Levels of Trace and Toxic Elements in Pakistani Varieties of Maize (*Zea mays* L.)

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Summary: In the present investigation the level of trace and toxic elements were determined in six different varieties of maize by flame atomic absorption spectrophotometric technique. Maize varieties contained higher concentration (in mg/kg) of Al, Ba, Cd, Co, Cr, Ni and Pb (28.42 ± 2.46, 4.70 ± 0.43, 0.81 ± 0.06, 0.56 ± 0.04, 0.49 ± 0.05, 0.74 ± 0.11 and 1.66 ± 0.10) were estimated in M2, M5, M1, M4, M6, M2 and M4 varieties respectively. The results obtained from the collected and certified samples were compared by conducting the t-test at 95% confidence limit. The concentration of trace and toxic elements in all maize varieties collected and certified samples is below the values recommended by WHO and hence is accepted.

Introduction

The role of trace and toxic elements in foods both in nutrition and toxicological interest has been recognized in recent years. Consequently, the levels of trace elements are being monitored on a continuous basis by many countries of the world to keep a check on their natural food supply. Surveys by WHO [1] and FDA[2] have shown that Al, Ba, Cd, Co, Cr, Ni and Pb are usually present in varying concentrations in foods. Thomas [3] also demonstrated that levels of lead and other trace metals were higher in canned products than in fresh products. Increasing industrialization and burning of fossil fuels together with excessive use of artificial crop enrichers have greatly polluted the environment with several toxic trace elements. The situation has obviously caused anxious concern to public health authorities all over the world, especially in relation to contamination of human food with these trace metals.

The presence of these metals specially even at trace level in water, air and food may pose health hazards to human life, due to the possibility of long term exposure and their accumulation in the body with age. The harmful effects of these have been well documented [4-6].

The concentration of Al, Ba, Cd, Co, Cr, Ni and Pb in cereals has been reported by various authors using different decomposition / mineralization methods and analytical techniques [7-13]. Among various analytical techniques flame atomic absorption spectrophotometry (FAAS) is one of the preferred technique due to its rapidness, high sensitivity and specificity. FAAS was used for the analysis of lead and cadmium in different varieties of maize. This study is in continuation of our work on measurement of trace and toxic elements in food items [14].

Aims and Objectives

The aims and objectives of this studies is to monitor the levels of Al, Ba, Cd, Co, Cr, Ni and Pb in maize varieties which is third major source of cereals for intake of trace elements. Such studies will be helpful to assess the safety of human diet.

Results and Discussion

Table 1. indicates the results of seven trace and toxic elements, which were analyzed from six varieties of maize. These varieties were collected from same geographical areas of Pakistan i.e. Maize and Millets Research Institute Yusafwala, District Sahiwal, Punjab.

Analytical results of maize samples show that highest level of aluminum (28.42 ± 2.46 mg/kg) is present in Agaiti-85 and lower level (11.01 ± 0.49 mg/kg) is bound in Akbar variety. The concentration in the remaining four varieties are between the two given values. Similarly, maximum barium was found (4.70 ± 0.43 mg/kg) in Sadaf, and not observed in Agaiti-72, Golden-85 and Sultan. Cadmium is one of

Table 1A. Determination the concentration of trace and toxic elements present in six varieties of the maize (mg/kg)

	Agaiti-72 (M1)		Agaiti-85 (M2)		Akbar (M3)	
Elements	Rep. sample	Cert. sample	Rep. sample	Cert. Sample	Rep. sample	Cert. sample
Al	18.01± 0.54	17.49± 0.79	28.42±/2.46	27.87± 1.28	11.36± 0.98	11.01± 0.49
Ba	0.00	0.00	4.66± 0.49	4.79± 0.31	4.35± 0.92	4.48± 0.74
Cd	0.81± 0.06	0.87± 0.04	0.81± 0.19	0.81± 0.12	0.64± 0.06	0.65± .05
Co	0.52± 0.09	0.53± 0.07	0.51± 0.11	0.50± 0.06	0.53± 0.07	0.52± 0.06
Cr	0.27± 0.03	0.30± 0.03	0.32± 0.09	0.35± 0.04	0.33± 0.07	0.30± 0.03
Ni	0.67± 0.07	0.69± 0.04	0.74± 0.11	0.73± 0.09	0.69± 0.04	0.72± 0.03
Pb	0.00	0.00	0.00	0.00	1.35± 0.15	1.39± 0.10

Table 1B. Determination the concentration of trace and toxic elements present in six varieties of the maize (mg/kg)

	Golden-85 (M4)		Sadaf(M5)		Sultan (M6)	
Elements	Rep. sample	Cert. sample	Rep. sample	Cert. sample	Rep. sample	Cert. sample
Al	21.11 ± 0.98	21.32 ± 0.69	19.02 ± 1.97	18.88 ± 2.56	14.15 ± 0.98	14.28 ±0 .79
Ba	0.00	0.00	4.70 ± 0.43	4.53 ± 0.18	0.00	0.00
Cd	0.73 ± 0.06	0.71 ± 0.03	0.68 ± 0.12	0.69 ± 0.09	0.60 ± 0.12	0.59 ± 0.09
Co	0.56 ± 0.04	0.54 ± 0.06	0.43 ± 0.07	0.45 ± 0.04	0.40 ± 0.03	0.39 ± 0.01
Cr	0.29 ± 0.04	0.30 ± 0.03	0.25 ± 0.00	0.28 ± 0.02	0.49 ± 0.05	0.45 ± 0.03
Ni	0.64 ± 0.04	0.67 ± 0.07	0.62 ± 0.00	0.63 ± 0.02	0.67 ± 0.07	0.65 ± 0.04
Pb	1.66 ± 0.10	1.60 ± 0.10	1.33 ± 0.17	1.39 ± 0.10	1.32 ± 0.19	1.36 ± 0.13

Rep. = Representative sample
Cert. = Certified sample

the third trace and toxic elements in which higher value (0.87 ± 0.04 and 0.81 ± 0.19 mg/kg) was observed in Agaiti-72 and Agaiti-85 where as the lower level (0.59 ± 0.09 mg/kg) was found in the Sultan.

The higher absorption rate (0.56 ± 0.04 mg/kg) of cobalt was found in Golden and lower absorption (0.39 ± 0.01 mg/kg) was detected in Sultan variety. The higher concentration of chromium was found in Sultan varieties as compared to the other varieties. There is no significant difference was observed in the concentration of nickel of all varieties. This indicates that the uptake of nickel was depends on the amount of nickel present in agricultural soil, it is independent of their genetic characteristics.

Maximum level (1.66 ± 0.10 mg/kg) of lead was found in Golden-85 and lower amount was observed in Akbar, Sadaf and Sultan, and it could not be detected in Agaiti-72 and Agaiti-85 varieties.

Experimnetal

Sampling and Sample Preparations:

Samples of six maize varieties were randomly collected from Maize and Millets Research Institute Yusafwala, District Sahiwal, Punjab, Pakistan. Maize varieties i.e. Agaiti-72, Agaiti-85, Akbar, Golden, Sadaf and Sultan were collected at the time of harvesting during the month of September 2000. Same varieties of the same location were obtained from FSC& RD Sahiwal. Samples of maize were washed with water and were oven dried at 105°C to constant weight.

Procedure

Five replicate 2gm samples of each variety in whole grains were weighed into 100ml conical flasks and treated with 5ml of nitric acid. The flasks were covered with watch glasses, and their contents were heated to reflux gently on an electric hot plate. After refluxing for one hour the contents of flasks were treated 5ml more of nitric acid, 2ml of 35% hydrogen peroxide was added, and the heating at gentle reflux was continued for another hour. The watch glasses were removed from the flasks, and the heating was continued until the volumes of their contents were reduced to 2-3 ml. The contents of flask were cooled, diluted with high purity water, and filtered through whatman # 42 papers into 25ml volumetric flasks. A blank was prepared similarly under identical conditions.

The contents of the flasks were brought to volume with high purity water and analysed by flame atomic absorption spectrometry for their aluminum,

Table 2. Maize varieties, their codes, year of release and registration as well as place of sampling

Code	Name of Variety	Year of Release	Year of Registration	Institution of breeding
M1	Agaiti-72	1972	1984	MMRI, Yusafwala
M2	Agaiti-85	1994	1996	Maize and Millets Research Institute Yusafwala Distt. Sahiwal, Punjab
M3	Akbar	1973	1984	
M4	Golden-85	1994	1996	
M5	Sadaf	1975	1984	
M6	Sultan	1986	1986	

Table 3. Instrumental conditions for the FAAS measurement of Al, Ba, Cd, Co, Cr, Ni, and Pb.

Elements	Wave Length (nm)	Slit Width (nm)	Lamp current (mA)	Fuel flow (acetylene) (l/min)	Flow rate (Air) (l/min)	Burner Height (mm)	Oxidant (Air) kg/cm^2	Fuel (Acetylene) kg/cm^2	Signal out put
Al	309.5	1.3	9.5	5.61	5.91(N_2O)	12.5	1.60(N_2O)	0.45	100%
Ba	553.8	1.3	9.5	5.61	5.91(N_2O)	7.5	1.60(N_2O)	0.45	100%
Cd	229.0	1.3	7.0	2.30	9.4	7.5	1.60	0.30	100%
Co	250.0	0.2	9.5	2.30	9.4	10.0	1.60	0.35	100%
Cr	358.2	1.3	6.0	2.30	9.4	7.0	1.60	0.30	100%
Ni	232.3	0.2	9.5	2.30	9.4	7.5	1.60	0.45	100%
Pb	232.3	1.3	7.0	2.30	9.4	7.5	1.60	0.45	100%

barium, cadmium, cobalt, chromium, nickel and lead contents. The result of these measurements are presented in Table: 1

Instrumentation

The FAAS analyses were performed with an atomic absorption spectrophotometer of Hitachi; Japan, Model 180-50 and equipped with a graphite furnace, a microprocessor and built in printer. Hollow cathode lamps (made by Meltorika Company) of aluminum, barium, cadmium, cobalt, chromium, nickel and lead were used as radiation source. Air-acetylene flame was used during atomization step of Cd, Co, Cr and Ni whereas for Al and Ba, nitrous oxide was used as oxidant The instrumental conditions used for the determination of trace and toxic elements are given in Table 3. Sample injection was done automatically using an auto sampler. Signal evaluation was based exclusively on integrated absorbance value.

Reagents and Calibration

Standard solutions 1000 mg/litre multi element solution (ICP Multi element standard iv, Merck, Darmstadt.) of Al, Ba, Cd, Co, Cr, Ni and Pb were prepared by dissolving appropriate amounts of distilled deionized water. Calibration was obtained with external standards. Stock and standard solutions were made in 0.02 N HNO_3. Distilled deionized water was used throughout this work. Glassware was cleaned by overnight soaking in nitric acid (1+1) followed by multiple rinses with distil and double distil water. Analytical reagent grade hydrogen peroxide (35%w/v) and distilled nitric acid (65% w/v, specific gravity 1.41kg) were used for digestion of the samples.

The statistical data for standards are given in table 4.

Table 4. Statistical data for standards of elements

Elements	Concentration range ppm (x)	Division (y)	Statistical calculation y = m x + c		
			m	c	r^2
Al	0 – 6	0 – 42	6.8793	-0.0862	0.9974
Ba	0 – 2	0 – 40	20.1	0.125	0.9992
Cd	0 – 0.25	0 – 28	110.39	0.052	0.9977
Co	0 – 0.50	0 – 29	58.4	-0.35	0.9994
Cr	0 – 0.125	0 – 15	121.59	-0.3977	0.9969
Ni	0 – 0.25	0 – 14	55.31	0.20	0.9984
Pb	0 – 0.25	0 – 15	60.80	-0.4	0.9968

div. =Divisions

Conclusions

It was observed that the aluminum, cadmium and nickel retained maximum concentration in Agaiti-85 variety, whereas higher level of cobalt and lead was found in Golden-85. In case of barium and chromium, higher value of the same was found in Sadaf and Sultan varieties respectively. Barium was not detected in Agaiti-72 and lead in Agaiti-72 & Agaiti-85 as well.

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