Determination of Inorganic Elements in White Rice by Neutron Activation Analysis.

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1. Introduction

Rice is a staple food and provides an important informaion of mineral supplement as well as a large portion of calorie for Korean. As scientists have focused their researches on health impacts caused by mineral nutrient deficiency and hazardous elements [1,2], public concerns about mineral intake by dietary food is rising.

The objectives of this study were to determine inorganic elemental contents in white rice by neutron activation analysis(NAA) and to assist the evaluation of nutritional and harmful status for Korean people.

2. Experiments

2.1 Sampling and Sample Preparation

Three different origin samples (Ganghwa, Gimpo, Ichoen) were purchased from a market in Daejeon and prepared as an analytical sample by mixing them. The mixed rice grains were cleaned once with tap water, twice with deionized (DI) water and then dried in a hot-air oven at 60 ^{0}C for 4 hours. And then, the sample was ground into fine particles using a high speed blender made of titanium to reduce contamination. The grinding step was repeated until fine particles passed completely through a No. 60 mesh sieve. Finally, three replicates with sample weights of 100 mg ~ 300 mg were prepared for instrumental neuton activation analysis(INAA)..

2.2 Neutron Activation Analysis

The NAA #2 irradiation holes with a Pneumatic Transfer System(PTS) of the HANARO research reactor was used for the activation of the prepared samples. In a typical INAA way, samples were activated by short (1 minute) and long (3 hours) irradiation to detect short-, median- and long-lived nuclides. In order to detect the gamma-rays emitted from the irradiated samples, HPGe detectors coupled to a multichannel analyzer were used. Consequently, inorganic elemental contents was determined by absolute method. NIST SRM 1568-Rice Flour for analytical quality control were analyzed under the same analytical condition with rice samples.

3. Results and Discussion

3.1 Inorganic Elemental Contents of White Rice

Fourteen elements such as Al, As, Br, Ca, Cl, Co, Cs, Fe, K, Mg, Mn, Na, Rb and Zn were determined by seven and the results are summarized in Table 1. K shows the highest values in the analyzed elements with a range of 660 mg/kg and the next are Mg and Cl. Co and Cs show the contents less than 10 μg/kg. Relative standard deviation of the analyzed elements is within 10% except for Al, Ca, Cs and Fe.

Table 1. Analytical results of white rice (unit : mg/kg)

Element	#1	#2	#3	Mean	±	SD
Al	1.46	1.05	1.13	1.21	±	0.22
As	0.124	0.119	0.119	0.121	±	0.003
Br	0.188	0.216	0.185	0.196	±	0.017
Ca	53.3	47.6	41.2	47.3	±	6.1
Cl	193	173	180	182	±	10
Co	0.0057	0.0058	0.0052	0.0055	±	0.0003
Cs	0.0101	0.0078	0.0080	0.0086	±	0.0013
Fe	1.35	1.64	1.74	1.58	±	0.20
K	639	678	662	660	±	20
Mg	201	188	203	197	±	8
Mn	7.45	7.33	7.36	7.38	±	0.06
Na	3.96	4.27	4.06	4.10	±	0.16
Rb	1.39	1.40	1.40	1.40	±	0.005
Zn	14.9	15.8	14.8	15.2	±	0.5

With respect to analytical quality control, analytical results in terms of relative error (%) are described in Fig. 1. Analytical results of most elements are within 20% of relative error when compared to certified or reference values of the NIST SRM 1568a-Rice Flour.

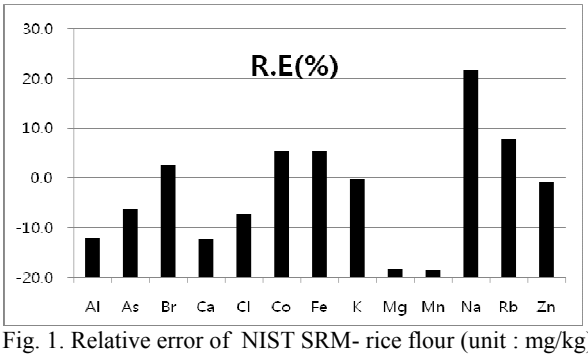

Fig. 1. Relative error of NIST SRM- rice flour (unit : mg/kg)

3.2 Evaluation of Dietary Intake level for Harmful and Essential Elements

In order to estimate dietary intake of inorganic elements via white rice, daily consumption survey is indispensible. For instance, the daily average consumption of rice with Korean in 2000 was 256 g [3]. However, rice consumption in Korea must be slightly

reduced every year. Hence, assuming that the average consumption of rice is 200 g/day, daily intake values can be simply calculated for five elements such as As, K, Mn, Na and Zn. The calculated daily intake value via white rice for As, K, Mn, Na and Zn are 26 μg, 132 mg, 1.81 mg, 0.82 mg, 3.06 mg, respectively. The Joint Food and Agriculture Organization of the United Nations and the World Health Organization Expert Committee on Food Additives (JECFA) has set a recommended weekly safe exposure limit which is 15 μg /kg in body weight for inorganic As [4]. Assuming that the body weight of adults is 70 kg, the daily safe exposure limit of As is equal to 150 μg. In addition, the Institute of Medicine (IOM) in the United States has set the values of Recommended Dietary Allowance (RDA) or Adequate Intake (AI) for essential elements [5-8]. RDA for Mn and Zn were set as 330 mg/day for adult men(19-30 years) and 14 mg/day for men, respectively. AI for K and Na set by IOM are 4.7 g/day for all adults and 1.5 g/day for young adults, respectively. Daily dietary level (%) for five elements according to safe limit, RDA and AI, was obtained and shown in Fig. 2. Dietary Level (DL) of As is evaluated to be 20% of the recommended safe exposure limits of JECFA and Mn level is almost 80% of RDA. It seems that Na intake via white rice is very tiny in comparison with other foodstuff.

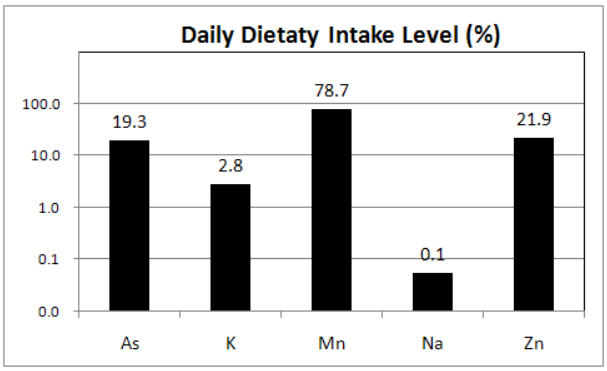

Fig. 2. Evaluation of daily dietary intake level (%) for five elements via white rice

4. Conclusions

Fourteen elements from white rice samples were determined by INAA. Daily dietary intake level was evaluated in comparison with recommended dietary allowance and adequate intake values set by IOM. NAA will be applied to evaluate nutritional status in terms of mineral intake by further analysis of a variety of food samples. .

REFERENCES

[1] World Health Organization, Trace elements in human nutrition and health. Geneva, WHO, Belgium, 2006.

[2] J. S. Garrow, W. P. T, James WPT, A. Ralph, Human nutrition and dietetics. Elsevier, Amsterdam, Netherland, 2000.

[3] Ministry of Agriculture and Forestry Agricultural and forestry statistical yearbook 2003. Ministry of Agriculture and Forestry, 2003.

[4] Joint FAO/WHO Expert Committee on Food Additives, Evaluation of certain food additives and contaminants, Thirty-third report of the joint FAO/WHO expert committee on food additives, WHO technical report series, No.776. Geneva, WHO, 1989.

[5] Institute of Medicine, Food and Nutrition Board, Dietary reference intakes for calcium, phosphorous, magnesium, vitamin D and fluoride. National Academy of Sciences, USA, 1997.

[6] Institue of Medicine, Food and Nutrition Board, Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. National Academy of Sciences, USA, 2001.

[7] Institue of Medicine, Food and Nutrition Board, Dietary reference intakes for water, potassium, sodium, chloride and sulfate. National Academy of Sciences, USA, 2004.

[8] Institue of Medicine, Dietary reference intakes for calcium and vitamin D. Report Brief, November, 2010.