The Elemental Analysis of Some Sudanese Food using Instrumental Neutron Activation Analysis (INAA)

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Abstract: ***In the present study, food samples have been collected from local markets in different States in Sudan. The average elemental concentrations for Al, Br, Ca, Cl, K, Mg, Mn, Na, Ti, V, Co, Cr, Feand Zn have been determined using Instrumental Neutron Activation Analysis (INAA). The accuracy of measurements has been investigated by using IAEA-V-10, 114IPE3 and NIST SRM 1573a peach leaves. Good agreement was found between certified and determined values. The elemental concentrations showed little difference amongst the different food samples and the values obtained indicate that these items can contribute to the Recommended Dietary Allowance (RDA) for these elements. Correlations between different elements were performed. Hierarchical cluster analysis was done for the data. The average elemental concentrations were calculated and compared with data from literature.***

Keywords: Elemental analysis, Trace elements, Food, Instrumental neutron activation analysis (INAA)

1. Introduction

Elements accumulated in plants are transferred to human beings through the food chain. Consequently the elemental composition of the food is very important because some of these elements are vital for normal growth and maintaining good health. Moreover with increasing industrialization and environmental pollution it is necessary to check the content of toxic elements in the food [(1)].

As a result of soil, atmosphere, underground and surface water pollution, foods and beverages are getting contaminated by heavy metals. The effect of environmental pollution on contamination of foods and on their safety for human consumption is a serious global public issue and widely addressed. The largest amount of trace elements found in human body has been absorbed via food [(2)]. If excessive amounts of these trace elements are accumulated in a plant, a pathway is created for potentially hazardous trace elements to enter the food chain and impact on human health[(3)]. They are being absorbed by plants to different extent depending on their source, soil and climatic factors and plant genotype, entering thereby the human food chain [(4)].

Trace metals are important in daily diets, because of their essential nutritious value and possible harmful effects. Metals like iron, copper, zinc and manganese are essential metals since they play an important role in biological systems; whereas lead and cadmium, etc. are non-essential metals which can be toxic even in trace amounts. The essential metals can also have harmful effects when their intakes exceed the recommended quantities significantly [(5)]. The intake of heavy metals through food chain is important in assessing risk to human health. Increasing environmental pollution has given rise to concern on the intake of heavy metals in humans. These metals enter the human body mainly by two routes namely: inhalation and ingestion. The intake of heavy metals through ingestion depends on the food habit [(6)].

Many analytical methods have been used in food analysis. Neutron Activation Analysis, NAA, has been successfully used on a regularly basis in several areas of nutrition and foodstuffs. NAA has become an important and useful research tool due to the methodology's advantages [(7)]. The objective of this study is to determine the levels of Al, Br, Ca, Cl, K, Mg, Mn, Na, Ti, V, Co, Cr, Feand Znin some Sudanese foods and also determine the heavy metals (Cd, As, Hg, Pb) and assess nutritional adequacy against Recommended Dietary Allowance (RDA).

2. Materials and Methods

Food items collected according to the statistical analysis of questioner. Food samples were collected in duplicate from local markets in different States in Sudan. Food samples were cut into pieces, inedible portions were removed, washed, dried, grinded, sieved through 200µm, and stored in polyethylene bags. Table 1 Shows Samples codes, common names, scientific names, family, locations and used parts. 200 mg of food samples were weighed onto transparent polyethylene films and wrapped to form pellets (pellets geometry of 8 mmx4mm). Three replicates were prepared for each sample, one each short-, intermediate-, and long lived radionuclide (elements) determination. Samples were ready for INAA analysis.

INAA measurement

Samples and standards were irradiated at the Ghana Research Reactor–1 (GHARR–1) facilities. The GHARR–1 is a 30kW tank-in-pool Miniature Neutron Source Research Reactor (MNSR) which uses 90.2% enriched U-Al alloy as fuel.The gamma spectrometry set up system at GHARR–1 NAA laboratory consists of a PC-based γ-ray spectrometry and N-type High purity Germanium (HpGe) detector (coaxialtype) coupled to a computer based multi-channel analyzer (MCA) via electronic modules. The relative efficiency of the detector is 40%. The detector has an energy resolution of 1.8 keV at a γ-ray energy of 1332keV for ^{60}Co. The data acquisition and identification of γ-rays of product radionuclide are identified by their γ-ray energies via ORTEC MAESTRO-32 software.

Table 1: Samples codes, common names, scientific names, family, locations and used parts:

Codes	Common name	Scientific name	Family	Location	Used parts
FS1	Wheat	Triticumaestivum	Poaceae	Al-kamleen	Seeds
FS2	Sorghum	Sorghum bicolor	Poaceae	Al-kamleen	Seeds
FS3	Bread			Shambat	
FS4	Bread			Shandi	
FS5	Wheat	Triticumaestivum	Poaceae	Kegi	Seeds
FS6	Sorghum	Sorghum bicolor	Poaceae	Kegi	Seeds
FS7	Corchorus	Corchorusolitorius	Malvaceae	Red Sea	Leaves
FS8	Onion	Allium cepa	Alliaceae	Barbar	Leaves
FS9	Tomato	Solanumlycopersicum	Solanaceae	Atabra	Fruits
FS10	Okra	Abelmoschusesculentus	Malvaceae	Abu Hamad	Fruits
FS11	Potato	Solanumtuberosum	Solanaceae	Al-kamleen	tuber (stems)
FS12	Corchorus	Corchorusolitorius	Malvaceae	Atabra	Leaves
FS13	Eggplant	Solanummelongena	Solanaceae	Shandi	Fruits
FS14	Corchorus	Corchorusolitorius	Malvaceae	Al-grief	Leaves
FS15	Purslane	Portulacaoleracea	Portulacaceae	Shambat	leaves +stems
FS16	Banana	Musa acuminata	Musaceae	Shandi	Fruits
FS17	Mango	Mangiferaindica	Anacardiaceae	Shambat	Fruits
FS18	Orange	Citrus sinensis	Rutaceae	Shambat	Fruits
FS19	String beans	Phaseolus vulgaris	Fabaceae	Shandi	Seeds
FS20	Broad Bean	Viciafaba	Fabaceae	Barbar	Seeds

Sample containments are usually polyethylene capsules (11.7 mm in diameter and 24 mm in height) and transparent polyethylene film which when it is contained with samples of about 200 mg (food) may end up with sizes of about 6×8 mm for food samples after folding.Each of the wrapped pellets (single pellet) was encapsulated into the rabbit capsule; heat sealed and irradiated for 30 sec and counted for 300 sec in order to determine short-lived radionuclide. Similar packaging was done for long-lived and intermediate element determination for which samples packaged for intermediate elements are irradiated for 30 min and counted for 400 second. However, the case of intermediate and long packaging, multiple packaging (for which each rabbit capsule may contain 5-8 pellets of samples including quality control materials) was done and activation period (long) were normally within 6 hrs. The long activated sample are separately counted in two occasions; one after 2-3 days decay and the other within 2 weeks of decay for respective determination of medium- and long-lived radionuclide.

For the purpose of k_0-analysis, flux monitor(s) (0.1% Au-Al wire; 3-5 mg) were first irradiated before short irradiations whereas flux monitors were affixed in each intermediate or long packaged sample. Radionuclide(s) measurement and identification were performed by a PC-based γ-ray spectrometry set-up. All measurements (spectrum acquisition) were done at a source-detector distance of 50 mm and 15mm for short/intermediate/medium and long-lived radionuclide respectively. The peak reduction and interpretation of gamma spectrum and elemental quantification, controls and monitors were done using multipurpose γ-ray spectrum analysis software; WinSPAN-2010 version 2.10 (comparator method) and the k_0-IAEA software version 4.04 (k_0-INAA method).

Table 2 presents the nuclear data and irradiation scheme used for the elemental determination in this work [8]. An irradiation time of 5 minutes were applied for the determination of short-lived radionuclide (element) and 6 hours for the determination of medium-live and long-lived radionuclide. The accuracy of the analytical procedure used is confirmed by the analysis of IAEA-V-10, Hay Powder, 114IPE3 Quality control materials and NIST SRM 1573a peach leaves. Table 3 shows the accuracy results for INAA analysis.

Table 2: Nuclear data used for the elemental analysis:

Target isotope	Target (Reaction) radionuclide	Gamma Energy (keV)	Half Life
Al	27Al(n, γ)28Al	1778.9	2.4m
Ba	137Ba(n, γ)139Ba	165.84	6m
Ca	48Ca (n, γ)49Ca	3084.4	8.72m
Cl	37Cl (n, γ)38Cl	1642	37.2m
Cu	65Cu (n, γ)66Cu	1039.4	5.1m
I	127I (n, γ)128I	442	25m
Mg	26Mg (n, γ)27Mg	1014.4	9.46m
Mn	55Mn (n, γ)56Mn	1810.7	2.58h
V	51V (n, γ)52V	1435	3.75m
K	41K (n, γ)42K	1524.58	12h
Na	23Na (n, γ)24Na	1368.6 / 2754.1	15h
Br	81Br (n, γ)82Br	776, 35	3h
As	75As (n, γ)76As	559.1	26.3h
Cd	114Cd (n, γ)115Cd	336	53.5h
Hg	198Hg (n, γ)197Hg	77.39	64.1h
Zn	64Zn (n, γ)65Zn	1115	344d
Fe	58Fe (n, γ)59Fe	1099.2,	44.5d

Table 3: The accuracy results of INAA analysis

Sample:	IAEA-V-10			114IPE3			NIST SRM 1573a peach leaves	
element	This work	average	95% confidence interval	This work	NDA	NDA st.dev	This work	Certificate value
Na	459.8±29.47	500	440-570	83.01±11.26	55.58	16.21	225.2±25.76	126±4
Mg	1996±282.83	1360	1330-1450	3246±485	2734	2.3	11820±762	(1.2)
Al	161±7.29	47	30-87	264.2±39.09	55.6	12.59	725.4±263	598±12
Cl	7644±355	NR		5852±300	6419	420	6189±283	(6600)
K	22960±1639	21000	19600-22500	13850±1782	9731	739	25870±2731	2.70±0.05
Ca	16260±769	21600	21000-22200	5162±321	6683	436	39240±2731	5.05±0.09
V	0.269±0.105	NR		0.3136±0.04	0.092	0.055	0.9759±0.36	0.835±0.01
Mn	49.9±2.48	47	44-51	376.9±34.56	420.9	38.7	210.3±28.43	246±8
Cu	ND	9.4	8.8-9.7	ND	5.72	0.93	2.52±	4.7±0.14
Br	9.798±1.04	8	7–11	13.13±1.58	16.08	2.12	1317±72.89	(1300)
Fe	204±18	186	177-190	102±15	80.41	8.22	326±23	368±7
Zn	30±1.9	24	23-25	27.54±1.44	19.79	1.69	28.44±3.2	30.9±0.7
Rb	8.9±2.1	7.6	7.3-7.8	12±1.9	10.93	1.57	13.33±1.9	14.89±0.27

Note: ***NDA*****–**Normal Distribution Approximation, ***NDA st.dev*****–**Normal Distribution Approximation Standard Deviation ***NR*****–**Not reported, ***ND*****–**not detected. ***114IPE3*** is an internal Quality Control material ***IAEA-V-10*** is an International Atomic Energy Agency IAEA-V-10 Trace Elements in Hay (powder)

3. Results and Discussion

Elemental concentration for food samples by INAA:

Food samples have been analyzed by INAA for short-, intermediate- and long-lived elements and the elemental concentrations in the food samples are listed in Tables (4, 5) and graphically displayed in Figures (1, 2). The concentration of aluminum ranges from 147.3 ppm to 8623 ppm with an average value of 2304.61 ppm. Sample FS18 showed the highest concentrations while the sample FS19 showed the lowest values. Bromine concentration ranges from 1.091 ppm to 1241 ppm with an average value of 90.24 ppm. Sample FS18 showed the highest concentrations while sample FS6 showed the lowest values. Calcium, concentration ranges from 438.3 ppm to 23420 ppm with an average value of 4995.56 ppm. Sample FS18 showed the highest concentrations while sample FS47 showed the lowest values.The concentration of chlorine ranges from 195.4 ppm to 8536 ppm with an average value of 2500.6 ppm. Sample FS7 showed the highest concentrations while sample FS10 showed the lowest values. Potassium concentration ranges from 2651 ppm to 58860 ppm with an average value of 17936.35 ppm. Sample FS15 showed the highest concentrations while sample FS3 showed the lowest values. The magnesium concentration ranges from 1099 ppm to 35260 ppm with an average 5029.66 ppm. Sample FS15 showed the highest concentrations while sample FS18 showed the lowest values

The concentration of Mn ranges from 14.6 ppm to 210.6 ppm with an average value of 66.86, sample FS7 showed the highest concentrations while sample FS20 showed the lowest values. Sodium concentration ranges from 8.549 ppm to 5491 ppm with an average value of 1201.09 ppm. Sample FS15 showed the highest concentrations while sample FS18 showed the lowest values. Cobalt concentration ranges from 0.297 ppm to 2.88 ppm with an average value of 1.429 ppm, sample FS18 showed the highest concentrations while sample FS2 showed the lowest values. Chromium, concentration ranges from 4.49 ppm to 56.36 ppm with an average value of 25.178 ppm, sample FS16 showed the highest concentrations while sample FS4 showed the lowest values. Fe concentration ranges from 61.8 ppm to 6486 ppm with an average value of 2327.15 ppm, Sample FS12 showed the highest concentrations while sample FS7 showed the lowest values. Zinc concentration from 11.51 ppm to 320.68 ppm with an average value of 62.423 ppm, sample FS18 showed the highest concentrations while sample FS4 showed the lowest values.

Correlation

Correlations between concentrations certain elements can be used as indicators of specific sources [(9)]. Pair wise correlation was performed. Table 8 show the correlation between the elemental concentrations data for food samples collected from different locations. The correlation data (bold correlation are significant at $p < 0.05$) results showed that are highly correlated with each other, suggesting clearly originating from similar sources.

Cluster analysis

The results of Cluster analysis of trace elements in food samples were obtained as dendograms displaying three main clusters. In the dendogram the first group containing the V, Co, Cr, Mn, Ti, Br, Na, Fe, Zn, Al, and Cl were generally as trace elements in plant. The second group includes Zn and Ca which closely connected with Mg, these elements which needed for plant as structural component of enzymes.The third cluster containing only K represents the element which highly enriched from the soil by plant.

Recommended Dietary Allowance (RDA)

By definition, every essential trace elements must have average of intake safe from toxicity but adequate enough to meet nutrition requirements. Essential elements generally are smaller than 100 mg/day. Although the RDA has not been established for some, several have been studied and the U.S Food and Nutrition Board of the National Academy of Sciences has been able to identify how much we should consume. Many foods that would normally be expected to supply the trace minerals unfortunately do not. Many soils are geographically deficient in certain minerals and therefore foods grown are in lack of those nutrients. A similar problem can be caused by over farming or poor soil management [(10)]. The comparison of recommended dietary allowance and safe daily dietary intake of trace elements with our analyzed values of trace elements are given in

Table 9.Comparison of average of elemental concentration of different food groups with pervious data from literature were listed in Table 10.

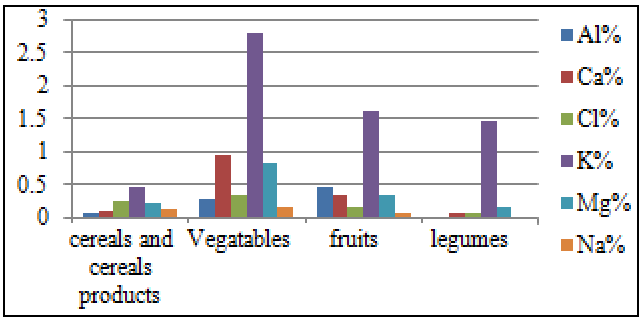
Table 4: Elemental concentrations (ppm±SD) of different food samples by INAA:

	Al	Br	Ca	Cl	K	Mg	Mn
FS1	281.6±4.49	5.63±6.97	724.3±11.11	930.1±5.26	5158±6.3	1738±11.99	27.26±0.16
FS2	712.6±17.43	12.64±5.79	ND	995.7±9.26	7546±6.4	2963±10.89	32.55±5.66
FS3	605.8±16.9	10.2±12	651.1±19.5	7724±4.45	2651±	ND	24.91±10.4
FS4	1875±4.37	8.98±9.3	1548±8.79	3720±4.9	3199±10	1099±10.13	35.17±7.511
FS5	570.5±26.32	1.09±13.88	477±17.47	472.3±9.3	4644±5.47	3261±11.56	26.64±6.19
FS6	446.6±37.9	4.21±7.24	683.8±12.6	758.5±5.22	4079±5.77	2248±10.43	51.89±5.05
FS7	8623±29.65	189.5±4.84	19880±5.36	8536±4.90	26210±6	11180±10.25	210.6±5.13
FS8	735.4±15.57	61.91±4.65	2764±6.76	1264±5.08	12990±5.77	1947±12.25	20.4±7.72
FS9	NA	12.29±5.74	NA	NA	12730±4.552	NA	NA
FS10	164.1±17.45	6.139±9.35	625.8±9.79	195.4±9.06	16850±4.92	1697±8.96	17.39±6.09
FS11	433.1±17.48	3.60±9.19	735.7±10.46	1211±6.604	18550±4.04	1826±11.91	ND
FS12	3225±12.81	38.98±6.30	10140±5.35	2340±4.98	34820±6.46	4370±14.07	134.8±4.677
FS13	3759±14.47	85.15±4.62	3470±8.50	6250±4.62	34880±4.57	4026±13.35	79.61±4.98
FS14	2911±13.36	16.92±5.62	13740±5.49	1487±4.65	38040±4.64	5448±10.5	136.9±4.74
FS15	3192±16.71	84.56±4.69	23420±4.55	6519±4.86	58860±3.76	35260±7.84	100.9±5.37
FS16	3514±16	11.16±6.249	2283±17.13	3082±4.59	19200±4.122	4464±13.4	86.15±4.87
FS17	4424±19.94	1.863±17.61	3537±12.76	770±6.06	14550±4.11	2968±13.62	72.5±5.193
FS18	5863±10.87	1241±6.50	4014±7.47	311.7±10.41	14660±5.63	2680±17.47	115.7±18.85
FS19	147.3±17.92	2.74±13.08	438.3±16.04	213.3±12.73	16810±5.66	1701±9.43	15.53±8.55
FS20	ND	6.121±11.9	788.1±13.42	731.4±5.70	12300±5.34	1658±7.72	14.6±5.90

Table 5: Elemental concentrations (ppm±SD) of different food samples by INAA:

	Na	Ti	V	Co	Cr	Fe	Zn
FS1	156.3±6.4	ND	ND	ND	ND	ND	29.617
FS2	98.56±9.68	ND	1.804±10.27	0.2975±15.52	ND	579.2±17.61	40.30±6
FS3	5491±5.14	ND	1.692±14.8	ND	ND	ND	50.59±7
FS4	2407±4.39	259.6±17.56	4.848±7.47	0.6309±18.17	4.49±11.71	1000±7.83	11.51±15
FS5	117.4±8.17	ND	1.884±5.48	ND	11.15±12.79	439±10.57	39.15±5
FS6	151.6±6.24	ND	1.036±11.6	0.35±14.15	10.94±19.51	319.4±15.28	61.56±10
FS7	3305±3.79	702.8±11.44	18.63±5.58	2.48±12.15	ND	6486±5.06	ND
FS8	646.7±7.04	54.68±18.56	2.05±6.70	ND	0.00E+00	608.7±18.33	***66.86±6***
FS9	1840±6.91	NA	NA	2.03±6.3	13.7±11.87	4564±4.28	ND
FS10	86.15±7.12	ND	0.24±17.14	0.97±10.05	ND	ND	35.44±10
FS11	297±7.72	71.28±11.43	1.60±8.346	ND	ND	618.2±16.14	42.00±10
FS12	1122±4.64	ND	19.76±5.15	2.43±18.61	41.79±8.12	61.80±5.41	ND
FS13	2154±0.07	534.5±10.36	11.13±6.07	1.4±15.53	ND	3055±10.73	ND
FS14	498±8.29	431.7±14.77	7.90±6.22	1.07±16.4	ND	1937±10.94	ND
FS15	3682±6.55	452.8±14.73	9.259±8.57	1.31±12.87	8.41±18.25	2960±7.2	53.45±6
FS16	846.8±7.59	ND	10.06±0.19.31	2.156±11.66	56.36±6.93	3392±12.68	ND
FS17	956.4±7.54	588±0.10.67	12.13±5.10	1.723±10.68	43.69±7.28	3706±9.71	ND
FS18	8.549±8.50	ND	15.69±6.65	2.88±11.41	36.08±19.51	5181±5.34	***320.68±2***
FS19	50.33±19.45	ND	0.2913±19.03	0.668±16.49	ND	ND	29.30±10
FS20	107.2±9.40	ND	ND	1.04±11.65	ND	ND	31.04±13

ND: not detected.



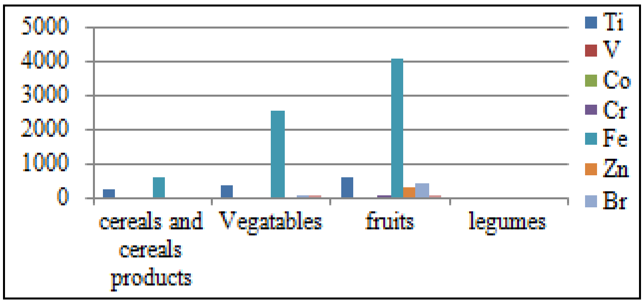


Fig 1 & 2: Mean elemental concentrations of different food group analyzed by INAA

Table 6: shows the correlation between elements:

	Al	Br	Ca	Cl	K	Mg	Mn	Na	Ti	V	Co	Cr	Fe	Zn
Al	1													

Br	.493	1												
Ca	.626	.087	1											
Cl	.477	-.47	.554	1										
K	.485	.041	.739	.333	1									
Mg	.308	.009	**.824**	.613	.653	1								
Mn	**.892**	.335	.786	.464	.674	.392	1							
Na	.296	.105	.439	**.925**	.154	.715	.268	1						
Ti	**.905**	.527	.554	.598	.459	.311	.773	.547	1					
V	**.869**	.428	.583	.362	.579	.258	.874	.206	**.966**	1				
Co	**.824**	.554	.338	.301	.358	.126	.722	.255	**.968**	**.904**	1			
Cr	.649	.203	-.145	-.255	.313	-.297	.575	-.393	.861	.690	.694	1		
Fe	**.926**	.472	.442	.528	.244	.287	.678	.462	**.911**	.664	.684	.324	1	
Zn	**.846**	**.987**	.085	-.181	.116	-.027	.737	-.167	-.196	**.828**	**.912**	**.991**	**.860**	1

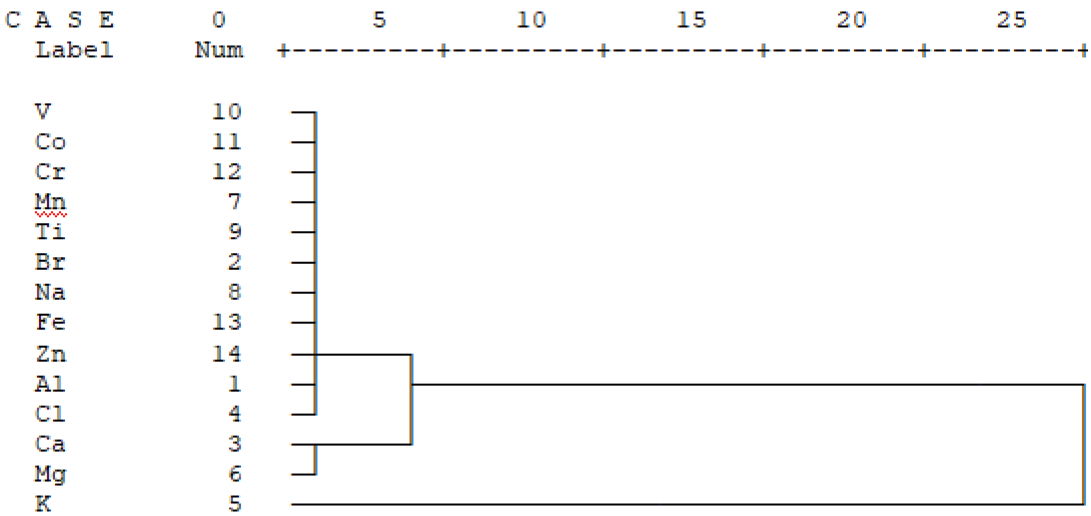


Figure 3: Hierarchical Cluster analysis of food samples

Table 9: Recommended dietary allowance and estimated safe daily intake of trace elements for human beings:

Trace elements analyzed	Maximum concentration of trace elements observed in the food samples (µg/g)			Recommended dietary allowance (RDA)	
	Fruit	Vegetables	cereals	Male	Female
K	2016	15588536	50218	4700mg	
Ca	17781	83545	28791	1000mg	
Cr	56.36	41.97	11.15	120µg	
Mn	674	1254	282	5mg	
Fe	4801	44417	7758	10-12mg	15mg
Mg	4464	32260	3261	400mg	
Zn	62	887	84	12-15 mg	15mg
Na	956.4	3682	5491	3300mg	2500mg
Co	2.88	2.84	0.63	1-2 µg	

Table 10: Comparison of average of elemental concentration of food samples with data from literature

Food	Country	Mass of elements (ppm)								
		K%	Ca%	Fe	Mg	Mn	Zn	Br	Na	Co
Wheat	This work	0.46	0.07	319	1738	27.26	45.58	4.9	165.3	ND
	Italy [11]	0.44	0.04	42	71	-	39.5	-	693	-
	Egypt [12]	-	-	-	29	0.86	12.02	-	202	12.2
Bread	This work	0.29	0.11	1000	1099	35.17	31.5	9.58	2407	0.63
	Brazil [13]	-	-	44.3	-	-	10.4	-	-	-
Potato	This work	1.85	0.07	618.2	1826	ND	42	3.6	297	ND
	USA [14]	2.09	0.04	34.95	1204	6.85	12.58	-	-	0.44
	Sudan [15]	1.06	0.03	284	886	10	14	-	-	0.7
Okra	This work	1.27	ND	4564	1697	17.39	ND	12.29	86.15	0.97
	Nigeria [16]	-	-	207.16	-	-	7.7	-	-	-
	Sudan [15]	1.72	0.58	135	1637	41	36	-	-	0.9
Purslane	This work	5.88	2.34	2960	35260	100.9	53.45	8.4	3682	1.31
	Sudan [15]	2.15	0.22	307	607	28	6	-	-	0.5
Onion	This work	1.29	0.27	608	1947	20.4	66.86	ND	646.7	ND
	Sudan [15]	0.52	0.38	115	969	20	18	-	-	0.9
	Nigeria [16]	1.43	0.88	4.34	-	-	-	-	-	-

Tomato	This work	1.68	ND	ND	ND	ND	35.44	6.13	1840	2.03
	Sudan [15]	1.98	0.07	90	1339	18	28	-	-	1
	Vietnam [17]	-	0.12	13.6	87	1.1	5.1	-	1934	-
	Pakistan [18]	-	-	7.92	-	0.049	12.34	-	-	0.34
	Nigeria [16]	1.45	1.65	2.03			-	-		
	Romania [19]	33.8	3.24	85.4	-	15.6	46.2	13	-	-
Egg-plant	This work	3.48	0.34	3055	4026	79.61	ND	85.15	2154	1.4
	Nigeria [16]	2.45	1.45	2.44	-	-	-	-	-	-
Banana	This work	1.92	0.22	3392	4464	86.15	ND	11.16	846.8	2.15
	Sudan [15]	1.66	0.01	131	1181	14	9	-	311	0.7
	Vietnam [20]	0.22	0.01	7.37	47	1.48	3.74	-	19	1.88
	Pakistan [18]	-	-	16.5	-	0.037	0.78	-	-	1.16
Orange	This work	1.46	0.40	5181	2980	115.7	320	1241	8.54	2.88
	Sudan [15]	1.84	0.21	168	1088	6	13	-	306	0.4
	Vietnam [20]	0.16	0.02	8.13	82	2.45	6.21	-	30	11.1
Mango	This work	1.45	0.35	3706	2680	72.5	ND	1.86	956.4	1.72
	Vietnam [20]	0.13	0.01	7.07	70	2.82	5.13	-	23	3.43
	Pakistan [19]	-	-	9.56	-	0.050	0.67	-	-	0.871
Legumes	This work	1.45	0.06	ND	1701	15.53	30.17	4.43	107.2	1.04
	Jamaica [21]	0.67	0.05	30	790	10.6	16.30	0.57	4.16	0.07

4. Conclusion and Recommendations

In this study, the elemental concentrations of different food samples are commonly consumed by people were investigated. This investigation provides practical and useful information on the chemical composition of food samples. The results of INAA analysis showed high levels of Ca, Cl, Mg, Mn and Na and in vegetables, while lower levels of these elements and Zn in legumes. The data showed high levels of K and Fe in vegetables, while lower levels these elements in cereals and cereals products. Co, Cr and Zn have high levels in fruits, while lower levels of Co and Cr in Cereals and cereals product. Heavy metals (Cd, As, Hg, Pb) were not detected in food samples. The chemical composition of elements in food may vary depending on the genetic of the species as well as environmental factors such as the use of fertilizer as well as the post-harvest process such as polishing and milling of foods.

The results of the assessment of deficiency or excess of trace elements can be avoiding the environmentally health-related problem. Ingesting specific food rich with element of interest can supply the dietary of that element. Further research is needed to expand samples numbers which may include new areas.

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References

[1] G.R.K. Naidua, H.O. Denschlag b, E. Mauerhofer b, N. Porte b, T. Balaji a "Determination of macro, micro nutrient and trace element concentrations in Indian medicinal and vegetable leaves using instrumental neutron activation analysis" Applied Radiation and Isotopes 50 (1999) 947-953.

[2] Gholamr. JahedKhaniki, MasudYunesian, Amirh. Mahvi and ShahrokhNazmara "Trace metal contaminants in Iranian flat breads" J. Agri. Soc. Sci., Vol. 1, No. 4, 2005

[3] Technical Reports Series No. 197. Vienna: International Atomic Energy Agency, 1980 ch. 3, p. 29.

[4] Yin-Mao Hsu, Jon-Mau Hwang and Taun-Ran Yeh "Inorganic Elements Determination for Algae/Spirulina Food Marketed in Taiwan" Journal of Food and Drug Analysis, Vol. 9, No. 3, 2001.

[5] Mustafa Tuzeni and Mustafa Soylak"Trace Heavy Metal Levels in Microwave Digested Honey Samples from Middle Anatolia, Turkey" Journal of Food and Drug Analysis, Vol. 13, No. 4, 2005.

[6] S.M. FARID, M.A.ENANI and S.A. WAJID "Determination of Trace Elements in Cow's Milk in Saudi Arabia" *JKAU: Eng. Sci.*, vol. 15 no. 2, (2004) pp. 131-140.

[7] 7.Vera A. Maihara1, Roseane P. Avegliano, Paola S.Santos, PatríciaL.C.Moura, Lilian P. de Castro "Neutron activation analysis applied to nutritional and foodstuff studies" INAC 2009Rio de Janeiro, RJ, Brazil.

[8] IAEA-TECDOC-564 "Practical Aspects of Operating NAA Laboratory," IAEA, Vienna, (1990) pp. 197-237.

[9] Annegarn, H, J., Braga Marcaazzan, G. M., Cereda, E., Marchionni, M. and Zucchiatti, A "Sources profiles by unique rations (SPUR) analysis: determination of source profiles from receptor-site streaker sample" Atoms. Envir. 26A, (1992) 333-343.

[10] Lawrence, K.A., A.J. Pesce and S.C. Kazmierczak "Clinical Chemistry" 4th edn., Theory, Analysis, Correlation, ISBN 0-323-01716-9, Published by mostly Inc. USA, (1993) p. 707-721.

[11] Ginevra Lombardi-Boccia, AlteroAguzzi, MarsilioCappelloni, Giuseppe Di Lullo and Massimo Lucarini "Total-diet Study: dietary intakes of macro elements and trace elements in Italy" British Journal of Nutrition 90, (2003) 1117-1121.

[12] A.E. Mohmed and G.M. Taha "Levels of trace elements in different varieties of wheat determined by atomic absorption spectroscopy" The Arabian Journal for Sciences and Engineering Vol 28 no 2A July 2003.

[13] Vera A. Maihara, Roseane P. Avegliano, Paola S. Santos, Patericia L. C. Moura, Lilian P. de Castro "Neutron Activation Analysis applied to nutritional and foodstuff studies" International Nuclear Atlantic Conference INAC Rio de Janeiro, Brazil 27 sep- 2 Oct 2009.

[14] Kim A. Anderson, Bernadene A. Magnuson, Matthew L. Tschirgi, and Brian Smith "Determining the Geographic Origin of Potatoes with Trace Metal Analysis Using Statistical and Neural Network Classifiers" J. Agric. Food Chem. 47, (1999) 1568-1575.

[15] A. N. Ahmed, Dr. A. H. Ali, Dr. M .A.H Eltayeb, Dr. M. M. O., Ahmed K. KH.Taha "Application of Spectroscopic Techniques for the Determination of Trace Element Concentrations in some Sudanese vegetables and fruits" 7th Arab Conference of a safe uses of Atomic Energy , Yemen, Sanaa (2004).

[16] Opaluwa, O. Da., Aremu, M. O., Ogbo, L. O, Abiola, K. A., Odiba, I. E, Abubakar, M. M. and Nweze, N.O "Heavy metal concentrations in soils, plant leaves and crops grown around dump sites in Lafia Metropolis, Nasarawa State, Nigeria" Advances in Applied Science Research, 3 (2), (2012) 780-784.

[17] Nguyen Giang, Nguyen Thanh Tarn, Le Tlii Ngoc Trinh, Truong Phuong Mai and Nguyen Van Minh "Application of Atomic Absorption Spectrometry to determine Cd, Cu, Pb, Zn, … in Vegetables samples in Dalat" The Annual Report, VAEC(2003).

[18] ErumZahir, Iftikhar Imam Naqvi and Sheikh Mohi Uddin "Market Basket Survey of Selected Metals in Fruits from Karachi City (Pakistan)" Journal of Basic and Applied Sciences Vol. 5, No. 2, (2009) 47-52.

[19] AnaPantelica, AntoanetaEne, M. Gugiu, C. Ciortea, O. Constantinescu "PIXE Analysis of Some Vegetables Species" Romanian Reports in Physics, Vol. 63, No. 4, (2011), P. 997–1008.

[20] Nguyen Van Minh, Le Thi Ngoc Trinh, Le Thai Dung, Ta ThiTuyetNhung, Nguyen Dang Khoa, Nguyen Tien Dat, Nguyen Thi Hong Tham and Cao Dong Vu "Study and apply of Neutron Activation Analytical and related methods for determination of content of Na, K, Cu, Co, Mn, ca, Mg, Fe, P and Zn in a lot of specialty fruits of vietNam (banana, Orange, longan, Dragon and mango)" The Annual Report, VAEC (2006).

[21] Andrea Howe, Leslie Hoo Fung, Gerald Lalor, Robin Rattray and MitkoVutchkov "Elemental composition of Jamaican foods 1: A survey of five food crop Categories" Environmental Geochemistry and Health 27, (2005) 19–30.