

Contents of Phytic Acid and Minerals of Rice Cultivars from Korea

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Abstract

To elucidate the contents of phytic acid and minerals in rice produced in Korea, samples of 68 varieties of brown rice and 9 varieties of polished rice were analyzed for phytic acid by colorimetric method, and Ca, Fe, Mg and Zn contents by the atomic absorption spectrophotometer. Selenium was measured by fluorometry. Average of phytic acid content of the 68 brown rice were 12.6g/kg, whereas that of the 8 polished rice were 1.83g/kg on dry matter. Averages of Ca, Fe, Mg and Zn contents on the 68 brown rice were 111, 7.4, 1,068 and 19.1mg/kg, and those of the polished rice were 45.6, 2.1, 250 and 14mg/kg, respectively. A average of selenium content of the brown rice was 38.3µg/kg.

Key words: rice seeds, phytic acid, minerals, Korea cultivar

INTRODUCTION

Phytic acid is the storage form of phosphorus in seeds and is deposited during seed development as phytate salt mixed with several important mineral cations(1). Many investigators have shown beneficial or adverse biological effects of phytic acid in *in vivo* and *in vitro* experiments (2-4). For example, phytic acid has a strong chelating ability to divalent cations, resulting in the reduction of bioavailability of the trace elements such as zinc, iron, calcium, and copper during intestinal absorption(2,5-7).

According to the national nutrition survey, the national average of anemia frequency, evaluated by using WHO's criteria for anemia, was 21.4% in 1979. The high anemia frequency coincides with the low dietary intake or bioavailability of iron(8).

Rice is one of the principal cereals consumed by the Korean peoples. In this regard, it would be important to evaluate the contents of phytic acid in rice since it may reduce the bioavailability of iron and other minerals. Nevertheless, there has been no report on the content of phytic acid and minerals such as zinc and selenium in the rice harvested in Korea so far. This investigation was undertaken to obtain the information on the contents of the phytic acid and minerals in rice obtained from Korea cultivars, with the purpose of developing the low phytate rice seeds.

MATERIALS AND METHODS

Materials

68 samples of rice seeds, 8 varieties of Odae(sample number(sn)=21), Jinmi(sn=15), Sangju(sn=14), Ilpum(sn=12), Hwasung(sn=5), Bongkang(sn=3), Chukang(sn=3), Dongjin(sn=1) were obtained from Kangwon Provincial Institute of Agriculture, Korea. Rice seeds were dehulled to the state of the brown rice in a laboratory mill. In second experiments, 9 samples of degermed and polished rice were purchased from markets. Brown and polished rice were used for samples, separately. Reagents used were the special grade for mineral determination and chemical grade for phytic acid.

Methods

Phytic acid extracted with 0.2N HCl from powdered rice overnight was quantitated according to Haug and Lantzsch's method(9). For mineral analysis, samples were digested by nitric acid-sulfuric acid. The contents of calcium, magnesium, zinc and iron were determined by atomic absorption spectrophotometer(SpectraAA 300, Varian Co., Australia) and selenium content by fluorometry(LS-3, Perkin Elmer Co., Ltd., USA)(10). Statistical analysis were done by the one-way analysis followed by LSD-test among the varieties except for Dongjin.

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RESULTS

Table 1 shows the content of phytic acid and mineral contents of brown rice cultivated in Kangwon Province, Korea. Brown rice contained the phytic acid in the range of 8.6 to 17.6g/kg (Mean \pm SE, 12.6 \pm 0.19g/kg).

Although there were differences among samples of each rice variety, the varieties of Jinmi and Sangju showed higher content of phytic acid than Hwasung, and the varieties of Odae and Ilpum were intermediate. The contents of iron in brown rice samples were in the range of 1.6 to 14mg/kg (7.4 \pm 0.25mg/kg). The higher content of iron was obtained for the varieties Odae, Ilpum and Hwasung. Zinc contents in the brown rice samples were in the range of 12.7 to 37.5mg/kg (19.1 \pm 0.47mg/kg). There were no marked differences in the zinc content among the varieties. Calcium contents of brown rice samples were in the range of 64.8 to 146.5mg/kg. The average of calcium content of the brown rice samples was 111 \pm 2.2mg/kg. Hwasung, Bongkang and Zhukang varieties contained relatively lower content of calcium than those of the other varieties. Magnesium contents were in the range of 746 to 1,442 mg/kg (1,068 \pm 23.2mg/kg). It was significantly higher level in the varieties of Odae, Jinmi and Sangju than in the other varieties. Selenium contents were in the range of 1.1 to 121.6 μ g/kg with wide variation. The average content of selenium was 38.3 \pm 2.98 μ g/kg. Dongjin variety (sn=1) contained 13g/kg, phytic acid; 103mg/kg, calcium; 812mg/kg, magnesium; 7.3mg/kg, iron; 21mg/kg, zinc and 26 μ g/kg, selenium, respectively.

Table 2 shows phytic acid and mineral contents of polished rice samples harvested in Korea. Polished rice samples contained 1.83 \pm 0.18g/kg of phytic acid, ranging between 0.81 and 2.65g/kg. The content of iron, zinc, calcium and magnesium were 2.1 \pm 0.20, 14.0 \pm 0.66, 45.6

Table 2. The contents of phytic acid and minerals in polished rice collected in Korea

	Contents
Phytic acid(g/kg)	1.83 \pm 0.18
Calcium(mg/kg)	46 \pm 1.9
Magnesium(mg/kg)	250 \pm 2
Iron(mg/kg)	2.1 \pm 0.20
Zinc(mg/kg)	14 \pm 0.7

Mean \pm SE

\pm 1.89 and 250 \pm 1.7mg/kg, respectively.

DISCUSSION

Phytic acid is concentrated in the germ and pericarp of the kernel cells in rice and its content in rice may vary depending upon the variety, cultivar and/or location(1). Therefore, we analyzed the phytic acid content together with the mineral contents in rice (mainly short grain) grown in different areas of Korea.

Average of phytic acid content of brown rice grown in Korea was 12.6g/kg on dry weight. This value is higher than previous report using long grain rice (0.89% phytic acid)(1). We were able to confirm that phytic acid content of brown rice varies depending upon the variety and location from this experiment. That is, the varieties of Odae, Jinmi and Sangju contained much more phytic acid than the other varieties (Table 1). The Odae, Jinmi and Sangju are known to be main rice variety produced in Kangwon province. Here, brown rice harvested in coast area of Kangwon province seemed to contain more phytic acid than those harvested in the inland area (data not shown).

The contents of iron, zinc, calcium and magnesium in brown rice also showed the variation depending on the cultivars. These minerals content were similar to the data that has been already reported in Korea(11), but the cal-

Table 1. The contents of phytic acid and minerals in brown rice collected in Korea

Varieties	Phytic acid (g/kg)	Ca (mg/kg)	Mg (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Se (μ g/kg)
Odae	13 \pm 0.4 ^{abc}	117 \pm 4 ^a	1,140 \pm 42 ^a	8.0 \pm 0.27 ^a	20 \pm 0.7 ^a	29 \pm 4.6 ^a
Jinmi	13 \pm 0.4 ^{bc}	123 \pm 2 ^a	1,077 \pm 40 ^{ab}	6.5 \pm 0.46 ^a	19 \pm 0.8 ^a	45 \pm 3.2 ^{ab}
Sangju	13 \pm 0.5 ^c	113 \pm 1 ^a	1,188 \pm 37 ^a	7.1 \pm 0.59 ^a	18 \pm 1.6 ^a	34 \pm 2.8 ^{ab}
Ilpum	12 \pm 0.4 ^{ab}	104 \pm 2 ^{ab}	904 \pm 58 ^b	8.3 \pm 0.86 ^a	20 \pm 0.8 ^a	46 \pm 3.6 ^b
Hwasung	11 \pm 0.4 ^a	86 \pm 3 ^c	838 \pm 51 ^b	8.4 \pm 1.02 ^a	21 \pm 1.6 ^a	27 \pm 4.3 ^a
Bongkang	11 \pm 0.8 ^a	86 \pm 6 ^{bc}	896 \pm 72 ^b	6.4 \pm 2.75 ^a	17 \pm 1.8 ^a	42 \pm 3.0 ^b
Chukang	11 \pm 0.1 ^a	89 \pm 9 ^{bc}	942 \pm 42 ^b	6.7 \pm 0.75 ^a	16 \pm 0.2 ^a	50 \pm 3.0 ^b
Total	12.6 \pm 0.19	111 \pm 2	1,068 \pm 23	7.4 \pm 0.25	19.1 \pm 0.47	38.3 \pm 2.98

Mean \pm SE

^{abc}Values in a same column without common superscript letters denote significant differences (p < 0.05)

cium contents seemed to be higher in rice harvested from mine area than in those from inland area, probably reflecting the type of soil. In this study, we could not observe a meaningful relationship between phytic acid content and mineral content in the varieties of brown rice. The content of selenium showed a big variation, ranging from 1.1 to 121.6 μ g/kg. There were significant differences in the selenium content among the varieties, but not between location. Until now, there is no available data on the selenium content of brown rice harvested in Korea. Noda et al.(12) reported that selenium contents of brown rice grown in Japan were 30~40 μ g/kg on dry weight which are similar to our data.

On the other hand, the content of phytic acid in the polished rice obtained from Korean markets was 15% of brown rice mentioned above. However, as the polished rice samples were not originated from the brown rice analyzed in the this experiment, it is impossible to compare the polished rice with brown rice in phytic acid content directly. Also, the mineral contents of polished rice analyzed were lower than those obtained from the brown rice, especially in the contents of iron, calcium and magnesium. These results suggest that minerals such as iron, calcium and magnesium would be eliminated with the phytic acid during the milling process of brown rice. However, the reduction of mineral contents in polished rice by milling seems to be less significant than that of phytic acid.

Although desirable effects of phytic acid have been reported recently(1-4), the decreased bioavailability of minerals by phytic acid in diet may be the significant nutritional problem for people who are taking cereals as a staple food including the Koreans. We have tried to develop rice seeds containing the low phytic acid with the relatively high contents of beneficial minerals. These rice variation may contribute to the improvement of the nutritional status of Koreans(13).

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