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Determination of Essential Minerals and Trace Elements in Nigerian Sesame Seeds, Using TXRF Technique

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Abstract: Total Reflection X-Ray Fluorescence (TXRF) technique was used to determine the elemental concentrations of major, minor and trace elements in sesame seeds, *Sesame indicum* collected from Ogbomoso, Southwestern, Nigeria. Samples were pulverized, digested, and then, analyzed. Eleven elements (P, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn and Sr) were detected and their concentrations determined. P, K, and Ca were present at the highest concentrations, 0.17 - 0.23 %, 0.46 - 0.53 % and 0.96 - 1.28 % respectively. The results indicate that sesame seed is a good source of essential and beneficial micronutrients required for healthy growth. The accuracy and precision of the technique were assured by analyzing certified standard reference materials IAEA-V-10 Hay (powder).

Key words: Sesame seeds, minerals and trace elements, TXRF technique

Introduction

Sesame is ascribed to have originated from Africa and it is thought to be the oldest oil seed known to man. It is the seed of an annual herb, *Sesame indicum.* Sesame plant grows in tropical and subtropical regions with a dry and a rainy season. It is grown in many parts of the world today for its important uses as edible oil, spices, insecticides, medicines, soap, green manure and ornaments (Brar and Ahuja, 1979). The oil of sesame seed, known as teel or benne oil is very resistant to rancidity especially after hydrogenation due to the presence of natural anti-oxidants such as sesamolin, sesamin and sesamol. It is therefore useful in increasing the shelf life of margarine and other vegetable oil products (Yermanos *et al.,* 1972; Brar, 1982; Irvine, 1969). It has been suggested that sesame oil could have a positive effect on cholesterol levels because of its remarkable antioxidant function. Also sesame oil has a very high level of unsaturated acids, which is assumed to have reducing effect on plasma-cholesterol, as well as on coronary heart disease (Agboola, 1979). Sesame seeds have a positive amino-acid structure - high level of methionine and low level of lysine, this makes it an excellent protein complement to other plant proteins.

Sesame plant is grown in different parts of Nigeria. In Tiv and Idoma areas of Nigeria's Benue state, two breeds of sesame seed are cultivated viz; *Sesame indicum* and *Sesame radiatum* mainly for their seeds and leaves. The fruit is inform of oblong, pubescent capsule and it contains many small, and flattened oval and yellow, white, red, brown or black seeds (Agboola, 1979). The seeds could be consumed either through oil, roasted or as animal feeds (Johnson *et al.*, 1979). The proximate analysis of sesame seed indicates that it contains about 50 - 60% oil, 8% protein, 5.8% water, 3.2% crude fiber, 18% carbohydrate, 5.7% ash and it is very rich in minerals such as Ca, P and vitamin E (Joshi, 1961).

Table 1: Concentrations (in µg/g) obtained for the IAEA reference material IAEA-V-10, Hay (powder), compared certified values

Element	Measured value*	Certified value	Certified Range
P	2240 ± 120	2300	2100 - 2500
K	18900 ± 170	21000	19600- 22500
Ca	19300 ± 700	21600	21000 - 22200
Cr	8.7 ± 1.5	6.5	5.6 - 7.1
Mn	46.8 ± 2.5	47	44 - 51
Fe	244 ± 26	186	177- 190
Ni	4.7 ± 0.2	4.2	3.8 - 4.9
Cu	13.5 ± 0.3	9.4	8.8 - 9.7
Zn	23.4 ± 2.5	24	23 - 25
Rb	7.8 ± 0.5	7.6	7.3 - 7.8
Sr	40.4 ± 1.0	40	37 - 44
Pb	2.0 ± 0.5	1.6	0.8 - 1.9

*Average of three measurements with a relative standard deviation of less than 10%.

The present work reports the elemental analysis of sesame seeds grown in Ogbomoso town, Southwestern, Nigeria, using the TXRF technique. Nutritional experts and medical doctors now recognize and are emphasizing the important roles of minerals and trace elements to human health and well being (Tolonen, 1990). It is estimated that about 70 biological trace elements are needed by all living things for the normal function of their metabolism, reproductive and immune systems. To the best of our knowledge there exits no previous studies of the trace element content of Nigerian sesame seed.

Table 2: Concentration of elements in whole dry Sesame seeds (in µg/g) analyzed by TXRF technique

Element	Farm Locations				
	1	2	3	4	5
P	1820±30	1870±30	1700±35	2170±30	2270±30
K	4820±20	5000±20	4600±20	5340±20	5000±20
Ca	12200±25	12050±25	12800±25	11580± 5	9550±25
Ti	12±2	31±3	21±3	24±2	27±3
Cr	10±3	6±3	8±3	8.5±3	6±3
Mn	27±5	33±5	32±5	24±5	23±5
Fe	98±10	110±10	115±10	120±10	120±10
Ni	4±1	4±1	5±1	3±1	4±1
Cu	24±2	19±2	20±2	22± 2	17±2
Zn	105±5	86±5	98±5	108±5	69±5
Sr	77±3	67±3	79±3	69±3	59±3
Element	Mean	Range	mg/100g	DRI	
				RDA/AI	UL
P	1966	1700 – 2270	196.6	500 – 1250	3000-4000
K	4952	4600 – 5340	495.2	550 – 1650	No UL
Ca	11636	9550 – 12800	1163.6	800 – 1300	2500
Ti	23	12 – 31	2.3	NA	ND
Cr	7.8	6 – 10	0.78	0.015 – 0.045	ND
Mn	27.8	23 – 33	2.78	1.5 – 2.6	3 – 11
Fe	112.6	98 – 120	11.26	10 – 27	40 – 45
Ni	4	3 – 5	0.4	0.3 – 1.0	0.3 – 1.0
Cu	20.4	17 – 24	2.04	0.44 – 1.3	3 – 10
Zn	93.2	69 – 108	9.32	5 – 12	12 - 40
Sr	70.2	59 – 79	7.02	NA	NA

DRI – Dietary Reference Intakes. RDA - Recommended Dietary Allowance (in mg/day). AI – Adequate Intakes (in mg/day). UL – Tolerable Upper Intake Levels (in mg/day). ND – Not determined. NA - Data not available.

Though many trace element studies in biological samples have used the AAS technique, we have used the TXRF technique because it has the advantage of being multi-elemental and also requires only very small samples. The TXRF is a well-established technique in trace analysis.

Materials and Methods

Sample collection and preparation: Samples of dried sesame seeds, *Sesame indicum* were collected from five different farm locations in Ogbomoso town, Southwestern, Nigeria. The samples were pulverized to aid digestion using agate mortar.

0.25 g of the ground sample was digested in a 125 ml Teflon bomb with 3 ml of concentrated HNO_3 and 3 ml 50% H_2O_2. The digestion was carried out according to Ogner *et al*. (1991). The Teflon bomb with its content was heated in a microwave oven at 300 W, 450 W and 600 W, for 7 minutes at each level. After digestion, the bomb was allowed to cool to room temperature for a few hours. The bomb was then opened and 5 µg of gallium was added as an internal standard.

A 5 µl aliquot of each of the digested samples, with Gallium as internal standard, was pipetted unto a clean quartz sample carrier and dried under an infrared lamp. Also the International Atomic Energy Agency (IAEA) reference material, IAEA-V-10 Hay (powder) was equally prepared in a similar manner as the samples and was used for quality assurance.

Analysis: The elemental analysis of the samples was performed using the Total Reflection X-Ray Fluorescence (TXRF) spectrometer at the Environmental Research Laboratory, Department of Physics, Obafemi Awolowo University, Ile-Ife. The TXRF spectrometer consists of a COMPACT 3K5 X-ray generator with X-ray tube (Model IS 221520), with a Mo anode, manufactured by Ital Structures, a Canberra (SL 80175) Si(Li) detector (resolution 175 eV at 5.9 KeV), coupled to a Canberra Inspector-2000 Digital Signal Processor. Canberra Genie-2000 software was used for data acquisition.

Each sample on the quartz carrier was irradiated for 1000 seconds at fixed tube operating conditions of 40 kV and 20 mA. The spectral data analysis was done with the AXIL fitting program contained in the QXAS software package supplied by the International Atomic Energy Agency (I.A.E.A) (IAEA, 1996).

Quality assurance: The accuracy and precision of the technique were assured by analyzing the IAEA reference material IAEA-V-10, Hay (powder). The reference was prepared under the same conditions as the samples. Three replicates of the standard were analyzed under the same conditions as the samples. The results of the analysis are shown in Table 1. These results are in good agreement with the certified values (IAEA, 2000). Blank determination was also made and all the reagents used were of BDH Analar grade.

Results and Discussion

The concentrations of the elements in the sesame seed are presented in Table 2. All data are the results of average of three measurements on each sample with a relative standard deviation of less than 10%. Eleven elements (P, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn and Sr) were detected. The results show a similar pattern for the trace elements in sesame seeds from all the farm locations. P, K, and Ca are present at the highest concentrations, 0.17 - 0.23%, 0.46 - 0.53% and 0.96-1.28% respectively. This is followed by Fe, Zn, Sr, Mn, Ti, Cu, Cr and Ni in decreasing order, except for sesame seeds from farm plot 1, were Zn was higher than Fe and also Cu was higher than Ti. These results also show that the Nigerian sesame seeds are rich in essential minerals and trace elements that promote well being in humans. Minerals are unique nutrients because of their important role in metabolism. They are essential part of many important enzymes and they also play roles as catalysts and antioxidants. Iron and copper for example are essential in blood formation and copper is also involved in normal carbohydrate and lipid metabolism (Hambidge *et al.,* 1987). Chromium regulates the action of insulin and is also essential in carbohydrate and lipid metabolism (Alam and Mahpara, 2003). Zinc for its part is a multi functional nutrient involved in glucose and lipid metabolism, hormone function and wound healing (Hambidge *et al.,* 1987)and is also associated with proper hair growth (Wang *et al.,* 1985).

As can be seen from Table 2, at a daily consumption rate of 100 g/day, the values of all the elements in sesame seed fall within the US recommended Dietary Reference Intakes (DRIs) (National Academy of Sciences, 1998).

Conclusion: The TXRF analytical technique was used in the elemental analysis of sesame seed. Concentrations of 11 micronutrients and trace elements (P, K, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Sr) were determined. The accuracy and precision of the technique were assured by analyzing the IAEA standard reference material, IAEA-V-10, Hay (powder). The results show that the sesame seed is rich in the essential micronutrients that are of importance in man's well being. P, K, and Ca are present at the highest concentrations, 0.17 - 0.23%, 0.46 - 0.53% and 0.96 - 1.28% respectively. The results also show that at consumption rate of 100 g daily, the values of all the essential elements in the Nigerian sesame seed fall within recommended US Dietary Reference Intakes values.

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