Oriental Journal of Chemistry Vol. **26**(3), 819-824 (2010)

Elemental content in wheat products of Riyadh region, Saudi Arabia using INAA technique

SAAD A. AL-KAHTANI and OMAR A. AL-DAYEL

King Abdulaziz City for Science and Technology (KACST), P. O. Box 6086, Riyadh 11442 (Saudi Arabia).

(Received: June 15, 2010; Accepted: July 18, 2010)

ABSTRACT

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 and its products (bran and flower) is of great importance from nutrition point of view. Wheat samples were obtained from Riyadh region in Saudi Arabia and analyzed. Up to 50 elements (Al, Sb, As, Ba, Br, Cd, Ca, Cs, Cl, Cr, Co, Cu, Ga, Au, Hf, In, I, Ir, Fe, Mg, Mn, Hg, Mo, Ni, K, Rb, Sc, Se, Ag, Na, Sr, Ta, Te, Th, Sn, Ti, W, U, V, Zn, Zr, Ce, Dy, Eu, La, Lu, Nd, Sm, Tb and Yb) in wheat products were determined. It was observed that the mineral content of bran was much higher than white flour.

Key words: Elemental content, wheat products and INAA technique.

INTRODUCTION

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 matrices[1,2,3].

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 [1,4,5 and 6]. 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[7,8,9 10].

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, multielements capability and low detection limit are among the advantages of this analytical technique. For such advantages it has been widely used in various investigations[11-17].

The present study was, therefore, undertaken to investigate the elemental concentration of the wheat products produced in Riyadh region and to provided an important data for the nutrition scientists.

EXPERIMENTAL

Sampling

Generally wheat consists of 22.5 % bran, 2.5 % wheat germ and 75% semolina [18]. White bread is made of white flour free of bran (semolina

Table 1: Concentration of elements obtained in this study for wheat products

Sample Moisture	Bran 7.30%		Semolina Flour 7.70%		50%Brown Flour 7.80%		100%Brown Flour 7.70%	
Elements	**PPM**	**RSD %**	**PPM**	**RSD %**	**PPM**	**RSD %**	**PPM**	**RSD %**
Al (%)	3.78E-03	3.4	9.34E-04	3.7	1.11E-03	3.7	1.20E-03	3.6
Sb<	9.20E-03		2.90E-03		3.70E-03		4.10E-03	
As<	3.60E-02		1.20E-02		1.40E-02		1.80E-02	
Ba<	14		1.8		3.4		2.8	
Br	6.03	3.1	2.56	3.1	2.96	3.1	3.56	3.1
Cd<	0.36		0.11		0.14		0.16	
Ca (%)	0.155	4.4	2.63E-02	6	4.04E-02	5	4.92E-02	4.8
Cs<	1.60E-02		6.10E-03		6.80E-03		8.10E-03	
Cl	930	3.1	829	3	861	3	869	3
Cr	0.16		4.80E-02		6.60E-02	44.6	<7.50E-02	
Co	0.1	5.6	1.00E-02	22.5	1.60E-02	14	2.51E-02	9.7
Cu	13.7	7.1	3.75	8.1	4.02	7.6	5.36	7.2
Ga<	1.1		0.36		0.39		0.57	
Au (PPB)	<0.36		<0.11		<0.14		<0.16	
Hf<	1.30E-02		4.00E-03		5.20E-03		5.80E-03	
In<	1.10E-02		3.70E-03		4.20E-03		4.50E-03	
I<<	0.49		0.11		0.15		0.18	
Ir (PPB)<	0.38		0.12		0.15		0.18	
Fe (%)	1.01E-02	4.7	1.88E-03	8	1.97E-03	8.5	3.58E-03	6
Mg	0.559	3.2	3.55E-02	5	6.83E-02	3.9	0.121	3.4
Mn	126	3.1	6.6	4.2	18.3	3.3	31.6	3.2
Hg<	4.10E-02		1.20E-02		1.50E-02		1.90E-02	
Mo	1	13.4	0.37	10.1	0.4	11.7	0.44	13.4
Ni<	2.5		0.77		1		1.1	
K (%)	1.4	3.5	0.177	4.4	0.287	3.9	0.381	3.7
Rb	5.12	5.9	0.85	11	1	11.6	2.1	7.2
Sc	4.70E-03	13.2	1.60E-03	13.3	1.10E-03	21.8	1.10E-03	24.9
Se<	0.18		0.12	20.5	0.14	28.1	0.13	25.5
Ag<	5.50E-02		1.80E-02		2.20E-02		2.50E-02	
Na (%)	4.12E-02	3.3	5.04E-03	3.9	9.75E-03	3.5	1.26E-02	3.4
Sr	51.6	8.4	2.2	29.3	6.2	18.9	14	11.2
Ta<	7.30E-03		4.50E-03		5.50E-03		5.30E-03	
Te<	0.56		0.16		0.21		0.25	
Th<	1.70E-02		4.90E-03		6.20E-03		7.60E-03	
Sn<	7.1		2.1		2.7		3.2	
Ti (%)<	9.40E-04		2.30E-04		2.90E-04		3.50E-04	
W<	5.90E-02		1.80E-02		2.20E-02		2.70E-02	
U<	4.60E-02		1.30E-02		1.70E-02		2.10E-02	
V	8.10E-02	28.1	2.90E-02	28.4	1.90E-02		4.60E-02	21.7
Zn	86.9	5.1	9.45	5.7	16	5.4	23.7	5.3
Zr<	5		1.8		2.1		2.4	
Ce<	0.16		4.70E-02		5.90E-02		7.50E-02	
Dy<	6.50E-02		1.40E-02		1.70E-02		2.00E-02	
Eu<	2.50E-03		4.30E-03		2.30E-03		6.50E-03	
La<	1.10E-02		3.70E-03	33.5	3.60E-03		4.10E-03	
Lu<	5.70E-03		1.60E-03		2.00E-03		2.60E-03	
Nd<	0.54		0.15		0.19		0.24	
Sm<	1.70E-03		4.40E-04		5.40E-04		7.20E-04	
Tb<	9.10E-03		3.00E-03		3.60E-03		4.30E-03	
Yb<	1.20E-02		3.50E-03		4.60E-03		5.10E-03	

flour), Brown bread is made of either 50% brown flour (flour with a half of the bran contents) or 100% brown flour (whole wheat, flower with a 100% bran contents).

Analysis of the samples

The samples were analyzed by Instrumental Neutron Activation Analysis method (INAA). The procedure is of two steps. One for the short-lived isotopes and the other for the long-lived isotopes.

Short-lived irradiation

Approximately 1 g of bran samples or 0.34 to 0.6 g of other samples were irradiated in the Mcmaster University Nuclear Reactor in Hamilton, Ontario, Canada. It is an open pool research reactor type with a 2 megawatt operating power level. The sample irradiated for 60 seconds at a thermal flux of approximately 5 x 10^{12} n cm^{-2} $s^{-1,}$ counted after 8 minutes cooling time then recounted after 24 hours cooling time.

Long-lived irradiation

Approximately 9 to 16 g of bran samples or 25 to 35 g of other samples were irradiated for 20 minute at thermal neutron flux 8x 10^{12} n cm^{-2} s^{-1}, counted after 5 days cooling time, thin again at 21 days decay.

Spectrum analysis

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 a final report. Table 1 gives the elemental concentration in the bran, semolina flour, 50% brown flour, 100%brown flour.

Moisture was measured for each samples and also reported in table 1.

Table 2: Comparison of elemental concentration of SRM 18 and this work

Element	Certified values		Present work	
	Concentration	Rang	Concentration	%RSD
Al %	2.57	2.54-2.61	1.29	4
Fe %	0.29	0.28-0.29	0.2	3
Ti %	0.114	0.111-0.116	0.071	4
Ca %	0.18	0.17-0.19	0.149	8
Mg %	0.11	0.1-0.11	0.041	29
K %	0.145	0.140-0.150	0.12	11
Ba ppm	78	71-82	87.8	5
Ce ppm	22	21-24	20.9	3
Co ppm	6.7	5.5-7.2	6.88	3
Cr ppm	16	14-18	15.40	3
Hf ppm	1.7	1.7-1.9	1.51	3
La ppm	10	9-13	10.1	3
Mn ppm	22	21-23	17.8	6
Rb ppm	8.1	6.7-9.5	8.14	5
Sc ppm	4.3	4.0-4.7	4.71	3
Sm ppm	2.0	1.9-2.2	1.61	5
Sr ppm	44	42-45	42	14
Th ppm	3.4	3.0-4.3	3.17	3
U ppm	1.5	1.5-2.0	1.72	3.1
V ppm	23	21-25	20.8	3
Zr ppm	67	62-71	60	10

Quality assurance

To assess the analytical process and make a comparative analysis, Standard Reference Material, 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 analysed in a same manner of all samples [19,20]. Tables 2 and 3 reporting the comparison of the certified values and this work values of each reference materials. The results were in a good agreement with the certified values.

RESULTS AND CONCLUSION

The elemental concentration of the samples under investigation of the wheat products such as bran, white flour, 50% brown flour and 100% brown flour (whole-wheat flower) are shown in table 1 together with the RSD values. It can be noticed from this table that using the INAA technique it is possible to report the concentration of around 50 elements.

It can be seen that elemental concentration is highest in the bran samples and lowest in the semolina (white flour) samples.The concentrations of elements in bran samples in this work generally agree with Iskander and Morad work [1] as shown in table 4. Except for Na where a big difference exists which could be caused by the salty ground water used in the wheat irrigation in Saudi Arabia.

The quantitative results obtained in this work will be of great interest for future work of developing reference materials for wheat based diets. It is also anticipated that these results will assist nutritionists in knowing which elements need to be enriched using wheat and bran in diets for human and farm animals.

Table 3: Comparison of elemental concentration of SRM 1566a and this work

Element	Certified values		Present work	
	Concentration	Rang	Concentration	%RSD
Al ppm	202.5	±12.5	212	3
Fe ppm	539	±15	530	3
Cl %	0.829	±0.014	0.856	3
Ca %	0.196	±0.019	0.198	5
Mg %	0.118	±0.017	0.112	8
K %	0.790	±0.047	0.78	4
Na %	0.417	±0.013	0.416	3
S %	0.862	±0.019	1.59	4
Co ppm	0.57	±0.11	0.579	3
Cr ppm	1.34	±0.46	1.55	6
As ppm	14.0	±1.2	14.30	3
Cd ppm	4.15	±0.38	2.6	10
Cu ppm	66.3	±4.3	50.9	8
I ppm	4.46	±0.42	6.66	6
Se ppm	2.21	±0.24	2.17	4
U ppm	0.132	±0.012	0.14	16
V ppm	4.68	±0.15	5.1	3
Zn ppm	830	±57	869	5
Mn ppm	12.3	±1.5	11.8	8

Table 4: Comparison of the elemental concentration in bran samples in this work and that of reference 1

Element	Concentration in ppm of present work	Concentration rang in ppm in reference 1
As	<0.036	<0.3
Ba	14	27
Br	6.03	12.7-10
Ca	1550	1530-983
Ce	<0.16	<0.3
Cl	930	770-504
Co	0.1	0.23-0.1
Cr	<0.16	0.6-0.2
Cs	<0.016	<0.02
Eu	<0.0025	0.006-0.002
Fe	101	152-112
Hf	<0.013	<0.02-0.01
Hg	<0.041	<0.1
K	14000	12200-9840
La	<0.011	<0.1-0.08
Mg	5590	5360-4780
Mn	126	177-104
Na	412	45.1-39.8
Rb	5.12	5.55-4.51
Sb	<0.009	<0.3-0.1
Sc	<0.0047	<0.004-0.002
Se	0.18	0.89-0.5
Sr	<51.6	30.3-<20
Th	<0.017	<0.04-0.03
U	<0.046	<0.4-0.1
Zn	86.9	68.7-60

ACKNOWLEDGMENTS

The authors are grateful to the Flour Mills Organization, Riyadh plant, particularly Mr. Khalil I. Al-Abdulathim for helping in samples arrangement and collection.

King Abdulaziz City for Science and Technology for financially supporting this project and Dr. Omar Al-Dayel for his valuable discussions.

REFERENCES

1. F.Y Iskander and M. M. Morad, *J. Radioanal. Nucl. Chem.., Letters*, **105**(3): 151 (1986).
2. Y. Pomeranz and E. Dikeman, *Cereal Chem.*, **60**: 80 (1982).
3. V. A. Maihara and M. B. A. Vasconcellos, *Radioanalytical and Nuclear Chemistry*, **132**(2): 329 (1989).
4. C. J. Petrson, V. A. Johnson and P. J. Mattern, *Cereal Chem.,* **60**: 450 (1983).
5. K. Lorenz, R. Loewe, W. Weadon and W. Wolf, *Cereal Chem.*, **57**: 65 (1980).
6. W. J. Garcia, C. W. Blessin and G. E. Inglett,

Cereal Chem., **49**: 158 (1972).
7. W. J. Garcia, C. W. Blessin, h. W. Gardner, J. F. Cavins, A. C. Stringfellow and G. E. inglett, *Cereal Chem*., **49**: 499 (1972).
8. B. L. O'Dell, A. R. Debol and S. R. Koirtyohann, *J. Agric. Food Chem*., **20**: 718 (1972).
9. R. A. Nadkarni and W. D. Ehmann, *Radiochem. Radioanal. Lett*., **6**: 89 (1971).
10. E. G. Zook, F.E. Green and E. R. Morris, *Cereal Chem*., **47**: 720 (1974).
11. J. J. M. de Goeij, *Radioanalytical and Nuclear Chem*. **245**: 5 (2000).
12. S.L. Bansal, S. Aggarwal and R. K. Mohindra, *Proc Indian natn Sci Acad* **56**A: 395 (1990).
13. V. A. Maihara and B. A. Vasconcellos, *Radioanalytical and Nuclear Chem, Articles*, **132**(2): 329 (1989).
14. O. Al-Dayel, Characterisation of Ancient Egyptian Ceramic by Neutron Activation Analysis, PhD thesis, University of Manchester (1995).
15. S. A. Al-Kahtani, H. P. Chou and M. A.Obeid, *Radioanalytical and Nuclear Chemistry*, **109**(1): 201 (1987).
16. J. Casta, R. Gwozdz, P. Katrik and F. Grass, *Radioanalytical and Nuclear Chemistry*, **244**(2): 349 (2000).
17. D. Samudralwar and A. Garg, *Fresenius J. Anal. Chem*., **348**(7): 433 (1994).
18. K I. Al-Abdulathim, Flour Mills Organization, Riyadh plant, Private communication (1998).
19. D. Anderson and W. Cunningham, J.AOAC.Int., **83**(5): 1121 (2000).
20. E. Curdova, C. Mohl and P. Ostapczuk, *Fresenius J. Anal. Chem*. **345**(2-4): 227 (1993).