Nutritive Value of Selected Forest/woodland Edible Fruits, Seeds and Nuts in Tanzania

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Abstract

A study was carried out to evaluate the nutritional value of 18 indigenous forest fruit species from different parts of Tanzania. The edible fruit pulp, nuts and seeds were analysed for protein, fat, ash, fibre, total carbohydrates; minerals (Fe, Na, K, Ca, Mg and P), reducing sugars and vitamin C. Protein for fruit pulps ranged from 0.6% in Strychnos cocculoides to 13.3% in Sorindeia madagascarriensis and for nuts and seeds it ranged from 4.8% Allanblackia stulhmanii to 40.5% in Tylosema fassoglensis, fat ranged from 0.3% in Tamarindus indica (sweet) to 7.5% in Pachystela msolo for fruit pulps and 29.1% in Tylosema fassoglensis to 68.2% in Allanblackia stulhmanii.for nuts and seeds. Ash ranged from 2.1% in Allanblackia stulhmanii to 9.8% in Grewia smills while fibre was lowest in the fruit pulp of Strychnos cocculoides, and highest in the pulp of Grewia smillis. Mean values of vitamin C in fruit pulps ranged from 5.5mg/100 g in Tylosema fassoglensis to 964.4mg/100 g in Hyphaena compressa, while in nuts and seeds it ranged from none to 5.8 mg/100g. Reducing sugars ranged from 14 mg/g in Tamarindus indica (sour) to 111 mg/g in Parinari curatellifolia fruit pulp. Potassium was the most abundant mineral element. Seeds and nuts contained more fat, protein and minerals, while fruit pulps were rich in reducing sugars, carbohydrates and vitamin C. Among the 15 fruit pulps analysed, 95% contained higher vitamin C content than that of oranges, mangoes, lemons and passion fruits reported in literature. Nuts of Allanblackia stulhmanii were found to be rich in fat (68%). This study has shown that indigenous fruits can be used as the novel food for malnourished people and therefore recommended for increased consumption in our diet.

Key words: Indigenous fruits; nutrient composition

Introduction

Wild forest trees and shrubs originate from a wide range of species offering varied food products. In many developing countries, rural populations derive a significant part of their food and energy requirement from trees/shrubs (FAO, 1983; Shankarachrya, 1998). Information on the nutritional value of these forest fruits, nuts and seeds has not been well documented because food products such as juices, from these forest fruits are not fully appreciated by many people. Nutritional value information is needed for aiding decision making on the choice of species for domestication.

The domestication of forest food and fruit bearing forest plant species to agricultural areas in the rural as well as urban areas will improve their nutritional status and provide cash derived from the sale of fresh fruits or processed products. Improved nutrition increases immunity especially to people living with HIV/AIDS, reduces its effect and arrests its progression (Rajabiun, 2001). These wild fruits and foods make a significant contribution to human food consumption; they provide a supplement to the large starch diets based on subsistence crops, they provide essential vitamins and minerals for the poor people (Saka and Msonthi, 1994; Ramadhani *et al.*, 1998; Saka and Akinnifesi, 2000). When other means fail, local inhabitants can often rely on the presence of these forest fruit species for survival.

In the effort to look at the nutritional potential of the forest tree/shrub fruits and seeds, a study was carried out on 18 forest/woodland tree

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and shrub fruits and seeds species in Tanzania to assess their nutritional value.

Materials and methods

Source of fruits, seeds and nut material

Mature fruits, seeds and nuts were collected from 15, 3 and 1 forest woodland trees, shrubs and climber species respectively, from Southern and Northern parts of Tanzania using 20 trees per fruit category. Samples were then composted for analyses.

Fruit pulps were prepared from; *Tamarindus indica* (both sour and sweet varieties), *Vitex mombassae*, Parinari *curatelifolia*, *Azanza garckeana*, *Uapaca kirkiana*, *Vitex doniana*, *Vangueria infausta*, *Pachystela msolo*, *Syzygium guineense*, *Sorindeia madagascarriensis*, *Mryanthus arborcus*, *Hyphaena compressa*, *Grewia similis*, *Vitex payos*, and *Strychnos cocculoides*. Seeds were obtained from *Allanblackia stuhlmannii*, *Tylosema fassonglensis* and *Bussea massaiensis* and nuts from *Parinari curatellifolia*. Samples were composted for each species sun dried and pounded into fine powder using a pestle and mortar to pass through a mesh of size 500 microns then stored in a refrigerator in well labelled sterile screw cup bottles for further chemical analyses. These were analysed for proximate compositions, reducing sugars, iron, sodium, potassium, calcium, magnesium and phosphorus.

For dry matter (DM) and vitamin C analysis, fresh fruit pulp except that of *T. indica*, nuts and seeds for each species were separately homogenised using a moulinex blender (France) into a smooth pulp and paste respectively, packed in well-labelled plastic containers and stored at 4°C prior to analyses.

Chemical analyses

Ash, crude protein, dry matter, fat, fibre, and vitamin C contents of the fruits, nuts and seeds were determined using the standard methods (AOAC, 1990), using micro-Kjeldahl, SOXTEC 1043 and FIBERTEC 1020 TECATOR equipment for protein, fat and fibre respectively. Crude protein was estimated by multiplying percent nitrogen by a factor of 6.25 (Paul and Southgate, 1985). Total carbohydrates were calculated as the percent difference (Liversey, 1995). Amounts of reducing sugars in seeds, nuts and fruits were determined using the Luff-Schoorl method (Kirk and Sawyer, 1991). Calcium, iron, magnesium, potassium and sodium were determined using the UNICAM 919 atomic absorption spectrophotometer, while phosphorus was determined colorimetrically by the ammonium molybdate method using the UNICAM 8625 UV/visible spectrophotometer (AOAC, 1990). All samples were analysed in triplicates.

Results and discussion

Proximate compositions

Table 1 shows the proximate compositions of 15 edible fruits, while Table 2 is for the seeds and nuts. The DM contents were higher in seeds and nuts (76.4 – 85.2 %) than in fruit pulps (19.5 – 74.4 %). The high DM contents for seeds and nuts are expected since the nuts and seeds are used when dry. Higher value for *T. indica* both sweet and sour among fruit pulps was due to the fact that the pulps of these species were first sun dried after picking them from trees because the pulps are utilized as snacks or as an ingredient in other food products while dry unlike other fruit pulps, which are eaten fresh.

Ash contents for seeds were 5.1% in *A. stuhlmanii* and 4.7% in *T. fassoglensis* (Table 2.). Ash content for most fruit pulps was generally less than 10% (Table 1). Ash represents the total mineral content in foods. The values show variations from those reported by Saka and Msonthi, (1994) for *A. garckeana* (6.2%), *P. curatellifolia* (pulp) (1.8%), *S. guineense* (7.1%), *U. kirkiana* (2.2%) and *V. doniana* (4.8%). This variation could probably be due to variations between laboratories, the nature of the fruits and localities.

The fibre contents for fruit pulps ranged from 1.9% for *S. cocculoides* to 36.8 for *G. similis*. The percent crude fiber for *T. indica (sweet)* and *P. curatellifolia* were similar to those reported by Saka and Msonthi (1994).

Among the 18 species analysed for fat, seeds of *A. stuhlmanii* ranked first with 68.2%, nuts of *P. curatellifolia* ranked second (47%), while *T. fassoglensis* contained (29.1%) (Table 2). Most of the fruit pulps had very low fat values ranging from 7.5 to 0.3 % for *P. msolo* and *T. indica*, respectively (Table 1). Total carbohydrate ranged from 44 to 86.9% for fruit pulps and from 12 to 26 % for seeds and nuts (Table1 and 2).

Among the analysed fruit pulps, *S. madagascariensis* had the highest protein content (13.3%) followed by *A. garckeana* (10.2%). The rest had low contents of protein (Table 1). Seeds and nuts of *T. fassoglensis* and *P. curatellifolia* were rich in protein content (40.5% and 27.1%, respectively). The seeds obtained from the fruits of *T. fassoglensis* are pounded and used in soup.

Table 1. Proximate composition, reducing sugar and vitamin C of edible portion of fruit pulp of selected forest trees/ shrubs species in Tanzania

Species	Common name	DM (%)	Ash (%)	Fat (%)	Fibre (%)	Protein (%)	Total carbohydrate (%)	Reducing sugar mg/100g)	Vitamin C mg/100g
A. garckeana	Snot apple	57.2	4.7	0.4	22.8	10.2	61.6	49.3	928.2
G. similis	-	54.5	9.8	2.3	36.8	9.1	44.0	46.2	24.6
H. compressa	Doum palm	30.6	3.8	4.0	11.9	2.3	78.0	90.3	964.4
M. arboreus	-	25.6	3.8	1.3	13.1	9.5	72.3	35.3	748.8
P. msolo	-	21.5	4.3	7.5	18.7	5.5	64.0	92.3	330.3
P. curatellifolia	Mobola plum	29.0	3.9	0.9	5.4	3.4	86.2	111.0	532.1
S. madagascariensis	-	19.5	5.0	2.9	5.9	13.3	72.4	81.8	548.7
S. cocculoides	Monkey orange	25.1	5.4	1.3	1.9	0.6	90.8	36.9	135.3
S. guineense	Water berry	21.0	4.4	4.7	18.9	4.1	67.8	49.3	533.4
T. indica (sweet)	Tamarind	74.4	5.0	0.3	6.0	3.4	85.4	46.0	354.2
T. indica (sour)	Tamarind	69.2	4.8	0.7	5.2	3.1	86.2	14.0	534.4
U. kirkiana	Wild loquat	29.5	5.4	2.4	14.9	7.0	70.2	98.6	430.8
V. infausta	Wild medlar	28.1	3.6	0.5	6.7	1.9	86.9	60.7	431.6
V. doniana	Black plum	28.0	5.6	0.5	6.6	2.0	80.8	93.7	107.5
V. mombassae	Smelly berry	32.1	5.1	1.5	12.3	3.9	77.2	24.7	427.7

Values are means of triplicate determinations based on DM, DM (determined on fresh weight basis), - Common names not known

Table 2. Proximate composition, reducing sugar and vitamin C of edible portion of seeds and nuts of selected forest trees/ shrubs species in Tanzania

	Seeds		Nuts
Species	*A. stulhmannii*	*T. fassoglensis*	*P. curatellifolia*
Common name	*	Fish poison bean	Mobola plum
Nutrients			
Dry matter (DM) (%)	85.2	76.4	80.6
Ash (%)	5.1	4.7	-
Fat (%)	68.2	29.1	47.0
Fibre (%)	8.5	5.2	-
Protein (%)	4.8	40.5	27.1
Total carbohydrate (%)	12.4	20.5	26.0
Reducing sugars (mg/100g)	47.6	23.3	61.8
Vitamin C (mg/100g)	5.8	3.5	-

Values are means of triplicate determinations based on DM

- **Values not determined**

* **Common name not known**

These seeds could be a good source of energy because of their high content of fat and possibly fat-soluble vitamins and also a good source of protein (Table 1). These two species could also be utilized as novel food for weaning children. The study also showed that these two species contain appreciable amounts of protei , which represents a higher proportion as compared to the value reported for peanuts, coconuts and almonds (Paul and Southgate, 1985). Among the fruit pulps analysed for protein, *A. garckeana* had a slight difference between values reported by Saka and Msonthi (1994), for the same species (12.0% protein). This could have been due to climatic differences between Malawi and Tanzania, and also on the maturity of the fruit when it was collected, different soil management and variations between laboratories.

In rural areas of Usambara, Nguru and Uluguru Mountains in Tanzania, the seeds of *A. stuhlmannii* are used to extract cooking oil. They contain more fat than those reported by Paul and Southgate (1985) for coconuts (36%), almonds (53.5%) and peanuts (49%). FAO (1983) reported that sun dried nut of *A. stuhlmannii* had fat content of 71%, which does not differ much with fat content (68%) obtained in this study. This clearly shows that seeds of *A. stuhlmannii* could be a very good source of income if planted on medium to large-scale farms as the seeds could be collected and sold to the cooking oil industry after improving its quality. It has been reported by FAO, (1983) that seeds of *P. curatellifolia* yield oil, which could also be used in paint and varnish making. If this could be exploited these seeds could also be a good source of income by selling to the paint and varnish manufactures.

Minerals

The mineral contents of fruit pulp, seeds and nuts are summarized in Tables 3 & 4. Iron contents were generally low ranging from 0.02 to 0.18% for *A. garckeana* and *P. curatellifolia*, respectively for fruit pulps. Sodium ranged from 0.23 to 1.64% for *A. garckeana* and *P. curatellifolia*, respectively. Calcium varied between 0.26 % in *M. arborcus* and 1.93 % in *G. similis*. Consumption of *G. similis* could be a good supplement of calcium for rural children, who have little access to milk that is a rich source of calcium. In humans calcium is responsible for neuromuscular excitability, blood coagulation, maintenance and function of cell membrane and formation of new bones (Anderson *et al.*, 1987). Besides calcium, *G. similis* is also an excellent source of magnesium (Table 2). Phosphorus content varied between 0.01 % in *H. compressa* to 0.48 % in *U. kirkiana*. The seeds of A. *stuhlmannii* were also rich in phosphorus. Unfortunately, it was found out while collecting the seeds that, *A. stuhlmannii* seeds are only used for extraction of cooking oil. As a result, most of the nutrients are lost in the waste. More work is needed to find out if these wastes could be used as animal feeds.

Table 3. Mineral content of selected edible fruit pulps in Tanzania

Name of species	Common name	Mineral content (%)					
		Fe	Na	K	Ca	Mg	P
A. garckeana	Snot apple	0.02	0.23	3.13	0.60	0.17	0.22
G. similis	-	0.06	1.14	2.76	1.93	0.48	0.09
H. compressa	Doum palm	0.03	0.07	1.95	0.39	0.24	0.01
M. arboreus	-	0.05	0.04	2.74	0.26	0.14	0.08
P. misolo	-	0.02	0.36	2.80	0.92	0.09	0.25
P. curatellifolia	Mobola plum	0.18	1.64	2.23	0.36	0.16	0.18
S. madagascariensis	-	0.08	1.13	3.06	1.31	0.47	0.03
S. cocculoides	Monkey orange	0.07	1.11	1.68	1.04	0.25	0.02
S. guineense	Water berry	0.10	0.07	2.64	0.28	0.21	0.02
T. indica (sweet)	Tamarind	0.06	0.70	2.25	0.73	0.07	0.19
T. indica (sour)	Tamarind	0.06	0.82	2.30	0.82	0.07	0.18
U. kirkiana	Wild loquat	0.09	0.34	3.09	0.72	0.17	0.48
V. infausta	Wild medlar	0.03	0.27	2.04	0.55	0.14	0.32
V. doniana	Black plum	0.08	0.27	3.21	1.09	0.25	0.30
V. mombassae	Smelly berry	0.05	0.11	3.41	0.87	0.07	0.32

Values are means of triplicate determination expressed on DM
- Common names not known

Table 4. Mineral content of seeds and nuts of selected forest trees/ shrubs species in Tanzania

Species Common name Nutrients (%)	Seeds		Nuts
	A. stulhmannii *	*T. fassoglensis* Fish poison bean	*P. curatellifolia* Mobola plum
Fe	-	0.05	-
Na	0.40	1.12	0.15
K	3.11	1.37	2.64
Ca	0.77	1.16	1.05
Mg	0.08	0.54	0.14
P	0.57	0.10	0.34

Values are means of triplicate determinations based on DM.
- Values not determined
*** Common name not known**

U. kirkiana which, ranked first in phosphorus content among the fruit pulps, was also rich in reducing sugars and vitamin C (Table 1). This species is one of the most important indigenous fruit trees, and is liked by people of all ages. The ripe fruits are sold in the local market and used to make a sweet local wine called *masuku*. This could increase the income of rural families if its utilisation is promoted and domesticated. The first provenance trial in Tanzania has been established in Iringa. This is geared towards tree improvement for fruit production. *P. uratellifolia and V. mombassae* were rich in potassium. The potential of *P. curatellifolia* has been discussed under protein and fat. Among the minerals analysed, potassium was found to be the most abundant. Saka and Msonthi (1994) also found potassium to be the most abundant element in wild fruits of Malawi.

The amount of minerals in 90% of the fruits studied have equivalent amount of minerals recommended by WHO, (1999). This study has shown that most of the 18 species analysed contained higher contents of minerals than those reported by Paul and Southgate (1985), for groundnuts, coconuts, oranges, avocadoes, passion fruits and apples.

Reducing sugars

The fruit pulp of *P. curatellifolia* had the highest content of reducing sugars followed by *U. kirkiana, V. doniana, P. msolo, H. compressa* and *S. madagascariensis*. The rest had reducing sugars ranging from 14.0 to 60.7 mg/100g of (Table 1). *P. curatellifolia* pulp is a very popular fruit for children of all age groups. The fruit pulp is also an excellent source of vitamin C, potassium and magnesium. These figures could not be compared with any published report, as there is no documentation on reducing sugars that have been reported for these wild fruits. *P. curatellifolia* is considered as one of the best wild fruits of tropical Africa as reported by FAO (1983). In Tanzania, the potential of this species has not been fully exploited. This fruit could be used to process jam, jellies and other sweet products as these products require fruits with high sugar content.

Vitamin C

The highest concentration of vitamin C was found in *H. compressa,* while the lowest concentration was from in *V. doniana,* with concentration ranging from 107.5 to 964.4 mg/100 g (Table 1). Fruit pulps of *A. garckeana* were second to *H. compressa* in vitamin C content. Third in the ranking were those of *S. madagascariensis* and *M. arboreus,* which had same amounts of vitamin C content. A wide variation in vitamin C content among species could be due to the distribution of ascorbic acid within an individual fruits, differences between fruit types, varieties, degree of ripeness and climatical variations.

H. compressa is a very popular fruit among young people, who eat the fruit pulp of mature fruits. This could be a very good source of vitamin C, especially for rural children, who do not have access to citrus fruits or cannot afford to buy them. *A. garckeana,* which ranked second in vitamin C, is also a very popular wild fruit for children in the southern parts of Tanzania. Since the fruits are eaten raw, most of the vitamin is taken in. Vitamin C is a powerful antioxidant and very important in human nutrition, for lowering of blood pressure, enhancement of immunity and prevention of scurvy (Marangoni *et al.*, 1988; Sauberlich, 1994). Deficiency of this vitamin causes scurvy and leads to reduced resistance to infection (Anderson *et al.*, 1987; Sauberlich, 1994). It is interesting to note that even those species with low levels of vitamin C (that is excluding *G. simillis* and *T. fassonglensis*) were higher in vitamin C content than those of common fruits reported by Paul and Southgate (1985). In Tanzania, the most common fruits rich in vitamin C contents are in mg/100g oranges (50), mangoes (30), lemon (50) and passion fruits (20) (Paul and Southgate, 1985). The daily adult requirement for vitamin C as reported by Lutham (1997) and Belitz and Grosch (1999) range between 45 to 85 mg which implies that only 50g of the edible part of indigenous fruits is sufficient to supply the body requirement for the vitamin. This indicates that indigenous fruits can be used as novel food in the household, particularly for special groups in the household like the malnourished and HIV/AIDS affected people.

Conclusions and recommendations

This study showed that the seeds and nuts of *P. curatellifolia, A. stulhmanii* and *T. fassoglensis* are excellent sources of proteins, fat and minerals. Among the three species, *A. stuhlmannii* was the richest in fat. Since it is only the seeds that are utilised to extract cooking oil, more future work should focus on seed production for oil. *P. curatellifolia* (nuts) and *T. fassoglensis* could be used as cheap sources of protein supplementation.

Fruits that are mostly eaten raw as snack food provide useful source of minerals and vitamin C. Among the 15 species, *T. indica* (both sweet and sour varieties), *P. curatellifolia, A. garckeana, U. kirkiana, V. doniana, H. compressa, A. stuhlmannii, T. fassonglensis, G. similis, S. madagascarriensis, P. msolo* and *V. infausta.*were found to be rich in vitamin C and minerals.

More work is needed to determine the essential amino acids, other vitamins that are nutritionally important and limiting in most rural communities, such as vitamin A and B. Analysis of fatty acid composition is essential to assess the quality and safety of the fat for human consumption. Also, determination of antinutritional factors such as trypsin inhibitors, cyanogenic glycosides and tannins, which reduce the bioavailability of the limiting nutrients need to be looked at before the species are recommended for wider production of fruits, nuts or seeds.

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References

Anderson, L., Dibble, M.V., Turkki, P. R., Mitchel, H. S. and Rynbergen, H. J. (1987). *Nutrition in Health and Disease.* 17th edition. pp 142-143. Interamerican, Mexico.

AOAC (1990). Official Methods of Analysis. *Association of Official Analytical Chemists.* 15th edition. Arlington, V.A.

Belitz, D. and Grosch, W. (1999). *Food Chemistry,* 2nd Ed. Springer-Verag. Berlin,German, pp 987.

FAO, (1983). *Food and Fruit Bearing Forest Species.* 1. Examples from Eastern Africa pp 91, 125, & 165. Food and Agricultural Organisation, Rome.

Kirk, R.S. and Sawyer, R., (1991). *Pearson's Composition and Analysis of Foods.* pp 165 – 167, Longman Scientific Technical, United Kingdom.

Liversey, G., (1995). Metabolizable energy of macronutrients. *American Journal of Clinical Nutrition.* 62: 11355-1145S.

Lutham, M.C. (1997). *Human Nutrition in the Developing World.* FAO, food and nutrition series No. 29, FAO, Rome Italy, pp508.

Marangoni, A., Alli, I. and Kermasha, S. (1988). Composition and properties of seeds of tree legume *Tamarindus indica. Journal of Food Science,* 53 (5): 1452-1455.

Paul, A.A., and Southgate, D.A.T. (1985). *The Composition of Foods.* 4th edition. pp 194 – 229. London, Amsterdam, New York and Oxford.Rajabiun, S. (2001). A guide for nutrition, care and support. Technical assistance project, Academy for Educational Development, Washington DC, 55pp.

Ramadhani,T, Swai, R. and Chile, P. (1998). Indigenous Miombo fruits selected for domestication in Tanzania. In: Maghembe JA Simmons AJ Kwesiga F and Reieya M (eds) Selecting Indigenous Fruits for Domestication in Southern Africa: Priority setting with farmers in Malawi, Tanzania, Zambia and Zimbabwe.

Saka, J. D. K. and Msonthi, J.D. (1994). Nutritional value of fruits of indigenous wild trees in Malawi. *Forest Ecology and Management* 64: 245-248.

Saka, J. D. K. and Akinnifesi F.K. (2000). Nutritional value of fruits from miombo indigeous trees. Proceedings of first international workshop on fruits and tree crops, Mangochi, Malawi.

Shankaracharya, N.B. (1998). Tamarind: chemistry, technology and uses. A critical appraisal. *Journal of Food Science and Technology- Mysore,* 35 (3), 193-208.

Sauberlich, H.E. (1994). Pharmacology of vitamin C *Annual Review of Nutrition,* 14: 371-391.

WHO, (1999). Management of severe malnutrition: *a manual for physicians and other senior health workers.* World Health Organization, Geneva. pp 60.