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Nutritional Composition of Ready-to-Eat Cereals in the Malaysian Market

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ABSTRACT

Introduction: This study aimed to determine the nutrient content of cornflakes and muesli, ready-to-eat cereal products available in the Malaysian market. Cornflakes and muesli were chosen due to their popularity as a breakfast meal especially in urban areas. **Methods:** A total of six brands each for cornflakes and muesli were purchased from supermarkets in the Klang Valley using stratified random sampling. All samples were analysed using AOAC official methods of analysis. The validity of the test data was monitored with the application of internal quality controls in line with the requirements of ISO 17025. **Results:** Proximate analysis revealed significantly higher mean levels of carbohydrate (86.94 ± 0.59 mg/100g), minerals such as iron (8.48 ± 1.72 mg/100g) and sodium (674.83 ± 102.99 g/100g), B3 as niacinamide (25.87 ± 6.14 g/100g) and sucrose (5.10 ± 0.90 mg/100g) in cornflakes than in muesli. However, muesli contained significantly more mean moisture (10.23 ± 0.72 mg/100g), protein (10.07 ± 0.79 mg/100g), total dietary fibre (12.49 ± 1.44 mg/100g), magnesium (113.22 ± 7.93 mg/100g), zinc (1.65 ± 0.16 mg/100g), copper (0.25 ± 0.02 mg/100g), total sugar (18.75 ± 2.05 mg/100g), glucose (7.70 ± 1.77 mg/100g) and fructose (8.68 ± 1.76 mg/100g) than cornflakes. Most of the fatty acids analysed were not detected or of low value in both the cereal products. **Conclusion:** The nutrient analysis of cornflakes and muesli suggests that both ready-to-eat cereals are nutritionally good choice as breakfast for consumers as it provides carbohydrate, minerals, fibre and vitamins. The data provides additional information to the Malaysian Food Composition Database.

Key words: Cornflakes, Malaysian Food Composition Database, muesli, nutritional, proximate, ready-to-eat cereal(s)

INTRODUCTION

Eating breakfast is considered the most important meal of the day and this good practice will help ensure a person's healthy lifestyle (Reeves *et al.*, 2013). Breakfast is defined as 'any food or beverage consumed in a meal occasion named by the respondent as breakfast'. The definition

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was used in the Third National Health and Nutrition Examination Survey (NHANES III) (Cho *et al.*, 2003). Regular breakfast consumption is related to a reduced body weight (USDA, 2011) and higher cognitive performance in school children (Cooper, Bandelow & Nevill 2011). Despite the importance of breakfast, most people have ignored taking it due to time constraints and lack of appetite in the morning (Sun *et al.*, 2013). Skipping breakfast can lead to overweight and obesity (Horikawa *et al.*, 2011). It can also cause metabolic and hormonal differences in response to foods consumed later in the morning as well as differences in subjective appetite and increased energy intake (Astbury, Taylor & Macdonald, 2011). In Malaysia, previous studies have shown that skipping breakfast was moderately high among secondary school children in Kuantan and other districts (47.4%)%)(Chin & Mohd Nasir, 2009) and in adults aged 18-25 years in one of the public universities surveyed (29.2%) (Moy *et al.*, 2009). Organising campaigns on health awareness and promoting healthy eating among the targeted groups are two of the best ways to overcome this problem (Chin & Mohd Nasir, 2009).

In recent years, a number of companies have come up with ready-to-eat cereals such as cornflakes and muesli to cater to the needs of consumers. In the United States, the word "cereal" refers to a product that is suitable for human consumption without further cooking and is usually eaten at breakfast. These ready-to-eat cereals are relatively shelf-stable, lightweight, and convenient to ship and store. Corn, wheat, oats, and rice are the main grains usually used in the formulation. However, they are typically grouped by cereal form rather than the type of grain used. These groups are flaked cereals, extruded flaked cereals, gun-puffed whole grains, extruded gun-puffed cereals, shredded whole grains, extruded shredded cereals, oven-puffed cereals, and granola cereals (US EPA, 1995). Cereals are becoming increasingly popular as an alternate breakfast option to traditional food such as rice and wheat-based food because they can provide an important source of energy for children and adults (Rufian-Henares, Delgardo-Andrade & Morales, 2006). Furthermore, an increasing number of manufacturers have fortified cereals with vitamins, minerals, and substances that can enhance the well-being of consumers, making the products more popular and gaining a good impression among consumers. Consumption of ready-to-eat cereals is found to be associated with improved nutrient intake, while simultaneously maintaining body weight among children and adolescents (O'Neil *et al.*, 2012). Consumers associated with a higher level of educational attainment and higher social class status are more likely to consume ready-to-eat cereals due to their lifestyle and their ability to spend more (Galvin, Kiely & Ga, 2003).

In Malaysia, a wide range of ready-to-eat cereal products are readily available in hypermarkets, and retail and grocery stores. Most of them are imported from Australia, United Kingdom, and United States of America. These products are consumed by children and adults in Malaysia for breakfast or as a healthy snack between meals. Cornflakes and muesli are cereal products that were not listed in the Malaysian Food Composition Database (1997). Hence in 2012, the products were analysed as part of the Malaysian Food Composition Database updating project. Therefore, the aim of the study was to investigate the nutritional value of cornflakes and muesli ready-to-eat cereals found in the Malaysian market.

METHODS

Sample collection and preparation

Six brands of cornflakes and muesli ready-to-eat cereals were selected using stratified randomly sampling from local supermarkets in Klang Valley, Kuala Lumpur based on the Protocol for

Sampling and Methods of analysis for Malaysian Food Composition (2011). The samples were confirmed to represent brands/varieties consumed and available nationwide. Each kilogram of the same brand of cereals was mixed thoroughly and crushed into fine powder using a food grinder and transferred into air tight containers and stored at room temperature (25°C ± 2 °C) for up to two weeks. The analysis of proximate, mineral and vitamin compositions, sugar and cholesterol contents, and fatty acids component of lipids were carried out for each of the six brands of cereal within a given schedule. One pooled set of data for the mean of each reported nutrient was calculated based on the average of the six brands tested.

Proximate analysis

Energy content was calculated by the summation of the multiplied values of protein, carbohydrate, and fat by the factors of 4, 4, and 9, respectively and expressed as kilocalories (kcal). Moisture content was determined by drying 10 g of finely ground samples in an air-oven at 105°C overnight until constant weight was achieved (AOAC, 2008). Protein content was determined using the Kjeldahl method (AOAC, 2005). A conversion factor of 6.25 was used to convert the measured nitrogen content to protein content. Fat content was determined by semi-continuous solvent extraction method (AOAC, 2006). Available carbohydrate content was calculated by subtracting the sum of protein, fat, moisture, ash, and total dietary fibre from 100%. Total dietary fibre (TDF) was determined using enzymatic-gravimetric method (AOAC, 2005). For TDF, enzyme digestate was treated with alcohol to precipitate soluble dietary fibre (SDF) before filtering and TDF residue was washed with alcohol and acetone, dried, and weighed. For insoluble dietary fibre (IDF) and SDF, enzyme digestate was filtered and IDF residue was washed with warm water, dried, and weighed. For SDF, combined filtrate and washes were precipitated with alcohol, filtered, dried, and weighed. TDF, IDF, and SDF residue values were corrected for protein, ash, and blank. Ash content was determined using dry-ash method (AOAC, 2005).

Mineral analysis

Calcium (Ca), Iron (Fe), Magnesium (Mg), and Sodium (Na) were analysed according to the standard method (AOAC, 2005) by inductively coupled plasma-optical emission spectrometry (ICP-OES). Zinc (Zn) and copper (Cu) were analysed using atomic absorption spectrophotometry (Perkin Elmer, Germany).

Vitamin analysis

Vitamin C was analysed by high performance liquid chromatography (HPLC) using UV detector. Thiamin (B1), Riboflavin (B2), Niacin (B3), Folic acid (B9), and Pyridoxine (B6) were analysed by HPLC with photodiode array detector (PDA) and fluorescent detector (Woollard & Indyk, 2002). Vitamins A and E (fat soluble vitamin) were analysed by HPLC with PDA and fluorescent detector.

Sugar analysis

Total sugars, sucrose, glucose, fructose, lactose, and maltose were analysed using HPLC with evaporative light scattering detector (ELSD).

Fatty acid and cholesterol analyses

Saturated, monounsaturated, polyunsaturated, and trans-fatty acids were determined by using gas chromatography (GC) with flame ionisation detector (FID) (AOAC, 2005). Retention times of fatty acids methyl esters standard were used to identify the fatty acids. Cholesterol in the sample was analysed by direct saponification using GC with FID (AOAC, 2008).

Quality control

Internal quality control materials prepared in the laboratory and NIST Standard Reference Material® (SRM) 1849a Infant/ Adult Nutritional Formula (USA) were used as control to monitor the quality of the resulting data for each sample. Results for all nutrients analysed were only accepted if they were within the control limits of the quality control material.

Statistical analysis

All data were analysed using Statistical Package for Social Science (SPSS) version 18.0 for Windows. Data are presented as mean with standard error of mean (SEM). The means and median difference between groups were compared using *t*-test (normally distributed data) and Mann-Whitney test (not normally distributed data). Values of $P<0.05$ and $P<0.001$ were considered statistically significant.

RESULTS AND DISCUSSION

The six brands of cornflakes and Muesli tested in this study for their nutrient content had different formulations, and were therefore expected to have different nutrient contents. Some of the brands' nutrient contents had been fortified. We expected to see variations in the values in every parameter, especially in minerals and vitamins.

Proximate compositions

The values from proximate analysis of cornflakes and muesli are presented in Table 1. Both ready-to-eat cereals are high in calories ranging from 371 to 499 kcal/100 g. In the Malaysian context, the Technical Working Group on Nutritional Guidelines (2013) had suggested that 170 – 440 kcal/100g for breakfast was sufficient to accommodate the energy needed by children and adolescents. The calories

Table 1. Comparison of proximate nutrients between cornflakes and muesli

Nutrient	*Cornflakes*	*Muesli*	*p-value*
	Mean ± SEM (Range) g/100g	*Mean ± SEM (Range) g/100g*	
Energy (Kcal)	386.41 ± 1.50 (379.59-389.35)	408.22 ± 19.63 (370.98-498.84)	0.294
Water	5.17 ± 0.46 (4.09-7.29)	10.23 ± 0.72 (7.34-12.07)	**<0.001
Protein	7.63 ± 0.23 (6.90-8.50)	10.07 ± 0.79 (8.10-13.30)	*0.026
Fat	0.24 ± 0.06 (0-0.37)	6.67 ± 2.92 (2.00-20.30)	*0.004
Carbohydrate	86.94± 0.59 (84.06-88.08)	70.73 ± 3.05 (57.06-76.31)	*0.004
TDF	3.00 ± 0.49 (0.70-4.10)	12.49 ± 1.44 (9.03-17.35)	**<0.001
Ash	2.42 ± 0.41 (1.10-4.20)	2.30 ± 0.13 (2.00-2.90)	0.797

*$p<0.05$ and **$p<0.001$ are significant differences for *t*-test or Mann-Whitney test between cornflakes and muesli
SEM – Standard Error of Mean

contributed by the cereals are able to provide enough energy for consumers until lunch time because the energy required for children, adolescent, and adults per day was in the range of 910 to 2460 kcal (RNI, 2005). The moisture content of both cereals was generally low, with cornflakes (5.2g/100g) having significantly lower moisture content compared to muesli (10.2g/100g). The low moisture content is beneficial for longer storage time as freshness and crispiness of the cereals can be maintained. Low moisture content can also inhibit the growth of microorganisms and prevent the cereals from becoming stale (McKevith, 2004). The mixture of different ingredients such as raisins or other dried fruits in muesli might contribute to the slightly higher moisture content compared to cornflakes.

The protein content for both cereals was significantly different with cornflakes having a lower value. Higher protein content in muesli could have been contributed by the ingredients of mixed nuts that are rich in proteins and nut oils (Jones, 2003). Muesli contains significantly high fat content compared to cornflakes due to the presence of ingredients such as almonds, hazelnuts, pecan, and pistachios. Our findings were comparable with USDA (0.75g/100g) and Brazilian foods (0.67g/100g) (USDA, 2011; Padovani *et al.*, 2007)). A study by Smith *et al.* (2001) showed that high-fibre cereals intake is associated with a reduction in fatigue, emotional distress and less cognitive difficulties. The ash content in both cereals was in quite a similar range of 2.30 to 2.4 g/100 g, indicating that both cereals contain about the same level of inorganic content (Pojic *et al.*, 2010).

Mineral composition

The mineral contents of cornflakes and muesli are shown in Table 2. Minerals consisting of Ca, Fe, Mg, Na, Zn, and Cu were analysed. There was no significant difference in the calcium content between

Table 2. Mineral composition of cereals

Nutrient	*Cornflakes*	*Muesli*	*p-value*
	Mean ± SEM (Range) mg/100g	*Mean ± SEM (Range) mg/100g*	
Calcium	123.13 ±120.37 (2.10-725.00)	67.83 ± 13.07 (44.20-129.00)	0.054
Iron	8.48 ± 1.72 (1.10-13.70)	4.10 ± 0.53 (2.60-5.80)	*0.035
Magnesium	16.88 ± 2.73 (9.50-25.80)	113.22 ± 7.93 (90.50-137.10)	**<0.001
Sodium	674.83 ± 102.99 (182.80-896.60)	72.77 ± 13.34 (25.00-116.60)	*0.004
Zinc	0.18 ± 0.05 (0.10-0.40)	1.65 ± 0.16 (1.00-2.00)	*0.004
Copper	0.02 ± 0.01 (0-0.03)	0.25 ± 0.02 (0.20-0.30)	*0.003

*p<0.05 and **p<0.001 are significant differences for t-test or Mann-Whitney test between cornflakes and muesli
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cornflakes and muesli. However, there were significant differences in the content of Fe, Mg, Na, Zn, and Cu between cornflakes and muesli. The sodium content in cornflakes was higher than in muesli due to the added calcium (calcium carbonate) and salts (iodised salt) as stated on their packaging. Mg was found to be higher in muesli, perhaps due to the presence of ingredients such as bran (wheat, oat, rice, barley), seeds (pumpkin, flax, sesame, sunflower, buckwheat, linseed), and nuts (almonds, hazelnuts, peanuts, pecan, pistachio). USDA (2011) also reported a higher concentration of magnesium in muesli (78 mg/100g) as compared to cornflakes (39 mg/100g). In general, muesli which contained whole grains wheat and oat flakes showed higher levels of specific minerals compared to cornflakes due to the presence of the outer kernel layers where minerals are concentrated (Ragaee, Abdel-Aal & Noaman, 2006).

Vitamin composition

Table 3 shows the vitamin content of cornflakes and muesli. Vitamin C, B1, B3 (as niacinamide), B9 and A, were present in cornflakes but were not detected in muesli. Vitamin B3 (as niacinamide) was considerably significantly higher in cornflakes compared to muesli. Vitamin B2, B3 (as nicotinic acid), and E were of comparable values in both cereals. Most of the respective vitamins found in cornflakes were fortified into the cereals as stated on their packaging labels. Vitamins

Table 3. Vitamin composition of cereals

Nutrient	*Cornflakes*	*Muesli*	*p-value*
	Mean ± SEM (Range) mg/100g	*Mean ± SEM (Range) mg/100g*	
Vitamin C	6.75 ± 4.33 (0-23.10)	0.00 ± 0.00	-
Thiamin (B1)	2.31 ± 0.54 (0.21-4.13)	0.00 ± 0.00	-
Riboflavin (B2)	1.10 ± 0.22 (0.06-1.56)	0.58 ± 0.41 (0-2.4)	0.103
Niacin (B3) as nicotinic acid	2.57 ± 1.11 (0-7.70)	3.31 ± 0.36 (2.4-4.6)	-
Niacin (B3) as niacinamide	25.87 ± 6.14 (0-44.74)	0.00 ± 0.00	*0.014
Pyridoxine (B6)	1.30 ± 0.46 (0-2.8)	0.19 ± 0.02 (0.15-026)	0.335
Folic Acid (B9) (µg/100 g)	407.88 ±124.22 (49.60-837.00)	0.00 ± 0.00	-
Vitamin A (µg/ 100 g)	103.17 ± 103.17 (0-619.00)	0.00 ± 0.00	-
Vitamin E	3.43 ± 2.02 (0-10.60)	1.24 ± 0.41 (0.48-3.12)	0.747

*p<0.05 and **p<0.001 are significant differences for t-test or Mann-Whitney test between cornflakes and muesli
SEM – Standard Error of Mean

are susceptible to heat treatment and technological processing, thus, in order to comply with daily recommended intake, products are enriched with vitamins, especially the group B vitamins (Lebiedzinska & Szefer, 2006).

Sugar composition

The results in Table 4 indicate that among all the sugars analysed, sucrose was found significantly higher in cornflakes (5.1 g/100 g) compared to muesli (0.43 g/100 g). On the other hand, total sugars, glucose, and fructose were significantly higher in muesli than in cornflakes (Table 4). US Dept of Agriculture (2011) databases also showed a higher concentration of total sugar in muesli (with dried fruit and nuts) (31 g/100g) compared to cornflakes (9.5 g/100g). Lactose was not detected in cornflakes but was available in muesli due to milk being one of the ingredients. Maltose was found in both cereals in the range of 0.0 to 6.7 g/100 g. According to the Dietary Guidelines for Americans (2010), addition of small amounts of sugars to nutrient-dense foods such as breakfast cereals may enhance the palatability of these products, thus increasing a person's intake of such foods and improving nutrient intake without contributing to excessive calorie intake (Schwartz *et al.*, 2008).

Fatty acid composition

The content of specific fatty acids in the products evaluated is presented in Table 5. Total saturated fat that comprised isomers of 16: 0 was significantly higher in muesli compared to cornflakes (Table 5). These variations are due to different ingredients used in producing the ready-to-eat cereals (Thomas *et al.*, 2013). Cornflakes are produced through the hydrothermal treatment of maize whereas muesli comprises uncooked rolled oats, fruits, and nuts that have lower levels of fats. No trans-fatty acids were detected in both cereals. Moreover, their cholesterol level was very low, in the range of 0.8 to

Table 4. Comparison of sugars between cornflakes and muesli

Nutrient	*Cornflakes*	*Muesli*	*p-value*
	Mean ± SEM (Range) mg/100g	*Mean ± SEM (Range) mg/100g*	
Total sugar	8.58 ± 1.09 (6.10-12.50)	18.75 ± 2.05 (11.0-24.90)	*0.0014
Sucrose	5.10 ± 0.90 (2.30-8.50)	0.43 ± 0.43 (0-2.60)	*0.005
Glucose	1.92 ± 0.47 (0-3.30)	7.70 ± 1.77 (0-11.50)	*0.010
Fructose	1.52 ± 0.43 (0-3.00)	8.68 ± 1.76 (1.70-13.60)	*0.009
Lactose	0.00 ± 0.00	0.83 ± 0.83 (0-5.00)	-
Maltose	0.05 ± 0.05 (0-0.30)	1.12 ± 1.12 (0-6.70)	0.902

*$p<0.05$ and **$p<0.001$ are significant differences for *t*-test or Mann-Whitney test between cornflakes and muesli
SEM – Standard Error of Mean

Table 5. Fat composition of cereals

Nutrient	*Cornflakes*	*Muesli*	*p-value*
	Mean ± SEM mg/100g	*Mean ± SEM mg/100g*	
Total Saturated Fat	0.15 ± 0.02	1.65 ± 0.96	*0.004
C4:0	0 ± 0.00	0 ± 0.00	-
C6:0	0 ± 0.00	0 ± 0.00	-
C8:0	0 ± 0.00	0.05 ± 0.05	-
C10:0	0 ± 0.00	0.05 ± 0.05	-
C12:0 (Lauric acid)	0.02 ± 0.01	0.32 ± 0.32	0.674
C13:0	0 ± 0.00	0 ± 0.00	-
C14:0 (Myristic acid)	0.067 ± 0.01	0.13 ± 0.13	0.305
C15:0	0.00 ± 0.00	0 ± 0.00	-
C16:0 (Palmitic acid)	0.10 ± 0.02	0.81 ± 0.29	*0.004
C17:0	0 ± 0.00	0.004 ± 0.002	-
C18:0 (Stearic acid)	0.03 ± 0.01	0.21 ± 0.10	*0.013
C20:0	0.00 ± 0.00	0.02± 0.01	-
C21:0	0.00 ± 0.00	0.01 ± 0.01	-
C22:0	0.00 ± 0.00	0.02 ± 0.01	-
C23:0	0.00 ± 0.00	0.001 ± 0.001	-
C24:0 (Lignoceric acid)	0.00 ± 0.00	0.03 ± 0.02	-
Total Monounsaturated Fat	0.08 ± 0.02	2.90 ± 1.39	*0.004
C14:1	0 ± 0.00	0 ± 0.00	-
C15:1	0 ± 0.00	0 ± 0.00	-
C16:1	0 ± 0.00	0.01 ± 0.01	-
C17:1	0 ± 0.00	0.002 ± 0.002	-
C18:1 (Oleic acid)	0.08 ± 0.02	2.83 ± 1.36	*0.004
C20:1	0 ± 0.00	0.04 ± 0.02	-
C22:1	0 ± 0.00	0.01 ± 0.01	-
C24:1	0 ± 0.00	0.01 ± 0.01	-
Total Polyunsaturated Fat	0.03 ± 0.01	2.14 ± 0.71	*0.004
C18:2 (Linoleic acid)	0.03 ± 0.01	1.98 ± 0.65	*0.004
C18:3	0 ± 0.00	0.06 ± 0.01	-
C20:2	0 ± 0.00	0.07 ± 0.07	-
C20:3	0 ± 0.00	0.01 ± 0.01	-
C22:2	0 ± 0.00	0.01 ± 0.01	-
C20:5	0 ± 0.00	0.02 ± 0.02	-
Trans fatty acids	0 ± 0.00	0 ± 0.00	-
Cholesterol (mg/100g)	0.90 ± 0.58	0.62 ± 0.22	0.631

*$p<0.05$ and **$p<0.001$ are significant differences for *t*-test or Mann-Whitney test between cornflakes and muesli
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0.39 mg/100 g (wet basis). Our findings were comparable with USDA data (USDA, 2011). This is beneficial for human health because a review study had shown that the intake of trans-fatty acid ranging from 2.8 to 10 g per day had been directly associated with 22% increased risk of cardiovascular diseases (Bendsen *et al.*, 2011). This has also been observed for cholesterol which has been demonstrated to have a strong link to the prevalence of coronary heart diseases (Chen *et al.*, 2011).

CONCLUSION

In conclusion, this study has shown that the commercially available cornflakes and muesli ready-to-eat cereals are a good source of nutrients such as carbohydrate, minerals (calcium, magnesium, iron), and vitamins needed for daily life. They contain low levels of sugars, fats, and cholesterol that are only needed in small amounts to maintain a healthy well-being. These findings are beneficial because they provide more information and guidelines for consumers in selecting healthy food especially for breakfast. The data on the nutritional content of the two cereal products can also be used by nutritionists, dieticians, researchers, and students in Malaysia for various activities related to nutrition and health, and lastly for updating the Malaysian Food Composition Database.

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