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Radial Distribution of Calcium, Phosphorus, Iron, Thiamine and Riboflavin in the Degermed Brown Rice Kernel

Sung-Kon Kim and Hong-Sik Cheigh
Food Grain Technology Lab., Korea Institute of Science and Technology, Seoul
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현미입(玄米粒) 내의 칼슘, 인, 철, 비타민B_1 및 B_2의 분포에 관한 연구

김 성 곤 · 최 홍 식
한국과학기술연구소 곡류공학연구실
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Abstract

Degermed brown rice of Akibare (short grain) and Milyang 23 (medium grain) was abraded five consecutive times to remove outer 5~6 % of the kernel per milling. Samples were analyzed for calcium, phosphorus, iron, thiamine and riboflavin. Milled fraction I (about 5~6 % of the kernel) contained 8 times as much calcium and phosphorus as did the original kernel; iron, 4~5; thiamine, 3; and riboflavin, 4. Contents of fraction I were much greater than those in the residual kernel: 18 times as great for calcium; 32~36 times for phosphorus; 5~10 times for iron 5 times for thiamine; and 19~30 times for riboflavin. Milyang 23 showed a steeper concentration gradient of calcium and riboflavin, but more even distribution of iron than did Akibare. There were no significant differences in phosphorus and thiamine gradients between the two rices.

Introduction

Although considerable information is available concerning the content of nutrients in the various anatomical parts of rice kernel[1], only ample data are available on the distribution patterns of constituents within the kernel itself. The general distribution patterns of major rice constituents within the kernel exhibit two main types of curves; one, represented by starch, shows a continuous increase in concentration from the periphery to the center of the kernel; a second type, including the rest constituents, shows a reverse pattern[2]. These distribution patterns of constituents, are common for all rice varieties and lots. There are, however, some minor differences among the rices in these patterns[2].

Most studies on the concentration gradient for constituents throughout the kernel have been carried out with milled rice. However, present knowledge on the distribution of vitamin and mineral constituents within milled rice kernel is fragmentary. Only data for thiamine[3,4,5], riboflavin[3,4,5], niacin[3,4,5], pyridoxine[3,4,5], total ash[3,6,7,8], iron[8], calcium[4,8], phosphorus [4,8], magnesium[8], sodium[8] and potassium[8] have been reported. All vitamins and minerals show a common pattern of distribution, and the sharp decrease of concentration within the outermost layer, representing about 5 to 10 % by weight of the milled kernel. Since little knowledge exists on the distribution of constituents within brown rice kernel, the present study was undertaken to investigate the distribution of calcium, phosphorus, iron, thiamine and riboflavin in degermed brown rice of Akibare (short grain) and Milyang 23 (medium grain).

Materials and Methods

Akibare (short grain) and Milyang 23 (medium grain) paddy rices from 1977 crop were obtained from the College of Agriculture, Seoul National University, Suweon, Korea. The paddy was dehusked, degermed and then abraded five consecutive times by a Satake Grain Testing Mill(Satake Engineering Co., Ltd., Tokyo, Japan). The milling time was controlled to remove outer 5~6 % by weight of the kernel per milling and the milled fraction was collected after each milling. Milling time and average yield of milled fractions are given in Table 1. Portions of the original degermed brown rice and the residual kernels were ground to pass through a 60-mesh sieve.

Calcium and iron were analyzed by atomic absorption spectroscopy[9] and phosphorus was determined by a hetero-blue method[10]. Thiamine and riboflavin were determined by the thiochrome method[11] and by the fluorescence method[11], respectively.

Table 1. Milling time and average yield of milled fractions

Material	Milling time for each fraction (min)	Weight percent	
		Akibare	Milyang 23
Fraction I	1	5.3	6.0
II	2	5.2	6.3
III	3	5.5	6.0
IV	5	5.4	5.0
V	10	6.7	6.6
Residual kernel	—	71.9	70.1
Original kernel	—	100	100

Results and Discussion

Contents of calcium, phosphorus, iron, thiamine and riboflavin in the original kernels and their milled fractions are presented in Table 2. Concentrations of the minerals and vitamins in milled fractions and residual kernels as compared with the original rices are shown graphically in Fig 1. For each of the component studied, the values in the milled fractions were highest in fraction I (representing outer 5~6 % of the degermed brown rice), decreased from the periphery to the interior of the kernel and were lowest in the residual kernel (Table 2).

Calcium contents of the original kernels for Akibare and Milyang 23 were 9.4 and 6.9 mg per 100 g sample, respectively (Table 2). Calcium content of fraction I for both Akibare and Milyang 23 was 8 times as

Table 2. Contents of calcium, phosphorus, iron, thiamine and riboflavin in degermed brown rice and its milled fractions (per 100 g, dry basis)

Material	Calcium(mg)		Phosphorus(mg)		Iron (mg)		Thiamine(μg)		Riboflavin(μg)	
	Akibare	Milyang 23	Akibare	Milyang 23	Akibare	Milyang 23	Akibare	Milyang 23	Akibare	Milyang 23
Fraction I	73.4	57.5	2,209	2,568	39.3	17.7	1,135	1,162	224	214
II	47.4	22.1	1,512	1,759	18.7	17.9	1,071	1,015	145	77
III	13.1	7.2	340	585	16.4	14.3	522	580	51	35
IV	7.8	4.2	131	175	17.4	13.1	260	274	21	21
V	5.6	3.4	86	131	15.2	12.0	232	233	18	12
Residual kernel	4.1	3.0	62	81	3.8	3.5	232	235	12	7
Original kernel	9.4	6.9	269	348	7.4	5.2	435	455	58	49

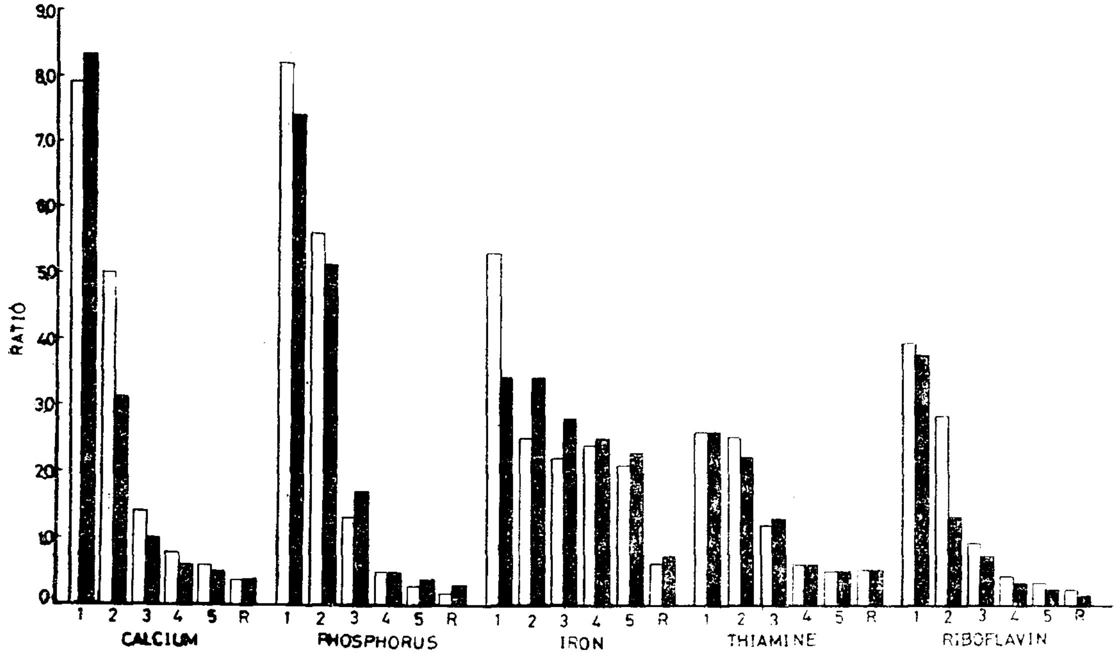

Fig. 1. Ratio of contents of calcium, phosphorus, iron, thiamine and riboflavin in flours and residual kernel, with respect to those of the degermed whole kernel brown rice of Akibare (white bar) and Milyang 23 (blackbar): 1, fraction I; 2, fraction II; 3, fraction III; 4, fraction IV; 5, fraction V; R, resudial kernel.

high as that for the original kernel, and 19 times that for the residual kernel. Fractions II~V for Akibare had twice as much calcium as those for Milyang 23. Calcium contents in fraction I for Akibare and Milyang 23 corresponded to 42 % and 50 % of those found in the original kernels. However, the content in fraction II for Milyang 23 was 20 %—3.2 times as great as in the original brown rice. These results indicate that calcium gradient within the kernel for Milyang 23 is steeper than that for Akibare (Fig. 1).

Phosphorus contents of the original kernels for Akibare and Milyang 23 were 269 and 348 mg per 100 g sample, respectively (Table 2). Phosphorus values of fraction I for Akibare and Milyang 23 were respectively 8.2 and 7.4 times as high as those of corresponding original kernels, and 36 and 32 times of the residual kernels. Phosphorus content in fraction I for both Akibare and Milbare and Milyang 23 was about 44 % of that in the original kernel. There were no significant differences in phosphorus gradient patterns between Akibare and Milyang 23, indicated by ratios of phosphorus contents in the milled fractions and residual kernels with respect to those of the original brown rices (Fig. 1).

Iron contents of the original kernels for Akibare and Milyang 23 were 7.4 and 5.2 mg per 100 g sample, respectively. Although these values were close to those for calcium, the fractions I and II had much lower iron content than calcium and fractions III, IV and V had 2~3 times as much iron as calcium (Table 2). Iron contents of fraction I for Akibare and Milyang 23 were respectively 5.3 and 3.4 times as high as those of the corresponding original kernels, and 10 and 5 times of the residual kernels. Iron content of fraction I for Akibare was 28 % of that of the original kernel, while that for Milyang 23 was 20 %. Milyang 23 showed more even distribution of iron throughout the kernel than did Akibare (Fig. 1).

Thiamine contents of the original kernels for Akibare and Milyang 23 were 435 and 455 μg per 100 g sample, respectively (Table 2). Fraction I for both Akibare and Milyang 23 contained 2.6 times as much thiamine as did the original kernel, and 5 times as did the residual kernel. There were essentially no differences of thiamine contents in fractions and residual kernels between the two rices, indicating that there is no varietal difference in the concentration gradient of thiamine within the kernel between Akibare and Milyang 23 (Fig. 1).

Riboflavin contents of the whole kernels for Akibare and Milyang 23 were 58 and 49 μg per 100 g sample, respectively (Table 2). Riboflavin values in fraction I for both Akibare and Milyang 23 were about 4 times as great as in the original kernel. Fraction I contained 19 and 30 times as much riboflavin as did the residual kernels of Akibare and Milyang 23, respectively. Fraction II of Akibare contained twice as much riboflavin as that of Milyang 23. The concentration gradient of riboflavin was steeper for Milyang 23 than for Akibare (Fig. 1). These patterns are similar to those of calcium in which a sharp decrease of calcium content in fraction II for Milyang 23 was observed (Fig. 1).

The results in Table 2 and Fig. 1 indicate that varietal differences are apparent in the gradient of components studied. Milyang 23 showed steeper concentration gradient of calcium and riboflavin, but more even distribution of iron than did Akibare. There were no significant differences in phosphorus and thiamine gradients between the two rices.

요 약

배아를 제거한 현미(품종 : 아끼바레 및 밀양 23호)를 중량비로 약 5~6 %씩 계속 5번 나누어 제거후 각 가루획분, 잔여 미립 및 현미의 칼슘, 인산, 철분, 비타민 B_1 및 B_2를 정량하여 이들 성분의 분포를 살펴보았다. 처음 획분(현미를 5~6% 도정한 가루)은 현미 자체보다 칼슘 및 인산이 8배, 철분이 4배, 비타민 B_1이 3배, 비타민 B_2가 4배 많았다. 이들 성분은 미립 외부로부터 중심으로 갈수록 그 함량이 적었다. 인산 및 비타민 B_1의 분포양상은 두 품종간에 차이가 없었으나 밀양 23호는 아끼바레에 비하여 칼슘 및 비타민 B_2의 함량은 중심으로 갈수록 급격히 감소한 반면 철분은 오히려 균일하게 분포되어 있었다.

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