Mal J Nutr 15(2): 213 - 222, 2009

Determination of Phytate, Iron, Zinc, Calcium Contents and Their Molar Ratios in Commonly Consumed Raw and Prepared Food in Malaysia

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ABSTRACT

The inhibitory effect of phytate on the bioavailability of iron, zinc and calcium was determined by measuring their molar ratios. A total of 29 food samples consisting of 12 rice and rice products, 5 wheat and wheat products, 5 grains and cereal based products and 7 different popular varieties of cooked rice and rice products were selected. The phytate content was analysed using anion-exchange chromatography whereas mineral contents were analysed using atomic absorption spectrophotometry(AAS). One-way ANOVA test was used to statistically analyse the mean difference between the phytate and mineral contents between the food group samples. In general, results show that cooked products have lower content of phytate and minerals as compared to raw products. This could be due to the influence of the cooking method on phytate and mineral content in the food. Based on one-way ANOVA test, there were no significant difference in phytate and zinc content between four food groups (p >0.05). Significant differences were found only in iron and calcium content (p <0.05). Of the 29 food samples, 25 food samples had a phytate/iron molar ratio > 1, 5 food samples had a phytate/zinc molar ratio > 15 and 23 food samples had a phytate/calcium molar ratio of 0.24. These results show that although many of the food samples analysed had high mineral content, the high phytate content may impair the bioavailability of the mineral in the body.

Keywords: Calcium, iron, molar ratios, raw and prepared food, phytate, zinc,

INTRODUCTION

Bioavailability is a general term that refers to how well a nutrient can be absorbed and used by the body. It can be affected by many factors such as the presence of anti-nutrients, for example, phytates, oxalates, tannins and polyphenols in foods, a person's need, fibre, competition with other nutrients and acidity of intestinal environment (Paul, Turner & Ross, 2004).

Minerals, classified as micronutrients are needed by our body in small amounts. Deficiency in minerals, however, can have a major impact on health such as anemia and osteoporosis that commonly occur in both developed and developing countries. This study focused only on iron (Fe), zinc (Zn) and calcium (Ca). In Malaysia, the incidence of anemia due to deficiency of iron is nearly one million cases (969,645), osteoporosis due

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to calcium deficiency is 2, 421, 432 cases while data on Zn status in the Malaysian population is unavailable. The cause of mineral deficiency is commonly due to its low bioavailability in the diet. One of the factors as mentioned earlier is the presence of phytate.

Phytate, which is also known as inositol hexakisphosphate, is a phosphorus-containing compound that binds with minerals and inhibits mineral absorption. The presence of phytate in foods has been associated with reduced mineral absorption due to the structure of phyate which has high density of negatively charged phosphate groups which form very stable complexes with mineral ions causing non-availability for intestinal absorption (Walter *et al*., 2002). Phytates are generally found in food high in fibre especially in wheat bran, whole grains and legumes (Lori, Thava & James, 2001). Due to evidence showing that fibre-rich foods protect against diseases such as cardiovascular disease (CVD), colon and breast cancer, more Malaysian have now started adopting a dietary pattern containing high fibre foods. Also, the food industry has introduced various food products enriched with fibre. This has indirectly caused increased consumption of phytates, hence possibly reducing bio-availability of minerals.

There have been a number of studies determining the level of phytate content in different foods in other countries. A few studies show that the Asian diet contains very high amounts of phytate compared to western diets. For example, a study in India showed that the phytate content in their foods ranged from 480 to 520mg / 100g (Pushpanjali & Santosh, 1995). The phytate content of Korean foods ranged between 191.7 to 973.3mg / 100g for cereals and 508.5 to 1371.8mg / 100g for legumes (Joung *et al*., 2004), while a study in Indonesia showed that phytate content ranged between 8 to 319 mg / 100g for cereals and 24 to 1018 mg / 100g for legumes (Sanny *et al*., 2007). The phytate intake of Malaysians is still unknown. This is due to the lack of data on phytate content in local food. Even though the phytate content in other Asian foods might be available for use, the different cooking methods, food processing techniques and the variety of food consumed by Malaysians compared to the people of other countries renders such data unusable for assessing the phyate intake of Malaysians.

There are many techniques used to determine the bioavailability of minerals in the human body. One of the methods is by measuring the molar ratio of phyate / minerals in the food and diet (Morris & Ellis, 1989). The proportion of samples with ratios above the suggested critical values has been calculated: phytate: calcium > 0.24 (Morris & Ellis, 1985), phytate : iron > 1 (Hallberg, Brune & Rossander, 1989), phytate : zinc > 15 (Turnlund *et al*.,1984; Sandberg *et al*., 1987; Morris & Ellis, 1989), phytate : calcium / zinc > 200 (Davies, Carswell & Mills,1985; Bindra, Gibson & Thompson, 1986).

This study aimed to estimate the inhibitory effect of phytate on the bio-availability of iron, zinc and calcium in commonly consumed raw and prepared food in Malaysia by measuring their molar ratios.

MATERIALS AND METHODS

Sample selection and collection

A total of 29 different food samples were selected consisting of 12 rice and rice products, 5 wheat and wheat products, 5 grains and cereal based products and 7 different popular varieties of cooked rice and rice products by convenience sampling. Each raw sample was purchased from three different supermarkets and shops while the cooked samples were purchased from three different shops in Seri Serdang, Selangor. Each type of sample was then homogenised and kept at –20°C until further use.

Determination of phytate

Phytate was determined using anion-exchange method following Ma *et al.* (2005). Samples were accurately weighed (1.0 – 2.0g) and transferred into 100ml conical flasks. A total of 40 – 50ml of Na_2SO_4 (100g / l)-HCl (1.2%) was added. Flasks were then capped and shaken vigorously for 2 hours on a rotator at ambient laboratory temperature. The supernatant was then filtered through qualitative filter paper no 4.

A total of 10ml of filtered extract was diluted to 30ml with distilled water after mixing with 1ml of 0.75M NaOH and then passed through an anion resin column (resin AG1-X4, ~ 100 – 200mesh, Biorad Laboratory Inc., column 0.8 x 10cm). The column was washed before use with 0.5M NaCl solution and deionised water. After sample application, the column was washed with 15ml of distilled water and 20ml of 0.05M NaCl solution in order to remove the inorganic phosphate. Then the retained phytic acid was eluated with 0.7M NaCl. The post column reagent was made up as a 0.03% $FeCl_3$ solution containing 0.3% sulphosalicyclic acid. A total of 4ml of the reagent was added into 5ml of collected eluate and centrifuged at 3000rpm for 10 minutes. The absorbance of the supernatant was measured at 500nm using a spectrophotometer (SECOMAM CE, France). A calibration curve for the colorimetric method was obtained by using sodium phytate standards (P-8810 Sigma, USA) as shown in Figure 1.

Determination of calcium, zinc and iron

The contents of Ca, Zn and Fe in foods were measured by atomic absorption spectro-photometer (AAS) (Analytikjena AG, Germany) according to the method of Hernandez *et al.* (2004). A 5g sample was placed in a previously weighed porcelain crucible and heated. The resulting white ash was weighed, dissolved in 3ml of concentrated nitric acid and diluted with distilled water in a 25ml calibrated flask. The solution then was used to determine Ca, Zn, and Fe. Standard stock solution of iron, zinc and calcium was prepared from AAS grade chemicals (Sigma, USA) by appropriate dilution.

Determination of molar ratio of phytate/ mineral

The mole of phytate and minerals was determined by dividing the weight of phytate and minerals with its atomic weight

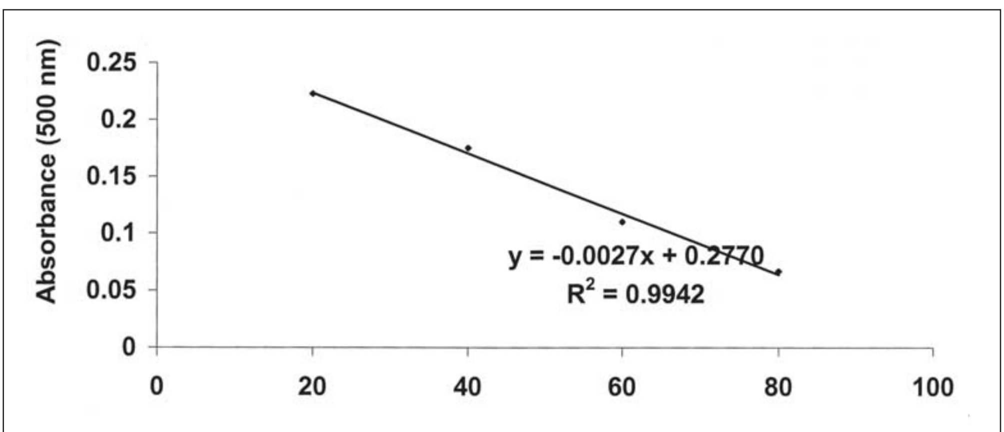

Figure 1. The concentration of sodium phytate (mg / ml) against absorbance (500nm).

(phytate: 660g / mol; Fe: 56g / mol; Zn: 65g / mol; Ca: 40 g / mol). The molar ratio between phytate and mineral was obtained after dividing the mole of phytate with the mole of minerals.

Statistical analysis

The statistics software Statistical Package for Social Sciences (SPSS) version 12.0 for Windows was used to analyse the phytate, iron, zinc and calcium content and the results expressed as mean ± standard deviation (SD). The comparison of the difference in phytate and mineral content between food groups was analysed using one-way analysis of variance (ANOVA) analysis. Significant difference was determined by $p <$ 0.05. Triplicate sample solutions from each food sample were analysed. The measurement was repeated until the relative standard deviation (%RSD) was within 10%.

RESULTS AND DISCUSSION

Phytate and mineral content within food groups

All 29 food samples were analysed for phytate and mineral content as well as their molar ratio. Table 1 presents the phytate and mineral content in all food samples while the molar ratios of phytate / mineral of all food samples are summarised and shown in Table 2.

Rice and rice products

Rice is the main staple food in Asia including Malaysia. Rice products such as mee hoon is a common food choice of Malaysians. In this study a total of 12 rice and rice products were analysed for phytate, iron, calcium and zinc content. Phytate contents ranged from 15.12 ± 0.07 mg / 100g for glutinous flour to 91.52 ± 1.00 mg / 100g for Malaysian rice (Brand D). For iron content, the highest value obtained was 1.98 ± 0.03 mg / 100g for rice flour and the lowest was 0.24 ± 0.03 mg / 100g for Malaysian rice (Brand B). The range of zinc content in rice and rice products was between 0.14 ± 0.01 mg / 100g for *kueh teow* to 1.70 ± 0.04 mg / 100g for Malaysian rice (Brand C), while calcium content ranged from 0.26 ± 0.01 mg / 100g for *kueh teow* to 0.64 ± 0.03 mg / 100g for Malaysian rice (Brand B).

The molar ratios of phytate / iron of all rice and rice products were > 1.00. A similar molar ratio for phytate / calcium of > 0.24 was obtained. These ratios predict that all the food samples from rice and rice products had poor bioavailability of iron and calcium. This could be due to the high content of phytate in this food group which affects the mineral bioavailability of these foods. Another possibility could be due to a loss of nutrients during the polishing process, the main process to produce white rice. Most of the nutrients in rice can be found in the rice bran. However, during the polishing process, the rice bran is removed along with its nutrient composition. For zinc content, all food samples had good bioavailability except for *kueh teow*, which had > 15 molar ratios of phytate / zinc.

Wheat and wheat products

Wheat is an important ingredient in bread, flour, cookies, noodles etc. Wheat and wheat products are other important staple foods that are commonly consumed in Malaysia. An analysis of the five samples chosen, showed that the phytate content ranged from 2.86 ± 1.23 mg / 100g for *mee kuning* and 110.07 ± 2.01 for wheat *kueh teow*. Iron content in wheat and wheat products ranged between 0.87 ± 0.06 mg / 100g for wheat flour and 3.07 ± 0.09 mg / 100g for white bread, while zinc content ranged between 0.32 ± 0.003 mg / 100g for *mee kuning* (noodles) and 1.99 ± 0.09 mg / 100g for wholegrain bread. Lastly for calcium, the range was between 0.39 ± 0.02 mg / 100g for *mee kuning* and 110.66 ± 2.04 mg / 100g for white bread.

A factor that decreases phytate content is bread making. During bread making, the phytate content decreases due to the action

Table 1. Phytate, iron, zinc, and calcium content of the foods analysed

Sample	*Phytate content (mg/100g)*	*Iron content (mg/100g)*	*Zinc content (mg/100g)*	*Calcium content (mg/100g)*
Rice and rice products				
Malaysia rice (Brand A)	60.96 ± 1.29	0.70 ± 0.02	0.92 ± 0.05	0.53 ± 0.02
Malaysia rice (Brand B)	36.40 ± 0.67	0.24 ± 0.03	1.63 ± 0.02	0.64 ± 0.03
Malaysia rice (Brand C)	76.24 ± 1.07	0.32 ± 0.03	1.70 ± 0.04	0.62 ± 0.01
Malaysia rice (Brand D)	91.52 ± 1.00	0.62 ± 0.04	1.64 ± 0.02	0.52 ± 0.002
Malaysia rice (Brand E)	68.05 ± 0.98	0.39 ± 0.05	0.80 ± 0.01	0.59 ± 0.02
Malaysia rice (Brand F)	62.59 ± 0.89	0.44 ± 0.03	1.22 ± 0.03	0.38 ± 0.02
Indian rice (Brand A)	66.41 ± 1.11	0.55 ± 0.03	0.81 ± 0.01	0.46 ± 0.01
Glutinous rice	57.14 ± 1.33	0.53 ± 0.05	1.50 ± 0.02	0.59 ± 0.02
Glutinous flour	15.12 ± 0.07	0.57 ± 0.05	0.91 ± 0.01	1.60 ± 0.04
Mee hoon	17.84 ± 0.18	1.23 ± 0.03	0.76 ± 0.01	0.56 ± 0.01
Rice flour	75.14 ± 1.43	1.98 ± 0.03	1.21 ± 0.01	0.45 ± 0.01
Kueh teow	38.04 ± 0.52	0.47 ± 0.03	0.14 ± 0.01	0.26 ± 0.01
Wheat and wheat products				
Wheat *kueh teow*	110.07 ± 2.01	1.18 ± 0.07	0.60 ± 0.02	5.78 ± 0.08
Wheat flour	84.96 ± 1.88	0.87 ± 0.06	0.37 ± 0.01	1.68 ± 0.03
Wholegrain bread	14.57 ± 0.09	2.78 ± 0.07	1.99 ± 0.99	51.58 ± 1.22
White bread	34.22 ± 0.65	3.07 ± 0.09	0.76 ± 0.02	110.66 ± 2.04
Mee kuning	2.86 ± 1.23	1.33 ± 0.02	0.32 ± 0.003	0.39 ± 0.02
Raw grain and cereal based products				
Oat cereal	394.92 ± 0.99	3.57 ± 0.12	2.94 ± 0.05	2.41 ± 0.08
Chocolate chip cookie cereal	120.98 ± 1.76	2.34 ± 0.06	0.42 ± 0.02	203.62 ±16.68
Honey coated cereal	27.12 ± 0.24	1.46 ± 0.02	0.42 ± 0.004	138.88 ± 5.89
Chocolate coated cereal	75.14 ± 1.69	2.49 ± 0.09	0.52 ± 0.01	70.78 ± 0.40
Chocolate malt drink	74.60 ± 1.47	2.33 ± 0.11	0.85 ± 0.01	69.61 ± 0.96
Cooked rice and rice products				
Chicken rice	4.20 ± 0.07	0.12 ± 0.03	0.32 ± 0.01	1.05 ± 0.03
Nasi lemak	187.56 ± 3.09	0.17 ± 0.03	0.34 ± 0.004	1.15 ± 0.01
White rice	18.20 ± 0.07	0.31 ± 0.02	0.47 ± 0.01	0.67 ± 0.02
Fried rice	12.93 ± 0.13	0.28 ± 0.05	0.13 ± 0.001	1.90 ± 0.03
Nasi dagang	53.86 ± 1.15	0.60 ± 0.02	0.84 ± 0.01	5.06 ± 0.05
Nasi kerabu	24.39 ± 0.52	0.44 ± 0.03	0.32 ± 0.002	0.42 ± 0.01
Fried *kueh teow*	4.75 ± 0.09	0.64 ± 0.03	0.13 ± 0.002	0.53 ± 0.004

Values are expressed as mean ± standard deviation, SD (n=3).

of phytase as well as the high temperature. Phytate is also affected by hydrolyses, including the type and extraction rate of flour, and fermentation techniques (Ma *et al.*, 2005). This explains why bread has lower phytate content compared to wheat flour. The iron and calcium content obtained in the wholegrain and white bread was also high due to addition of minerals in the fortification process (as stated in the food label). The addition of milk as a ingredient in bread making is also another possible reason for the high calcium in bread. In terms of bioavailability, two food samples

Table 2. The molar ratio between phytate and mineral of foods analysed

Sample	*Phytate/Fe*	*Phytate/Zn*	*Phytate/Ca*
Rice and rice products			
Malaysia rice (Brand A)	7.08	6.57	7.08
Malaysia rice (Brand B)	13.75	2.20	3.44
Malaysia rice (Brand C)	19.33	4.46	7.25
Malaysia rice (Brand D)	12.64	5.56	10.69
Malaysia rice (Brand E)	14.71	8.58	6.87
Malaysia rice (Brand F)	11.88	5.00	9.50
Indian rice (Brand A)	10.10	8.42	8.42
Glutinous rice	9.67	3.78	5.80
Glutinous flour	2.30	1.64	0.58
Mee hoon	1.23	2.25	1.93
Rice flour	3.26	6.00	10.36
Kueh teow	7.25	29.00	8.29
Wheat and wheat products			
Wheat *kueh teow*	7.95	18.56	1.15
Wheat flour	8.06	21.50	3.07
Wholegrain bread	0.44	0.71	0.02
White bread	0.95	4.33	0.02
Mee kuning	0.17	0.80	0.40
Raw grain and cereal based products			
Oat cereal	9.34	13.29	9.97
Chocolate chip cookie cereal	4.36	30.50	0.04
Honey coated cereal	1.58	6.83	0.01
Chocolate coated cereal	2.59	14.25	0.06
Chocolate malt drink	2.69	8.69	0.06
Cooked rice and rice products			
Chicken rice	3.00	1.20	0.23
Nasi lemak	94.67	56.80	9.79
White rice	4.67	4.00	1.65
Fried rice	4.00	10.00	0.42
Nasi dagang	7.45	6.31	0.65
Nasi kerabu	4.63	7.40	3.36
Fried *kueh teow*	0.64	3.50	0.54

Values are expressed as mean ± standard deviation, SD (n=3).

in this food group, wheat *kueh teow* and wheat flour, might have poor bioavailability of iron, zinc and calcium. This could be due to the high phytate content in these foods. However, another three food samples, wholegrain bread, white bread and *mee kuning*, were found to have good bioavailability of these minerals.

The study reveals that the fortification process helps in improving the bioavailability of minerals. However, as all wheat products require extra processing to improve texture, loss of nutrient content in wheat during the process is possible.

Raw grain and cereal based products

Our analysis revealed that the phytate content in these food groups was higher compared to other food groups. Phytate content ranged from 27.12 ± 1.69 mg / 100g for honey-coated cereal to 394.92 ± 0.99 mg / 100g for oat cereal. Iron content ranged from 1.46 ±0.02 mg / 100g to 3.57 ± 0.12 mg / 100g, while calcium content ranged from 2.41 ± 0.08 mg / 100g to 203.62 ± 16.68 mg / 100g. The high mean contents of iron and calcium in this food group compared to other groups could be due to the fortification of these grain and cereal based products with iron and calcium. For zinc content, the range was from 0.42 ± 0.02 mg / 100g for chocolate chip cookie cereal to 2.94 ± 0.05 mg / 100g for oat cereal.

The molar ratios of phytate / minerals in grain and cereal-based products were almost similar to the other groups, although iron was added during the fortification process. This could be due to the high content of phytate in this food group. From the analysis of data, indications are that all food samples from this food group might have poor bioavailability of iron because the molar ratios of phytate / iron were > 1.00. However, all food samples had high bioavailability of zinc and calcium except for chocolate chip cookie cereal and oat cereal, respectively. From these results, it is suggested that the food industry take the initiative of adding extra minerals or reducing the phytate content in food in order to improve bioavailability of minerals.

Cooked rice and rice products

There are many different ways to cook rice, for example *nasi lemak* is prepared by adding coconut milk, chicken rice is prepared by boiling rice in chicken broth, or even by using different types of rice. Seven popular cooked rice and rice products consumed in Malaysia were analysed for phytate and mineral contents. In general, the phytate content in this food group was lower compared to other food groups except for *nasi lemak.* The phytate content ranged from 4.20 ± 0.07 mg / 100g for chicken rice to 187.56 ± 3.09 mg / 100g for *nasi lemak.* For minerals, iron content ranged from 0.12 ± 0.03 mg / 100g for chicken rice to 0.64 ± 0.03 mg / 100g for fried *kueh teow,* while the range for zinc content was from 0.13 ± 0.002 mg / 100g for fried *kueh teow* to 0.84 ± 0.01 mg / 100g for *nasi dagang*. Meanwhile, calcium content ranged from 0.42 ± 0.01 mg / 100g for *nasi kerabu* to 5.06 ± 0.05 mg / 100g for *nasi dagang*. The mean of iron, zinc and calcium content in cooked rice and rice products were 0.37 ± 0.20, 0.36 ± 0.24, and 1.54 ± 1.63 mg / 100g, respectively. Most of the food samples selected had a phytate / iron and phytate / calcium molar ratios > 1.00 and 0.24, respectively. This shows that the bioavailability of iron and calcium is more likely to be affected by phytate in these kinds of food. All the food samples had a phytate / zinc ratio < 15 which indicates good bioavailability of zinc except for *nasi lemak*. In general, the phytate and mineral contents in this food group were lower compared to other groups. This could be due to the variety of cooking methods used. For example, Almana (2000) reported that discarding excessive water in cooking rice may result in phytate degradation of ~37% to 65%, while retaining the water only results in a phytate reduction of 12%.

The results from this study also found that *nasi lemak* and *nasi dagang* had the highest phytate content compared to other cooked rice. Both of these two rice preparations had been cooked with coconut milk. So, we suspect that high phytate content could be due to coconut milk that has been added during cooking. According to Oberleas & Harland (1986), fat content influences the extractability of phytate from food products and should be kept low (<5%) or reduced before phytate determination. However, fat content in *nasi lemak*, which comes from coconut milk is only about 3.6% (Tee *et al*., 1997), indicating that the method used to analyse phytate in this study should not be the problem. Generally high fibre foods have high phytate content. Coconut milk as stated in the Nutrient Composition of Malaysian Foods (Tee *et al*., 1997) does not contain fibre, an indication that the high phytate content

Table 3. The mean of phytate and mineral content between food groups

	Rice and rice products	*Wheat and wheat products*	*Raw grain and cereal based products*	*Cooked rice and rice products*	*P-value*
Mean phytate content (mg/100g)	55.45 ± 23.72	60.19 ± 38.30	138.55 ± 147.11	43.70 ± 65.63	0.170
Mean iron content (mg/100g)	0.67 ± 0.48	1.80 ± 1.03	2.44 ± 0.75	0.37 ± 0.20	0.000*
Mean zinc content (mg/100g)	1.10 ± 0.47	0.78 ± 0.71	1.03 ± 1.08	0.36 ± 0.24	0.122
Mean calcium content (mg/100g)	0.60 ± 0.33	34.01 ± 47.84	97.06 ± 76.66	1.54 ± 1.63	0.001*

does not necessarily come from high fibre food. This is supported by the results obtained by Chen (2004) who showed that there was no correlation between total phytic content with total dietary fibre in raw and dry red kidney beans. It is suggested that further research investigate the phytate content of coconut milk.

Phytate and mineral content between food groups

The comparison of phytate content between food groups shows that raw grain and cereal based products have the highest level of phytate followed by wheat and wheat products, rice and rice products and lastly cooked rice and rice products (Table 3). For iron content, the food group that had the highest value is raw grain and cereal based products while cooked rice and rice products had the lowest. Raw grain and cereal-based products also had the highest content of calcium while rice and rice products had the lowest. However, zinc, rice and rice products had the highest level followed by raw grain and cereal-based products. Based on one-way ANOVA test, there were no significant differences in phytate and zinc content for four food groups ($p > 0.05$). Significant differences were found only for iron and calcium content ($p < 0.05$).

A study by Ma *et al.* (2005) in China showed that grain food groups had the highest phytate content (223 to 1419 mg/100g) followed by rice and rice product groups (14 to 183 mg/100g) and wheat and wheat product groups (3 to 420 mg/100g). In this study, we found that the phytate content of the sample (4.20 to 394.92 mg/100g) was low but still within the phytate range found in other Asian countries. This could be due to the influence of factors such as soil, climate, duration of growth period and human intervention in food processing and cooking.

There are two major ways to improve mineral bioavailability: (i) by reducing the phytate content in the foods or (ii) by adding extra minerals in the fortification process. Effective reduction of phytate can be obtained via the action of exogeneous phytate-degrading enzymes (use of microbial or fungal phytases), breeding (selection of low phytate varieties), agronomic conditions (optimisation of fertilisation, better knowledge of the benefits or organic crop growing), genetic engineering or food processes (bread making, lactic acid fermentation) (Walter *et al.*, 2002). Studies have been carried out on food processing to reduce phytate content by soaking whole grain, soaking pounded grains, dehulling, malting and fermentation (Hotz & Gibson, 1995; Lestienne *et al*., 2005). There are also recommendations to reduce phytate content of bread by lowering the extraction rate of flour, prolonging the time for yeast fermentation or addition of phytase in the products (Almana, 2002). Bioavailability of minerals such as iron also can be increased under certain conditions. For example, by including meat, fish, poultry and vitamin C in the diet. So by adding fruits that are rich in vitamin C in our breakfast cereal or having fish, eggs and chicken in our meals will help increase the absorption of iron from our meal.

A study by Shamsuddin (1999) has shown that only phytate in the form of inositol trisphosphate (IP3) can inhibit the absorption of minerals. In our study, however, we have looked at the total phytate content and did not differentiate between the different classes of phytate. It is probable that the phytate present in the foods analysed was not in the form of IP3 that would inhibit the absorption of minerals. Further *in vivo* and *in vitro* studies need to be carried out in order to get a clearer picture of the effect of phytate on bioavailability of minerals.

CONCLUSION

In conclusion, varying levels of phytate can be found in food commonly consumed in Malaysia. Variation in phytate level was not only observed in different food groups, but also in the same food samples but prepared (cooked) differently. Of the 29 food samples, 25 food samples had a phytate / iron molar ratio > 1, 5 food samples had a phytate / zinc molar ratio > 15 and 23 food samples had a phytate / calcium molar ratio of 0.24. These results show that although the foods analysed had high mineral content, they also had a high phytate content which may impair the bioavailability of minerals to the body. Therefore, optimal food processing and cooking methods should be chosen to minimise this effect.

ACKNOWLEDGEMENTS

We would like to thank the Government of Malaysia for financial support (03-03-08-44FR) and the laboratory staff of the Department of Nutrition and Dietetics of UPM for their technical assistance.

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