

EFFECT OF PARBOILING ON MINERALS AND HEAVY METALS OF SELECTED SRI LANKAN TRADITIONAL RICE VARIETIES GROWN UNDER ORGANIC FARMING

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ABSTRACT

The study was conducted to evaluate the effects of parboiling treatment on the minerals and heavy metals of six Sri Lankan traditional rice varieties; Kalu heenati, Pokkali, Gurusinghe wee, Kahawanu, Sudu murunga and Unakola samba. Metals were determined by using ICP-AES and AAS. Parboiling can be considered as a suitable rice processing method for Pokkali and Kahawanu and not for Kalu heenati and Unakola samba in order to furnish the recommended daily intake of the micronutrients. Un-parboiled Kalu heenati and both un-parboiled and parboiled Kahawanu can be considered as the most suitable rice varieties for daily consumption in order to maintain the recommended daily intake of iron. It was identified that Pokkali rice contained the highest iron content of 29.5 mg/100 g. This amount has further increased by 66.7% after parboiling. Therefore both parboiled and un-parboiled Pokkali can be considered as the best dietary supplement among these rice varieties for iron deficiency and for pregnant mothers. Selected heavy metals including As, Cd, Pb and Cu were not detected in the selected Sri Lankan traditional rice varieties.

Key words: Heavy metals, Parboiling, Sri Lanka, Traditional rice varieties

INTRODUCTION

In ancient times, over 2000 different varieties of rice are said to be grown all over the Sri Lanka (Amarasingha *et al* 2013). With the current trend of global awareness of the benefits of organic food and medicinal properties of Sri Lankan traditional rice varieties (STRV), and nowadays need of traditional rice is becoming very high. Organic farming relies on ecofriendly techniques which preserve the nutritional values and sustainability of the environment. Almost all the STRV were organically farmed, which relies on techniques such as crop rotation, green manure, compost, biological pest control and depends on ancient irrigation systems for a sustained water supply. The trend of organically farmed STRV is becoming popularized as a result of the negative impact of agrochemicals and fertilizers to the environment and human health.

STRV show high nutritional value, different texture, appearance, aroma and taste compared to improved rice varieties. Previous studies of twenty five indigenous rice varieties showed bio-activities such as antioxidant, anti-amylase, anti-glycation and anti-inflammatory properties and higher nutritional composition compared to improved varieties (Abeysekera *et al* 2013). Nutrient rich food play a vital role as a way to decrease the growing numbers of children and women in Sri Lanka affected by nutrient deficiencies, including Iron Deficiency Anemia (IDA).

Parboiled rice is the major staple throughout South Asia. About one-fifth of the world's rice is parboiled (Bhattacharya *et al* 1985). Hence, parboiling can be regarded as one of the most popular processing methods in the rice industry. This includes soaking paddy, steaming at high or atmospheric pressure, and

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drying under sunshine, shade or mechanically using hot air. Parboiling process produces better quality rice having less breakage (5-15%) during milling than raw rice processing (15-25%), hard and uniform color, better flavor and more nutrition value, the milled rice remains firm during cooking and its texture becomes unstick and the preservation of parboiled paddy and milled rice is longer and better than in the raw state (Wimberly 1983).

There are some claims that rice consumed in Sri Lanka is contaminated with some toxic heavy metals including arsenic in recent years. Several cases of human disease, disorders, mal-function and malformation of organs due to metal toxicity have been reported. The effect of parboiling on mineral and heavy metal contents of STRV is not studied. Hence uncovering the mineral and heavy metal content of organic farming based STRV and the effect of parboiling on mineral and heavy metal contents have become very important for the assessment of quality and development of therapeutic diets. Moreover, this study will provide a useful tool for the field of public health nutrition. This study focuses on the effect of parboiling on mineral and heavy metal contents of Kalu heenati, Pokkali, Gurusinghe wee, Kahawanu, Sudu murunga and Unakola samba.

MATERIALS AND METHODS

Collection and Storage of Paddy: Five traditional varieties of long grain rice consisting of Kalu heenati (red), Pokkali (red), Gurusinghe wee (red), Sudu murunga (white) and Unakola samba (white), and one short grain rice variety consisting of Kahawanu (white), grown under organic farming were used for the study. Paddy samples were packed in polyethylene bags and stored in a refrigerator at -10 °C.

Parboiling Process : Three samples from each paddy variety were parboiled by soaking the cleaned paddy in distilled water at 60 °C for 3 ½ hours (for short grain rice) or 4 hours (for long grain rice), steaming at 100 °C for 20

minutes and air drying at 50 °C for 12 hours. It was kept for 48 hour to reach moisture equilibration. Parboiled paddy sample was packaged in polyethylene bags and stored in a refrigerator at -10 °C until time of analysis. Parboiling process was triplicated for each paddy variety.

Preparation of Rice: Un-parboiled (UPB) and parboiled (PB) samples were dehulled manually and grounded by using mortar and pestle. They were sieved using 60 mesh sieve in order to obtain a homogeneous fine powder.

Analysis of Metals: About 5.0 g from each of the ground rice samples was taken to a crucible and ashing procedure was carried out ($n = 3$) by using the methods given in AOAC (2002). Then about 50 drops of concentrated Hydrochloric acid were added to the ash in order to digest the sample. It was filtered to a 250ml volumetric flask and was topped up to the mark using distilled water. The final solutions were used to analyze selected minerals and heavy metals. Metals including Fe, Zn, As, Cd and Pb were analyzed using inductively coupled plasma atomic emission spectrometry (ICP-AES, Varian 720-EZ) and, K, Mg, Ca, Mn and Cu were analyzed using atomic absorption spectrometry (Thermo scientific, iCE3000 Series AA).

RESULTS AND DISCUSSION

Mineral content in UPB and PB STRV

Iron content: It was identified that Pokkali rice contained exceptionally high iron content of 29.5 mg/100 g. This amount has further increased by 66.7% (49.2 ± 0.7 mg/100 g) as a result of parboiling. Iron content of the rest of the STRV was significantly low compared to Pokkali. Parboiling of Gurusinghe wee also desirable since it has increased the iron content by 15.4%. Iron contents of UPB ($2.1 \pm 0.01 - 3.5 \pm 0.03$ mg/100 g) and PB ($1.3 \pm 0.09 - 3.3 \pm 0.07$ mg/100 g) Kahawanu, Kalu heenati, Gurusinghe wee, Unakola samba and Sudu murunga were also higher compared to improved rice varieties in Sri Lanka. For improved rice

varieties iron content was in the range of 1.7 – 2.5 mg/100 g. (Industrial Technology Institute and the Department of Agriculture 2011). However, parboiling has affected to lower the iron content of Kalu heenati, Unakola samba and Sudu murunga. Therefore UPB Kalu heenati and both PB and UPB Kahawanu can be considered as good sources to maintain daily intake of iron.

Zinc content: Zinc content of the selected STRV ranged from 2.3 ± 0.14 - 3.8 ± 0.01 mg/100 g for UPB rice and 2.1 ± 0.07 - 4.7 ± 0.4 mg/100 g in PB rice. Parboiling has slightly effected to lower the zinc content of these STRV except for Pokkali. PB Pokkali contained the highest zinc content of 4.7 ± 0.4 mg/100 g among all STRV whether PB or UPB.

Potassium content: Potassium content of all the selected STRV has slightly decreased after parboiling except for Kahawanu. For Kahawanu, it has slightly increased from $4.28 \pm$

0.2 to 4.81 ± 0.4 mg/100 g of rice flour.

Magnesium content: Magnesium content of Kahawanu has increased by 64.3% due to parboiling. Parboiling has slightly increased the magnesium content of Pokkali and Gurusinghe wee varieties and it has slightly decreased in Kalu heenati, Sudu murunga and Unakola samba.

Manganese content: Although the selected STRV show low manganese contents, parboiling has played a vital role in increasing the manganese content in most of the selected STRV. Manganese contents of Pokkali, Gurusinghe Wee, Sudu murunga and Kahawanu have increased by 1342.9%, 133.3%, 75% and 50% respectively after the parboiling treatment.

Calcium and heavy metals: Calcium and the selected heavy metals including As, Cd, Pb and Cu were not detected in selected STRV.

Table 1. Effects of parboiling on mineral content (mg / 100 g of rice flour) of STRV

Rice Variety	Fe		Zn		Mn		K		Mg	
	UPB	PB	UPB	PB	UPB	PB	UPB	PB	UPB	PB
Pokkali	29.5 ± 0.50	47.4 ± 0.70	3.2 ± 0.14	4.7 ± 0.40	0.07 ± 0.00	1.01 ± 0.01	4.82 ± 0.40	4.62 ± 0.50	1.42 ± 0.30	1.49 ± 0.40
Kahawanu	3.5 ± 0.03	3.3 ± 0.07	3.1 ± 0.07	3.2 ± 0.06	0.04 ± 0.00	0.06 ± 0.00	4.28 ± 0.20	4.81 ± 0.40	1.26 ± 0.30	2.07 ± 0.60
Kalu heenati	3.0 ± 0.05	1.3 ± 0.09	2.3 ± 0.14	2.1 ± 0.07	0.03 ± 0.00	0.02 ± 0.00	4.79 ± 0.20	4.20 ± 0.30	1.83 ± 0.50	1.51 ± 0.50
Sudu murunga	2.1 ± 0.01	1.7 ± 0.04	3.8 ± 0.01	3.5 ± 0.35	0.04 ± 0.00	0.07 ± 0.01	4.52 ± 0.30	4.36 ± 0.40	1.59 ± 0.20	1.45 ± 0.40
Unakola Samba	2.5 ± 0.20	2.2 ± 0.14	2.7 ± 0.14	2.5 ± 0.20	0.05 ± 0.00	0.03 ± 0.00	4.21 ± 0.50	4.08 ± 0.70	1.48 ± 0.30	1.36 ± 0.50
Gurusinghe wee	2.6 ± 0.14	3.0 ± 0.20	3.0 ± 0.07	2.7 ± 0.07	0.03 ± 0.00	0.07 ± 0.01	4.72 ± 0.20	4.43 ± 0.40	1.56 ± 0.40	1.59 ± 0.60

Limits of quantification (LOQ) for Ca, Pb, As, Cd and Cu are 1.0 ppm, 0.04 ppm, 0.02 ppm, 0.01 ppm, 0.5 ppm respectively.

Reduction of the minerals upon parboiling may possibly due to the leaching of metal ions during the soaking and steaming processes. An increment in some metal levels also was observed after parboiling. This happens due to the retaining of minerals by solubilizing and migrating minerals towards the center of the grain during the soaking process and settling during the gelatinization process. There is a possibility of solubilizing minerals present in the husk during the soaking process. Since Pokkali is a salt tolerant variety (Gregorio and Senadhira 1993) there is a likelihood of collecting the excess minerals in the husk, which may responsible for the increment in the mineral contents of the rice grain upon parboiling. Retaining of minerals with the simultaneous leaching of solid substances from the grain during the parboiling process can be a reason for the increment in the metal levels. Ability of retaining the metals by the grain depends on the mineral location in the grain, solubility of the mineral during soaking and the migrating ability of the minerals under constant parboiling conditions (Rivero-Huguet 2007).

CONCLUSION

According to this study selected STRV show high iron and zinc contents compared to improved varieties in Sri Lanka. Effect of parboiling on mineral content depends on the rice variety despite whether it is red or white. Parboiling can be considered as a suitable rice processing method for Pokkali and Kahawanu and not for Kalu heenati and Unakola samba in order to furnish the recommended daily intake of the micronutrients. UPB Kalu heenati and both UPB and PB Kahawanu can be considered as the most suitable rice varieties for daily consumption in order to maintain the recommended daily intake of iron. Both parboiled and un-parboiled Pokkali can be considered as the best dietary supplement

among these rice varieties for iron deficiency and for pregnant mothers. STRV will not cause any toxic effects due to As, Cd, Cu and Pb.

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