Distribution of Phytic Acid and Zinc in Rice Kernels

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INTRODUCTION

Information on the distribution of nutrients in rice will greatly help to understand the effect of milling and aid in designing procedures that improve technological and sensory properties of rice while retaining its essential nutrients as much as possible.

The purpose of this study was to compare the distribution of Zn and phytic acid in short-, medium- and long-grain rice kernels using a combination of abrasive milling and X-ray imaging methods. Based on this distribution, milling could be optimized for maximum removal of phytic acid, maximum retention of Zn, and appropriate whiteness relevant for sensory properties.

METHODS

Paddy: Ganwanxian 30 (G30, long-grain), Zhongyou 752 (Z752, medium-grain) and Bijing 37 (B37, short-grain) were selected (Liang et al. in press).

Hulling and Milling: paddy was dehusked with a hulling machine (THU-35C, Satake, Japan). Unbroken hulled kernels were used for subsequent milling experiments. Brown rice was milled for different durations from 6s to 300s with a milling machine (TM 05C, Satake, Japan). Whole milled rice kernels were separated and ground with grinder (HY-04B, Beijing Xinhuanya, China) for chemical analysis.

Zinc: samples were digested with HNO_3 and H_2O_2 using a microwave laboratory system (Milestone, Italy). Concentrations of Zn in solutions were measured with a Vario 6 Atomic Absorption System (Analytik Jena, Germany).

Phytic Acid: was analysed using a modified AOAC method as described by Ma et al. (2005).

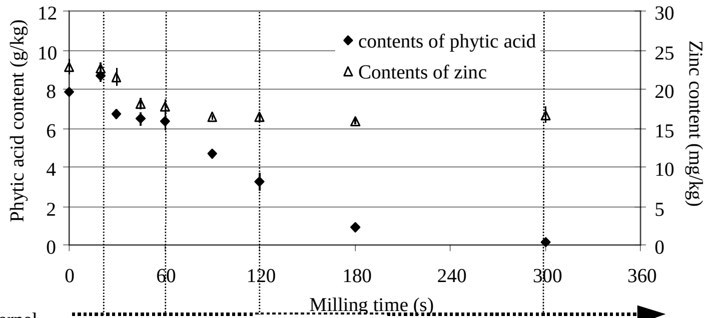
X-ray Fluorescence Imaging: X-ray elemental maps were obtained with a micro-X-ray fluorescence instrument developed at Osaka City University (Emoto et al. 2004).

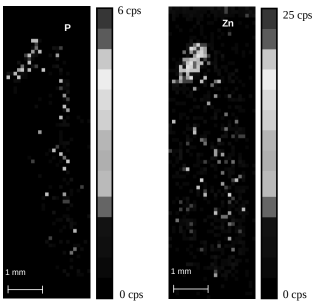
RESULTS AND DISCUSSION

Images of P, phytic acid and Zn in brown rice are shown in Figure 1 (only results of medium-grain are presented).

In all three varieties, the density of P decreased from the surface region inward. The embryo region did not contain much P, whereas the highest density was at the interface of embryo and perisperm. Phytic acid levels (y, mg/g) and milling duration (x, s) were inversely related (R^2= 0.82-0.91). Differences in the distribution of phytic acid in brown rice kernels between varieties mainly occurred in the outer part of the kernel.

The images showed that the location of Zn was similar in all three varieties. All three varieties had the highest density of Zn in embryo, whereas Zn was relatively uniformly distributed in other regions. The location of Zn indicates that it may be beneficial to retain more embryos or more parts of the embryo to obtain higher final levels of Zn. Further analysis showed there was no correlation between Zn contents and milling duration.





Situation of kernel	Brown rice		Milled rice	Core of kernel
Milling time (s)	20	60	120	300
Mass loss (%)	3.1	6.5	12.6	24.7
Loss of PA (%)	---	25	64	99
Loss of zinc (%)	4	27	37	45
Molar ratio of PA/Zn	38	35	20	<1
Regression of PA (y, %) retention to milling time (x, s)	$y = -0.0322x + 8.2556$ $R^2 = 0.8456$			

Fig.1 Distribution of phytic acid and Zn in Zhongyou 752 (medium-grain).

Fig.1 also shows that more than 60-70% of total phytic acid and less than 40% of Zn were located in 10% of the surface layer. Molar ratios of phytic acid to Zn (PA/Zn) varied with regions of kernel and varieties. For all varieties, only when more than 20% of the outer layer was removed, PA/Zn decreased to less than 1. This is however unacceptable from a commercial point of view.

CONCLUSION

The distribution of phytic acid differed between rice varieties, and in parts of the rice kernel. Most of the phytic acid in the rice kernels was located in the outermost layer. The distribution of Zn was similar in different rice varieties and relatively uniform in rice kernels with the exception of the embryo where Zn is present in high density. The results show show a way to process brown rice that has a low phytic acid and a relatively high Zn content.

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