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Effect of Variety and Polishing on Cooked Red Rice Colour Change after Blending with Iron and Folic Acid Fortified Kernels

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Abstract: Micronutrient malnutrition is a global issue and iron deficiency is a major public health concern, particularly, in young children and pregnant women in Sri Lanka. Rice fortification with micronutrients has been recognized as a key approach to alleviate micronutrient deficiency in rice eating populations. Sri Lankans consume both parboiled (55%) and raw rice (45%) in red (23%) and white (77%) forms. Therefore, this study was conducted to investigate the issue of iron and folic acid fortified kernel blending with red pericarp rice. The objective was to investigate the influence of the variety and degree of polishing on the intensity of blue colour spot development in cooked rice around kernels during cooking. Nine red rice varieties; Bw 361, Attakari, Bg 252, Ld 365, Ld 356, Bg 406, At 303, At 362 and Bw 364 were polished to 2 and 8 %. Rice blending was done at 1: 99 ratio (kernel: red rice) with kernels having 8 mg/100 g of ferric pyrophosphate and folic acid (13.5 mg/100 g). Fifty grams of blended and normal rice (control) in raw and parboiled forms were cooked under same conditions and blue color spot development was visually observed. Results revealed that no colour change in controls and blended parboiled red rice after cooking. However, Attakari and Bg 252 raw rice developed high and slightly greenish blue color spots, respectively under both polishing levels. The blue color intensity decreased with the increasing degree of polishing for both varieties. Therefore, it is assumed that the phenolic compounds (antioxidants) in the bran reduce Fe^{3+} to Fe^{2+} during cooking and the variety and polishing influences the intensity of colour change.

Keywords: Antioxidants, Iron Fortification, Red Rice Blending.

Introduction

Food fortification has the advantage to deliver nutrients to large segments of the population without requiring radical changes in food consumption patterns. The main reason for the increased interest is the realization of public health implications of micronutrient malnutrition are potentially huge (Allen *et al.,* 2006). Micronutrient deficiencies in iron, zinc, vitamins A and B, iodine, and folic acid affect more than 2 billion people worldwide today (Tontisirin *et al.,* 2002), of which iron deficiency is the most prevalent. Especially, in pregnant women and young children the effects are serious as they affect fetal and child growth, cognitive development, education, economic development, productivity and resistance to infection. People in different age groups in many regions of Sri Lanka are affected by iron deficiency. According to WHO mortality data, around 0.8 million

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deaths (1.5% of the total) are attributed due to iron deficiency each year (Allen *et al.,* 2006). Iron-deficiency anemia results in 25 million of the global population (WHO, 2002). According to the national nutrition and micronutrient survey, 15.1% of children between 6-59 month ages suffer from anemia in Sri Lanka.

The highest iron deficiencies of children under above age group were reported in Kilinochchi (26.9%), Moneragala (25.6%), Trincomalee (23.1%) and Puttalam (20.3%) districts in Sri Lanka (Jayatissa *et al.,* 2012). Iron is considered as one of the most limiting micronutrients, especially in diets with polished rice. Unpolished rice contains about 2.6 mg iron/100 g whereas polished rice contain as low as 0.4–0.6 mg/ 100 g (Steiger *et al.,* 2014).

Iron fortification is the optimal approach to reduce high iron deficiency anemia (Cook and Reusser, 1983). The bioavailable forms of iron are chemically reactive and produce undesirable effects when added to food. Iron compounds that have a high bioavailability and whose absorption is not so susceptible to the negative effects of inhibitory ligands would be the ideal way of administering iron via food (Davidsson *et al.,* 1994).

Although such compounds are commercially available for fortification at present, they develop quality issues in cooking locally available red pericarp rice. Therefore, the objective of this study was to investigate the influence of variety, parboiling and degree of polishing of red pericarp rice on cooked rice colour change when blended with iron and folic acid fortified kernels.

Materials and Methods

Collection and preparation of samples

Nine varieties of red pericarp rice (*Oryza sativa* L.) samples were collected from Rice Research Station, Paranthan. For this experiment, two different degree of polishing (2% and 8%), form of rice (parboiled or raw) were used for blending while unblended normal rice of the same sample was used as the control. The nine popular red rice varieties were selected; Bw 361, Attakari, Bg 252, Ld 365, Ld 356, Bg 406, At 303, At 362 and Bw 364. Freshly de-husked red rice of each variety was used for the study. They were milled and raw rice was produced using a SATAKE laboratory rice mill and a polisher. Parboiled rice was also produced from all above varieties in the laboratory and milled using the same milling machines.

Fortificants and rice blending

The source of iron used for the fortified kernel production was Ferric pyrophosphate (8 g/100 g) and hot extruded kennels were used. These kernels were also fortified with folic acid as well (13.5 mg/100 g). Rice fortification is usually done by blending fortified kernels with normal at a 1: 99 ratio (Global Alliance for Improved Nutrition, 2015). The two different levels of polished raw and parboiled rice samples were blended with kernels at 1% level.

Cooking fortified rice

Water (75 mL - 100 mL depend on variety) was added to fifty grams of normal (Control) or blended, raw and parboiled rice and cooked for 20 min in a 250 mL glass beaker. Observations were made for 2% and 8% polished rice of both parboiled and raw forms. Blue colour development of cooked rice was visually observed. The colour comparison of cooked rice was done by a qualitative duo-trio test with 30 untrained panelists. Significance was tested at three different significance levels; 90%, 95% and 99.1%.

Results and Discussions

Polished Raw Rice cooking

It was observed that normal rice (unblended) had no any greenish blue color development in both 2% and 8% polishing levels after cooking. Two rice varieties Attakari and Bg 252 have shown hard greenish blue color at 2% polishing level and slight greenish blue color at 8% polishing level. The sensory panel test results revealed that there was a "Perceptually different" colour between the control and the blended rice at three different significant levels. Other seven tested rice varieties developed undetectable blue color after cooking and the sensory result revealed that it was "Perceptually similar" at three different significant levels;

Table 1: Visual observation of blue color development of rice bran and different raw rice varieties after cooking

Varieties	Samples	2 % Polished Rice		8 % Polished Rice	
		Blended	Unblended	Blended	Unblended
Bw 361	Rice	VSGBC	NGBC	VSGBC	NGBC
	Rice bran	DGBC	NGBC	DGBC	NGBC
Attakari	Rice	DGBC	NGBC	MGBC	NGBC
	Rice bran	SGBC	NGBC	DGBC	NGBC
Bg 252	Rice	DGBC	NGBC	MGBC	NGBC
	Rice bran	SGBC	NGBC	MGBC	NGBC
At 362	Rice	VSGBC	NGBC	NGBC	NGBC
	Rice bran	VSGBC	NGBC	NGBC	NGBC
Ld 365	Rice	VSGBC	NGBC	VSGBC	NGBC
	Rice bran	NGBC	NGBC	NGBC	NGBC
Bg 406	Rice	VSGBC	NGBC	NGBC	NGBC
	Rice bran	GBC	NGBC	VSGBC	NGBC
Bw 364	Rice	VSGBC	NGBC	NGBC	NGBC
	Rice bran	VSGBC	NGBC	NGBC	NGBC
Ld 356	Rice	VSGBC	NGBC	VSGBC	NGBC
	Rice bran	VSGBC	NGBC	NGBC	NGBC
At 303	Rice	VSGBC	NGBC	VSGBC	NGBC
	Rice bran	VSGBC	NGBC	NGBC	NGBC

* DGBC-Dark Greenish Blue Colour, MGBC- Moderate Greenish Blue Colour, SCBS- Slight Greenish Blue Colour, VSGBC- Very Slight Greenish Blue Colour, NGBC- No Greenish Blue Colour

Bg 252 at 2% Polishing
Hard Blue Colour Spots

At 362 at 8% Polishing
No Blue Colour development

Parboiled Blended Rice (Bg 406)- at 2% Polishing
No Blue Colour Appearance

Iron Fortified Kernels
No Blue Colour Appearance

Plate 1: Blue color development of different rice varieties at different polishing levels

90%, 95% and 99.1% . It may be due to the lower available phenolic compounds and antioxidant properties of those rice varieties. The concentration of total phenolic compounds in the grain has been positively associated with the antioxidant activity (Goffman and Bergman, 2004; Itani *et al.,* 2002; Zhang *et al.,* 2006). It is also reported that the grains with a darker red pericarp colour, such as red and black rice, contain higher amounts of polyphenols and anthocyanin (Acquaviva *et al.,* 2003; Tian *et al.,* 2004; Zhou *et al.,* 2004; Tian *et al.,* 2005).

Besides the difference in the content of total phenolics related to the colour of the grains, variation was also observed in the content of total phenolics among the genotypes with the same pericarp colour (Goffman and Bergman, 2004). Minerals have also been reported to interact with anthocyanins containing vicinal hydroxyl groups causing a red to blue colour change (Clydesdale, 1991). The cooking parameters for control and fortified brown rice such as cooking time and water uptake were quite close to the control (normal rice) sample. Water uptake was higher for some rice varieties as Attakari, Bg 252 and Bg 406 compared to other rice varieties and this may be due to the internal grain structural differences.

Parboiled Rice Cooking

None of the blended parboiled rice samples developed even a trace of green colour after cooking at both 2% and 8% polished levels and the test result was "Perceptually similar". This could be due to the reduction of phenolic compounds and antioxidant activity due to parboiling process. The polyphenols are water soluble due to their chemical characteristics. A portion of these compounds may be solubilized in the parboiling water. Goffman and Bergman (2004) and Zhang *et al.* (2006) have reported that a small part of reduction in the polyphenol concentration in the parboiled grains is due to the loss of polyphenols in the water.

Conclusion

The present study led to draw the following conclusions on the influence of blending iron and folic acid fortified kernels with red pericarp rice. The results revealed that, there is an effect of red rice bran on blue colour development during cooking of red pericarp rice. No colour development was observed for parboiled rice for all rice varieties at levels of polishing. A significant blue colour development was observed in two locally grown rice varieties; Attakari and Bg 252 when blended with iron fortified kernels at 1%. However, this change was significant with cooked raw rice which is polished to either a lower degree or to a relatively higher degree. It may be due to the reducing phenolic compounds available in the red rice bran facilitating the reduction of ferric to ferrous. Reducing ability depends on the antioxidant capacity available in the rice bran of a particular variety and polishing or parboiling reduces that capacity. Therefore further studies are needed to develop stable forms of iron compounds to be used for the fortification of some red rice varieties in future.

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