Determination of Trace Elements, Heavy Metals and Rare Earth Elements in Corn Seeds from Beijing by ICP-MS Simultaneously

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Abstract: Food nutrition and food safety have been paid more and more attention, so it is important to find new detecting method. ICP-MS is a good method to detect many elements simultaneously with high accuracy, but detecting more than ten elements simultaneously has little been reported, especially in cereal. Contents of forty elements in corn kernel from Beijing were detected by ICP-MS, we conclude that; 19 elements (Li, I, Co, Ni, Mo, Cs, B, Mn, Fe, Cu, Zn, Rb, Sr, Ti, Cd, Sn, Tl, Pb and Cr) in corn can be precisely and accurately determined simultaneously. As, Se, Bi, Th, U, Sb, Al and rare earth elements could not be precisely detected at this condition, probably due to too low concentrations; Corn from Beijing contains many wholesome trace elements, such as Mo, B, Mn, Fe, Cu, Zn, Rb and Sr; but the toxic elements little, so it is safe and not polluted.

Keywords: Corn, Trace elements, Heavy metals, Rare Earth, Beijing, ICP-MS

Introduction

Corn is the second cereal crop in China, which is mostly used as food material and feed¹. With the quick development of industry, the environment where corn grows is being damaged, which has resulted many food safety case, so more and more attention has focused on food safety². Beijing as the capital of China has dramatically developed in the last decades, especially the development of cars and urban construction, which can carry many toxic elements³ and these toxic elements could change the contents of other elements in corn, especially the wholesome trace elements, so it is important to study contents of trace elements, heavy metals and rare earth in corn seed.

Before the application of ICP-MS, the usual methods to detect trace elements, heavy metals and rare earth elements are atomic absorption spectrometry (AAS)⁴ and atomic fluorescence spectrometry (AFS)⁵, which have made great devotions to food nutrition and food safety. But usually many elements need detecting at the same time to determine causes of food safety or environment problem, the method ICP-MS is better than methods AAS and AFS, because ICP-MS has the ability to detect many elements simultaneously and high accuracy⁶.

Experimental

All the 15 corn samples were grown in Shangzhuang experimental station of China Agricultural University, Beijing. The ICP-MS instrument was the PQ Excell instrument (ELAN DRCII, PE Company, USA) from Central Laboratory, School of Public Health, Peking University.

Sample preparation

The corn seeds were washed with deionized water three times, then samples were prepared by microwave digestion, detailed methods for which were given by Shen⁷ with some changes. 0.5 g Corn seeds were grinded in 1% nitric acid 8 mL, PTFE was added to the digestion tank, the microwave digestion conditions was shown in Table 1. After cooling the digestion tank, 25 mL of 1% nitric acid was added for detection.

Table 1. Microwave digestion temperature control program

Step	Maximum power (W)	Climb time, min	Pressure, psi	Temperature, °C	Hold time, min
1	1250	6	300	120	5
2	1250	8	300	210	10

Instrument parameters

Instrument parameters were as described in the literature⁸⁻⁹, with some modifications, given in Table 2.

Table 2. The operating parameters for ICP-MS

Method parameters	Value
Power (W)	1350
Plasma flow, L/min	13.0
Nebulizer flow, L/min	1.00
Auxiliary flow, L/min	1.25
Sampling depth, mm	2.0
Scanning times	160
Exit plate (V)	0
Pump rate (rpm)	20
Rinse time (s)	10
Replicates	5
Replicate read time (s)	8
Instrument stabilization (s)	8
Sample delay uptake (s)	60

Results and Discussion

Precision, accuracy and limits of detection of method

The relative standard deviation of most elements is below 10%, especially the wholesome trace elements (Table 3) and toxic elements (Table 4). But the relative standard deviation of elements As, Se, Bi, Th, U, Sb and Al are higher than 15%, which could be interfered by other elements. Relative standard deviations of elements rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm and Yb) are all higher than 20% (Table 5), so it is not a good methods to simultaneously at this condition. From these data 19 elements (Li, I, Co, Ni, Mo, Cs, B, Mn, Fe, Cu, Zn, Rb, Sr, Ti, Cd, Sn, Tl, Pb and Cr) can be precisely determined simultaneously. Recoveries of all elements mostly range from 90% to 110%, which showed that this method is accurate to determine these elements (Table 3-5).

Concentration of trace elements, heavy metals and rare earth elements in corn seeds

From the tables Table 3-5, corn from Beijing contains many wholesome trace elements, such as Mo, B, Mn, Fe, Cu, Zn, Rb and Sr, especially the contents of B, Mn, Fe, Cu, Zn, Rb and Sr are higher than 2.80 µg/g; but the toxic elements and rare earth elements are mostly below 50 ng/g. Reason for the low levels of toxic elements and rare earth elements may be due to; (i) concentrations of these elements are low in soil or environment; (ii) the forms of these elements in soil are not active and difficult to absorb by plant. All these data showed that corn is a nutritional and healthy food for human

Table 3. Contents and relative standard deviations of trace elements

Element	Content	RSD, %	Recovery, %
Li	6.42 ng/g	8.65	98.76
I	14.09 ng/g	4.72	97.63
Co	6.58 ng/g	3.54	102.91
Ni	123.34 ng/g	2.93	99.74
Se	27.20 ng/g	46.6	108.15
Mo	759.02 ng/g	1.63	101.27
Cs	51.97 ng/g	6.14	100.91
Bi	0.06 ng/g	39.33	94.51
Th	0.80 ng/g	40.10	106.34
U	0.20 ng/g	16.8	99.46
B	2149.12 ng/g	9.33	105.21
Mn	4.40 µg/g	4.18	100.54
Fe	28.89 µg/g	3.92	98.64
Cu	2.86 µg/g	12.27	103.24
Zn	15.03 µg/g	1.88	101.35
Rb	5.91 µg/g	2.04	104.61
Sr	6.02 µg/g	6.56	99.61

Table 4. Contents and relative standard deviations of toxic elements

Element	Content, ng/g	RSD/%	Recovery, %
Ti	353.58	11.95	89.61
Cd	32.31	1.98	110.34
Sn	0.36	13.08	107.59
Sb	0.72	65.9	104.21
Tl	0.38	7.57	94.67
Pb	38.15	4.98	100.61
Cr	338.75	2.08	103.54
Hg	0.00	-	92.64
As	8.03	23.9	95.46
Al	6.09 µg/g	16.4	97.81

Table 5. Contents and relative standard deviations of rare earth elements

Element	Content, ng/g	RSD%	Recovery, %
La	4.50	29.0	98.89
Ce	8.00	27.5	105.61
Pr	0.91	29.5	107.51
Nd	3.86	27.6	95.68
Sm	0.71	28.7	100.34
Eu	<0.100	-	105.21
Gd	0.65	28.6	109.28
Tb	<0.100	-	94.87
Dy	0.36	35.07	89.67
Ho	<0.100	-	105.62
Er	0.14	18.84	99.46
Tm	<0.100	-	102.21
Yb	<0.100	-	105.39

Conclusion

19 Elements (Li, I, Co, Ni, Mo, Cs, B, Mn, Fe, Cu, Zn, Rb, Sr, Ti, Cd, Sn, Tl, Pb and Cr) in corn can be precisely determined simultaneously. As, Se, Bi, Th, U, Sb and Al could not be precisely detected at this condition, the cause should be other element¹⁰, so we should select another condition or method, rare earth elements could not neither be precisely detected at this condition, the cause should be that their concentrations are too low, rare earth elements should be condensed before detection. Corn from Beijing contains many wholesome trace elements, such as Mo, B, Mn, Fe, Cu, Zn, Rb and Sr, but little toxic elements, so it is safe and not polluted.

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