

Availability of Hazardous Minerals and Macronutrients in Various Foods from Sudan

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ABSTRACT

In addition to the toxic minerals (Be, Ba, Cd, Cr, Al, Pb, As, Sb, Sn, and Sr), this study measured the availability of the macronutrients (Na, K, Mg, Ca, and P) in various traditional Sudanese cuisines. A total of fifteen distinct food species' samples were gathered from Khartoum State's local marketplaces. Roselle, Tamarindo, Baobab, Doum, Grewia tenax, Cowpeas, Gondaila Dates, Lupine, Cajanuscajan, Millet, Wheat, and three distinct varieties of Sorghum were among the samples (fetarita, abahmed and tabat). The concentrations of the minerals were measured using inductively coupled plasma spectroscopy (ICP). The concentrations, which ranged from extremely low to noticeably high, were discovered to be different in the tested species. Between Gondaila date (0.1441 ppm) and Roselle (220 ppm), sodium concentrations were found. Sorghum (fetarita) had a potassium range of 4,295 ppm while Doum had a range of 27,648 ppm. From 13.51ppm in Cowpeas to 3,245ppm in Roselle, the magnesium concentration varied. The calcium content of lupines ranged from 1,966.24ppm to (0.1999ppm) in sorghum (Abahmed). Baobab had the lowest phosphorus level (638.5 ppm), while Cajanuscajan had the highest (3,639ppm). All of the samples that were tested included trace levels of the minerals (Be, Cd, Cr, As, Pb, Sr, and Sn). Roselle had a comparatively high concentration of barium (Ba) and strontium (Sr) (30.34 and 74.35ppm respectively).

KEYWORDS: cereal grains, macronutrients, ICP, baobab, grewia tenax, undesired minerals

INTRODUCTION

Sudanese people eat a variety of foods with plant origins, including as fruits, vegetables, and cereal grains. The majority of Sudanese rely on wheat, millet, and several varieties of sorghum for their daily meals. Dates, cowpeas, chick peas, lupines, baobab fruit pulp, tamarind fruit pulp, doum fruit pulp, grewia tenax, and Roselle are some common foods that both children and adults commonly eat. Several of these fruits are made into juice or used to make tea. Depending on how they are consumed, the three types of species under investigation can be divided.

➤ Cereal grains

The three main cereal grains consumed in Sudan are sorghum, wheat, and millet. Sorghum was said to be abundant in minerals, ranging from greater levels of salt and potassium to as little as 1% iron in some forms. Sorghum includes Mg (75.02 mg/100 g), Ca (3.75 mg/100 g), Fe (2.24 mg/100 g), and P (100.6 mg/100 g), according to Noha A. Mohammed et al. (2011) [14]. Two Sudan esesorghum cultivars, fetarita and dabar, were examined by Amir et al. (2015) [3]. Fetarita cultivar revealed Na content as (5.98mg/100g), K(247.23mg/100g), Ca (2.73mg/100g), and Fe (14.54mg/100g). The Na level was 4.83 mg/100 g, K was 307.51 mg/100 g, Ca was 3.33 mg/100 g, and Fe was 11.32 mg/100 g in the other cultivar (dabar). Mineral content of sorghum was reported as Ca(168 mg/kg), K(3,330 mg/kg), Zn(30 mg/kg), Mn(16 mg/kg), Fe(45 mg/kg), Sr(1.2 mg/kg), Ni(0.90 mg/kg), and Cu(4.0 mg/kg) by A. Mubark Ebrahim et al. (2014) [5]. Mineral concentration ranges in millet samples were reported by Shimelis A. et al. (2009) [22] as Ca (50.66 to 319 mg/100g), Mg (78.0 to 201 mg/100g), Fe (4.59

to 53.39 mg/100g), P (3.46 to 147 mg/100g), and Mn(17.61 to 48.43 mg/100g). Mineral content of millet was determined by A. Mubark E. et al. (2014) to be Ca(219 mg/kg), K(4,995 mg/kg), Zn(34 mg/kg), Mn(13 mg/kg), Fe(138 mg/kg), Sr(1.8 mg/kg), Ni(1.2 mg/kg), and Cu(6.4 mg/kg). According to A. Mubark et al study's from 2014, wheat has the following amounts of minerals: Ca (561 mg/kg), K (5895 mg/kg), Zn (31 mg/kg), Mn (20 mg/kg), Fe (77 mg/kg), Cu (3 mg/kg), and Sr (3.4 mg/kg). Sorghum, millet, and wheat produced in the Jebel Marra region have considerably high quantities of iron, magnesium, zinc, and copper, according to Abdelmoneim A. Mohamed (2001) [2].

➤ Roselle and forest fruits (baobab, tamarindus, doum, grewatenax)

All of these fruits, save Roselle, grow wild in Sudan. In Sudanese households, roselle is frequently drunk as juice or hot tea. Children and adults utilise baobab, tamarindus, grewia tenax, and doum to make juice or consume them straight. Roselle was discovered to be extremely high in K (24,138ppm), Mg (3,790ppm), Ca (1,311ppm), P (1,238ppm), and Na, according to Rahma Ismael et al (2016) [16]. (93.92 ppm). Rahma's investigation also revealed that the hazardous minerals Ba (63.53 ppm), Al (369 ppm), and Sr were present in quite high amounts in Roselle (99.82ppm). In three ecotypes of Roselle from Niger, Sanossi et al. (2013) [20] described high availability of Fe (197 to 1,580 g/g), Mn (11 to 924 g/g), Cu (49 to 73 g/g), and Zn (37 to 43 g/g). According to reports, the pulp from baobab trees has high levels of K (17,406 ppm), Ca (2,282 ppm), Mg (1,707 ppm), P (537.3 ppm), and Fe (939.5 ppm) (Esra Ezeldeen

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M.O., 2018). Baobab fruit pulp may be regarded as a naturally organic, dry food that is high in fibre, potassium, calcium, magnesium, iron, and zinc, according to Muthai K.U. et al. (2017). Baobab fruit pulp revealed significant quantities of K (1240 mg/100 g), Ca (295 mg/100 g), Mg (90 mg/100 g), Na (27.9 mg/100 g), and Fe (9.3 mg/100 g) in a research conducted by Osman M.A. (2004) [4]. Rahma Ismaeil et al. (2016) [16] revealed that tamarind fruit pulp included unusually high quantities of the undesirable minerals Al(566.8ppm) and Ba, as well as K(9,512ppm), Ca(1,956ppm), Mg(965.8ppm), P(913.2ppm), and Na(52.95ppm) (16.14ppm). According to Safia Atuhami et al. (2016), tamarind fruit pulp is an excellent source of K, Na, Ca, P, and Fe. Mineral concentrations of tamarind pulp extract were reported by Gali Adamu et al. in 2016 [8] as K (187.73mg/100g), Na (112.76mg/100g), Ca (21.57mg/100g), Mg (10.54mg/100g), Fe (1.05mg/100g), and Mn (0.13mg/100g). Tamarind pulp minerals were found to contain K (12,000 mg/kg), Ca (1,310 mg/kg), Zn (9.0 mg/kg), Mn (8.0 mg/kg), Fe (96 mg/kg), Cu (7.0 mg/kg), Sr (13.7 mg/kg), Ni (1.3 mg/kg), Co (0.5 mg/kg), and Cr (0.5 mg/kg), according to A. Mubark et al. (2014). One of the well-known and widely-distributed plants in Sudan is the doum palm (*Hyphaenethebaica*), whose fruit pulp is widely consumed by kids as a favourite snack. Doum fruit was deemed a rich source of K (2,947.6 mg/100 g), Ca (284 mg/100 g), Na (364.7 mg/100 g), Mg (185.62 mg/100 g), P (154.6 mg/100 g), and Fe (12.18 mg/100 g) by Waleed Abushora (2004). Sara O. Mamoon (2017) used XRF to test the doum fruit pulp powder and found that K (26,600ppm), Ca (3,730ppm), Fe (59.6ppm), Cu (11.63ppm), and Zn had considerably high quantities (5.49ppm).

➤ Garden crops (Gondaila date, Chick peas, lupines, Cajanuscajan and Cowpeas)

These are commercial crops in Sudan. Whereas the other four crops are legumes, the gondaila date is a tree fruit. Five different date cultivars, including gondaila, were examined by Abdelmoneim E. Suliman et al. in 2012 [2]. The mineral content values for the gondaila cultivar were Ca (59.09ppm), P (16.201ppm), Zn (0.46ppm), and Mn (0.36ppm). Mineral content ranges in three distinct date fruits were reported by Sultana P. et al. (2015) [18] as K (460 to 680mg%), Ca (51 to 60mg%), P (52 to 60mg%), Mg (48 to 53mg%), Fe(0.79 to 0.9mg%), Mn(0.85 to 1.1mg%), Zn (0.69 to 0.72mg%), Cu (0.32 to 36mg%), Cr (0.36 to 42mg %) and Se (0.22 to 0.31mg %). According to Taylor C. Wallace et al. (2016) [24], chickpeas are said to be high in potassium, sodium, magnesium, calcium, phosphorus, iron, manganese, copper, zinc, and selenium. According to Abdel moneim A. Mohamed (2001), lupines contain the following minerals in varying amounts: Fe (160 ppm), Mn (143.18 ppm), Zn (9.39 ppm), Cu (3.38 ppm), Cr (0.18 ppm), and Co. (0.52ppm). The chemical composition of lupines in Ethiopia was revealed by Tizazu H.I. and S. A. Emire (2010) [25] as P (248.9mg/100g), Fe (12.5mg/100g), Zn (4.68mg/100g), Ca(82.56mg/100g), Protein (40.22 g/100g), crude fat(8.92 g/100g), total carbohydrates(47.73 g/100g), crude fiber(10.08 g/100g), and crude ash (3.15 g/100g). On the semi-arid West African savannah, the cowpea, a crucial tropical legume crop with

African roots, has become an essential component of the traditional cropping system (Steele1972). According to M. Harmankaya et al. (2016) [12], cowpea is a viable substitute for meat and fish protein. Cowpeas, according to Sert and Ceyhan (2012), are a rich source of K, P, Ca, S, Mg, Fe, and Zn. Cowpeas are eaten in Sudan as dried grains, fresh seeds, fresh pods, and green leaves. Among 30 cowpea cultivars, I.K. Asante et al. (2007) [10] reported the greatest mineral concentrations as K (19,050 g/g), Ca (2,096 g/g), Mg (5,170 g/g), Na (192 g/g), and Cu (12.3 g/g). (2016) [12] M. Harmankaya et al. Three cowpea genotypes' chemical composition was determined, with protein content ranging from 27.6 to 30.1%, carbohydrates from 56.3 to 60%, fat content from 2.0 to 2.3 %, ash from 3.8 to 4.2 %, moisture from 5.9 to 7.2%, and mineral content mean values from K (114.6 mg/100g), Ca (95 mg/100g), Mg (209.3 mg/100g), P (556.7 mg/100g), Fe (5.8 mg/100g)

METHODOLOGY

At Khartoum State marketplaces, random food samples from 15 different types of Sudan were taken (Sudan). The samples comprised Gondaila dates, Roselle, Tamarindo, Baobab, Doum, Lupine, Cajanuscajan, Cowpeas, Millet, Wheat, and three distinct Sorghum cultivars (Feterita, Abahmed and Tabat). The minerals included in the food samples under investigation were determined using inductively coupled plasma mass spectrometry (ICP-MS - PQ9000). Analytical-grade chemicals were utilised throughout.

RESULTS

Table 1: Macronutrients content of cereal grains samples (ppm)

Mineral	Cereal grain				
	Fetarita	Abahmed	Tabat	Millet	Wheat
Na	0.4991	11.67	24.86	53.76	58.49
K	4,295	4,563	4,375	5,882	4,587
Mg	1,595	1,244	1,217	1,508	1,300
Ca	34.44	0.01999	11.70	235.8	462.2
P	3,164	2,574	2,260	3,571	2,667

The number of macronutrients in cereal grains was shown to be rather high (table1). The three samples of sorghum had dramatically varied amounts of sodium and calcium. Fetarita has the least amount of sodium (0.4991ppm), followed by Abahmed (11.67ppm), and Tabat (0.4991ppm) (24.86ppm). Reduced sodium content in meals may be a positive thing as excessive sodium content is one of the variables that might raise blood pressure. Wheat and millet have nearly identical salt contents (53.76 and 58.49ppm respectively). The five samples of cereal grains were notably high in K, P, and Mg. The sorghum varieties have the lowest levels of calcium (34.44, 0.01999 and 11.70 ppm). Calcium concentrations were considerably high in millet and wheat. The amounts of macronutrients found in this study are consistent with those discovered by Noha A. Mohammed, et al. (2011) [14] and Shimelis Admassu, et al. (2009) [22]. According to A. Mubark Ebrahim et al. (2014) [5], potassium levels in sorghum, millet, and wheat were 3,330 mg/kg, 4,595 mg/kg, and 5,895 mg/kg, respectively. According to A. Mubark et al study, 's the concentrations of calcium were (168mg/kg) in sorghum, (219mg/kg) in millet, and (561mg/kg) in wheat.

Table 2: The toxic minerals content of cereal grains (ppm)

Mineral	cereal grain				
	Fetarita	Abahmed	Tabat	Millet	Wheat
Be	0.0100	0.0100	0.0100	0.0100	0.0100
Sr	1.208	1.419	1.369	1.380	5.601
Ba	0.3793	0.1999	0.1899	0.320	2.845
Cr	0.0599	0.1099	0.0900	0.930	0.190
Cd	$<198 \times 10^{-7}$	$<198 \times 10^{-7}$	$<198 \times 10^{-7}$	$<198 \times 10^{-7}$	$<2547 \times 10^{-7}$
Al	1.817	5.007	6.098	35.72	23.53
Sn	0.7187	0.6896	0.5998	0.350	0.6190
Pb	$<4727 \times 10^{-7}$	$<4727 \times 10^{-7}$	$<4727 \times 10^{-7}$	$<4727 \times 10^{-7}$	$<4727 \times 10^{-7}$
As	$<2547 \times 10^{-7}$	$<2547 \times 10^{-7}$	$<2547 \times 10^{-7}$	0.020	$<2547 \times 10^{-7}$
Sb	$<6078 \times 10^{-7}$	$<6078 \times 10^{-7}$	$<6078 \times 10^{-7}$	$<6078 \times 10^{-7}$	$<6078 \times 10^{-7}$

Table 3: Macronutrients content in garden crops (ppm)

Mineral	Crop type					
	Roselle	Cajanuscajan	Lupines	Gondila Date	Cowpeas	Chick peas
Na	220.9	35.9228	28.19	<0.01421	22.23	108.0
K	22,112	17,414	6,931	9,628	12,343	10,275
Mg	3,245	1,302	1,370	728.7	1,351	1,437
Ca	16,436	1,004	1966.241	1,041	689.14	1,152
P	1,606	3,639	2,909	777.6	2,864	2,466

Table 4: Toxic minerals content of garden crops (ppm)

Mineral	Crop type					
	Roselle	Cajanuscajan	Lupines	Gondila Date	Cowpeas	Chickpeas
Be	0.0200	$<3 \times 10^{-5}$	0.0100	$<3 \times 10^{-5}$	0.0100	0.0100
Sr	74.35	7.169	7.851	2.537	7.111	11.98
Ba	30.34	0.7499	7.131	0.3895	0.9688	1.270
Cr	2.067	0.0100	3.416	0.320	$<583 \times 10^{-4}$	0.0300
Cd	0.0499	198×10^{-7}	198×10^{-7}	198×10^{-7}	198×10^{-7}	198×10^{-7}
Al	223.7	$<333 \times 10^{-7}$	26.34	11.32	<0.002547	$<333 \times 10^{-7}$
Sn	0.2796	0.9498	2.497	0.6193	1.019	0.9098
Pb	$<4727 \times 10^{-7}$	$<4727 \times 10^{-7}$	0.3296	0.0400	$<4727 \times 10^{-7}$	$<4727 \times 10^{-7}$
As	$<2547 \times 10^{-7}$	$<2547 \times 10^{-7}$	$<2547 \times 10^{-7}$	$<2547 \times 10^{-7}$	$<2547 \times 10^{-7}$	$<2547 \times 10^{-7}$
Sb	<0.006078	0.1000	0.0899	0.0899	0.1298	0.0500

Table 5: Macronutrients content of forest fruits (ppm)

Mineral	Fruit			
	Baobab	Tamarindous	Grewiatenax	Doum
Na	122.3	76.33	69.59	151.3
K	16,081	11,434	9,410	27,648
Mg	1,370	1,208	1,225	1,260
Ca	2,629	1,767	5,412	851.4
P	638.5	902.3	1,103	1,111

CONCLUSION

All of the food kinds examined were shown to be abundant suppliers of the macronutrients Na, K, Mg, Ca, and P. If Sudanese consume these food items, they might not require any dietary supplements for minerals. In general, the quantities of undesirable minerals—those that are hazardous, poisonous, or carcinogenic—were quite low. Thus, it is possible to classify the investigated food categories as safe and nearly devoid of any unfavourable inorganic pollutants.

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