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Nutritional Composition of Germinated Brown Rice Porridge

Khairul Kamilah Abdul Kadir[1] • Azrina Azlan[2*] • Zulkhairi Amom[1] • Norhaizan Mohd Esa[2] • Maznah Ismail[2,3]

[1] Department of Human Anatomy, Universiti Putra Malaysia, 43400 Serdang, Malaysia
[2] Department of Nutrition and Dietetics and Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Malaysia
[3] Laboratory of Molecular Medicine, Institute of Bioscience, Universiti Putra Malaysia, 43400 Serdang, Malaysia

Corresponding author: * azrina@medic.upm.edu.my

ABSTRACT

In industrialized and developed countries more people are seeking preventive medicine rather than a curative approach. Considering germinated brown rice (GBR) is dense in dietary fibers, nutrients and antioxidants, the development of instant nutritious GBR porridge (GBRP) was proposed. The nutrient composition and fatty acid profile of GBRP were investigated. A comparison between GBRP, white rice porridge (WRP) and commercial porridge (CP) was carried out. GBRP contained significantly higher ($P<0.05$) ash (0.86 g/100 g sample) and dietary fiber (8.03 g/100 g sample) contents compared to WRP (0.81 g/100 g and 4.84 g/100 g sample) and CP (0.74 g/100 g sample and 6.46 g/100 g sample). Higher ash content was correlated with a higher level of sodium, calcium, potassium and magnesium. Protein content of GBRP was also significantly higher ($P<0.05$; 1.74 g/100 g sample) than CP (1.17 g/100 g sample). Interestingly, GBRP had 0.17 g/100 g sample of fat, which is four-fold higher than in WRP (0.04 g/100 g sample) and CP (0.03 g/100 g sample). The higher percentage of fat was correlated to a higher level of unsaturated fatty acids (USFA) than saturated fatty acids (SFA). The results from the present study revealed a higher potential of GBRP as a healthier option that is abundant in health-promoting compounds.

Keywords: fatty acid, proximate analysis
Abbreviations: BR, brown rice; **CP**, commercial porridge; **GBRP**, germinated brown rice porridge; **SFA**, saturated fatty acids; **USFA**, unsaturated fatty acids; **WR**, white rice; **WRP**, white rice porridge

INTRODUCTION

Rice is one of the most important cereals in South East Asian countries. Commercially, there are more than 2000 varieties of rice grown throughout the world. It is the staple food of more than three billion people, mainly in Asia. The most common rice consumed by humans is white rice (WR), followed by brown rice (BR). In making WR, the bran and germ are removed from BR, and the remaining endosperm is WR (Lee *et al*. 1988; Jacobs *et al*. 1998). In the refining process, important disease-preventing nutrients and phytochemicals (such as tocotrienols, γ-oryzanol, γ-aminobutyric acid, β-sitosterol and unsaturated fatty acids) are removed (Saunders 1985; Marlett 1993) along with the bran. Many studies reported that the rice bran layer has a high nutritive value which may contribute to a reduction in cholesterol (Saunders 1985; Sharma and Rukmini 1987; Yoshino *et al.* 1989; Sugano and Tsuji 1997).

Due to the nutrient content of BR, its consumption has become popular in Japan since the 1970s. However, the cooking time is generally longer in BR compared to WR, because of a thick aleurone layer and a pericarp which delay water penetration into the grains during cooking (Deepa *et al.* 2008). BR also is hard to chew and less tasty compared to WR (Shoichi 2004). Therefore, the production of germinated brown rice (GBR) was introduced and has overcome BR's entire problem. GBR is produced by soaking BR in water for a certain duration. Interestingly, during the germination process, major changes in nutrient contents have been observed, namely in dietary fiber, γ-aminobutyric acid, inositols, ferulic acid, tocotrienols, γ-oryzanol, magnesium, potassium and zinc (Kayahara and Tsukahara 2000).

Porridge is easy to chew, swallow, digest and absorb as it is a semi-fluid food (Zhang *et al.* 2003). Cereal porridges are based on common grains, such as rice, maize, wheat, oat, or sorghum. They are often combined with large volumes of water and swell during cooking, making them very viscous (Rombo *et al*. 2001; Helland *et al*. 2002). In an industrialized country like Malaysia, people prefer fast food or instant food especially when they are in a rush. The lack of time has had a significant impact on meal and eating behaviors. Malaysian consumers are replacing traditional sit-down meals with 'grab-and-go' or easy preparation foods. On the other hand, people are also seeking preventive medicine rather than a curative approach. Based on these facts, a healthy germinated brown rice porridge (GBRP), which offers a healthier option utilizing a local product, BR, is proposed in this study. It is not only an opportunity to explore Asian staple food in promoting overall health but also contributing to the country's economic enhancement. In the Malaysian market, most commercialized porridge produced is made from WR. In contrast to WR, porridge from GBR is more nutritious as it is high in dietary fiber and antioxidants. GBRP is also a better choice relative to most fast foods or instant food which causes problems such as obesity and associated chronic disease (Ismail 2002; Sherina and Rozali 2004). As rice is easily obtained in Malaysia, introducing BR in a more presentable manner would be another beneficial means to our market industry. Therefore, this study was carried out to determine the nutrient composition of GBRP and compare its nutritive value with that of WRP and CP, which are available on the market.

MATERIAL AND METHODS

Rice porridge samples

Three types of porridges were evaluated for their composition. White rice porridge (WRP) and germinated brown rice porridge (GBRP) with chicken flavor were prepared in our food laboratory to resemble the flavor of commercial porridge (CP) that we have selected in the study. The basic ingredients of the porridges are

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Table 1 Basic ingredients of prepared WRP and GBRP.

Ingredients	Weight (g)	
	WRP	GBRP
[a] WR	18.04	-
[ab] GBR	-	18.04
Non-dairy creamer	0.33	0.33
Chicken broth	1.05	1.05
Salt	1.26	1.26
Dried processed vegetable	0.15	0.15
Dried chicken flesh	5.80	5.80

Abbreviations: **GBR**, germinated brown rice; **GBRP**, germinated brown rice porridge; **WR**, white rice; **WRP**, white rice porridge

[a] WR and BR were obtained from BERNAS Tiram Jaya, Hulu Langat, Selangor, Malaysia.

[b] GBR has been produced from brown rice.

described in **Table 1**. Meanwhile, CP was purchased from a local supermarket in Serdang, Selangor. The prepared WRP, GBRP and CP were kept in a freezer (-80°C) until analysis. Both WRP and CP were used for comparison to determine the superiority of GBRP.

Proximate analysis of rice porridge

Prior to analyses, samples were unfrozen at room temperature (20°C) and analyzed in triplicate. Porridge moisture and ash contents were determined according to AOAC (1996). Crude protein content was estimated using the Kjeldahl method, fat content using the Soxhlet method (AOAC 1996) and total dietary fiber using enzymatic and gravimetric methods (AOAC 1996).

Mineral determination

Calcium, zinc, iron, magnesium, copper and potassium contents of the three types of porridge were determined from ashed samples using the flame system of the Atomic Absorption Spectrophotometer (GBC, Model 908AA, USA). Contents of minerals were determined in duplicate samples using methods described by Tee *et al.* (1996).

Fatty acid profile

Extraction of lipids

Total lipids were extracted using the Soxhlet Method (AOAC 1996). Petroleum spirit 40-60°C (AOAC 1996) was the solvent used for the determination of fat content. Ten grams of porridge was weighed into a pre-dried extraction thimble and the oil was extracted using the solvents mentioned above. The oil was recovered after stripping off the solvent in a rotary evaporator (Rotavapor® R200, Buchi, Switzerland).

Preparation of fatty acid methyl esters (FAME)

Ours, a modified version of that by Ainie *et al.* (2005), was used for fatty acid analysis. Approximately, 10 ml of hexane was added into 100 mg of extracted lipids, the mixture was then methylated with 100 µl of 2N KOH in dry methanol and the samples were vortexed for 30 sec. The mixture was centrifuged to separate the layers. The upper layer containing FAME was transferred into a small tube and stored at −20°C until further analysis by GC.

Analysis of FAMEs

FAME was analyzed in a gas chromatograph (Agilent 6890 GC, USA) equipped with a flame ionization detector and a fused silica capillary column DB-23 (30 m × 0.25 mm, USA). Helium was used as the carrier, with the following oven temperature programme: maintain at 40°C for the first 2 min; increase to 250°C at a rate of 58°C/min then hold at this temperature for the final 5 min. Fatty acids were identified by comparing the relative retention times of FAME peaks of the samples with FAME standards from Sigma (USA) by spiking samples with standards using Agilent 6890 software. The data were expressed as percentages of the normalized area of fatty acids (Rowe *et al*. 1999; Milinsk *et al*. 2005).

Statistical analysis

Data were expressed as the mean ± SD. Analysis of Variance (ANOVA) and Tukey's were used to detect whether significant difference existed in the proximate and mineral compositions of WRP, GBRP and CP at the 5% level of significance.

RESULTS

The nutritional composition of WRP, GBRP and CP are described in **Table 2**. The ash content of all porridge samples ranged between 0.74 and 0.86 g/100 g sample. The ash content of GBRP was significantly higher (P<0.05) than that of WRP and CP, by 0.86 g/100 g, 0.81 g/100 g and 0.74 g/100 g sample, respectively. The main difference between all of these porridges was the source of rice used. GBRP was produced from brown rice (BR); meanwhile WRP and CP were produced from white rice (WR). The higher level of ash in GBRP could be easily explained by the presence of the outer fraction layer, which is bran layer. The high levels of ash in the dried GBRP sample were characterized by a high mineral content: Na (253 mg/100 g sample), Ca (33 mg/100 g sample) and K (23 mg/100 g sample). GBRP was also rich in Mg (15 mg/100 g sample), Zn (11 mg/100 g sample) and Cu (3 mg/100 g sample) (**Table 3**). CP however, contained 295 mg Na/100 g sample, 110 mg Ca/100 g sample, 18 mg K/100 g sample, 8 mg Zn/100 g, and 3 mg Cu/100 g sample. Mg content in GBRP was seven-fold higher than in CP. Moisture content of GBRP was 87 g/100 g sample which is quite similar to CP (89 g/100 g sample) and WR porridge (84 g/100 g sample).

Protein content of different porridge samples ranged between 1.17 and 1.97 g/100 g sample. Protein content of GBRP was 1.74 g/100 g sample, which is significantly higher (P<0.05) than in CP (1.17 g/100 g sample), but lower than in WRP (1.97 g/100 g sample; not significant). GBRP also contained a significantly higher (P<0.05) amount of dietary fiber (8.03 g/100 g sample) than WRP and CP. WRP contained 0.04 g/100 g of fat, while CP and GBR contained 0.03 g/100 g and 0.17 g/100 g, respectively. The percentage of fat in GBRP was four times higher than in CP and WRP. The level of unsaturated fatty acid (USFA) was significantly higher in GBRP than WRP, 54.4% and 33.7%, respectively,

Table 2 Proximate analysis of WRP, GBRP and CP.

Analysis	Type of porridge (g/100 g sample)		
	WRP	CP	GBRP
Ash	0.81 ± 0.02 ab	0.74 ± 0.02 ab	0.86 ± 0.06 a
Moisture	84.14 ± 0.06 a	88.89 ± 0.01 b	86.50 ± 0.58 c
Protein	1.97 ± 0.02 a	1.17 ± 0.04 b	1.74 ± 0.11 a
Carbohydrate	13.05 ± 0.06 a	9.18 ± 0.01 b	10.74 ± 0.53 c
Total dietary fiber	4.84 ± 0.03 a	6.46 ± 0.04 b	8.03 ± 0.04 c
Fat	0.04 ± 0.00 a	0.03 ± 0.00 a	0.17 ± 0.00 b

All values are expressed as (mean ± SD). Letters in a row without same superscript are significantly
different, $p < 0.05$ according to Tukey's HSD *post hoc* test.
Abbreviations: **CP**, commercial porridge; **GBRP**, germinated brown rice porridge; **WRP**, white rice porridge.
A total calorie per 100 g of WRP is 60.5 kcal, CP is 41.7 kcal and GBRP is 51.43 kcal; which was calculated as follows: (4 x crude protein) + (9 x crude fat) + (4 x carbohydrate).

Table 3 Mineral composition of WRP, GBRP and CP.

Mineral	Type of porridge (mg/100 g sample)		
	WRP	CP	GBRP
Na	279.30 ± 3.64 a	294.78 ± 2.50 b	252.57 ± 3.28 c
Mg	2.85 ± 0.04 a	2.93 ± 0.03 a	14.93 ± 0.03 b
K	13.49 ± 0.10 a	17.71 ± 0.09 b	22.87 ± 0.01 c
Ca	37.81 ± 2.50 a	109.86 ± 2.16 b	32.66 ± 2.23 a
Zn	7.34 ± 0.09 a	7.68 ± 0.23 a	10.67 ± 0.10 b
Cu	2.37 ± 0.18 a	2.80 ± 0.83 b	2.75 ± 0.35 b

All values are expressed as (mean ± SD). Letters in a row without same superscript are significantly different, $p < 0.05$ according to Tukey's HSD *post hoc* test.
Abbreviations: **CP**, commercial porridge; **GBRP**, germinated brown rice porridge; **WRP**, white rice porridge.

Table 4 Fatty acid composition of WRP, GBRP and CP.

Analysis	Type of porridge (%)		
	WRP	**CP**	**GBRP**
Saturated fatty acid (SFA)	66.31 ± 1.35 a	*	45.59 ± 1.74 b
Unsaturated fatty acid (USFA)	33.70 ± 1.46 a	*	54.41 ± 1.58 b
Mono-unsaturated fatty acid (MUFA)	22.25 ± 0.97 a	*	33.15 ± 0.54 b
Poly-unsaturated fatty acid (PUFA)	10.45 ± 1.32 a	*	21.27 ± 1.19 b

All values are expressed as (mean ± SD). Letters in a row without same superscript are significantly different, $p < 0.05$ according to Tukey's HSD *post hoc* test.
Abbreviations: **CP**, commercial porridge; **GBRP**, germinated brown rice porridge; **WRP**, white rice porridge. * cannot be detected in sample

whereas saturated fatty acid (SFA) was significantly lower in GBRP than in WRP, 45.6% and 66.3%, respectively (**Table 4**). Fatty acid composition was undetectable in CP.

DISCUSSION

We carried out a nutritional composition to determine the nutrients and fatty acid composition in WRP, GBRP and CP. Porridge is consumed widely because it is not only an instant food but also made from staple food, namely rice. Many previous studies showed that GBR offers a cardioprotective effect. Ling *et al*. (2001) showed that supplementation of a diet with the bran layer resulted in significantly reduced atherosclerotic plaque formation in rabbits compared to a diet supplemented with WR outer layer fraction.

Nowadays, the purchasing power has increased among Malaysians who enjoy purchasing highly calorie food stuff and whose shift in working style has demanded more time in the working place. Such a life-style creates an environment in the community in which there is less physical activity but requires highly nutritious food. These cumulative factors result in an increased prevalence of obesity (Ismail *et al*. 2002). Taking the current competing lifestyle into consideration, an easy-prepared but well balanced food regime would be ideal, hence our development of instant porridge from GBR.

The GBRP we studied was superior to the other two rice porridges as it was higher in minerals, especially Mg and K. Similar findings by Juliano and Bechtel (1985) showed that high amounts of Mg and K in BR. The mineral levels obtained in this study were appreciably high. In another study, Ling *et al.* (2002) revealed that black and red rice are denser in nutritive value especially in the bran layer, which contribute to a high ash percentage. In addition to minerals, GBRP also is richer in other nutrients such as total dietary fiber and protein. Similar findings by Saunders (1990) showed that rice bran (rice component) was rich in protein, oils, dietary fiber, vitamins and minerals. Miura *et al.* (2006) also reported that BR contains an abundant amount of dietary fibers, vitamins and minerals in the bran layer and hence, in Japan, BR has become very popular. The dietary fibers of cereals such rice, especially the soluble (viscous) fibers, are associated with a reduced risk of coronary heart disease (Truswell 2002).

GBRP also was found to be lower in SFA and contained an appreciable amount of USFA, especially monounsaturated fatty acids and polyunsaturated fatty acids, which were higher than in WRP. However, in our study, the percentage of fatty acid for CP could not be detected as the percentage of fat in 100 g of commercial porridge was very low (0.03%). It is well known that various fatty acids in the diet exert different effects on serum lipid and lipoprotein concentrations. SFA are thought to increase cardiovascular disease risk because they elevate serum total and LDL-cholesterol concentrations relative to MUFA and PUFA. These unfavourable effects have been reported by controlled dietary studies (Hegsted *et al*. 1965; Keys *et al*. 1965). Oleic and linoleic acids, which were mostly present in GBRP, contribute to the nutritive value of GBRP. According to Djousse *et al*. (2001), a higher intake of both α-linolenic (18:3n-3) and linoleic acid (18:2n-6) is inversely related to the risk of coronary artery disease in a high-risk population. A study by Kris-Etherton *et al*. (1993) tested the effects of natural edible fats and oils rich in stearic acid (cocoa butter), oleic acid (olive oil), or linoleic acid (soybean oil) on the serum lipoprotein profile in 19 young men. They found that a diet rich in linoleic acid significantly lowered the serum total cholesterol concentrations relative to stearic acid or oleic acid diets. All of these findings showed that GBRP, which is higher in USFA, can be used as healthier option to reduce cardiovascular risk.

In conclusion, GBRP is a more nutritious porridge than WRP or CP. GBRP also can be "heart-friendly" as it contained an increased level of compounds that may help to reduce the risk of cardiovascular disease.

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