International Food Research Journal 25(5): 2063-2067 (October 2018)
Journal homepage: *http://www.ifrj.upm.edu.my*

Mineral content of dehulled and well-milled pigmented and non-pigmented rice varieties in the Philippines

*Hurtada, W. A., Barrion, A. S. A. and Nguyen-Orca, M. F. R.

Institute of Human Nutrition and Food, College of Human Ecology, University of the Philippines Los Baños

Article history

Received: 21 July 2017
Received in revised form: 27 September 2017
Accepted: 13 October 2017

Keywords

Milled rice
Dehulled rice
Mineral content of rice

Abstract

The iron, zinc, phosphorus, and manganese contents of dehulled and well-milled pigmented and non-pigmented rice varieties were determined. Pigmented rice had the highest mineral content compared to the non-pigmented rice, regardless of variety. However, non-pigmented had higher phosphorus content. Among the non-pigmented rice varieties, Jasmin rice contains the highest zinc content. Sinandomeng contains the highest iron content, IR 64 contains the highest manganese content, and Milagrosa contains the highest phosphorus content. On the other hand, upon comparing the pigmented rice varieties, Dinorado contains the highest zinc and phosphorus content, Perurutong contains the highest iron, and Malagaya Tapul contains the highest manganese content. The dehulled varieties of pigmented rice contain high mineral content compared to well-milled rice. However, Ballatinao and Malagaya Tapul contain high levels of zinc and manganese in well-milled rice and high levels of iron and phosphorus in dehulled rice.

Introduction

Rice is known to be the staple food for Asians. It supplies most of the energy needed for the day. It is the main source of carbohydrate and usually eaten in breakfast, lunch and supper together with the meat, fish, poultry or vegetables. In the Philippines, rice contributes about 31.5% of food consumed. Intake of rice and rice products (282 g) constitutes 1/3 of the total food consumed per capita per day (803 g).

There are many kinds of rice including non-pigmented rice and several varieties of pigmented rice. Almost 85% type of rice has white pericarp referred as non-pigmented rice while pigmented rice has either green or black or red pericarp (Nyein Nyein *et al*., 2010). These two types of rice give different benefits to consumers. The most available and widely accepted rice is the non-pigmented variety and it is even extensively distributed in the Philippine market. On the other hand, pigmented rice is also consumed but the price is higher than the non-pigmented thus only few consumers buy this type of rice.

Non-pigmented rice and pigmented rice can be further categorized into two: dehulled rice and well-milled rice. When the rice grains undergone dehulling and no further processing was done then the product is known as brown rice or unpolished rice. Whereas, when the rice grains undergone processing such as milling until the rice reach a white color then the product is known as well-milled or polished rice.

Well-milled rice can be interchangeably known as white rice. Most of the rice grains in the Philippines are well-milled white rice. Pigmented rice, on the other hand, underwent the same processing as non-pigmented rice yet remains its distinct color.

Brown rice or dehulled is not that popular to consumers because of its color, price and difficulty in cooking. The brown color is due to the bran that was not removed. Furthermore, the cooking method for this rice is quite difficult due to the need for it to be soaked first before cooking.

Generally, rice is nutritionally complete with the major nutrient constituents of carbohydrates and proteins and minor constituents of fats (lipids), crude fiber (dietary fiber), minerals and vitamins. Thus, rice provides health benefits to its consumer. However, milling processes determine the level of nutrients remained on the grain itself. Moreover, in terms of the type of rice, pigmented variety is healthier than non-pigmented ones because of their greater antioxidative and radical scavenging properties that provide and promote human health by reducing the concentration of radical oxygen species and free radicals (Nyein Nyein *et al*., 2010).

This study is significant in knowing the facts about the mineral content of the different rice varieties. This could also help in determining whether what kind of rice the consumers should consume to gain the most

*Corresponding author.
Email: *wahurtada@up.edu.ph*

benefits.

This study aimed to determine the mineral content of different varieties of rice specifically to measure the amount of iron, zinc, phosphorus, and manganese contents of dehulled and well-milled pigmented and non-pigmented rice varieties.

Materials and Methods

Materials

The rice varieties of non-pigmented rice (such as Milagrosa, Jasmin, Basmati, IR 64, Sinandomeng) and pigmented rice (such as Kinanda, Dinorado, Perurutong, Ballatinao, Malagaya Tapul) were obtained from the International Rice Research Institute (IRRI).

The sample preparation was conducted at the Bio-Assay Laboratory in the Institute of Human and Nutrition and Food (IHNF) and the analysis was conducted at the Institute of Plant Breeding. A total of twenty rice samples were requested weighing 50 grams each for each dehulled and well-milled sample.

Mineral analysis

Preparation of sample by dry ashing method

One gram of ground rice sample was ignited in the furnace set at 550°C for eight hours. After ashing, the weight of the crucible was obtained then 1.0ml of concentrated HCL was added to the rice sample and stirred gently. Then 4.0 ml of water was added and heated on a hot plate at 100°C. The solution was then evaporated to 2.0 ml and 2.0 ml distilled water was added to the evaporated solution and it was heated again to 90°C. The solution was then filtered through ashless filter paper of medium porosity using a volumetric flask as receiver. Finally, the solution was diluted to 20 mL and stored for mineral analysis.

Phosphorus determination

An aliquot, about 1.0 ml, of ash solution was placed into a 50.0 ml volumetric flask. Then 25 ml of distilled water and 5.0 ml of ammonium molybdate was added and mixed well. 2.0 ml of amino-napthol sulfuric acid (ANSA) reagent was added after. The solution was diluted to volume with distilled water and mixed well again. Stand at room temperature for 20 minutes. The absorbance was read at 700 nm. Blank using distilled water was run as sample (AOAC, 2000).

Iron, zinc and manganese determination

In analyzing the iron, zinc, and manganese content of the pigmented and non-pigmented rice varieties, an Atomic Absorption Spectrophotometer was used (AOAC, 2000).

Statistical analysis

Analysis of Variance or ANOVA was used to determine the significance of the means of the different mineral contents of non-pigmented and pigmented rice. Where the means are found to be significant, Tukey's Test was used to determine the magnitude of the differences among the different mineral content as well as processing.

Results and Discussion

Mineral content of non-pigmented and pigmented rice varieties

Generally, pigmented rice has the highest mineral content compared to the non-pigmented rice regardless of variety (Table 1). Pigmented rice contains more zinc, iron and manganese than the non-pigmented rice. However, non-pigmented has higher phosphorus content.

Among the non-pigmented rice varieties, Jasmin rice contains the highest zinc content, Sinandomeng contains the highest iron content, IR 64 contains the highest manganese content, and Milagrosa contains the highest phosphorus content. On the other hand, upon comparing the pigmented rice varieties, Dinorado contains the highest zinc and phosphorus content, perurutong contains the highest iron, and Malagaya Tapul contains the highest manganese content.

Mineral content of different rice varieties under processing

Rice is commonly used as milled or white rice which is produced by removing the hull of the rough rice kernel (paddy) in hulling and bran layers during milling process. Dehulled rice is composed of surface bran (6-7% by weight), endosperm (approximately 90%) and embryo (2-3%). White rice, on the other hand, is referred to as well milled rice when 8-10% of mass (mainly bran) has been removed from brown rice. Milling causes considerable losses of nutrients (Liang, 2007).

The distribution of minerals in rice kernels is not uniform. About 50% of the mineral content is located in the bran layer and 10% in the embryo. Both are removed when producing well milled rice (Ayyangar, 1967).

According to Ensminger and Ensminger (1983), upon milling of brown rice into well-milled rice 50% of the manganese, 50% of the phosphorus, 60%

Table 1. Zinc, iron, manganese and phosphorus contents of non-pigmented and pigmented rice varieties

Rice Varieties	Minerals			
	Zn (µg/g)	Fe (µg/g)	Mn (µg/g)	P (µg/g)
Non-pigmented				
Milagrosa	32.02±0.08^{c}	3.02±0.07^{d}	51.78±0.30^{f}	347.32±0.32^{a}
Jasmin	38.65±0.12^{b}	2.97±0.17^{d}	56.63±0.15^{e}	247.85±0.29^{g}
Basmati	22.99±0.27^{g}	7.76±0.10^{b}	38.81±0.41^{i}	315.36±0.56^{b}
IR 64	22.88±0.38^{g}	2.53±0.08^{e}	61.42±0.15^{c}	256.07±0.09^{e}
Sinandomeng	26.25±0.15^{e}	7.90±0.27^{ab}	44.32±0.17^{h}	207.14±0.19^{h}
Pigmented				
Kinanda	25.31±0.17^{f}	3.06±0.09^{d}	42.74±0.43^{i}	250.89±0.21^{f}
Dinorado	39.90±0.18^{a}	3.06±0.19^{d}	59.35±0.32^{d}	308.52±0.12^{c}
Perurutong	38.40±0.24^{b}	8.30±0.06^{a}	64.84±0.07^{b}	260.89±0.25^{d}
Ballatinao	27.78±0.17^{d}	6.35±0.08^{c}	46.89±0.14^{g}	179.28±0.38^{j}
Malagaya Tapul	39.00±0.19^{b}	7.55±0.16^{b}	65.83±0.08^{a}	193.93±0.14^{i}

*Values are expressed as mean ± standard deviation (3 replicates); Means bearing different superscripts in columns are significantly different based on Tukey's Test at 5% level of significance.

of the iron, and other essential nutrients were loss. Dehulled rice contains the highest iron, manganese and phosphorus content (Table 2). The reason for this was the bran, which contains the most of the nutrients, was removed during milling. Pigmented rice contains mineral content compared to non-pigmented rice. Furthermore, in pigmented dehulled rice, the bran is still attached to the grains thus it consists of more minerals compared to non-pigmented rice.

The phosphorus content is generally higher in pigmented than non-pigmented rice varieties in comparison with other nutrients, regardless of processing. However, upon comparing with regards to processing, non-pigmented dehulled contains the highest phosphorus, followed by pigmented dehulled rice, then pigmented well-milled, and lastly non-pigmented well-milled. Similar study (Reddy and Sathe, 2002) showed that wild rice, brown rice and white rice contains 2.20%, 0.84-0.99%, 0.23% phytate, respectively. Thus, dehulled or brown rice contains the highest phosphorus content compared to well-milled rice.

The manganese is the second highest mineral present among the rice varieties. With regards to processing, pigmented and non-pigmented dehulled contains the highest manganese content. During milling process, 50% of manganese was lost. Furthermore, the hull and bran contained higher concentration of manganese. The hull contained about 3 times more and the bran 4 times more manganese than the paddy rice thus upon milling, the manganese was removed (Tabekhia and Luh, 1979).

Low levels of phytic acid is correlated to elevating levels of zinc content thus high zinc content in well-milled non-pigmented rice is observed. As mentioned above, non pigmented rice has lower phytate content and milling further contribute to its loss.

Iron is directly proportional to the manganese content. Iron is found concentrated in the hull and bran fraction thus upon polishing 60% was removed (Tabekhia and Luh, 1979). Dehulled rice contains more iron than well-milled rice.

Generally, in non-pigmented rice varieties, the dehulled contains the most mineral content. However, certain conditions could have affected some results like storage, milling, soil composition, and length of grain which could have an effect in the mineral content of rice. The phytic acid content also affects the mineral content thus increasing the zinc, manganese upon milling. On the other hand, the low levels of iron and phosphorus could be due to the removal of bran.

Milagrosa and Jasmin dehulled contain high levels of zinc, iron and manganese and phosphorus. In well-milled Basmati, there is high level of zinc and manganese content, while there is high levels in iron and phosphorus in dehulled rice. Moreover, similar study showed that zinc content of the reasonably milled and well-milled rice were close to the manganese content (Tabekhia and Luh, 1979).

In IR 64 well-milled, there is high zinc, while IR 64 dehulled contains high iron, manganese and phosphorus content. There is higher zinc and manganese content in Sinandomeng well-milled while sinandomeng dehulled is higher in iron and phosphours. Therefore, upon removal of the bran, the zinc and manganese elevates while the iron and phosphorus were decreased.

Kinandang, Dinorado and Perurutong contain high mineral content in dehulled rice. However, Ballatinao and Malagaya Tapul contain high levels of zinc and manganese in well-milled rice and high levels of iron and phosphorus in dehulled rice. In this varieties, the zinc and manganese contents elevates once the bran was removed. On the other hand, the iron is concentrated in the bran, thus it decreases upon polishing.

Generally, the dehulled varieties of pigmented rice contain high mineral content compared to well-milled rice varieties. The nutritive value of foods depends not only on the amount of the certain particular nutrients but also on their biological activity. Phytic acid binds with zinc, iron and other minerals (Tabekhia and Luh, 1979). High concentration of phytic acid could be found in the bran and when the bran is removed, small amount remains in the rice grain. In relation to the phytic acid and zinc content of rice, Frei and Becker (2004) stated that there is a relationship between low levels of phytic acid to elevating levels of zinc content, however studies have not yet been conducted to explain its relationship. Furthermore, the manganese content can also be associated with the phytic acid content. Thus, studies about this

Table 2. Zinc, iron, manganese and phosphorus contents non-pigmented and pigmented rice varieties in relation to processing

Rice Varieties	Zn (µg/g)	Fe (µg/g)	Mn (µg/g)	P (µg/g)
Non Pigmented				
Milagrosa WM	31.39±0.03^{ij}	1.70±0.10^{ij}	48.45±0.14^{j}	195.71±0.28^{m}
Milagrosa D	32.64±0.04^{h}	4.35±0.17^{fg}	55.11±0.09^{h}	489.93±0.06^{a}
Jasmin WM	32.78±0.08^{h}	1.78±0.11^{ij}	38.10±0.23^{m}	186.07±0.16^{n}
Jasmin D	44.52±0.06^{bc}	4.16±0.11^{fg}	75.15±0.18^{c}	309.64±0.08^{e}
Basmati WM	31.39±0.03^{ij}	5.22±0.11^{e}	52.99±0.23^{ij}	225.00±0.06^{j}
Basmati D	14.58±0.14^{o}	10.29±0.14^{c}	24.63±0.34^{o}	405.72±0.08^{b}
IR 64 WM	29.52±0.16^{ij}	1.51±0.24^{ij}	48.97±0.23^{ij}	153.93±0.10^{r}
IR 64 D	16.25±0.05^{n}	3.54±0.14^{h}	73.88±0.19^{d}	358.21±0.11^{c}
Sinandomeng WM	35.62±0.08^{g}	4.35±0.17^{fg}	60.15±0.03^{g}	162.50±0.14^{q}
Sinandomeng D	16.88±0.20^{m}	11.46±0.38^{b}	28.49±0.06^{o}	251.79±0.12^{h}
Pigmented				
Kinandang WM	16.60±0.24^{mn}	1.52±0.11^{ij}	28.02±0.12^{o}	165.36±0.05^{p}
Kinandang D	34.03±0.20^{f}	4.60±0.23^{f}	57.45±0.07^{f}	336.43±0.05^{d}
Dinorado WM	34.86±0.13^{g}	1.91±0.04^{ij}	42.84±0.23^{jk}	258.93±0.15^{g}
Dinorado D	44.93±0.17^{b}	4.20±0.01^{fg}	75.86±0.28^{b}	358.22±0.09^{c}
Perurutong WM	27.71±0.11^{k}	3.93±0.04^{gh}	46.78±0.03^{k}	238.93±0.08^{i}
Perurutong D	49.09±0.22^{a}	12.68±0.12^{a}	82.89±0.12^{a}	282.86±0.04^{f}
Ballatinao WM	33.40±0.17^{g}	4.01±0.21^{gh}	56.39±0.11^{g}	151.07±0.13^{s}
Ballatinao D	22.16±0.17^{l}	8.69±0.11^{d}	37.40±0.17^{n}	207.50±0.10^{l}
Malagaya Tapul WM	44.45±0.26^{c}	5.28±0.15^{e}	75.03±0.12^{c}	164.65±0.05^{p}
Malagaya Tapul D	33.55±0.11^{g}	9.82±0.05^{c}	56.63±0.25^{g}	223.22±0.11^{k}

*WM- well milled, D- dehulled; Values are expressed as mean ± standard deviation (3 replicates); Means bearing different superscripts in columns are significantly different based on Tukey's Test at 5% level of significance.

should also be included. Iron is concentrated in the bran of rice that dehulled rice has the highest iron content. It is considerably higher compared to the non-pigmented varieties of rice.

In addition, milling and polishing has benefit because it improve the acceptability and nutritive value (increase in zinc and manganese content) of rice by removing a portion of phytic acid (Tabekhia and Luh, 1979). But in general, consumers mainly get starch, some protein and a small quantity of minerals, since many important nutrients like minerals, vitamins and fiber are lost in the bran fraction (Liang, 2007).

Other considerations that may affect the mineral content of rice should not be neglected. The soil where the rice is planted could also be considered as one of the factors that determines its nutrient content. When the soil was given different treatment, it could either increase or decrease its content depending on the relationship of the nutrients of the plant to the treatment.

Conclusion

The study deals with comparing zinc, iron, manganese, and phosphorus contents of dehulled and well-milled non-pigmented and pigmented rice varieties. There are five varieties of non-pigmented rice and five varieties of pigmented rice. The paddy rice undergone processing namely, the brown or unpolished rice and the polished rice. Generally, pigmented rice has the highest mineral content compared to non-pigmented rice. On the other hand, in the processing, regardless of color, still dehulled contains the highest mineral content compared to well-milled. If the pigmented and non-pigmented were compared with the processing, the pigmented dehulled contains high levels of minerals. However, if it is compared to the non-pigmented dehulled, the iron, manganese and phosphorus is still high in dehulled but zinc is high in well-milled. The reason here is that pigmented rice contains more phytic acid than non-pigmented rice. The phytic acid affects the mineral content of rice. Once the bran was removed, the phytic acid was also removed thus increasing the zinc and sometimes the manganese level. In general, the bran consists of most of the minerals that a rice grain could contain however, upon processing which removes the bran, the mineral content lowers.

References

AOAC. 2002. Official Methods for Analysis. 17th ed. Gaithersburg, Maryland, USA: AOAC International.

Ayyangar, R. S. 1967. Iron and Manganese Nutrition Relationships in Rice Grown in Some Philippine Soils. College, Laguna, Philippines: University of the Philippines Los Baños.

Ensminger, A. H. and M. K. J. Ensminger. 1986. Food

for Health: A Nutrition Education. Clovis, California: Pegus Press.

Frei, M. and Becker, K. 2004. On Rice, Biodiversity & Nutrients. Stuttgart: Institute of Animal Production in the Tropics and Subtropics, University of Hohenheim. Retrieved on October 2016 from Greenpeace website: *http://www/greenpeace.org/raw/content/international/press/rice-biodiversity-nutrients.pdf*

Liang, J. 2007. Iron, Zinc and Phytic acid in Rice from China: Wet and Dry Process toward Improved Mineral Bioavailability. Wageningen, The Netherlands:Wageningen University. PhD Thesis.

Nyein Nyein, H., Srilaong, V., Tanprasert, K., Photchanachai, S., Kanlayanarat, S. and Uthairatanakij, A. 2010. Low oxygen concentrations affecting antioxidant activity and bioactive compounds in coloured rice. Asian Journal of Food and Agro-Industry 3(02):269-281.

Reddy, N. R. and Sathe, S. K. 2002. Food Phytates. America: CRC Press.

Tabekhia M. M. and B. S. Luh. 1979. Effect of Milling on Macro and Micro Minerals and Phytate of Rice. Deutsche Lebensmittel-Rundschau 75: 57–62.