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Elemental Composition of the Fruits of Baboon Grape (*Rhoicissus digitata*) and Impact of Soil Quality on Chemical Characteristics

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Abstract *Rhoicissus digitata* is an indigenous medicinal plant from which fruits are consumed by the local people in South Africa. This potential source of nutrients was investigated as a food-based approach to complement fortification efforts in South Africa targeted at vulnerable groups. This study also focused on the distribution of elements (essential and toxic) in the fruits of *R. digitata* as a function of soil quality. In general, the concentration of essential elements in the fruits were found to be in decreasing order of Ca > Mg > Fe > Mn > Zn > Cu > Se > Ni > Cr > Pb > Co. The data showed that the plant controlled uptake of nutrients to meet physiological requirement levels. A comparison of the fruits elemental concentrations with recommended dietary allowances (RDAs) revealed the fruits to be rich in Se and are a good source of essential elements with low concentrations of the toxic elements studied. These findings indicate that the fruits of *R. digitata* have high nutritional value and can introduce dietary diversity and food security to marginalized and poor communities in South Africa.

Keywords: *toxicity, nutritional value, bioaccumulation, medicinal plant*

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1. Introduction

Ethnomedical practices are common in rural areas of South Africa. A major source of ethnomedicine is plant extracts that are mostly extracted in water or alcohol. Some practices also involve consumption of edible fruits, which are thought to be "good" for various ailments and diseases. Heavy metals from the environment can be absorbed and stored by medicinal plants and since their consumption by humans does not preclude the intake of these heavy metals, it can affect human health. Heavy metals are major pollutants in the environment and their toxicity is reflected in food and the environment. Reports have shown that anthropogenic sources of metals in soil are higher than natural sources [1,2]. Highly contaminated soils are commonly found in areas of high industrial activity, which does not preclude areas further away, which have also shown high levels of metal contamination due to long-range atmospheric transport [3,4].

Bioaccumulation is defined as the gradual build-up of a substance or chemical in a living organism. This occurs when the rate at which the chemical is excreted or removed is slower than the rate at which it is consumed by the organism, or when the chemical cannot be broken down or metabolized by the organism. Bioaccumulation of essential elements is needed by living organisms for metabolism and growth. Bioaccumulation of harmful compounds such as mercury can accumulate in living tissues and affect human health. Pollutants can accumulate in organisms from different sources. These include organic and inorganic pesticides, and contents of industrial smokestacks, automobile emissions and deliberate discharge of pollutants into water [5].

Species within the plant family Vitaceae (grape **family**) are commonly used in South African traditional medicine to prepare the tonic known as *isihlambezo* which is taken by pregnant women in their last trimester to promote maternal and fetal well-being and to facilitate a quick, uncomplicated labor [6]. *Rhoicissus digitata*, of the plant family Vitaceae, is a vigorous, evergreen vine that is indigenous to southern Africa. It is well known as baboon grape and dune grape (in English), isinwazi (in isiZulu) and vyfvingerdruif (in Afrikaans). It is a robust, woody climber with glossy ornamental leaves shaped like an open hand. The plant produces edible round fruits that are black with white spots when ripe and ripen from September through to December. These edible fruits are usually enjoyed by birds and children.

Traditional subsistence systems in South Africa, that is mostly practiced in rural areas, depends mostly on staples such as rice and maize however such diets need to be balanced with complementary amounts of fruits, vegetables and meat or fish. Most of these fruits and vegetables are currently harvested from the wild, while few are cultivated. Indigenous fruits and vegetables offer unique opportunities to diversify farming systems in these areas. The fruits of *R. digitata* are an indigenous, underutilized food resource with nutrient potential that can be promoted to introduce dietary diversity to these vulnerable, food-insecure households. The aim of this study was to highlight the nutritional value of the indigenous, edible fruits of *R. digitata*, which is locally available in South Africa and which can be introduced into small-scale farms in rural areas to help mitigate nutrient malnutrition in these communities. There is also a need to regulate plants used by traditional practitioners as industrial contamination of the habitats in which these plants grow can alter their heavy metal concentrations, which are inevitably passed on to the local population through use of traditional medicine. The concentrations of toxic metals in the growth soil and the plants ability to accumulate these metals also need to be monitored. To this end, soil quality parameters for soils collected from nine different sites in KwaZulu-Natal, South Africa were evaluated to determine the impact of soil quality on elemental uptake by the fruits of *R. digitata*.

2. Material and Methods

2.1. Sample Collection

The fruits of *R. digitata* and soil samples were collected from nine different beach sites in the KwaZulu-Natal east coast region during the month of September 2012. These sites were S1-Durban Beach front, S2-Uvongo, S3-Southport, S4-Port Edward, S5-Shelly Beach, S6-Hibberedene, S7-Margate, S8-Umtentweni and S9-Banana Beach (Figure 1).

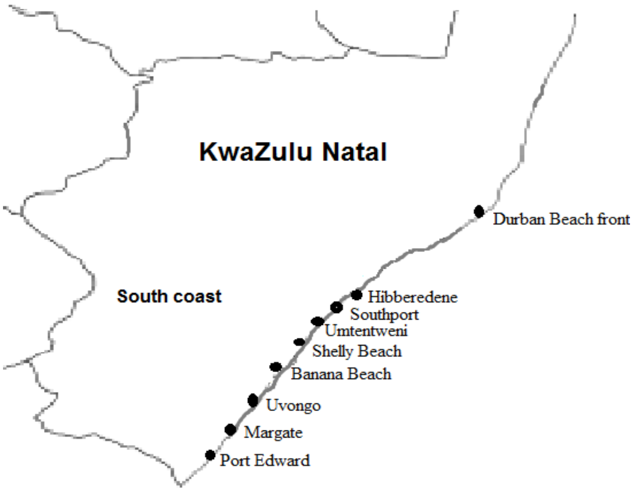

Figure 1. Map of sampling sites

The ripened fruit samples were picked from the plants and placed into plastic bottles. Samples were then dried to constant mass in an oven at 60 °C. Dried fruit samples were ground into a powder using a commercial food processor, transferred into polyethylene bags and stored in a refrigerator until analyzed. A plastic shovel was used to collect soil samples from four points around the plant at a depth of 15 cm. Collected soil samples were crushed using a mortar and pestle then passed through a 0.5 mm mesh sieve to eliminate the gravel and large particles to achieve homogeneity and get a composite soil sample. Soil samples were air dried to constant mass, stored in polyethylene bags and kept in a refrigerator until analyzed.

2.2. Reagents and Standards

All chemicals and reagents used were obtained from Merck (New Jersey, USA) and Sigma Aldrich (St Louis, Missouri, USA) and were of analytical grade. Double distilled water was used throughout the experiments. Working elemental standards for calibrations were prepared from spectroscopic grade stock standard solutions (1000 mg L^{-1}). Glassware and other equipment were cleaned with 6.0 M HNO_3 and rinsed off using double distilled water to avoid contamination.

2.3. Extraction of Bioavailable Metals

A combination of chemical extracts including ammonium acetate ($NH_4CO_2CH_3$, 38.542 g), 25 mL of 96% acetic acid (CH_3COOH) and ethylenediaminetetraacetic acid (EDTA, 37.225 g) were prepared in a 1 L volumetric flask and used to extract available metals from soil samples. Approximately 5 g of dry soil sample was mixed with 50 mL of the extractant solution in a 250 mL polyethylene bottle and shaken in a laboratory shaker for 2 hr. The resultant mixture was filtered through a Millipore filter membrane (pore diameter 0.45 μm, membrane type HVLP) to permit the determination of the extracted elements.

2.4. Digestion of Samples

The microwave-assisted closed vessel digestion technique was used for digestion of the certified reference material (CRM), fruit and soil samples. Digestions were performed using the CEM MARS 6 (CEM Corporation, USA) microwave reaction system with patented Xpress technology. Four replicates of each sample (both soil and fruit) were digested for accuracy. The CRM and fruit samples were accurately weighed (0.5 g) into 24 × 50 mL liners, to which 10 mL of 70% HNO_3 was added. For digestion of soil, 0.25 g was weighed accurately into the liners, to which 10 mL of 70% HNO_3 was added. Samples were allowed to pre-digest for 30 min before being digested by microwave. For the CRM and fruit samples, the power was set at 100% at 1600 W and the temperature ramped to 100 °C (ramp time 15 min), where it was held for 15 min. For the soil samples, the power was set at 100% at 1600W and the temperature ramped to 200 °C (ramp time 15 min), where it was held for 15 min. In both cases, the microwave power was reduced and the bombs cooled by forced ventilation for 15 min. Fruit and soil digests were transferred to 50 mL volumetric flasks, made to concentration with double distilled water and stored in polyethylene bottles in the refrigerator for elemental analysis.

2.5. Elemental Analysis

The quality, accuracy and reproducibility of elemental determinations was ensured by use of the CRM, *lyophilized brown bread* - BCR 191, from the Community Bureau of Reference of the Commission of the European Communities. The CRM was chosen to match the matrix and composition of the fruit samples.

All plant and soil digests and soil extracts were analyzed for the following elements (wavelengths): As (188.979 nm), Ca (315.887 nm), Cd (214.440 nm), Co (230.786 nm), Cr (205.560 nm), Cu (327.393 nm), Fe (238.204 nm), Mg (280.271 nm), Mn (259.372 nm), Ni

(231.604 nm), Pb (220.353 nm), Se (196.026 nm) and Zn (206.200 nm) using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) (Perkin Elmer Optima 5000 DV) due to its multi-element determination capability, high dynamic linear range and sensitivity. Working standards were prepared using double distilled water and 10 mL of 70% HNO_3 to match the matrix of the samples. Analytical wavelengths were selected based on minimum spectral interferences and maximum analytical performance.

2.6. Determination of Soil Parameters

The pH of the soil was determined using a 1:1 ratio of diluted $CaCl_2$ to soil. Soil organic matter (SOM) was determined by the Walkley Black method [7]. The cation exchange capacity (CEC) was determined by the Chapman method [8].

2.7. Bioaccumulation Factor (BAF)

Bioaccumulation is described as the ratio of the metal concentration in the plant to that in the soil. The bioaccumulation factor (BAF) can be calculated using Equation 1.

$$BAF = \frac{Cplant}{Csoil} \quad (1)$$

Where C_{plant} and C_{soil} represent the concentration of the metal in the plant and soil respectively [9]. BAF is categorized further as hyper-accumulators, accumulators and excluders. Hyper-accumulators have BAFs greater than one, sometimes reaching 50-100 [10].

3. Results and Discussion

3.1. Elemental Analysis

The results obtained for the metal content of the fruit samples from different sites were verified using the CRM, *lyophilized brown bread* -BCR 191. The values obtained for the CRM (n=4, p=0.05) (expressed in $\mu g\ g^{-1}$) were 2.6 ± 0.1, 39.3 ± 0.1, 20.1 ± 0.2 and 19.2 ± 0.5 for Cu, Fe, Mn and Zn, respectively; compared to their corresponding certified values 2.6 ± 0.1, 40.7 ± 2.3, 20.3 ± 0.7 and 19.5 ± 0.7. Recorded values for Ca and Mg (expressed in $mg\ g^{-1}$) were 0.45 ± 0.05 and 0.48 ± 0.03, which compared well to indicative values of 0.41 and 0.50, respectively.

Table 1. Concentrations and bioaccumulation factors (BAFs) of micro-elements in fruit and soil samples in $\mu g\ g^{-1}$ from nine sites[a] (T=Total and B=Bioavailable)

Sites		Concentration ($\mu g\ g^{-1}$)			BAF		[Soil]B/[Soil]T
		Fruit	Soil (T)	Soil (B)	[Fruit]/[Soil]T	[Fruit]/[Soil]B	%
S 1	Cu	16.53(0.1)[b]	18.92(0.1)	14.06(0.1)	0.9	1.2	74.2
S 2		24.18(0.1)	1.45(0.1)	0.24(0.1)	17.3	101.8	17.0
S 3		8.50(0.1)	4.44(0.1)	0.34(0.1)	1.9	25.2	7.7
S 4		12.00(0.1)	6.57(0.1)	4.41(0.1)	1.9	2.7	68.4
S 5		6.63(0.1)	1.79(0.1)	ND	-	-	-
S 6		8.63(0.1)	5.53(0.1)	3.88(0.1)	1.6	2.2	70.5
S 7		13.35(0.1)	5.36(0.1)	3.48(0.1)	2.5	3.8	65.8
S 8		13.60(0.1)	4.92(0.1)	2.51(0.1)	2.8	5.4	51.8
S 9		7.10(0.1)	2.19(0.1)	0.28(0.1)	3.5	25.8	13.4
S 1	Fe	121.9(0.1)	5597.0(2.2)	346.6(0.2)	0.0	0.4	6.2
S 2		77.4(0.1)	2169.9(0.9)	75.5(0.1)	0.0	1.0	3.5
S 3		98.6(0.2)	2200.0(0.5)	62.8(0.1)	0.1	1.6	2.9
S 4		68.4(0.1)	4395.0(0.4)	95.7(0.1)	0.0	0.7	2.2
S 5		56.8(0.1)	2166.0(0.7)	83.3(0.1)	0.0	0.7	3.8
S 6		61.7(0.1)	5132.5(1.0)	105.2(0.1)	0.0	0.6	2.1
S 7		48.7(0.1)	3337.5(0.9)	88.8(0.1)	0.0	0.5	2.7
S 8		60.8(0.1)	4247.5(0.2)	83.7(0.1)	0.0	0.7	2.0
S 9		64.1(0.2)	2500.5(1.0)	65.7(0.1)	0.0	1.0	2.6
S 1	Mn	30.05(0.1)	92.92(0.1)	47.73(0.1)	0.3	0.6	51.4
S 2		89.73(0.1)	30.85(0.1)	12.05(0.1)	2.9	7.4	39.2
S 3		42.95(0.1)	28.34(0.1)	9.51(0.1)	1.5	4.5	33.7
S 4		17.55(0.1)	70.98(0.1)	10.56(0.1)	0.2	1.7	14.9
S 5		30.22(0.1)	34.31(0.1)	11.76(0.1)	0.9	2.6	34.3
S 6		24.50(0.1)	63.26(0.1)	23.77(0.1)	0.4	1.0	37.6
S 7		16.73(0.1)	54.94(0.1)	15.66(0.1)	0.3	1.1	28.5
S 8		17.90(0.1)	55.89(0.1)	18.73(0.1)	0.3	1.0	33.6
S 9		21.03(0.1)	34.77(0.1)	12.90(0.1)	0.6	1.6	37.2
S 1	Se	5.75(0.1)	5.62(0.1)	4.30(0.1)	1.0	1.3	77.5
S 2		5.38(0.1)	5.78(0.1)	4.55(0.1)	0.9	1.2	79.8
S 3		4.10(0.1)	4.96(0.1)	4.34(0.1)	0.8	0.9	86.9
S 4		5.08(0.1)	5.53(0.1)	4.43(0.1)	0.9	1.1	81.2
S 5		4.37(0.1)	6.97(0.1)	4.89(0.1)	0.6	0.9	71.4
S 6		5.68(0.1)	5.61(0.1)	4.88(0.1)	1.0	1.2	87.1
S 7		4.73(0.1)	5.49(0.1)	4.51(0.1)	0.9	1.0	83.6
S 8		4.63(0.1)	6.75(0.1)	4.74(0.1)	0.7	1.0	71.2
S 9		4.95(0.1)	6.21(0.1)	4.94(0.1)	0.8	1.0	79.6
S 1	Zn	33.63(0.1)	23.72(0.1)	7.91(0.1)	1.4	4.2	33.4
S 2		36.53(0.1)	10.55(0.1)	1.94(0.1)	3.5	18.9	18.5
S 3		28.10(0.1)	10.93(0.1)	3.81(0.1)	2.6	7.4	35.1
S 4		13.88(0.1)	25.72(0.1)	0.93(0.1)	0.5	15.3	3.6
S 5		16.15(0.1)	13.97(0.1)	4.05(0.1)	1.2	4.0	29.2
S 6		16.78(0.1)	12.44(0.1)	5.96(0.1)	1.4	2.8	48.1
S 7		17.55(0.1)	9.39(0.1)	2.13(0.1)	1.9	8.3	22.8
S 8		16.47(0.1)	10.54(0.1)	4.50(0.1)	1.6	3.7	42.9
S 9		16.05(0.1)	8.27(0.1)	5.10(0.1)	2.0	3.1	62.2

[a] Sites - S1-Durban Beach front, S2-Uvongo, S3-Southport, S4-Port Edward, S5-Shelly Beach, S6-Hibberedene, S7-Margate, S8-Umtentweni, S9-Banana Beach
[b] – Concentration represented as mean (standard deviation), n=4.

The elemental concentrations for micro-elements (Cu, Fe, Mn, Se and Zn) and macro-elements (Ca and Mg) in fruit and soil samples and BAFs in the fruits of *R. digitata* are presented in Table 1. If present, Co and Pb in all fruit samples were below the instrument detection limit (Co – 0.25 ppb and Pb – 1.40 ppb). Lead is a known toxic element found in soil that affects plant growth, morphology and photosynthesis. Excessive amounts of Co in plants affect shoot growth and biomass, and inhibit the translocation of P, S, Mn, Zn and Cu from roots to shoots [11]. Total soil Co and Pb were found in small quantities, ranging from 0.78 to 2.41 μg g^{-1} and 6.0 to 14.6 μg g^{-1} in soil, respectively.

Iron was the micronutrient found in highest concentrations in the fruit, ranging from 48.7 μg g^{-1} (S7) to 121.9 μg g^{-1} (S1). Total soil Fe was found to be highest (5597 μg g^{-1}) at S1; 6.2% of this concentration was in available form and only 35% was taken up by the plant. Generally, only 2.0 to 6.2% of total soil Fe was in available form and most available Fe was taken up by the plant giving an average BAF of 0.74. Iron is an important essential element to plants and is involved in biological activities such as photosynthesis, chloroplast development and chlorophyll biosynthesis. Iron deficiency in plants results in retarded growth and renders them more susceptible to diseases.

In most cases, the concentration of Mn was found to be higher in the plants than Zn. Total soil Mn ranged from 28.3 to 92.9 μg g^{-1} which is comparable to the range for typical uncontaminated soils (100 to 4000 ppm) [2]. Excessive amounts of Mn in the leaves can cause a reduction in the photosynthetic rate and apoplastic deposition of oxidized Mn and phenolics [12]. Total soil Zn ranged from 8.2 to 25.7 μg g^{-1} which is comparable to the range for typical uncontaminated soils (10 to 300 ppm) [2]. Zinc is essential to plant growth but in excessive amounts it can lead to decreased growth, development and metabolism and induction of oxidative damage [2]. The plant appeared to accumulate Zn with BAFs being greater than 1 in most cases.

Copper concentrations in the fruit ranged from 6.6 to 24.2 μg g^{-1}. Total soil Cu ranged from 1.5 to 18.9 μg g^{-1} indicating high BAFs (>4). Selenium concentrations in the fruit ranged from 4.1 to 5.8 μg g^{-1} with fruit concentrations being more closely related to total soil Se. Nickel concentrations in the fruit ranged from 0.80 to 8.23 μg g^{-1}. Chromium in the fruits was found in relatively low concentrations compared to the other micronutrients, ranging from 0.48 μg g^{-1} to 0.88 μg g^{-1}.

Table 2. Concentrations and bioaccumulation factors (BAFs) of macro-elements in fruit and soil samples in μg g^{-1} from nine sites[a] (T=Total and B=Bioavailable)

Sites		Concentration (μg g^{-1})			BAF		[Soil]B/[Soil]T
		Fruit	Soil (T)	Soil (B)	[Fruit]/[Soil]T	[Fruit]/[Soil]B	%
S 1	Ca	26497(13)	21401(5.9)	19608(7.4)	1.2	1.4	91.6
S 2		18762(15)	30010(4.4)	27561(11)	0.6	0.7	91.8
S 3		27305(18)	7102(1.9)	6628(2.1)	3.8	4.1	93.3
S 4		22662(6.1)	17860(1.8)	16491(21)	1.3	1.4	92.3
S 5		16032(2.1)	18964(3.6)	17911(2.9)	0.9	0.9	94.4
S 6		17825(9.3)	19761(1.1)	18700(7.6)	0.9	1	94.6
S 7		21338(4.1)	22915(6.0)	18958(12)	0.9	1.1	82.7
S 8		13378(2.7)	21720(2.4)	20136(12)	0.6	0.7	92.7
S 9		14305(2.6)	11020(5.5)	10686(5.9)	1.3	1.3	97.0
S 1	Mg	6243(2.3)	2426(1.0)	1529(0.9)	2.6	4.1	63.0
S 2		8549(5.9)	1424(0.1)	1151(0.9)	6.0	7.4	80.8
S 3		5819(3.8)	515(0.1)	321(0.2)	11.3	18.1	62.3
S 4		4134(1.0)	1994(0.4)	520(0.4)	2.1	7.9	26.1
S 5		4726(0.5)	991(0.3)	873(0.6)	4.8	5.4	88.1
S 6		4219(0.7)	1335(0.4)	1021(0.5)	3.2	4.1	76.5
S 7		3878(0.5)	1388(0.5)	996(0.6)	2.8	3.9	71.7
S 8		3642(1.0)	1342(0.2)	939(0.4)	2.7	3.9	69.9
S 9		4063(1.0)	811(0.3)	655(0.3)	5.0	6.2	80.8

[a] Sites - S1-Durban Beach front, S2-Uvongo, S3-Southport, S4-Port Edward, S5-Shelly Beach, S6-Hibberedene, S7-Margate, S8-Umtentweni, S9-Banana Beach

[b] – Concentration represented as mean (standard deviation), n=4.

Calcium was the macronutrient in the fruit found in highest concentrations (13378 μg g^{-1} to 27305 μg g^{-1}) (Table 2). Total soil Ca ranged from 7102 to 22915 μg g^{-1} with most Ca in the soil being in available form (>83%). Magnesium in the fruit ranged from 3642 μg g^{-1} to 8549 μg g^{-1} (Table 2). On averge, 69% of Mg in the soil was in available form and a high amount was accumulated by the plant producing high BAFs (3.9 to 18.1). Table 2 shows higher accumulation of Mg compared to Ca in the fruits of *R. digitata*. In general, the concentration of the essential elements in the fruits of *R. digitata* were found to be in decreasing order of Ca > Mg > Fe > Mn > Zn > Cu > Se > Ni > Cr > Pb > Co.

3.2. Bioaccumulation factors (BAFs)

The BAF provides crucial information on absorption and transportation of essential elements and strongly affects the production and growth of the plant [13]. A plot of the BAF as a function of soil content indicates essentiality of an element if a rectangular hyperbola is observed for that element and non-essentiality if a linear plot parallel to the x-axis is observed [14]. Figure 2 shows the representative plots of BAFs versus soil concentrations (total and biavailable) for the macronutrient Ca and the micronutrient Mn. This shape was observed for all essential nutrients studied. The shape of the graph points to essentiality of nutrients (both micro and macro) which indicates accumulation by the plant when concentrations in the soil are below physiological requirement levels and exclusion when concentrations are above physiological requirement levels.

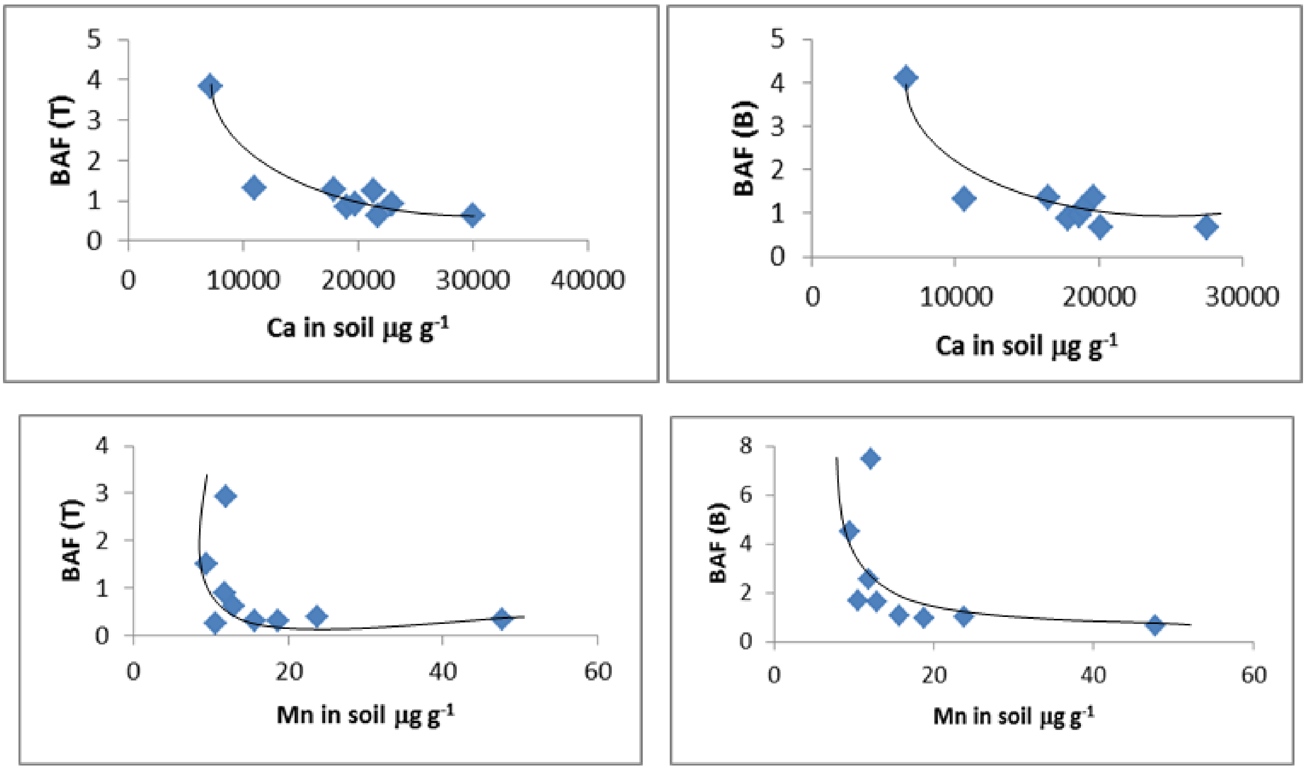

Figure 2. Graph of bioaccumulation factors (BAFs) versus concentration of Ca and Mn in the soil (Total (T) and bioavailable (B))

3.3. Contribution to the Diet

The ripe fruit of *R. digitata* have a tart-like taste and are picked and eaten by the local people in South Africa or used to make home-made jams. Due to the consumption of the fruits, their elemental concentrations were compared to dietary reference intakes (DRIs). The data is presented in Table 3. The results show that consumption of 20 g (average daily intake of *R. digitata* fruits) will contribute more than 36%, 31%, 30% and 28% for Cr, Mg, Ca and Cu, respectively, towards the RDA in most adults.

Selenium in 20 g of *R. digitata* fruit (0.10 mg, dry mass) contributes 180% towards the RDA (0.055 mg/day) for this element. However, this contribution is within the UL for Se (0.4 mg/day) and therefore consumption of *R. digitata* fruit will not pose the risk of adverse health effects due to Se toxicity. Food has been proven to be a preferable source of Se compared to ordinary supplements, because it is less expensive, has low risk of toxicity and is sustainable [16]. A study on the efficacy of Brazil nuts compared to selomethionine supplements was conducted on fifty-nine New Zealand residents with low blood Se levels. The study showed that consumption of two Brazil nuts per day is more effective than selenomethionine supplements to increase plasma Se and enhance GPx activity [17]. Similarly, consumption of *R. digitata* fruits in South Africa can serve as an alternative to selenomethionine supplements, especially to the rural population, who do not have access to nutritional supplements. In South Africa, many households rely on natural sources of food and information on the nutritive value of indigenous edible wild foods is vital [18,19].

Table 3. Dietary Reference Intake (Recommended Dietary Allowance (RDA) and Tolerable Upper Intake Level (UL)) of each element for most individuals – compared to average concentration of elements in fruits

Element	Average concentration[c] (mg/20 g dry mass)	DRI[a] (mg/day) RDA	UL	Estimated contribution to the RDA (%)
Ca	395.8	1000-1300	2500	30
Cr	0.012	0.024-0.035	ND	36
Cu	0.25	0.9	8	28
Fe	1.46	8-18	45	8
Mg	100.6	310-320	350	31
Mn	0.65	1.6-2.3	9	28
Ni	0.073	ND[b]	1	ND
Se	0.10	0.055	0.4	180
Zn	0.43	8-11	34	4

[a] DRI - Dietary Reference Intake [15],
[b] ND - not determinable,
[c] Average concentration – Mean, n = 4.

4. Conclusion

The nutritional value of the indigenous, edible fruits of *R. digitata* and impact of soil quality parameters on elemental uptake by the fruits was evaluated. In general, the concentration of the essential elements in the fruits were found to be in decreasing order of Ca > Mg > Fe > Mn > Zn > Cu > Se > Ni > Cr > Pb > Co. The data showed that the plant controlled uptake of nutrients to meet physiological requirement levels and contained low concentrations of toxic elements. A comparison of elemental concentrations in the fruits to RDAs indicated that the fruits were rich in Se and was a good source of other essential elements as well. These findings indicate that the fruits of *R. digitata* have high nutritional value and can introduce dietary diversity and food security to marginalized and poor communities in South Africa. Inclusion of these fruits to the diet of the local population can therefore be considered beneficial and as such, its utilization needs to be explored and opportunities in production areas and consumption need to be exploited.

Conflict of Interest

The authors declare that there is no conflict of interest.

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