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DETERMINATION OF ELEMENTAL CONCENTRATION IN SAUDI WHEAT SAMPLES USING INAA TECHNIQUE

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ABSTRACT

The determination of trace quantities of elements present in foodstuff is of considerable importance, because of the essential and toxicological action of some of these trace elements to the human body. Wheat is one of the most grown crops in Saudi Arabia. It is grown in various regions of the country. Accurate knowledge of the various elemental concentrations in wheat is of great importance from nutrition point of view. As part of on going research to develop reference materials at KACST wheat samples were obtained from 10 - different regions in Saudi Arabia and analyzed using Instrumental Neutron Activation Analyses (INAA) techniques. Information of up to 50 elements in wheat samples were obtained. These results are also of great interest to research and related food industry.

Key words: Elemental concentration, Instrumental neutron activation analysis.

INTRODUCTION

Neutron activation analysis is a sensitive and reliable method for the determination of trace elements in food and plant materials. High accuracy, minimum sample handling, no added reagents, multi-elements capability and low detection limit are among the advantages of this analytical technique. For such advantages, it has been widely used in various investigations[1-7].

The study of elemental contents in food, environmental and biological samples have attracted worldwide interest. The determination of trace quantities of elements present in these types of matrices is of considerable importance because of their essential and toxicological action of some of them in the human body. This has strengthened the need to use reliable analytical methods capable of analyzing food samples as well as other

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matrices[8-10].

Wheat grain contains several elements at minor or trace concentration. Several studies have been carried out to determine the elemental concentration in wheat, flour and bran[8, 11-13]. However, little attention was given to quantify trace elements. Information on the mineral content will assist in knowing which elements need to be enriched using wheat and bran in diets for human and farm animals[14-17].

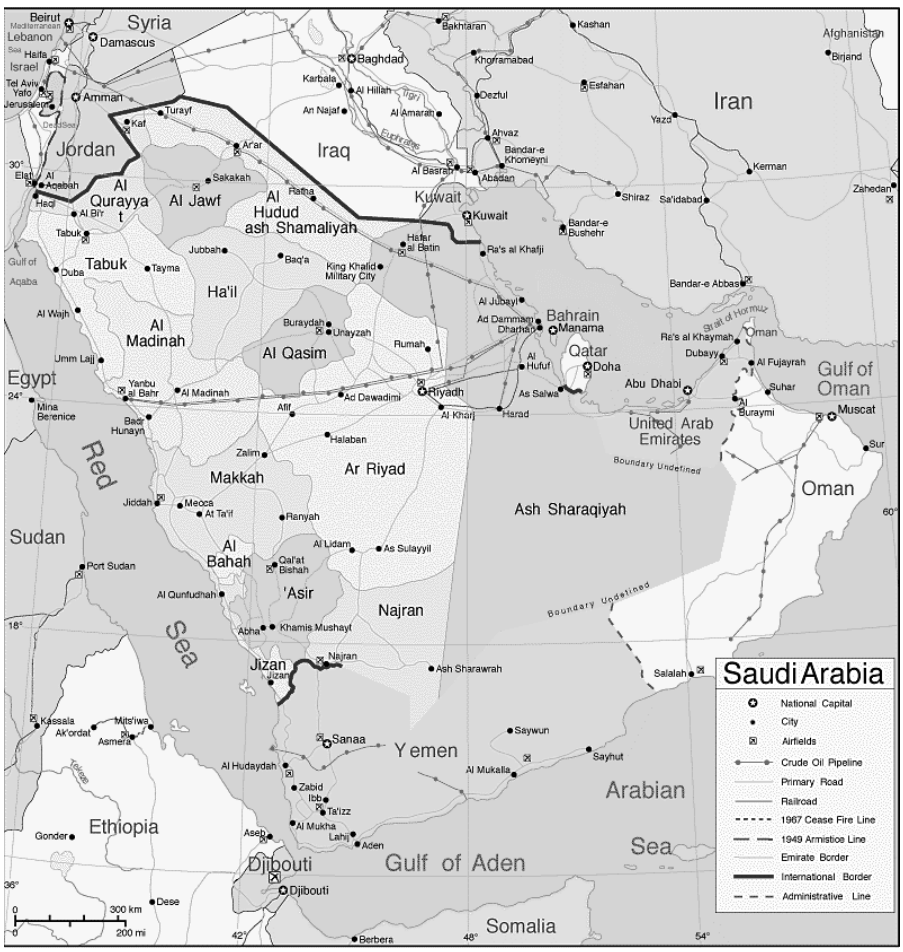

Fig. 1

In this study, this powerful technique is applied to investigate the elemental concentration in wheat samples collected from various wheat growing locations throughout Saudi Arabia as illustrated by the sampling map of Fig. 1. The two-megawatt McMaster University pool type Nuclear Research Reactor in Hamilton, Ontario, Canada was used to

irradiate the investigated samples. The γ – spectra obtained were then quantitatively analyzed .

In addition to the importance of the results of this work to nutritious scientists, they are used in ongoing project to produce reference materials for the Saudi Wheat based diets.

EXPERIMENTAL

Sampling

Wheat is grown throughout the Kingdom of Saudi Arabia. The collection and distribution of wheat from the various region is carried out by a government agency known as Grain Silos and Flower Mills Organisation (GSFMO). It has 10 branches in the various regions of Saudi Arabia as illustrated in Fig. 1. Farmers bring their wheat produce to GSFMO branch, where it is mixed and kept before sales and distribution. Ten samples were collected from these branches under the assumption that each collected sample represents its region.

Preparation of samples and standards

As mentioned above, wheat samples were collected from the various wheat growing regions through the cooperation of GFSMO. They were grounded up in a blender to a flour consistency. In order to maximize major, minor and trace elemental concentration determinations in this investigation, a multi-sample were prepared from the 10 grounded samples for different irradiation periods. Standard Reference Material (SRM), Coal sample from the South African Bureau of Standards named SARM-18 and OYSTER Tissue Sample from the National Institute of Standards and Technology (NIST) named 1566a were used in this study. The elemental concentrations in these standards are those published standard values[19,20]. In addition to the above, approximately 1 g from each sample was taken for moisture determination.

Irradiation and counting

All the irradiation of samples together with their standards were carried out in the thermal neutron flux facility of the McMaster University Nuclear Research Reactor. The irradiation procedures were of two steps:

(i) The short lived isotopes.

(ii) Where approximately 1 g of grounded wheat samples were irradiated for 60 seconds at a thermal flux of 5 x 10^{12} $n.cm^{-2}s^{-1}$. They were counted after 8 minutes cooling

time, and recounted after 24 hours cooling time for short-lived isotopes.

(iii) The long lived isotopes: Where approximately 30 g of grounded wheat samples were irradiated for 20 minutes at a thermal neutron flux of 8 x 10^{12} n.cm^{-2}s^{-1}. They were counted after 5 and 21 days cooling times for long-lived isotopes.

Gamma ray spectrum acquisition is carried out by use of a high-resolution intrinsic germanium detector with an Aptec MCA. Spectral data reduction by in-house Becuerel Laboratories software. Results from each of the four counts described above are combined to generate the final results as shown in Table 1.

RESULTS AND CONCLUSION

The elemental concentration results of the Saudi wheat samples under investigation are shown in Table 1. It can be noticed from this table that using the INAA technique, it was possible to report information on the concentration of around 50 elements, which demonstrate the usefulness of this non-destructive nuclear technique. In this stage of the reference material project development, the accuracy are assessed through a comparative analysis using the Standard Reference Materials (SRM) mentioned earlier. They were irradiated and analyzed in the same manner of all samples. The results were in fairly good agreement with the certified values as presented in earlier work[21,22].

By examining the results of Table 1, it can be seen that many trace elements were found to be less than the lower limit of detection for the used conditions of measurements, i.e., for spectrum collection time interval for each sample and for used shield around the germanium detector. Also, it can be seen that the concentration of some elements is different from one growing location to another as expected due to different agricultural soil characteristics in various regions. The results also show that the toxic elements concentrations of cadmium and mercury are below the detection limit for the applied sensitive analytical technique, which suggests that the contents of these two toxic elements in the Saudi wheat is probably very low. A further investigation in this field is recommended to quantify such concentrations and also to quantify lead content, the other important toxic elements, which is not suitable for analysis by INAA technique because it cannot be activated. Other important elements that were expected to be present in the Saudi wheat but could not be determined by INAA due to their low atomic numbers are P, S and Si.

Table 1: Elemental concentration in Saudi wheat samples

Element	Location									
	Asir	Qasim	Riyadh	Hail	Dawaser	Jiddah	Kharj	Dammam	Tabuk	Jawf
	Moisture (%)									
	7.10	7.30	6.90	6.80	7.30	6.80	7.20	7.00	7.30	6.90
Al	1.29E-03	4.61E-03	6.88E-03	6.66E-03	9.22E-04	1.47E-03	2.35E-03	1.24E-03	1.82E-03	7.99E-04
Sb	2.80E-03	2.60E-03	2.90E-03	3.40E-03	2.30E-03	2.40E-03	2.20E-03	3.30E-03	5.00E-03	2.70E-03
As	1.60E-02	4.80E-02	1.90E-02	1.30E-02	1.80E-02	3.10E-02	1.40E-02	2.80E-02	1.00E-02	1.50E-02
Ba	2.10	5.60	2.80	4.60	2.20	1.30	1.50	2.70	2.80	1.30
Br	2.48	3.21	2.83	2.16	1.75	2.00	2.35	3.85	2.23	2.90
Cd	0.11	0.11	0.11	0.10	9.10E-02	9.30E-02	0.13	0.12	0.12	0.10
Ca	5.50E-02	8.91E-02	6.86E-02	4.80E-02	4.69E-02	5.44E-02	5.79E-02	5.00E-02	5.52E-02	4.71E-02
Cs	4.00E-03	7.60E-03	5.20E-03	5.10E-03	4.20E-03	3.90E-03	4.70E-03	3.80E-03	4.30E-03	3.80E-03
Cl	1.04E+03	862	1.01E+03	736	1.07E+03	1.25E+03	792	1.13E+03	1.20E+03	864
Cr	6.50E-02	0.23	0.522	0.14	5.70E-02	0.2	0.12	0.12	0.13	6.70E-02
Co	2.08E-02	3.56E-02	3.75E-02	3.07E-02	2.33E-02	5.10E-02	2.48E-02	2.94E-02	2.23E-02	1.55E-02
Cu	4.76	5.88E+00	6.57	6.64	5.72	5.55	5.67	7.15	5.98	3.36
Ga	0.21	0.29	0.24	0.2	0.22	0.19	0.24	0.31	0.24	0.28
Au	0.11	0.1	0.11	9.40E-02	9.00E-02	9.30E-02	8.90E-02	0.13	0.12	0.1
Hf	3.10E-03	3.50E-03	3.60E-03	3.70E-03	3.10E-03	3.00E-03	3.20E-03	2.90E-03	3.20E-03	3.00E-03
In	4.30E-03	4.40E-03	6.50E-03	4.30E-03	4.20E-03	4.30E-03	1.20E-02	4.20E-03	5.00E-03	3.90E-03
I	0.16	0.17	0.16	0.17	0.16	0.16	0.17	0.15	0.19	0.15

Cont…

Element	Location									
	Asir	Qasim	Riyadh	Hail	Dawaser	Jiddah	Kharj	Dammam	Tabuk	Jawf
	Moisture (%)									
	7.10	7.30	6.90	6.80	7.30	6.80	7.20	7.00	7.30	6.90
Ir	0.12	0.11	0.1	0.11	9.30E-02	8.70E-02	9.40E-02	8.80E-02	0.1	8.90E-02
Fe	3.10E-03	4.09E-03	5.79E-03	4.78E-03	3.14E-03	3.17E-03	3.73E-03	2.65E-03	3.13E-03	2.84E-03
Mg	0.14	0.14	0.136	0.141	0.127	0.145	0.129	0.124	0.157	0.137
Mn	37	38.1	31	40.8	36.7	34.9	46.4	25.8	48.4	36.3
Hg	1.00E-02	1.10E-02	1.10E-02	1.20E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
Mo	0.374	0.3	0.588	0.23	0.368	0.436	0.365	0.741	0.553	0.672
Ni	0.59	0.76	0.8	0.76	0.63	0.64	0.71	0.58	0.65	0.58
K	0.488	0.474	0.422	0.486	0.441	0.465	0.388	0.469	0.507	0.442
Rb	1.51	1.55	1.3	1.75	1.84	1.42	0.55	1.7	0.821	1.23
Sc	1.60E-03	4.15E-03	9.33E-03	3.64E-03	1.40E-03	1.50E-03	3.93E-03	1.87E-03	2.21E-03	1.20E-03
Se	4.50E-02	4.90E-02	0.078	5.30E-02	4.50E-02	5.90E-02	4.80E-02	0.1	6.60E-02	0.094
Ag	1.30E-02	1.60E-02	1.70E-02	1.70E-02	1.30E-02	1.30E-02	1.50E-02	1.20E-02	1.40E-02	1.30E-02
Na	1.76E-02	9.80E-03	1.36E-02	6.87E-03	6.99E-03	1.01E-02	8.93E-03	2.44E-02	2.61E-02	1.71E-02
Sr	11	8.4	13.2	11.1	10.2	7.1	10.7	17.9	7.9	7.9
Ta	2.00E-03	2.20E-03	2.30E-03	2.10E-03	2.10E-03	1.90E-03	2.00E-03	2.20E-03	2.00E-03	1.80E-03
Te	0.13	0.15	0.14	0.16	0.13	0.12	0.13	0.13	0.13	0.13
Th	4.00E-03	4.60E-03	4.50E-03	4.90E-03	4.00E-03	3.90E-03	4.00E-03	3.90E-03	4.20E-03	4.00E-03

Cont…

Element	Location									
	Asir	Qasim	Riyadh	Hail	Dawaser	Jiddah	Kharj	Dammam	Tabuk	Jawf
	Moisture (%)									
	7.10	7.30	6.90	6.80	7.30	6.80	7.20	7.00	7.30	6.90
Sn	1.7	1.9	1.9	2	1.7	1.6	1.7	1.7	2.8	1.6
Ti	3.10E-04	3.30E-04	3.20E-04	3.30E-04	3.20E-04	3.10E-04	3.30E-04	2.90E-04	3.70E-04	2.90E-04
W	1.50E-02	1.60E-02	1.50E-02	1.20E-02	1.30E-02	1.30E-02	1.30E-02	1.90E-02	1.70E-02	1.60E-02
U	1.30E-02	1.40E-02	1.40E-02	1.20E-02	1.20E-02	1.20E-02	1.20E-02	1.50E-02	1.50E-02	1.30E-02
V	2.40E-02	6.50E-02	0.121	5.30E-02	2.00E-02	3.20E-02	5.10E-02	3.60E-02	2.80E-02	3.80E-02
Zn	19.70	35.90	35.80	33.00	20.80	18.60	35.80	14.20	25.40	20.90
Zr	1.30	1.50	1.60	1.60	1.30	1.20	1.50	1.20	1.40	1.20
Ce	4.20E-02	4.60E-02	4.40E-02	4.90E-02	4.00E-02	3.90E-02	4.00E-02	4.00E-02	4.20E-02	4.00E-02
Dy	1.80E-02	1.90E-02	1.90E-02	1.80E-02	1.80E-02	1.80E-02	1.90E-02	1.70E-02	2.00E-02	1.70E-02
Eu	5.90E-03	1.20E-03	1.10E-03	5.40E-03	5.30E-03	5.30E-03	1.10E-03	8.30E-04	7.40E-04	5.70E-03
La	3.00E-03	1.58E-02	1.40E-02	8.90E-03	3.80E-03	4.50E-03	7.90E-03	3.90E-03	3.60E-03	2.80E-03
Lu	1.30E-03	1.60E-03	1.40E-03	1.60E-03	1.40E-03	1.30E-03	1.40E-03	1.30E-03	1.30E-03	1.40E-03
Nd	0.13	0.15	0.14	0.16	0.13	0.13	0.13	0.13	0.14	0.13
Sm	4.00E-04	1.20E-03	2.15E-03	8.10E-04	4.00E-04	4.90E-04	1.00E-03	4.30E-04	6.60E-04	4.30E-04
Tb	2.20E-03	2.80E-03	3.00E-03	2.90E-03	2.40E-03	2.10E-03	2.80E-03	2.00E-03	2.40E-03	2.20E-03
Yb	3.70E-03	3.40E-03	3.70E-03	3.20E-03	3.00E-03	3.20E-03	2.90E-03	4.20E-03	4.10E-03	3.60E-03

The quantitative results obtained in this work will be of great interest for future work of developing reference materials for the Saudi wheat based diets at the Measurement and Instrumentation Center (MIC) of King Abdulaziz City for Science and Technology (KACST). It is also anticipated that these results will assist nutritionists in the Grain Silos and Flour Mills Organization in particular and to related food industry in general, in knowing which elements need to be enriched in, Saudi wheat based diets.

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