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The Chemical Composition of Selected Indigenous Fruits of Botswana

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ABSTRACT: In the rural areas of most African countries, many people may not have access to exotic fruits and may be eating mainly indigenous fruits. Very little information is documented on the composition of these fruits. This study was undertaken to provide this information. The edible portions of four indigenous fruits (*Adansonia digitata, Sclerocarya birrea, Strychnos spinosa and Vangueria infausta*) were analysed for proximate composition, minerals, and selected properties using Association of Official Analytical Chemists(AOAC) methods. The values (%) obtained were: dry matter 11.6 (*S. birrea*) – 86.0 (*A. digitata*), ash 3.9 (*V. infausta*)- 4.9 (*S. birrea*), crude protein 1.3 (*A. digitata*)- 3.7 (*S. birrea*), ADF 6.1 (*S.spinosa*) –39.5 (*V. infausta*), ADL 4.4 (*S. spinosa*)- 35.5 (*V. infausta*), NDF 6.2 (*S. spinosa*)- 39.4 *V. infausta*), pH 3.06 (*A. digitata*) – 3.98 (*S. birrea*), acidity 0.77 (*S. spinosa*) – 7.85 (*A. digitata*). The vitamin C content in mg/100g fresh sample were: 67.7 *(V. infausta*)- 141.3 (*A. digitata*). For the minerals the values (mg/100 g) were: Ca 56 (*S. spinosa*) – 128 (*A. digitata*), Mg 49 (*S. spinosa)* – 158 (*S. birrea*), P 50 (*A. digitata*)- 128 (*V. infausta*), K 1370 (*S.spinosa*) – 2183 (*S. birrea*), Na 13.0 (*S. birrea*)-21.7 (*S. spinosa),* Fe 0.07 (*S. birrea*) –0.11 (*S. spinosa*) and Zn 0.02 (*V. infausta*) – 0.22 (*S. spinosa*). The fruits appear to be good sources of vitamin C, and the minerals, K and Mg. They can contribute towards providing nutrient requirements particularly in the rural areas, therefore the consumption should be encouraged. @JASEM

INTRODUCTION

In Botswana there is a variety of indigenous fruits. They are valuable sources of vitamins and minerals in the rural areas where exotic species are limited. In some communities the fruits provide some of the nutrient requirements. These fruit trees are found wild and a few are domesticated. The Veld Product Research and Development undertook a project in 1997-2001 that involved the domestication and improvement of some of these wild fruit trees. Four of these fruits were analysed in this study. They are *Adansonia digitata* Linn, *Sclerocarya birrea* (A. Rich.) Hochst, *Strychnos spinosa* Lam and *Vangueria infausta* Burch .

Adansonia digitata is commonly called *baobab* (*mowana* in Setswana). It is usually harvested in April and May and it has a white pulp inside a hard husk. The pulp is edible, it has a sweet taste and makes a refreshing drink with water (Odetokun, 1996). *Sclerocarya birrea*, marula in English and *morula* in Setswana is the size of a small plum and pale yellow when ripe. The edible flesh is used to prepare juice, jam and alcoholic drinks. The fruits have considerable commercial value (Leakey, 1999). *Strychnos spinosa* is known as spiny monkey orange in English; and *morutla* in Setswana. The flesh is sweet when ripe. It has a yellowish skin but the flesh is brownish, it smells like ripened apples. *Vangueria infausta* is called wild medlar in English and *mmilo* in Setswana. The flesh is sweet and it tastes like wild apple. The fruits are brown–orange when ripe and have an orange flesh. The fresh fruit can be dried in the sun and then stored for about a year. This fruit is in season January to May and it has a potential for commercial use (Leger, 2002).

Most of the indigenous fruits are edible and they play an important role in the diet particularly in the rural areas. Information on the chemical composition of these fruits is limited. This study was therefore undertaken to obtain some of this data. This paper gives the dry matter, ash, crude protein, acid detergent fibre (ADF), acid detergent lignin (ADL), neutral detergent fibre (NDF), vitamin C, mineral (Ca, Mg, P, K, Na, Fe, and Zn) contents, pH and acidity of four indigenous fruits.

MATERIALS AND METHODS

Ripe fruits were collected from Veld products Research and Development in Gabane about 15 km from the capital, Gaborone. The fruits were sorted and the mature and unblemished ones were selected. The fruits collected were: *Adansonia digitata, Sclerocarya berria, Strychnos spinosa* and *Vangueria infausta*. The fruits were washed and the pulp of each variety was separated from the endocarp using a sterile knife. For *V. infausta* the exocarp and mesocarp were used. The edible portion of each fruit was homogenized using a blender and the mixture was then used immediately for the determination of dry matter, acidity, vitamin C and pH. The homogenized mixture was dried at 100°C to constant weight and stored at 4°C in the refrigerator. These were used for the determination of ash, crude protein, ADF, ADL, NDF and the minerals (Ca, Mg, P, K, Na Fe and Zn).

Dry matter, ash content, crude protein, ADF, ADL, NDF, were determined using AOAC 1996 methods. Titrable acidity was determined (AOAC, 1996) by titrating 2.0 g fresh samples in 100.0 mL of water with 0.1 M NaOH using phenolphthalein as the indicator and was calculated as percentage citric acid. The pH was estimated (using a GLP 21 pH meter) at 25°C.

Ascorbic acid was estimated using the method described by Kirk and Sawyer (1991). The Kjeldahl

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method was used to analyse protein. Nitrogen was converted to crude protein using 6.25 factor. Digested samples used for the protein determination were used for the estimation of the minerals. The minerals determined were: Ca, Mg, P, K, Na, Fe and Zn. Ca, Mg, Fe and Zn were measured using a GBC 908 Atomic Absorption spectrophotometer. P was determined colourimetrically by the ammonium molybdate method using a Shimadzu ultraviolet – Visible spectrophotometer 1601 PC. K and Na were analysed using a Corning 410 flame photometer. For the ash content the samples (2.0 g) were heated in pre weighed crucibles in a muffle furnace (Labcon, Type RM7) for two hours at 600° C. ADF, ADL and NDF were determined using an ANKROM 200/220 fibre analyzer. All the analyses were carried out in triplicate and the mean calculated. The data was analysed using Analysis of Variance (ANOVA). Duncan's Multiple Range Test was used to compare mean values. Significance was accepted at $p \leq 0.05$ level.

RESULTS AND DISCUSSION

Table one gives the details of the composition of the fruits. The dry matter content (%) varied from 11.6 for *S.birrea* to 86.0 in *A.digitata*. The pulp of *A.digitata* is less juicy than that of *S.birrea*. For *A.digitata* the value obtained in this study is in agreement with the 84% and 86.8% reported by FAO (1968) and Saka *et al*. (1992) respectively. However it is lower than the 95.3 cited by Murray *et al*. (2001). The dry matter for *S.birrea*, *S.spinosa* and *V.infausta* is lower than the 26%, 53% and 26% obtained by Mateke (2001) for samples grown in Botswana. For *S. spinosa* and *V. infausta* our values are similar to the 22.1% and 26.5% respectively reported by Saka *et al*. (1992) for samples from Malawi. The dry matter content of *S.spinosa* and *V. infausta* were similar but significantly different from that of *A.. digitata* and *S. birrea*.

Table 1. Composition (%) and pH (25° C) of the fruits analysed.

Fruit	Component								
	D M	Ash	C.P	ADF	ADL	NDF	pH	Acidity	Vit C
A.digitata	86.0 a	4.6 a	1.3 d	16.2 b	11.3 c	13.1 c	3.06 c	7.85 a	141.3 a
S.birrea	11.6 c	4.9 a	3.7 a	16.3 b	13.7 b	16.1 b	3.98 a	0.88 c	128.3 b
S.spinosa	19.7 b	4.6 a	3.3 b	6.1 c	4.4 d	6.2 d	3.96 a	0.77 c	88.0 c
V.infausta	23.5 b	3.9 b	3.0 c	39.5 a	35.5 a	39.4 a	3.38 b	1.71 b	67.7 d
MSE	2.69	0.20	0.16	0.89	0.52	0.63	0.01	0.158	2.00

D.M -dry matter, ADL -Acid detergent lignin, C.P -crude protein, ADF -Acid detergent fibre, NDF- neutral detergent fibre, MSE- Mean standard error. For each constituent, means with the same letters were not significantly different ($p>0.05$).

The latter had the highest ash content (4.9 %) and *V. infausta* the lowest (3.9%). The contents for *A.digitata*, *S. birrea* and *S. spinosa* were similar ($p>0.05$). The values obtained for *A. digitata*, *S. spinosa* and *V. infausta* are similar to the 5.0, 4.1, 3.4 respectively reported by Saka *et al*. (1994). For *A. digitata* the 1.98% reported by Odetokun (1996) for Nigerian species is lower than the 4.6 found in this study. However this value is similar to the 4.3 % reported by FAO (1968). The 4.9% found in this study for *S. birrea* is slightly lower than the 6.8 estimated by Murray *et al.* (200l) for wild samples from Tanzania.

The protein content (%) ranged from 1.3 for *A* d*igitata* to 3.7 for *S.birrea*. The protein content was low, this is in accordance with the observation of Saka *et al.* (1994) that the protein contents of most fruits is less than 5%. For *A.digitata* the 1.3 assessed in this study is slightly lower than the 3.1, 2.5 and 2.2% reported by Saka *et al*. (1994), Murray *et al*. (2001) and FAO (1968) respectively. For *S. birrea* the value obtained is lower than 8.0 reported by Mateke (2001). However it is similar to the 3.6 reported by Murray *et al*. (20012). Also, for *S. spinosa* the 3.3% assessed in this study is lower than the 5.4 and 5.05 reported by Saka *et al*. (1994) and Mateke (2001) respectively. The concentration for *V. infausta* is similar to the 3.0 recorded by Mateka (2001) but lower than the 5.7 cited by Saka *et al*. (1994). Statistically the protein content of the fruits analysed weree significantly different.

Table 2. Mineral contents of the fruits analysed

Fruit	Mineral	(mg/100 g)					
	Ca	K	Mg	Na	P	Fe	Zn
A.digitata	128 a	1866 b	121 b	13.3 b	50 c	0.10 ab	0.14 b
S.birrea	94 b	2183 a	158 a	13.0 b	69 b	0.07 c	0.13 b
S.spinosa	56 c	1370 d	49 d	21.7 a	66 b	0.11 a	0.22 a
V. infausta	124 a	1683 c	99 c	13.7 b	128 a	0.09 b	0.02 c
MSE	5.7	75	5.8	1.32	4.3	0.01	0.016

MSE: mean standard error. For each mineral, means with the same letters were not significantly different ($p>0.05$)

The highest ADF, ADL and NDF were obtained in *V. infausta* and these values were significantly different from those obtained for the other fruits . The lowest levels for ADF, ADL and NDF were obtained in *S. spinosa*. These were also significantly different from those of the other fruits. The data indicate that *V . infausta* is an important source of fibre and could be utilized if a high fibre fruit is required. There were no literature values available for comparison.

The ascorbic acid concentrations varied from 67.7 (*V. infausta*) to 141.3 (*A.digitata*) mg/100 g on a fresh weight basis. The pulp in *A. digitata* is rich in ascorbic acid. The value for *A.digitata* is lower than the 337 mg/100 g and 270 mg/100 g cited by Eromosele *et al.* (1991) and FAO (1968) respectively. The ascorbic acid contents for *S.birrea*, *S.spionsa* and *V. infausta* are in agreement with the 127, 89, 68 respectively determined for samples from Botswana, Mateke (2001). Eromosele *et al*. (1991) obtained a higher value 403mg/100 g for *S.birrea*. Saka *et al.* (1992) reported lower values 19.9 and 16.8 for *S.spinosa* and *V.infausta* respectively. The levels of ascorbic acid depend on stage of maturity and ripeness of fruit (Eromosele *et al*. 1991). When compared with vitamin C levels of exotic and domesticated fruits such as apples (5mg/100g), oranges (50) and melon 50 (Kirk and Sawyer,1991), the fruits analysed are a rich source of this vitamin. *A. digitata* and *S. birrea* can contribute substantial amounts of ascorbic acid towards the dietary needs of the consumer. Vitamin C an anti-oxidant can reduce the incidence of diseases such as cancer. The ascorbic acid content for each fruit was significantly different ($p< 0.05$).

The pH of aqueous extracts show that the edible portions of the fruits are acidic. The most acidic was *A.Digitata*. This may be responsible for the sour taste of the pulp. The pH value for the pulp of *A.digitata* , and *S. spinosa* are similar to the 3.30 and 4.01 respectively obtained by Saka *et al*. (1992). The *V.infausta* analysed by Saka *et al*. (1992) is more acidic, pH 2.18 than the samples of the same species analysed in this study. The pH value for *A.digitata* was significantly different from those of the other fruits.

A. digitata had the highest concentration of titrable acid and *S. spinosa* the lowest. The high level is consistent with the low pH and high ascorbic acid content in *A.digitata*. The level in *A.digitata* is significantly different from that of the other fruits analysed. That for *S.birrea* and *S. spinosa* are similar. The edible portions of these two fruits are not as acidic as the pulp of *A.digitata*

Nutritionally these fruits could contribute positively to the mineral intake, which is evident from the results presented in table 2. For the minerals, K was the most abundant element followed by Mg and Ca respectively. The levels of Fe and Zn were relatively low. The levels of K ranged from 1370 for *S.spinosa* to 2183 in *S.birrea*. The concentrations for *S.spinosa*, *V. infausta* and *A. digitata* are in line with the 1968.3, 1820.8 and 2836.4 mg/100 g reported by Saka *et al.* (1994). The K contents of the indigenous fruits is high in comparison with values (mg/100 g) reported for other fruits such as oranges 150, banana 400 and grapes 210 (Holland *et al*. 1997).

The highest Ca level (128) was recorded for *A. digitata* while *S.spinosa* gave the lowest (56). The level for *A.digitata* is closely related to the 115.6 obtained by Saka *et al*. (1994) but lower than the 481 obtained by Glew *et al*. (1997) for samples from Burkina Faso. Also, it is more than the 60.0 cited by Eromosele (1991). These researchers reported lower Ca values for *S.birrea* (36.2). Our values for *S.spionsa* and *V. infausta* are more than the 14.9 and 13.2 respectively recorded by Saka *et al*. (1994). Statistically the Ca values for *V.infausta* and *A.digitata* were similar. The four fruits anaysed have more Ca than banana, *Musa paradisiaca* (7.0), ripe pawpaw, *Carica papaya* (15.80), mango, *Mangifera india* (14.0) and sweet orange, *Citrus sinensis* (33), Ihekoronye and Ngoddy (1985). The fruits analysed can serve as a good source of Ca.

The Mg values ranged from 49 (*S.spionsa*) to 158 (*S.birrea*). The concentrations for A. *digitata* and *S.spinosa* are closely related to the 209 and 43 respectively reported by Saka *et al*. (1994). The data obtained for *S.birrea* is in agreement with the 140.9 reported by Smith *et al.* (1996) for species from West Africa. Eromoselo *et al*. (1991) recorded a lower value of 31.9. Also, Saka *et al*. (1994) cited a value of 181 for *V. infausta,* this is more than the figure obtained in this study. For each fruit the Mg value was significantly different. These indigenous fruits are a good source of Mg compared to the value recorded for grapes (7) and oranges (10) (Holland *et al.* 1997).

With Na the values obtained ranged from 13.0 for *S.birrea* to 21.7 for *S.spinosa*. The results obtained for *A.digitata* and *S.spinosa* compare favourably to the 25.3 and 18.8 reported by Glew *et al.* and Saka *et al.* (1994) respectively. The Na content of *S.birrea* is more than the 1.52 obtained by Glew *et al*. (1997). For *V. infausta* our value was lower than the 24.3 recorded by Saka *et al.* (1994). The Na contents of *A.digitata*, *S.birrea* and *V.infausta* were similar but different from that of *S.spinosa*. Banana and oranges have lower Na contents, 1 and 3 respectively, (Kirk and Sawyer, 1991).

The P concentrations obtained ranged from 50 in *A.digitata* to 128 for *V.infausta*. The 118 for *A. digitata* reported by FAO (1968) is more than the value obtained in this study. Our value is similar to the 45 obtained by Saka *et al*. (1994). Samples from Nigeria have a P content of 5.0, Ermosele *et al*. (1991). For *S. birrea* the value obtained in this study is more than 18 reported by Ermosele *et al*. (1991) but less than the 264 obtained by Glew *et al.* (1997*)* for samples in Bukina Faso. The 108 reported by Saka *et al*. (1994) for *S.spinosa* is more than the value obtained in this study. However for *V.infausta* our value is more than the 82.3 obtained by Saka *et al*. (1994). The P contents for *S. birrea* and *S.spinosa* were similar but significantly different from those of the other fruits. The P content of these fruits is more than that of banana (40), sweet orange (23) and ripe paw paw (7.4), Ihekoronye and Ngoddy (1985).

The Fe composition of the fruits analysed ranged from 0.07 in *S.birrea* to 0.11 in *S. spinosa*. The Fe content of *A.digitata* is similar to that of *S.spinosa* and *V infausta* respectively but significantly different from *S.birrea*. The Fe value for *A.digitata* is similar to the 1.7 and 1.2 reported by Glew *et al.* (1997) and Smith *et al*(1996) respectively but lower then the 5.8 and 7.4 cited by Saka *et al.* (1994) and FAO (1968) respectively. The Fe contents for *S.birrea* is lower that the 2.49 cited by Glew *et al.* (1997). Also lower concentrations were determined in this study compared to the. 13.6 and 28.3 respectively reported by Saka *et al.* (1994) for *S.spinosa* and *V. infausta* respectively. The Fe contents in these fruits are lower than those for banana (0.93), ripe paw paw (0.40) and sweet orange (0.40), Ihekoronye and Ngoddy (1985). These fruits will have to be supplemented with fruits of higher Fe contents in order to meet Fe requirements amongst consumers.

The Zn values were from 0.02 for *V. infausta* to 0.22 for *S. spinosa*. The data obtained for *A.digitata* and *S. birrea* were similar but different from that of the other fruits. For *A. digitata* the values obtained in this study are similar to the 1.04 and 0.64 reported by Glew *et al.* (1997) and Odetokun (1996) respectively. For *S.birrea* our value is comparable to the 0.66 obtained by Smith *et al*. (1996) but slightly more than the 0.34 obtained by Eromosele *et al.*(1991). For *S.spinosa* and *V. infausta* there were no data available for comparison. With the exception of *V. infausta*, the Zn values of the fruits analysed compare favourable with those of oranges 0.1, banana 0.2 and grapes 0.1 (Holland *et al.* 1997). The values obtained in this study compared with other studies may be due to the different environment and methods of analysis.

Conclusion: The data indicate that the best source of: ascorbic acid and Ca is *A.digitata;* K and Mg is *S.birrea*; Fe and Zn is *S.spinosa* and P and fibre *V. infausta*. The study revealed that the fruits are good sources of K and Mg compared to existing domesticated fruits. Also, the vitamin C,Ca and P contents compare favourably with those of well established exotic fruits. The consumption of these fruits may help to overcome micronutrient deficiency that are prevalent in poor urban and rural areas.

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