEM (mg 100 g^{-1} DW) (n = 3)
Water	240 ± 20	C	26.3 ± 4.9
Ash	5.3 ± 1.0	B1	n.d.
Protein	3.4 ± 0.07	B3	0.58 ± 0.2
Fat	0.44 ± 0.05	B6	0.11 ± 0.03
Fibre	60 ± 0.4	E	n.d.
Carbohydrate	30 ± 0. 3	K	n.d.
*Energy (kJ 100 g^{-1})	1064.1 ± 11.0	β-carotene	n.d.

DW, Dry weight; n.d., not detected, *assuming all fibres are metabolised (FAO, 2003).

of trees according to their average pulp dry weight. Trees with high pulp yield had over 200% more pulp than those with the least. Out of 18 trees, 8 (44.4%) produced fruits with at least twice as much pulp compared to low pulp producers (Figure 2).

Nutritional composition

Proximate compositions of the fruit pulp are shown in Table 2. The fruit pulp was rich in fibre (60 ± 0.4 g 100 g^{-1}) and moderate amount of carbohydrate (30 ± 0.3 g 100 g^{-1}). The pulp protein content was 3.4 ± 0.07 g 100g^{-1}. The fat was low in the pulp at 0.44 ± 0.04 g 100 g^{-1}, while the ash content was 5.3 ± 0.1 g 100 g^{-1}.

The fruit pulp of *V. payos* has three water-soluble vitamins, C (ascorbic acid), B3 (niacin) and B6 (pyridoxine) (Table 2). Results indicated that the fruit pulp is rich in vitamin C with 26.3± 4.9 mg 100 g^{-1} of pulp, while 0.58± 0.2 mg 100 g^{-1} of B3 and 0.11± 0.03 mg 100 g^{-1} of B6 are present (Table 2). On the other hand, vitamins B1, E, K and β-carotene (provitamin A) were not detected in the fruit pulp. Moreover, from the results presented in Table 3, the fruit pulp could provide potassium in large quantities (16 ± 0.4 mg g^{-1} DW) while it is a source of other macronutrients such as magnesium,

Table 3. Mean ± SEM (mg 100 g^{-1} DW) of mineral contents of fruit pulp.

Mineral	Mean ± SEM (n = 4)	Mineral	Mean ± SEM (n = 4)
K	1600 ± 40	Fe	11.9 ± 2.0
Mg	90 ± 3	P	11.5 ± 0.8
Na	30 ± 2	Mn	3.9 ± 0.1
Ca	20 ± 0.4	Zn	1.9 ± 0.04

DW, Dry weight.

sodium, phosphorus and calcium in smaller quantities (Table 3). The pulp contains micronutrients such as iron (11.9 ± 2.0 mg 100 g^{-1} DW), manganese (3.9 ± 0.1) and zinc (1.9 ± 0.04) (Table 3).

DISCUSSION

Black edible flesh surrounds a large nut in *Vitex payos* fruit, which contains four chambers potentially each with a seed. The pulp represents about 57% of the weight of the fresh fruit but varies greatly among individual trees. Majority of the pulp is fibre and carbohydrate (60 ± 0.44% and 30 ± 0.3% respectively). The high fibre content however causes the low energy of the pulp. Earlier studies on the species by Ondachi (2002) under the name '*Vitex doniana*', however, showed that the fruits contained more energy (1783 kJ 100 g^{-1}) than found in this study because of the high level of carbohydrate compared to the limited crude fibre. This could be due to the difference in methods of analysis used in determination of the two proximate. Fruits are generally not considered as good sources of protein; however, *V. payos* contains slightly higher protein than *Vitex doniana* with 2.8 g 100 g^{-1} (Ladeji and Okoye, 1993) and *Adansonia digitata* with 3.2 ± 0.1 g 100 g^{-1} (Osman, 2004), but lower than *Vitex mollis* which has 4.3 ± 0.11 g 100 g^{-1} (Montiel-Herrera et al., 2004). In addition, the fat content is lower than in *V. mollis*, but compares with that of *A. digitata.* The ash content compares with that of *V. mollis* at 2.9 ± 0.23 g 100 g^{-1} but was higher than for *V. doniana* and *A. digitata* at 0.3 g 100 g^{-1} (Osman, 2004).

Some of the macronutrients; (Na, K, Mg, Ca, and P) and micronutrients; (Fe, Mn, and Zn) were available in fruit pulp in quantities that could contribute significantly to the dietary requirements for humans. Their nutritional significance in the pulp is individually related to the contribution they make to the recommended dietary allowance in human beings. Potassium is the most abundant element in the pulp. The content available compares favourably with that of *V. mollis* at 1610 ± 57 mg 100 g^{-1} (Montiel-Herrera et al., 2004) and is higher than in *A. digitata,* which had 1240 ± 30 mg 100 g^{-1} (Osman, 2004). It plays an important role in the ionic balance and helps in maintaining the tissue excitability of the human body (Dhyani et al., 2007). With a daily requirement of 730 mg (Shells and Young, 1987), 50 g of fruit pulp is adequate to meet 100% of dietary requirement. K and Ca are reported as blood pressure lowering agents, thus reducing the occurrence of cardio-vascular diseases (Osborne et al., 1996).

Sodium in the pulp compares well with that of *A. digitata* but is only approximately 10% that of *V. mollis*. Sodium working together with K maintains appropriate acid-balance and is involved in enhancing nerve impulses transmission in the body (Umar et al., 2007). The Na content in the pulp is low compared to the K and this variation has significant importance in diets. According to Umar et al. (2007), during body growth, retention of protein requires a K/Na ratio within a range of 3 - 4. The ratio in *V. payos* pulp is around 53, thus indicating supplementary supply of Na could be necessary where these fruits are consumed in large quantities besides meeting the daily requirement of 1100 to 3300 mg (Shells and Young, 1987). The amount of Na available can only meet between 1 and 3% of the recommended daily allowance.

In our bodies, Mg plays an important role in circulatory diseases and Ca metabolism in bone (Ishida et al., 2000). The daily dietary requirement is 300 - 400 mg (Shells and Young, 1987) and thus 100 g of fruit pulp can therefore meet between 22 and 30%. The Ca content in *Vitex payos* is lower than in *A. digitata* with 90 ± 2 mg 100 g^{-1} (Osman, 2004) and *V. mollis* with 45 ± 3.9 mg 100 gm^{-1} (Montiel-Herrera et al., 2004) but significantly higher than in *V. doniana* which has 1 mg 100 g^{-1} (Ladeji and Okoye, 1993). Calcium is also necessary for healthy growth and maintenance of teeth and bones. With a dietary requirement of 800 -1200 mg (Shells and Young, 1987), 100 g of pulp can only supply between 1.7 and 2.5%. However, the availability of Ca and its absorption in the body depends on the Ca: P ratio (1:1) and the presence of anti-nutritional factors (Umar et al., 2007). The *V. payos* pulp however has a ratio of 2:1, thus the necessity of supplementary P in *V. payos* dependent diets to improve availability of Ca.

Phosphorus content in the fruit pulp is low with 100 g of pulp contributing between 1 and 1.4% of daily human requirement (Shells and Young, 1987). The mineral is important for bones, teeth and muscles growth and maintenance (Turan et al., 2003). Iron (Fe) is an important trace mineral and an essential nutrient that is

required in the body in small quantities: 10 to 18 mg per day (Shells and Young, 1987). It is an important component of the red blood cells. It is absorbed in human bodies in large quantities in the presence of Vitamin C (ascorbic acid) (Shells and Young 1987). A 100 g of *V. payos* pulp could contribute between 66 and 100% of daily requirement and since the pulp contains Vitamin C, it is a good source especially among communities that are resource poor. Manganese, on the other hand, is required in the body in small quantities of 2.5 to 5.0 mg daily (Shells and Young, 1987). The fruit pulp with 3.9 ± 0.1 mg per 100 g of pulp, could meet 78 to 100% of the daily requirement, and therefore a good source of this nutrient. Moreover, the Zn content in *V. payos* compares well with that of *A. digitata*, (1.8 mg 100 g^{-1}) (Osman, 2004), but higher than in *V. doniana* with 0.04 mg 100 g^{-1} (Ladeji and Okoye, 1993) and lower than in *V. mollis* with 4.4 ± 0.24 mg 100 g^{-1}). The available amount of zinc could meet just above 10% of the daily requirement (Shells and Young, 1987). Zn is an essential component of many enzymes participating in metabolism of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients (USDA, 2001). It also plays a central role in supporting the immune system of body (USDA, 2001).

The energy obtained from *V. payos* pulp is lower than that from *V. mollis* (1433 kJ 100 g^{-1}) (Montiel-Herrera et al., 2004) and *A. digitata* (1340.1 ± 18.4 kJ 100 g^{-1}) (Osman, 2004). This was mainly because the latter had minimal fibre with the bulk of their pulp made up of carbohydrates with higher energy contribution than fibres. In this study, *V. payos* pulp was composed of 60% fibre, thus reducing the overall energy realized. Mbora et al. (2008) recorded an even lower carbohydrate and energy levels of 27.4 g and 63 kJ 100 g^{-1} of pulp, respectively. In their study, the fibre content was 27 g 100 g^{-1}, thus leaving a substantial amount of pulp composition unexplained.

Conclusions

Awareness of the significant contributions that wild indigenous fruits make to the diet of the inhabitants of dry areas in Kenya is increasing (Muok, 2001; Maundu et al., 1999; Mbabu and Wekesa, 2004; Ondachi, 2002; Mbora et al., 2008; Kimondo, 2010). However, the knowledge gap of the nutritional content of most of these fruits is not yet complete. The *V. payos* fruits are not endowed with all the nutrients that were analysed. The fruit is, however, a good source of some important nutrients such as potassium, phosphorus and manganese, which could be adequately supplied from consumption of these fruits as snacks. The fruits also compare favourably with others of the same genera where quantities of nutrients vary slightly from one to the other.

Meanwhile, the nutritional analysis of *V. payos* by chemical means informs us only of the potential value of these foods to those populations who may rely upon them as staples or supplements to their diet. It is important to assess the bioavailability of the essential nutrients in these plants. Such studies and the improvement of the processing of fruit pulp into various end products are contemplated.

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