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Nutrient content in selected commercial rice in Malaysia: An update of Malaysian food composition database

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Abstract

There is an increase need and demand to update Malaysian Food Composition Database (FCD) which was last updated in 1997. The current FCD program was designed to expand the quantity and improve the quality of the existing database. The present work was aimed to determine the nutrient content of commercial rice products from three rice varieties classified as raw and processed foods, namely Basmati, Siam, and Fragrant rice. A total of six brands from each type of rice were sampled from a local supermarket within Klang Valley. Analyses were carried out for 27 nutrients that include proximate (Energy, Water, Protein, Fat, Carbohydrate, Total Dietary Fibre, and Ash), minerals (Magnesium, Calcium, Sodium, Iron, Zinc, and Copper), water soluble vitamins (C, B1, B2, B3, B6 and B9), fat soluble vitamins (A and E), total sugar, fatty acids (total saturated fat, total monounsaturated fat and total polyunsaturated), trans fatty acids, and cholesterol. The three rice varieties were found to contain comparable nutrient levels except for vitamin C, B1, A, E and total sugar which were not detected in all samples. The fatty acid (total saturated, total monounsaturated, and total polyunsaturated) as well as trans-fatty acid were detected at very low levels. Cholesterol was not detected in all samples. These findings can be utilised in raising public awareness and assistance to better estimate nutrient contents and intake depending on the varieties of rice.

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Introduction

Food Composition Database (FCD) is a resource that provides detailed food composition data on nutritionally important components in foods. FCD is normally used as an essential basic tool for dietary evaluation, quantitative nutrition research, development and implementation of nutritional policies at national and international levels, and to improved food products due to consumer's increasing demand for healthier foods (Barikmo *et al.*, 2004; Khokhar *et al.*, 2009). Nutritional epidemiologists used food consumption and composition data to investigate the relationship between health and disease. Failure to understand the relationships between diet and health or disease is often due to inadequacies in food composition or food consumption data (Ireland *et al.*, 2002; Greenfield and Southgate, 2003). Nowadays, there are significant gaps in available information on the composition of certain foods, particularly ethnic food as most of the available information is outdated.

It is important that the existing FCD is updated, extended, and maintained by relevant authorities to include the increasing variety of food items consumed by all population groups and that all nutrients of interest are analysed (Khokhar *et al.*, 2009). Hence, the Malaysian FCD which was last published in the year of 1997, is now in the process of being updated to include necessary foods and nutrients for the benefit of Malaysian, ASEAN, and world populations.

Rice is a popular cereal grain commonly used as human food and considered as an essential staple food in many parts of the world, especially in tropical regions. It is a type of grass and belongs to a family of plants that includes other cereals such as wheat and corn. Rice is rich in nutrients and contains a number of vitamin B such as B1, B2, B3, and minerals (Juliano, 1983; Fresco, 2005). Rice is an excellent

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source of complex carbohydrates providing the best source of energy. In Asia alone, more than 2 billion people obtain 60-70% of their energy intake from rice and related products (FAO, 2004). However, many of these nutrients are lost during milling and polishing, when brown rice turned into white rice by removing the outer rice husk and bran to reveal the white grain (Kennedy and Burlingame, 2003). There are several forms of grain, however, white and brown are the most common. In addition, various types of rice are available, including long-grain, medium-grain, and short-grain.

The species of rice considered important as food species for humans and grown worldwide is Oryza sativa that originated in the humid tropics of Asia (Juliano, 1983). Rice from the genus Oryza is tolerant to desert, hot, humid, flooded, dry and cool conditions, and grows in saline, alkaline, and acidic soils. Asian cultivated rice has evolved into three eco-geographic species which are indica, japonica, and javanica (FAO, 2000; Kennedy and Burlingame, 2003).

Basmati rice is a long, slender-grained aromatic rice with fragrant flavour and aroma, traditionally grown in Himalayan foothill regions of India and Pakistan. It is the rice used in Indian dishes. The grains are separated and fluffy when cooked. In Indian recipes, it is often cooked with spices to enhance the grain's aromatic properties (Bhattacharya *et al*., 2002; Schenker, 2012; The Rice Association, 2012).

Fragrant rice is an aromatic rice in which the flavour is slightly less pronounced than Basmati. The length and slenderness of the grains suggest that they should remain separate on cooking but it differs from other long grain rice in that it has a soft and slightly sticky texture when cooked. This rice is good with Chinese and South East Asian food. (Schenker, 2012; The Rice Association, 2012). A chemical compound of 2-Acetyl-1-pyrroline was identified as the most important compound contributing to the aromatic character of rice (Buttery *et al*., 1983).

Siam rice is considered as indica rice which is a broad group of many types of rice that is usually grown in hot climates. It has a typically long grain and when cooked, indica rice does not stick together and remains light and fluffy. Most of the indica rice produced in Southern Asia, including India and Thailand (Chang, 1976; IRRI, 2013). In this study, Siam and Fragrant rice were imported from Thailand. The present work was aimed to determine the nutrient content of commercial rice from three rice varieties namely Basmati, Fragrant, and Siam. These three varieties are the most consumed by Malaysians and therefore, were selected for the study. The nutrient content in these rice varieties will provide new data for the updates of the new Malaysian FCD.

Materials and Methods

Food sampling

One kilogram of rice samples were purchased from a local supermarket in the Klang Valley area, Kuala Lumpur on 18 July 2011. Six common polished rice brands were selected from each variety (Siam, Basmati, and Fragrant) based on the label of the packaging. The samples were confirmed to represent brands/varieties consumed and available nationwide.

Sample processing and storage

The same brand of rice samples was unpacked, thoroughly checked for any contaminants, and homogenized with a grinder (e-Blenders, Taiwan) until the particle size was < 1 mm. Each sample portion was placed in a clean polypropylene container and sealed to avoid any contamination to ensure the integrity of the sample. Each sample was labelled accordingly for future analysis. The samples were stored at room temperature (25°C ± 2°C) in an insect-free location until ready for analysis within two weeks after collection. The nutrient contents were determined using standard methods and the validity of test data were monitored with the application of internal quality controls in line with the requirements of ISO 17025.

Proximate

All methods were established based on the modified AOAC method. Energy was calculated and reported in Kcal unit. Water was determined using air oven method (AOAC, 2008). Protein was analysed using the Kjeldahl method. The conversion factor for nitrogen to protein was 5.95 for rice (Greenfield and Southgate, 1992; AOAC, 2005). Total fat in food was determined by automated soxlet extraction (AOAC, 2006). Carbohydrate content of the food sample was calculated by difference [100 − (ash+ moisture + fat + protein + total dietary fibre)] (Menezes *et al*., 2004). Total dietary fibre in foods was analysed by enzymatic gravimetric method (phosphate buffer) (AOAC, 2005). Determination of total ash was done by dry ashing method (AOAC, 2005).

Minerals

Mineral contents (calcium, sodium, magnesium, and iron) were determined by inductively coupled plasma – optical emission spectrometry (ICP-OES) after dry ashing. Zinc and copper were analysed by atomic absorption spectrophotometry (AAS) after dry ashing.

Vitamins

Vitamin C was analysed by high performance liquid chromatography (HPLC) with UV detector. The method involved dissolution of sample in Tris (2-carboxyethyl)-phosphine hydrochloride acid and simple removal of protein using trichloroacetic acid (TCA) followed by reversed phase LC (Brause *et al*., 2003). Five grams of sample was weighed into a 100 ml flask and then dissolved and acidified in 20 ml Tris (2-carboxyethyl)-phosphine hydrochloride solution. This solution was then made up to 100 ml with 1% TCA solution and shaken for about 1 minute. The resulting mixture was filtered into an HPLC vial and Vitamin C content determined by UV detector against the standard solution. Thiamin (B1), Riboflavin (B2), Niacin (B3), Folic acid (B9) and Pyridoxine (B6) were analysed by HPLC with photodiode array detector (PDA) and fluorescent detector. The method involved a simple removal of protein by chemical precipitation using trichloroacetic acid, followed by reversed phase LC with ion-pair reagent (Woollard & Indyk, 2002). Six grams of sample was weighed into a 100 ml flask. The sample was dissolved in 30 ml warm water followed by the addition of 0.6 M trichloroacetic acid (TCA). The flask containing the mixture was shaken on a mechanical shaker for 15 minutes. The resulting mixture was filtered into an HPLC vial and B1, B3 and B9 content determined by the Diode Array Detector against a standard solution, while the contents for B2 and B6 were determined by Flourescence Detector against the standard solution.

Fat soluble vitamins, A and E were analysed by HPLC with PDA and fluorescent detector. This method involved the saponification of standards and samples in basic ethanol-water solution, extraction of the analyte from the neutralised mixture, followed by reversed phase LC (DeVries and Silvera, 2002). During this process, fat was converted into fatty acids and vitamin A and vitamin E into retinol and alpha-tocopherol respectively. A five gram sample was weighed into a 250 ml flask followed by the addition of a pea-sized pyrogallol acid as an antioxidant and 40 ml of 95% ethanol. This solution was then saponified with 10 ml of 50% potassium hydroxide (KOH) under controlled conditions. Ten ml of glacial acetic acid was then added to neutralise the KOH and the vitamin A and vitamin E extracted into a mixture of THF and ethanol (50+50) solution, The extractant was filtered into an HPLC vial and the Vitamin A content was determined by Diode Array Detector against the standard solution, while Vitamin E content was determined by Fluorescence Detector against the standard solution.

Sugars

Sugars which consisted of sucrose, glucose, fructose, lactose, and maltose were determined by HPLC- Evaporative light scattering detector (ELSD). Four grams of sample was weighed into a 100 ml volumetric flask. Sample was dissolved in 20 to 30 ml water and HPLC.

Fatty acids and cholesterol

Fatty acids which consisted of saturated, monounsaturated, polyunsaturated, and trans-fatty acid were analysed in rice samples using gas chromatography (GC) with flame ionization detector (FID) (AOAC, 2005, Method 996.06). Identification of fatty acids was based on the retention times of fatty acids methyl esters standard. Cholesterol in food was analysed by direct saponification using GC with FID (AOAC, 2005 Method 994.10).

Quality control

The quality of the resulting data for every sample was controlled and monitored using internal quality control materials prepared in the laboratory and certified reference material where available. Results were accepted only when they are within the control limits for all nutrients tested.

Statistical analysis

All data were expressed by means ± standard deviation of the six brands of rice (n=6). Comparison of means in rice was performed by one-way ANOVA using SPSS version 18 software. The value when $p < 0.05$ will be considered as significant difference for all these varieties of rice.

Results and Discussion

The mean results from the six brands of three varieties of rice are listed in Tables 1, 2, 3, and 4. The nutrients analysed were divided into four categories, namely proximate, minerals, vitamins, and fatty acids and cholesterol.

Proximate

The term proximate is usually used to represent the gross components that make up foods such as water, protein, fat, carbohydrate, total dietary fibre, and ash. The water contents of all three rice varieties ranged from 12.20 to 13.21 g/100 g (Table 1). In our study, there were significant differences observed in water content between Fragrant rice and Siam rice (p=0.012). Sood *et al.* (2006) reported that the

Table 1. Nutrients (proximate) levels for fragrant rice, basmati rice, and siam rice

No	Parameter	Fragrant Rice /100 g Mean, n=6	Basmati Rice /100 g Mean, n=6	Siam Rice /100 g Mean, n=6
1	Energy (Kcal)	345.13 ± 2.27	348.93 ± 3.34	351.01 ± 1.69
2	Water (g)	13.21 ± 0.24[a]	12.56 ± 0.58	12.20 ± 0.40[b]
3	Protein (g)	7.17 ± 0.35[a]	8.35 ± 0.20[c,b]	7.55 ± 0.32[d]
4	Fat (g)	0.38 ± 0.24	0.41 ± 0.33	0.46 ± 0.14
5	Carbohydrate (g)	77.55 ± 0.82	77.63 ± 0.61	78.83 ± 0.48
6	Total Dietary Fiber (g)	1.40 ± 0.53	0.63 ± 0.28	0.65 ± 0.26
7	Ash (g)	0.28 ± 0.04[a]	0.40 ± 0.06 [b,c,]	0.30 ± 0[d]

* Different letters (a and b or c and d) within the same row indicate significant difference (p<0.05).

average water content in 12 Basmati varieties in India was 11.23%. Another study, by Tee *et al.* (1997), showed that water content in broken rice, husked rice, parboiled rice, and polished rice ranged from 11.8 to 12.7 g/100 g. Current results are also comparable with rice data (white, long grain, regular, raw, unenriched) from Brazil (12.9 g/100 g), and USDA (11.62 g/100 g) (Padovani *et al.*, 2007; USDA, 2012). The water content indicated similar storage conditions. Water content of approximately 12% was recommended for long-term storage to avoid insect infestation and microorganism development (Cogburn, 1985).

Protein is the most common nutrient analysed in rice. Table 1 shows that protein contents in Fragrant, Basmati, and Siam rice were 7.17 ± 0.35 g/100 g, 8.35 ± 0.2 g/100 g, and 7.55 ± 0.32 g/100 g, respectively (Table 1). Basmati rice contains the highest amount of protein. There were significant differences in the protein content among basmati, fragrant and Siam rice at p <0.001. In our study, the protein level was comparable with the previous study by Tee *et al.* (1997), ranged from 6.9 to 8.0 g/100 g, data from Brazil (7.47 g/100 g), USDA (7.13 g/100 g), and India (8.08 g/100 g) (Sood et al., 2006; Padovani *et al.*, 2007; USDA, 2012). However, studies by Barikmo *et al.* (2004) and Heinemann *et al.* (2005) showed that rice data from Brazil (brown, parboiled, and milled) and Mali (polished) were lower than the current findings. This may be due to ecological and climate variations such as temperature, rainfall, and access of water, use of fertilizer, nutrient content of the soil, and growing conditions for plants that may affect the nutrient content of the local food (Greenfield and Southgate, 1992; Barikmo *et al.*, 2004).

In our study, there was no significant difference in fat content among rice varieties (p>0.05) (Table 1). The fat content was in the range of 0.3 g to 0.4 g/100 g. In the available version of Malaysian FCD, the fat content was reported higher in broken rice (0.7 g/100 g), husked rice (unpolished) (1.8 g/100 g), parboiled rice (1.2 g/100 g), and polished rice (0.5 g/100 g) (Tee *et al.*, 1997), respectively. However, to the best of our knowledge, no study to date has analysed fat content in different varieties of rice in Malaysia. In Brazil, fat content in rice (white, long grain, regular, raw, unenriched) was 0.27 g/100 g (Padovani *et al.*, 2007) while in USA it was 0.66 g/100 g (USDA, 2012). In India, Basmati rice was found to be high in fat content (Sood *et al.*, 2006).

Carbohydrate levels were in the range of 77.55 to 78.83 g/100 g (Table 1) in all rice varieties. These levels were comparable with the previous data of Malaysian FCD (Tee *et al.*, 1997) and slightly lower than rice tested in Mali (83.7 g/100 g) (Barikmo *et al.*, 2004). These levels were also comparable with the available carbohydrate data from Brazil, USA, and India (Sood *et al.*, 2006; Padovani *et al.*, 2007; USDA, 2012).

In the Malaysian 1997 FCD (Tee *et al.*, 1997), fibre was reported as total crude fibre whereas in the current studies, fibre was determined as total dietary fibre which includes soluble and insoluble fibre. The total dietary fibre content in the three rice varieties ranged from 0.63 to 1.4 g/100 g (Table 1). The dietary fibre content for fragrant rice was comparable with the rice in Mali (1.1 g/100 g) and USDA rice (white, long grain, regular, raw, unenriched) (1.3 g/100 g) (USDA, 2012) but slightly lower than the dietary fibre content in the rice from Brazil (1.8 g/100 g) (Padovani *et al.*, 2007).

Ash is one of the components in the proximate analysis for biological materials. It is a non-aqueous residue that remains after a sample is burned, which consists mostly of metal oxides. Ash levels in food are required for the calculation of total carbohydrate and dietary fibre. A wide variation in ash contents was observed in rice samples from three different varieties, ranging from 0.28 to 0.4 g/100 g (Table 1). Fragrant rice has the lowest ash content while Basmati rice has the highest. There was significant difference between Basmati rice and Siam rice (p=0.003) and Basmati rice with Fragrant rice (p=0.001). The ash levels in the current FCD are considered low compared with the data from the 1997 Malaysian FCD (ranging from 0.5 to 1.0 g/100 g) (Tee *et al.*, 1997) and from the Brazil and USDA databases (0.54 g/100 g and 0.64 g/100 g, respectively) (Padovani *et al.*, 2007; USDA, 2012).

Table 2. Nutrients (minerals) levels for fragrant rice, basmati rice, and siam rice

No	Parameter	Fragrant Rice, mg /100 g Mean, n=6	Basmati Rice mg/100 g Mean, n=6	Siam Rice, mg /100 g Mean, n=6
8	Magnesium (Mg)	9.22 ± 1.13	12.53 ± 3.51	13.86 ± 3.58
9	Calcium (Ca)	4.52 ± 0.78[a]	5.87 ± 1.09[b]	5.08 ± 0.58
10	Sodium (Na)	2.58 ± 1.32[a]	3.92 ± 0.46[b]	3.85 ± 0.69
11	Iron (Fe)	2.60 ± 2.97	2.50 ± 3.49	0.38 ± 0.17
12	Zinc (Zn)	1.06 ± 0.32	1.07 ± 0.10	1.17 ± 0.11
13	Copper (Cu)	0.13 ± 0.16	0.02 ± 0.01	0.04 ± 0.045

*Different letters (a and b) within the same row indicate significant difference (p<0.05)

Minerals

Table 2 shows the levels of minerals in three different varieties of rice. The major minerals detected in rice were Mg ranging from 9.22 ± 1.13 to 13.86 ± 3.58 mg/100 g, Ca ranging from 4.52 ± 0.78 mg/100 g to 5.87 ± 1.09 mg/100 g and Na ranging from 2.58 ± 1.32 to 3.92 ± 0.46 mg/100 g. Padovani *et al*. (2007) reported a very much higher level of Mg (31 mg/100 g), while Na content was lower (1 mg/100 g) as compared with the present study. The degree of polishing has a significant effect on the quality and nutritional aspects of white rice, affecting properties such as content of minerals (Liang *et al*., 2008), phytochemicals, and grain breakage (Mohapatra and Bal, 2010).

The highest iron content was found in Fragrant rice and Basmati rice with similar levels, while Siam rice has the lowest iron content (Table 2). The iron content in rice is mainly affected by the iron absorption from soil, and the transportation and accumulation of iron in rice. Iron content also varies greatly based on rice cultivars or genotypes, mainly controlled by the correlated genes (Meng *et al*., 2005).

Zinc was present in all three types of rice tested at the average level of 1 mg/100 g. The level was similar to the findings reported by USDA (2012). A trait for high iron and zinc has been linked to aromatic varieties such as jasmine and Basmati (Graham *et al.*, 2001). Copper (Cu) was detected at trace level in all rice varieties ranging from 0.021 to 0.045 mg/100 g. However, this result was in contrast with the higher Cu level found in rice from Brazil (brown, parboiled brown, parboiled milled, and milled) and USDA (white, long grain, regular, raw, unenriched) with an average of 0.17 mg/100 g (Heinemann *et al*., 2005; Padovani *et al*., 2007; USDA, 2012). A previous study by Xu *et al.* (2006) reported that 1/3 of the Cu in rice grain was eliminated after grain processing. Other factors could be due to different soil characteristics, fertilizer, different geographical area.

Table 3. Nutrients (vitamins and sugar) levels for fragrant rice, basmati rice, and siam rice

No	Parameter	Fragrant Rice (/100 g) Mean, n=6	Basmati Rice (/100 g) Mean, n=6	Siam Rice (/100g) Mean, n=6
14	Vitamin C (mg)	ND	ND	ND
15	Thiamin (B1) (mg)	ND	ND	ND
16	Riboflavin (B2) (mg)	0.06 ± 0.01	0.06 ± 0.004	0.06 ± 0.0
17	Niacin (B3) (mg)	0.86 ± 0.86	1.05 ± 0.19	1.06 ± 0.19
18	Pyridoxine (B6) (mg)	0.15 ± 0.015[a]	0.16 ± 0.0	0.17 ± 0.04[b]
19	Folic Acid (B9) (μg)	51.00 ± 25.65	97.50 ± 18.43[a]	98.17 ± 10.80[b]
20	Vitamin A (μg)	ND	ND	ND
21	Vitamin E (mg)	ND	ND	ND
22	Total sugar (g)	ND	ND	ND
	Sucrose (g)	ND	ND	ND
	Glucose (g)	ND	ND	ND
	Fructose (g)	ND	ND	ND
	Lactose (g)	ND	ND	ND
	Maltose (g)	ND	ND	ND

*Different letters (a and b) within the same row indicate significant difference (p<0.05).
ND: Not detected

Vitamins

Vitamins are essential organic compounds required in small amounts in the diet to promote and regulate body functions for growth, reproduction, and the maintenance of health (Smolin and Grosvenor, 2008). Vitamin C was not detected in all samples (Table 3). The results were as predicted as there were none detected in samples from Brazil and USDA (white, long grain, regular, raw, unenriched) (Padovani *et al*., 2007; USDA, 2012).

Vitamin B1 (Thiamin) is a water-soluble vitamin. It exists as part of the co-enzyme TPP (Thiamin pyrophosphate) in the human body that assists in energy metabolism (Ellie and Sharon, 2008; Smolin and Grosvenor, 2008). Thiamin was not detected in all three rice varieties (Table 3). However, Thiamin was found in broken rice (0.14 mg/100 g), polished rice (0.11 mg/100 g), husked rice (unpolished) (0.38mg/100g), and parboiled rice (0.22 mg/100 g) as in the previous FCD report (Tee *et al*., 1997). Rice is a good source of vitamin B1, especially brown rice, long grain brown rice, wild rice, and parboiled rice (Lebiedzinska and Szefer, 2006). Low levels of Thiamin were found in rice (white, long grain, regular, raw, unenriched) from Brazil (0.2 mg/100 g), USDA (0.07 mg/100g) (Padovani *et al*., 2007;

Table 4. Nutrients (fatty acids and cholesterol) levels for fragrant rice, basmati rice, and siam rice

No	Parameter	Fragrant Rice (/100 g) Mean, n=6	Basmati Rice (/100 g) Mean, n=6	Siam Rice (/100 g) Mean, n=6
23	Fatty acid, total saturated fat (g)	0.46 ± 0.16	0.24 ± 0.19	0.27 ± 0.07
	12:00 (Lauric Acid)	0.02 ± 0.02	<0.05	<0.05
	14:00 (Myristic acid)	0.01 ± 0.01	0.01 ± 0.01	0.02 ± 0.01
	16:00 (Palmitic acid)	0.21 ± 0.14	0.19 ± 0.15	0.23 ± 0.06
	18:00 (Stearic acid)	0.03 ± 0.01	0.03 ± 0.017	0.03 ± 0.01
24	Fatty acids, total monounsaturated fat (g)	0.07 ± 0.04	0.12 ± 0.048	0.08 ± 0.03
	18:01 (Oleic acid)	0.05 ± 0.04	0.08 ± 0.048	0.07 ± 0.03
25	Fatty acids, total polyunsaturated fat (g)	<0.05	0.05 ± 0.0156	0.11 ± 0.04
	18:02 (Linoleic acid)	<0.05	0.03 ± 0.016	0.04 ± 0.05
	18:03	<0.05	<0.05	0.001 ± 0.0004
	20:02	<0.05	0.01 ± 0.003	0.003 ± 0.001
26	Trans fatty acids (g)	<0.05	<0.05	<0.05
27	Cholesterol (mg)	ND	ND	ND

ND: Not detected

USDA, 2012), India (Basmati) (0.067 mg/100 g) (Sood *et al*., 2006) and Poland (0.053 mg/100 g) (Lebiedzinska and Szefer, 2006). The absence of Thiamin in all samples could be due to the milling and polishing process in white rice production that significantly decreases the nutrient content (Prinzo and Benoist, 2002).

Vitamin B2 (Riboflavin) acts as a coenzyme in many reactions, most notably in the release of energy from carbohydrate, fat, and protein in all body cells (Ellie and Sharon, 2008; Smolin and Grosvenor, 2008). The mean levels of Riboflavin detected in Fragrant, Basmati, and Siam rice was approximately at 0.06 mg/100 g (Table 3). There was no significant difference among all samples (p>0.05) tested. The Riboflavin levels in the previous FCD was detected at a slightly higher range of 0.06 to 0.14 mg/100 g in broken rice, polished rice, husked rice, and parboiled rice (Tee *et al*., 1997). Nevertheless, lower levels of riboflavin in rice (white, long grain, regular, raw, unenriched) from Brazil and USDA were reported. They were at < 0.02 mg/100 g and 0.049 mg/100 g, respectively (Padovani *et al*., 2007; USDA, 2012). Lower level of Riboflavin at 0.033 mg/100 g was also found in Basmati rice from India (Sood *et al*., 2006).

Vitamin B3 (Niacin) is commonly found in two water-soluble forms, i.e. nicotinic acid and nicotinamide (Lebiedzinska and Szefer, 2006; Smolin and Grosvenor, 2008). Niacin levels are statistically similar among the four varieties (p>0.05), ranging from 0.86 to 1.06 mg/100 g (Table 3). Fragrant rice has the lowest level of Niacin among other three varieties. These results were comparable to Brazil and USDA databases of 0.5 mg/100 g and 1.6 mg/100 g of Niacin level in rice (white, long grain, regular, raw, unenriched), respectively. However, vitamin B3 level reported by Tee *et al.* (2012) in broken rice (1.9 g/100 g), polished rice (3.3 g/100 g), husked rice (unpolished) (5.5 g/100 g), and parboiled (3.3 g/100g) were higher compared with the current FCD.

Vitamin B6 (Pyridoxine) is one of the water soluble vitamins that can influences cognitive performance, immune function, and steroid hormone activity (Ellie and Sharon, 2008). The level of vitamin B6 was not measured according to previous Malaysian FCD (Tee *et al*., 1997). As shown in Table 3, vitamin B6 concentration in rice ranged from 0.15 to 0.168 mg/100 g (Table 3). There was a significant difference between Siam rice and Fragrant rice (p=0.032) while there was no significant differences among the other rice varieties. In other databases such as Brazil and USPA's, the vitamin B6 level in rice (white, long grain, regular, raw, unenriched) were reported as 0.057 mg/100 g and 0.164 mg/100 g, respectively (Padovani *et al*., 2007; USDA, 2012).

Vitamin B9 (Folic acid) is another water soluble vitamin with very important function in the body in one-carbon metabolism, nucleic acid metabolism, and amino acid metabolism (Ellie and Sharon, 2008; Smolin and Grosvenor, 2008). There was evidence that folate deficiency can cause megaloblastic anaemia, low birth weight, birth defects, and cognitive impairment (Prinzo and Benoist, 2002). The level of folic acid in three rice varieties ranged from 51 to 98.17 µg/100 g where the Fragrant rice showed the lowest as compared with other two rice varieties (Table 3).There were significant differences in folic acid level between Siam rice and Basmati rice (p=0.008). Folic acid was not reported in the previous 1997 FCD (Tee *et al*., 1997). A recent study by Chew *et al*. (2012) reported a lower level of folic acid in Basmati rice at 25 ± 0.7 µg/100 g and Fragrant rice at 18.0 ± 0.5 µg/100 g. Folate level in rice from the USA (white, long grain, regular, raw, unenriched) was also reported at a very lower level of 8 µg/100 g (USDA, 2012). Vitamins A and E, and total sugar were not detected in all samples analysed in this study (Table 3).

Fatty acids and cholesterol

All rice analysed in this project were milled and polished rice. Milled rice normally contains small amount of lipids (below 5% on dry weight basis) as compared with bran rice (about 15% on dry weight basis) (Kitta *et al*., 2005). The major fatty acids in all samples tested were palmitic acid (16:00). The palmitic acid content was highest in Siam rice (0.23 ± 0.06 g/100 g), followed by Fragrant rice while Basmati rice was the lowest (0.194 ± 0.148 g/100 g) (Table 4). The total saturated fat was detected at a low level for all rice around 0.24 to 0.46 g/100 g (Table 4). The low level of total saturated fat in rice was also reported by USDA for rice (white, long grain, regular, raw, unenriched) with a level of 0.18 g/100 g (USDA, 2012).

The oleic acid content in all rice was at a very low level of from 0.05 to 0.08 g/100 g (Table 4). The level of total monounsaturated fat detected in decreasing order was Basmati, Siam, and Fragrant rice (Table 4). In comparison, USDA (2012) reported a higher level of total monounsaturated fat in rice (white, long grain, regular, raw, unenriched) of 0.21 g/100 g than the new Malaysian FCD rice.

Linoleic acid (18:2) was the least abundant fatty acid in rice reported in this project. The total polyunsaturated fat also followed the same trend as that reported for linoleic acid (Table 4). Rice (white, long grain, regular, raw, unenriched) as reported by USDA (2012) contains 0.177 g/100 g total polyunsaturated fat. The major fatty acids in non-glutinous rice cultivars of Japonica type were reported as oleic (18:1) (>30%), linoleic (18:2) (~30%), and followed by palmitic acid (16:0) (20%) (Kitta *et al*., 2005). Trans fatty acid in the three rice varieties were detected but only at trace level (<0.05 g/100g) and can be considered as negligible. Cholesterol was not detected in all four rice varieties in this project. USDA (2012) also reported that fatty acids and cholesterol were not detected in rice (white, long grain, regular, raw, unenriched).

Conclusion

Results in the study indicated that the three rice varieties contain comparable nutrient levels except for vitamins C, B1, A, and E, and total sugar which were not detected. The fatty acid (total saturated, total monounsaturated, and total polyunsaturated) as well as trans-fatty acid were at very low levels. The nutrient content in these rice varieties will provide new data for updating the new Malaysian FCD.

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