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Effect of polishing on glycemic index and antioxidant properties of red and white basmati rice

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ABSTRACT

Four different pigmented dark-red (red) and non-pigmented white basmati rice varieties were tested for their nutrient composition, glycemic index (GI), total phenolic content (TPC), total anthocyanin content (TAC) and antioxidant activity (AOA) at 10% and 100% polished levels. The red basmati had higher content of ash, protein, fat, TPC, TAC and AOA than white basmati. Red and white basmati varieties can be classified as low GI and medium GI rice, respectively. The degree of polishing had no effect on the GI. However, there was a significant negative correlation ($r > -0.81$; $P < 0.01$) between GI value with amylose, crude fiber, crude fat, crude protein, ash, AOA, TPC and TAC contents of basmati. Relatively higher levels of TPC, TAC and AOA were found in red basmati than white basmati varieties. Therefore, red basmati varieties can serve as low GI sources of functional food.

1. Introduction

Foods having a low glycemic index (GI) and high antioxidant content are gaining increased attention as they can potentially reduce the risk of diseases related to impaired glucose metabolism. Natural antioxidants such as plant polyphenols and flavonoids reduce the incidence of degenerative diseases such as diabetes, cancer, cardiovascular disease and aging (Srinivasan, Sudheer, & Menon, 2007).

Rice (*Oryza sativa* L.) is the principal dietary source of carbohydrates consumed by almost one-half of the population throughout the world. More than 5000 varieties of rice are available in the world having different physical, biochemical, milling and cooking qualities (Bhattacharjee, Singhal, & Kulkarni, 2002; Yang, Shewfelt, Lee, & Kays, 2008). Recently, aromatic rice varieties, collectively known as "Basmati rice", have obtained a huge demand in Asian and European countries because aroma is rated as the highest preferred characteristic of rice followed by taste and elongation after cooking (Kale, Jha, Jha, Sinha, & Lal, 2015; Yang et al., 2008). Basmati rice has unique quality characteristics such as extra-long supreme slender grains, pleasant aroma, sweet taste, soft texture, length-wise elongation with least breadth-wise swelling on cooking and tenderness of cooked rice (Bhattacharjee et al., 2002; Kale et al., 2015). As a result of all these organoleptic properties, basmati rice varieties fetch a premium price in the world market, especially in Europe and USA. It is consumed as whole kernel after milling of rough basmati grain into different degrees by removing the rice bran layer (Babu, Subhasree, Bhakyaraj, & Vidhyalakshmi, 2009).

Widely consumed type of rice in the world is white rice, which is non-pigmented. In addition, there are two other types of pigmented rice consumed in the world known as dark and light pigmented rice. In dark pigmented rice, flavonoid group of anthocyanin pigments are accumulated in different concentrations of the rice bran (pericarp, seed coat and aleurone), therefore raw rice kernels (unpolished) appear in different colours such as black, purple, dark-brown or dark-red (Sompong, Siebenhandl-Ehn, Linsberger-Martin, & Berghofer, 2011). Sri Lanka has the second largest resource of pigmented rice in the world next to China (Sompong et al., 2011). Approximately 30–40% of total rice consumption in Sri Lanka is pigmented rice, generally known as

Abbreviations: GI, glycemic index; TPC, total phenolic content; TAC, total anthocyanin content; AOA, antioxidant activity; BMI, body mass index; IAUBG, incremental area under blood glucose concentration curve; DPPH, 2,2-diphenyl-1-picrylhydrazyl; GAE, gallic acid equivalent; SD, standard deviation; SE, standard error; DNMRT, Duncan's new multiple-range test; CHO, available carbohydrate.

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"red-rice" in the market regardless of their bran colour intensity. Previous studies have shown that in most of Sri Lankan "red-rice" pigmentation is due to anthocyanin content (Perera & Jansz, 2000; Sompong et al., 2011). There is a high consumer demand due to its appealing darker colour of the red rice varieties in the market. Red rice varieties such as pigmented dark-red basmati usually undergo low level of polishing to preserve the bran layer than white rice. It has been reported that red rice have higher antioxidant activities than white rice (Jun, Song, Yang, Youn, & Kim, 2012; Payakapol, Moongngarm, Daomukda, & Noisuwan, 2011; Sompong et al., 2011; Sutharut & Sudarat, 2012). However, dark-red rice or less polished rice contains characteristic flavors that consumers find unacceptable due to its characteristic roughness.

The pigmented dark-red rice has potential health benefits due to its high dietary fiber content which could help reduce the GI, thereby reducing the risk of type II diabetes (Babu et al., 2009). According to Miller, Pang, and Bramall (1992), GI of rice can vary within a wide range of 64–93%. Foster-Powell, Holt, and Brand-Miller (2002) reported that GI values of Bangladeshi rice ranged from 37–38%. In Sri Lanka, some of the commercial white rice varieties have shown GI values ranging from 67% to 72% (Darandakumbura, Wijesinghe, & Prasantha, 2013) with majority of them classified as medium-high GI rice. The variation in the GI of rice results from inherent varietal differences of rice grown in different countries (Foster-Powell et al., 2002; Panlasigui & Thompson, 2006; Panlasigui et al., 1991). Therefore, Miller et al. (1992) highlighted the importance of maintaining their own GI testing, mainly with staple agricultural products like rice. In addition, rice bran contains a variety of health-promoting antioxidant compounds such as phenolic acid, flavonoids, anthocyanins, proanthocyanidins, tocopherol, vitamin E, γ-oryzanol and phytic acids which are highly abundant in the pigmented rice (Goufo & Trindade, 2014; Jun et al., 2012). Since most of these healthy phytochemicals are concentrated in the bran layer of rice kernel, they can be substantially removed during bran removal by rice polishing.

Limited research had been conducted on the relationship among GI, rice bran colour and antioxidant potential of basmati rice subject to different degrees of milling. Such information is valuable for consumers, rice millers and nutritionists in the world to formulate rice-based foods. Hence, the objective of this study is to investigate the effect of varietal differences and degree of polishing on the GI and antioxidant properties of pigmented and non-pigmented basmati rice varieties.

2. Materials and methods

2.1. Rice samples

Four different pigmented dark-red (red) and non-pigmented white (white) basmati rice varieties namely CIC-red (CIC-RB), CIC-red fragrance (CIC-RF), CIC-white (CIC-WB) and white basmati (At 405) were used in the study. Of these four varieties, CIC-RF was an improved variety from CIC-RB rice. Paddy (rough rice) samples were collected from CIC rice breeding laboratory (Palwehara, Sri Lanka) after two seasons of cultivation, having a moisture content of 10–11% (dry basis). Prior to the experiment, fresh paddy samples were stored about one month at room temperature (28 ± 2 °C) in hermetically sealed containers. Stored paddy samples were de-husked using a laboratory de-husker (Model *P*-1, Ngek Seng Huat, Thailand) and then polished at 10% and 100% level (wt/wt degree of polishing) by using a laboratory rice polisher (Model K-1, Ngek Seng Huat, Thailand). A total weight reduction of 0.7% and 9% of brown rice was considered as 10% and 100% polishing levels, respectively. Polished rice samples were then ground into fine flour using a domestic grinder and sieved through a 100 μm mesh, stainless steel sieve. All samples were stored in a refrigerator at 4 °C for further biochemical analysis.

2.2. Nutrient composition

The moisture, ash, crude fiber, crude protein and crude fat contents of rice samples were determined according to AACC (2000) standard methods. Available carbohydrate of each rice variety was determined by phenol sulfuric colorimetric method (AACC, 2000). Apparent amylose content of rice was measured by iodine colorimetric method (Juliano, 1971). A rice flour sample weighing 100 mg was well mixed with 1 ml of ethanol (95%) and 9 ml of 1 N NaOH. The content was heated in a boiling water bath to gelatinize starch and allowed to cool for one hour. The sample was transferred into a 100 ml volumetric flask and 5 ml of starch solution, 1 ml of 1 N acetic acid and 2 ml of iodine solution were added. The volume was adjusted to 100 ml with distilled water and the mixture was allowed to stand for 20 min. for colour development. The absorbance was measured using a UV–visible spectrometer (Shimadzu, UV-1601, Japan) at 620 nm. The amylose content was determined by using a standard curve prepared from potato amylose (Sigma-Aldrich, UK). All laboratory experiments were performed in triplicate and data were expressed in percentage dry basis (g/100 g dry weight or %).

2.3. Anthropometric and demographic description of subjects

Healthy, non-diabetic individuals (4 females and 9 males) aged between 20–31 years with a normal body mass index (BMI) were the subjects participating in the study. The participants were not on medication and all were non-smokers. Before recruiting to the study, subjects were given a detailed written and oral explanation of the study protocol and the opportunity to ask questions. A questionnaire was used to collect the information of the subjects' personal characteristics including age, gender, medical history and socio demographic characteristics. Informed written consent was obtained from each individual before participation. Weight and height of the subjects were measured before commencement of the study and the BMI was calculated. The study was conducted as a random crossover study. Ethical clearance was obtained prior to the study from the ethical review committee of the Faculty of Medical Sciences, University of Peradeniya, Sri Lanka.

2.4. Determination of in-vivo glycemic response

The method used to measure GI was in line with procedures recommended by the FAO/WHO Joint Expert Consultation (FAO/WHO, 1998). Subjects were requested to report at 6.45 am in the laboratory, after fasting for 12 h on the assigned days. Initial fasting blood glucose level was measured using a standardized glucometer (Bene Check™ PLUS Meter, Germany). Rice samples were cooked (100 g rice in 250 ml of water) using an electric rice cooker until the amount of added water was fully absorbed into rice kernels (no solid loss) and left for about one hour before starting the study. Subjects were asked to eat a cooked rice sample containing 50 g of available carbohydrate completely within 10 min. with 250 ml of water. Thereafter, finger-prick blood samples were obtained at 15, 30, 45, 60, 90 and 120 min. after the consumption of the test rice. As the standard, a 50 g of glucose in 250 ml of water was given in two separate mornings (before the test and 5 days after) and blood glucose responses were taken at similar intervals. The GI of rice varieties for each subject was calculated using the following Eq. (1) according to FAO and WHO (1998).