

## Nutritional changes in germinated legumes and rice varieties

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**Abstract:** Proximate content and fatty acid composition of germinated and non-germinated legumes (kidney, mung, soy bean and peanut) and rice varieties (red, black, Barrio, brown and milled) were evaluated. In germinated samples, moisture content increased significantly while carbohydrate, protein and fat were decreased significantly. Total dietary fibre was increased in germinated samples except germinated kidney and mung bean. Germination also increased saturated fatty acids (SFA) in legumes, black, red and brown rice. Monounsaturated fatty acids (MUFA) decreased in all samples except germinated kidney, soy and Barrio rice. Polyunsaturated fatty acids (PUFA) increased in some germinated samples (mung bean, peanut, red, brown, Barrio and white rice) but decreased in other legume and rice samples. Generally, palmitic acid increased while stearic, oleic and linoleic acids decreased after germination. Overall, the proximate content and fatty acids of legume and rice varieties changed after germination and may be used as alternate resources for individuals with lifestyle diseases.

**Keywords:** Germination, legume, rice, proximate content, fatty acid composition

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### Introduction

Legume is a plant in the family of *Fabaceae* (or *Leguminosae*), or a fruit of these specific plants, characterized by edible seeds, borne in pods that often open along two seams, by pea-shaped flowers, and by compound stipulate leaves (Mazur *et al.*, 1998). It is one of the important source of protein, carbohydrate, dietary fibre and minerals (Tharanathan and Mahadevamma, 2003). Soy beans and peanut are well known of their high oil content. Their fat characteristics and fatty acid components have been extensively investigated. On average, soy bean contains 18.0-22.0% oil while peanut contains 40-50% oil (Yoshida *et al.*, 2003; Yoshida *et al.*, 2004). However, other leguminous seeds were reported to be low in lipid with percentage between 1 and 2% (Akpinar *et al.*, 2001).

Rice is a staple food of the world and being a major source of carbohydrates over half the world's population (Ohtsubo *et al.*, 2005). Rice is in the grass family of *Gramineae* and related to other grass plants such as wheat, oats and barley which produce grains for food (Padiberas Nasional Berhad, 2009). Rice also provides nutritionally significant amounts of thiamin, riboflavin, niacin and zinc with lesser amounts of other micronutrients (Kennedy *et al.*, 2002). There are about 40,000 different varieties of rice worldwide as report by Brown (2008). White rice contains small amount of lipids (below 5% on

dry weight basis) predominated with long chain fatty acids such as linoleic (18:2) and linolenic (18:3) acids. In comparison, rice bran is rich in these fatty acids and comprises about 15% on dry weight basis (Wilson *et al.*, 2000). Long storage can degrade these unsaturated fatty acids which results in deterioration of flavor, tastiness and eating quality (Zhou *et al.*, 2003). In non-glutinous brown rice, lipid content and fatty acids composition are affected by daily mean temperature during the ripening stages (Taira *et al.*, 1979).

Germination is a natural process occurred during growth period of seeds in which they meet the minimum condition for growth and development (Sangronis *et al.*, 2006). During this period, reserve materials are degraded, commonly used for respiration and synthesis of new cells prior to developing embryo (Vidal-Valverde, 2002). The process starts with the uptake of water by the quiescent dry seed and terminates with the emergence of the embryonic axis, usually the radical (Bewley and Black, 1994). Several studies on the effect of germination on legumes found that germination can increase protein content and dietary fiber, reduce tannin and phytic acid content and increase mineral bioavailability (Rao and Prabhavathi, 1982; Hussein and Ghanem, 1999; Ghavidel and Prakash, 2007). Germination also was reported to be associated with increase of vitamin concentrations and bioavailability of trace elements and minerals (El-Adawy *et al.*, 2004). Kaushik *et*

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*al.* (2010) found that germination improves calcium, copper, manganese, zinc, riboflavin, niacin and ascorbic acid content. In cereal grains, germination increase oligosaccharides and amino acids concentration as observed in barley (Rimsten *et al.*, 2003), wheat (Yang *et al.*, 2001), oat (Mikola *et al.*, 2001) and rice (Manna *et al.*, 1995). Decomposition of high molecular weight polymers cause generation of bio-functional substances and improvement of organoleptic qualities due to softening of texture and increase of flavor in grains (Beal and Mottram, 1993). In Japan, germination was used to enhance flavor and nutrients in brown rice apart from softened the texture (Ohtsubo *et al.*, 2005).

To date, usage and intake of germinated legumes and grains are not common locally. Legumes and cereals (rice varieties) were used as these food groups provide significant amount of macro- and micronutrients to human. Therefore, this study aims to determine the effect of germination process on proximate content and fatty acid composition of dried legumes (kidney, mung, soy bean and peanut) and rice varieties (white, black, red, brown and Barrio rice). Availability of these data is important as the effect of germination on the chemical and biochemical constituents of seeds vary greatly with plant species, seed varieties and the germination conditions such as temperature, light, moisture and the time of germination (Abdus Sattar *et al.*, 1989; Bau *et al.*, 1997; Kuo *et al.*, 2003). Since germination is cheap and more effective in improving nutritional value, it is hoped that this can contribute to nutrition of people.

## Materials and Methods

### Legumes

Dried legumes (kidney, mung, soy bean and peanut) were purchased from Giant supermarket, Mines Shopping Centre, Seri Kembangan. Legumes were stored in refrigerator at 4°C before germination process.

### Rice

Red, black and bario rice were purchased at India Street, Kuching, Sarawak while brown rice and milled white rice were purchased from hypermarket in Serdang, Selangor. Each type of rice was purchased for 1 kg weight. The samples were contained in plastic sealed and stored in refrigerator at 4°C.

### Chemicals

Petroleum ether (Merck, Germany), standard

of FAMES (AccuStandard, USA), hexane (Merck, Germany), potassium hydroxide (Merck, Germany), sulfuric acid (BDH Chemicals Ltd, England), sodium hydroxide (Merck, Germany), boric acid (BDH Chemicals Ltd, England), Toshiro indicator, hydrochloric acid (Merck, Germany), perchloric acid (Merck, Germany), glucose stock standard solution (Merck, Germany), Anthrone reagent (BHD, Germany), Celite (HmbG Chemicals, Germany), ethanol (HmbG Chemicals, Germany), butylated hydroxytoluene (Merck, Germany). All the chemicals used were of analytical grade.

### Germination process of legumes and rice

**Legumes:** Samples were washed and cleaned with tap water before soaked for 6 hr in room temperature (28°C). After 6 hr, samples were placed under wet muslin cloth and left germinated for 48 hr in room temperature (28°C) without direct contact with sun light (Yasmin *et al.*, 2008).

**Rice:** Samples were sterilized using 0.1% sodium hypochloric for 30 min and washed with sufficient tap water. Then, samples were soaked in distilled water for 72 hours with the water was changed in every 24 hr (Ohtsubo *et al.*, 2005).

### Chemical component analysis

After germination, all legume and rice samples were dried at 60°C using air oven (Memmert, Germany) until constant weight was achieved. Later the dried samples were grind into powder using grinder (Waring, USA) and sieved to comparable particle size.

Moisture, ash, carbohydrate, protein and fat were determined using AOAC (1990) with modifications described by Tee *et al.* (1996). Total dietary fibre was determined using method described by Prosky *et al.*, (1988).

### Fatty acid analysis

The fat extracted from legume and rice samples was used to determine their fatty acid compositions.

### Preparation of Fatty Acid Methyl Esters (FAME)

About 0.1g of extracted fat from legume and rice samples was transferred into 20 ml screw cap test tube. The oil sample was dissolved in 10 ml of hexane. Then, 0.1 ml of 2N potassium hydroxide (KOH) in methanol was added. Test tube was closed and vortexed for 30 sec. The mixture was centrifuged and the clear supernatant was transferred into 2 ml autosampler vial for fatty acids determination (Frank

*et al.*, 2006).

#### Gas chromatography (GC) analysis

Fatty acid composition was analyzed using GC model Agilent 6890 (USA Agilent Technology) equipped with a split-splitless injector, detector Hewlett-Packard EL-980 flame ionization detection (FID) system which was used to separate and quantify each FAME components. DB-23 column with 60m x 0.25 mm I.D., 0.15  $\mu$ m polyethylene glycol film was used to separate the FAMES. Chemstations software (version 6.0) was used to record and integrate the chromatography data. The oven temperature was held at 50°C for 1 min, before increased to 175°C at 4°C/min and lastly increased to 230°C for 5 min. Temperature for injector and detector was set at 250°C and 280°C, respectively. One micro litre of sample volume was injected with split ratio of 0:50 at column temperature of 110°C. The carrier gas was helium (1.0 ml/min) controlled at 103.4 kPa, hydrogen and air were used for FID and was held at 275.6 kPa (Frank *et al.*, 2006).

#### Statistical analysis

Samples were triplicate for each determination of chemical components and fatty acid composition. The FAME samples were injected two times into the GC and the average value for each of the triplicate samples was used for data analysis. Data was analyzed by using SPSS (Statistical Packages of Social Sciences) software version 16.0. One-way ANOVA and Bonferroni tests were used to analyse the differences in proximate content between germinated and non-germinated samples. Significant differences were determined at  $p < 0.05$ .

## Results and Discussion

#### Chemical components

As shown in Table 1, moisture content was significantly increased after germination in both legume and rice samples ( $p < 0.05$ ). This finding is similar to the results reported by Khatoon and Prakash (2006) in germinated legumes (green, Bengal and horse gram). However, Ohtsubo *et al.* (2005) found a contradictory finding in the analysis of macronutrients in brown and germinated brown rice that contained lower moisture in the germinated rice samples. As germination proceeds, legumes took up water from the surrounding in order for the metabolic process to commence. Dry legumes absorb water rapidly, influenced by the structure of the legume. The increase in water uptake with time is due to the

increasing number of cells within the seed becoming hydrated (Nonogaki *et al.*, 2010).

Ash content was significantly decreased in all germinated samples with significant decrease found in germinated mung and soy beans ( $p < 0.05$ ), parallel to observations of Ahmad and Pathak (2000), Ohtsubo *et al.* (2005), Khatoon and Prakash (2006) and Hahm *et al.* (2008). Wang *et al.* (1997) reported that the differences in ash content after soaking for a specific time was due to decreased ash content. The decrease in ash content represents loss in minerals due to rootlet and washing of the rice in water to reduce the sour smell during the period of germination (Tatsadjieu *et al.*, 2004).

Carbohydrate content was increased in germinated mung and kidney beans and decreased significantly in germinated white, black, red and brown rice ( $p < 0.05$ ). Vidal-Valverde *et al.* (2002) explained that during germination, carbohydrate was used as source of energy for embryonic growth which could explain the changes of carbohydrate content after germination. Additionally,  $\beta$ -amylase activity that hydrolyzes the starch into simple carbohydrate was increased (Suda *et al.*, 1986). Starch in cotyledon was broken down into smaller molecules such as glucose and fructose to provide energy for cell division while the seeds mature and grow (Vidal-Valverde *et al.*, 2002; Nonogaki *et al.*, 2010). Ohtsubo *et al.*, (2005) explained that carbohydrate breakdown in which  $\alpha$ -amylase activities were found to parallel with the pattern of starch breakdown.

Protein content was significantly decreased in both germinated legume and rice varieties ( $p < 0.05$ ). Vellupillai *et al.* (2009) observed that the decreased in total protein content is simultaneous with increased in amino acid content caused by increased level of protease activity. Ohtsubo *et al.* (2004) however, found that crude protein content was increased in germinated brown rice. Torres *et al.* (2007) reported there were differences in raw pigeon pea and germinated pigeon pea where the germinated pigeon pea had lesser crude protein content. King and Puwastien (1987) also reported a small decrease in protein nitrogen after 72 hr of germination that could result in decrease of crude protein content of germinated sample. However, other studies done by Khatoon and Prakash (2005), Urbano *et al.* (2005), Ghavidel and Prakash (2007), and Kaushik *et al.* (2010) found different results. They found that total protein increased after germination process. Bau *et al.* (1997) assumed that the increased was due to synthesis of enzyme proteins or a compositional change following the degradation of other constituents. A further explanation was done by Nonogaki *et al.* (2010) where they noted that

**Table 1.** Chemical components of legume and rice samples

Samples	Moisture(%)	Ash (%)	Carbohydrate(%)	Protein(%)	Fat(%)	Total dietary fiber (%)
<b>Legumes</b>						
Kidney bean						
NG	18.89 ± 0.07*	6.27 ± 0.18	27.94 ± 3.85	37.78 ± 0.28*	7.58 ± 0.89	54.27 ± 0.60*
G	57.76 ± 8.11*	3.34 ± 0.60	21.31 ± 2.85	15.40 ± 0.61*	1.76 ± 0.18	32.99 ± 0.51*
Mung bean						
NG	16.53 ± 0.02*	9.36 ± 0.96*	22.32 ± 5.41	46.09 ± 0.21*	5.69 ± 0.32	26.79 ± 0.48*
G	62.73 ± 8.60*	4.31 ± 0.05*	15.28 ± 6.80	15.79 ± 0.29*	0.89 ± 0.11	24.60 ± 0.12*
Soy bean						
NG	8.00 ± 1.21*	3.68 ± 0.09*	37.37 ± 2.07*	30.88 ± 0.42*	20.07 ± 0.87*	23.24 ± 0.77*
G	57.05 ± 2.45*	1.71 ± 0.17*	17.99 ± 3.33*	17.85 ± 0.22*	4.61 ± 1.08*	55.43 ± 1.55*
Peanut						
NG	8.59 ± 0.19*	2.02 ± 0.02	20.06 ± 0.8	22.74 ± 0.72*	46.59 ± 6.96*	16.43 ± 0.14*
G	33.31 ± 0.48*	1.20 ± 0.06	16.42 ± 7.18	15.09 ± 0.31*	33.98 ± 3.71*	30.83 ± 0.21*
<b>Rice varieties</b>						
White						
NG	12.37 ± 0.04*	0.41 ± 0.03	77.99 ± 7.75*	6.45 ± 0.59*	1.42 ± 0.04*	7.18 ± 1.44
G	42.02 ± 0.08*	0.27 ± 0.05	52.75 ± 3.44*	4.78 ± 0.19*	0.18 ± 0.01*	8.31 ± 1.17
Black						
NG	12.57 ± 0.07*	0.62 ± 0.43	76.91 ± 0.87*	8.60 ± 0.19*	1.29 ± 0.02*	8.63 ± 1.13
G	37.92 ± 0.07*	0.25 ± 0.01	53.21 ± 1.84*	6.67 ± 0.26*	0.96 ± 0.02*	9.36 ± 0.88
Red						
NG	12.57 ± 0.09*	0.65 ± 0.28	81.69 ± 3.40*	6.06 ± 0.26*	1.5 ± 0.09*	7.22 ± 4.20
G	43.09 ± 0.59*	0.20 ± 0.07	48.56 ± 4.96*	6.12 ± 0.26*	1.02 ± 0.13*	12.00 ± 0.21
Brown						
NG	10.97 ± 0.06*	0.57 ± 0.33	79.21 ± 3.43*	6.35 ± 0.82*	1.89 ± 0.04*	8.24 ± 1.14
G	39.20 ± 0.43*	0.30 ± 0.02	52.51 ± 0.97*	5.49 ± 0.26*	1.49 ± 0.03*	9.61 ± 1.75
Barrio						
NG	10.64 ± 0.03*	0.36 ± 0.02	81.34 ± 2.13	6.50 ± 0.75*	0.14 ± 0.01	7.28 ± 0.54
G	24.14 ± 0.12*	0.07 ± 0.02	71.87 ± 0.27	3.83 ± 0.33*	0.07 ± 0.00	8.58 ± 1.54

Means marked by (\*) are significantly different ( $p < 0.05$ )  
 NG: Non-germinated; G: Germinated

protein synthesis occurred during imbibition and that hormonal changes play an important role in achieving the completion of germination. Furthermore, the drop in protein content seems to indicate that proteolysis outpaces protein synthesis in the growing sprouts (Rodriguez *et al.*, 2008).

Fat content was decreased in all germinated samples with significant decrease found in germinated soy bean, peanut, white, black, red and brown rice ( $p < 0.05$ ). Similar results occurred in study by Dhaliwal and Aggarwal (1999), El-Adawy *et al.* (2004), Ghavidel and Prakash (2007) and Hahm *et al.* (2008) where the fat content decrease with increase in the time of germination. This is because fat was used as the major source of carbon for seed growth (Bau *et al.*, 1997). Hahm *et al.* (2008) also suggested that fatty acids are oxidized to carbon dioxide and water to generate energy for germination.

Total dietary fibres were significantly decreased in germinated kidney and mung beans ( $p < 0.05$ ) but significant increased was found in germinated soy bean and peanut ( $p < 0.05$ ). Martin-Cabrejas *et al.* (2008) reported that the effect of germination on total dietary fibre was dependent on type of legumes. In germinated rice, the amount of total dietary fibre was contributed by the presence of bran layer, an outer layer of rice that contained fibre (Ohtsubo *et al.*, 2005). Study by Azizah and Zainon (1997) demonstrated that total dietary fibre was decreased

in soaked wheat, barley, peanut and mung bean, but conversely increased in soaked rice and soy bean. This indicates that germination process affect the level of total dietary fibre during the period of soaking before the actual phase of germination.

Studies have shown that intake of legumes have many health effects in controlling and preventing metabolic diseases such as diabetes mellitus and coronary heart diseases (Slavin *et al.*, 1997; Liu *et al.*, 1999). Combination of whole grain and legume powder in coronary artery disease patients without diabetes mellitus can reduce fasting levels of glucose and insulin (Jang *et al.*, 2001). Germination meanwhile, altered the biochemical composition of legumes. Decrease of carbohydrate level is beneficial to diabetes mellitus patients. In addition, increase of total dietary fiber and decrease of fat content can give benefit to people with cardiovascular disease and hypercholesterolemia.

There are wide applications of germinated food products besides as ingredient in normal food preparation. Some of the identified uses of germinated legumes and cereals include flour (Pomeranz *et al.*, 1977; Giami, 2004; Charoenthaikij *et al.*, 2010), beverage (Tonella and Berry, 1987) and weaning food (Marero *et al.*, 1988). Bread made using germinated products has increased nutritive value (Charoenthaikij *et al.*, 2009) compared to control bread without germination. Tonella and Berry (1987) also found

**Table 2.** Fatty acid composition of total lipids obtained from legume and rice samples

Fatty acid	Kidney Beans		Mung Beans		Soy Beans		Peanuts		Black		Red		Brown		Barrio		White		
	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	
	Caprylic acid (C8:0)	12.18	-	10.22	-	-	-	-	0.71	-	-	-	-	-	-	-	-	-	0.09
Lauric acid (C12:0)	5.11	7.12	4.82	-	-	-	-	0.12	-	-	-	-	-	-	-	-	-	0.06	0.59
Tridecanoic acid (C13:0)	3.04	7.95	3.06	1.08	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myristic acid (C14:0)	-	-	-	-	-	-	-	0.29	0.61	-	0.63	0.44	-	-	2.91	1.22	0.78	0.59	-
Palmitic acid (C16:0)	17.92	12.06	18.47	20.76	12.17	12.07	13.54	13.6	13.97	15.16	32.84	16.81	19.85	97.09	23.73	31.90	19.55	-	-
Stearic acid (C18:0)	5.13	2.69	5.32	5.78	4.48	4.17	3.80	3.70	1.77	1.93	2.38	2.33	-	-	-	-	4.87	2.55	-
Arachidic acid (C20:0)	1.81	1.82	-	3.10	-	0.91	1.73	1.63	-	1.11	-	-	-	-	-	-	-	-	0.84
Behenic acid (C22:0)	2.77	12.80	2.89	8.45	-	1.47	-	3.29	-	-	-	-	-	-	-	-	-	-	-
Lignoceric acid (C24:0)	-	7.36	-	7.10	-	-	1.29	1.21	-	-	-	-	-	-	-	-	-	-	-
<b>SFA</b>	<b>47.96</b>	<b>51.80</b>	<b>44.78</b>	<b>46.26</b>	<b>16.65</b>	<b>18.62</b>	<b>20.36</b>	<b>23.43</b>	<b>16.03</b>	<b>18.93</b>	<b>35.71</b>	<b>19.58</b>	<b>19.85</b>	<b>100.00</b>	<b>26.56</b>	<b>37.70</b>	<b>37.70</b>	<b>24.12</b>	<b>24.12</b>
Pentadecenoic acid (C15:1)	-	10.82	-	-	-	-	-	-	-	-	-	-	-	-	-	0.22	-	-	-
Oleic acid (C18:1)	9.73	2.52	11.37	3.63	20.40	27.7	37.82	36.78	50.96	48.83	44.65	44.65	43.90	-	36.61	49.51	40.14	-	-
<b>MUFA</b>	<b>9.73</b>	<b>13.34</b>	<b>11.37</b>	<b>3.63</b>	<b>20.40</b>	<b>27.7</b>	<b>38.75</b>	<b>37.64</b>	<b>50.96</b>	<b>49.12</b>	<b>44.65</b>	<b>44.65</b>	<b>44.19</b>	<b>-</b>	<b>37.46</b>	<b>49.82</b>	<b>40.40</b>	<b>40.40</b>	<b>40.40</b>
Linoleic acid (C18:2)	29.56	18.93	31.16	33.09	54.76	48.53	37.41	36.35	31.87	31.67	64.10	34.54	35.96	-	33.94	12.06	34.84	-	-
Linolenic acid (C18:3, n-3)	12.75	8.88	12.70	17.02	8.19	5.17	-	-	1.16	-	1.27	1.24	-	-	-	0.39	1.15	-	-
<b>PUFA</b>	<b>42.31</b>	<b>27.81</b>	<b>43.86</b>	<b>50.10</b>	<b>62.95</b>	<b>53.7</b>	<b>37.41</b>	<b>36.35</b>	<b>33.03</b>	<b>31.67</b>	<b>36.72</b>	<b>35.78</b>	<b>35.96</b>	<b>-</b>	<b>33.94</b>	<b>12.45</b>	<b>35.99</b>	<b>35.99</b>	<b>35.99</b>
Others	-	7.05	-	-	-	-	5.70	2.73	-	0.56	-	-	0.29	-	-	-	-	-	-

NG: Non-germinated; G: Germinated

that chocolate beverage made from germinated chickpeas, sugar, cocoa, salt, vegetable oil and water showed reduced viscosity and improved consistency when compared with control formulated using non-germinated chickpeas.

#### *Fatty acid composition*

The percentage of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) in germinated and non-germinated legumes and rice samples are as shown in Table 2. Generally, SFA predominate in non-germinated legumes, followed by PUFA and MUFA. Conversely in non-germinated rice varieties, MUFA was the most dominant, followed by PUFA and SFA.

Germination has increased SFA in all legume samples, black, red and brown rice. However, the level of SFA in germinated Barrio and white rice was decreased. Hahm *et al.* (2008) indicated that SFA was decreased in germinated sesame seeds. In our study, palmitic acid (C16:0) was increased in all germinated legumes and rice varieties except in germinated kidney and soy beans and germinated barrio and white rice. Meanwhile, stearic acid (C18:0) was decreased in most germinated legumes and rice varieties except in germinated mung beans and black rice while in germinated red, brown and Barrio rice, stearic acid was not found. This was different with that found by Hahm *et al.* (2008) who indicated an increase of stearic acid and reduced palmitic acid after germination.

In addition, MUFA was increased in germinated kidney, soy bean and Barrio rice, similar to the findings of Hahm *et al.* (2008). Meanwhile in other germinated samples, MUFA was decreased. Oleic acid (C18:1) was the most common MUFA found in all samples. The amount, however, was decreased in most germinated samples except in germinated soy beans and Barrio rice. The result was in contrast with the findings of Hahm *et al.* (2008) as they reported that oleic acid was increased after germination. In germinated kidney beans and Barrio rice, pentadecenoic acid (C15:1) was also found after germination. Comparing the result of germinated legumes with other types of legumes, the oleic acid found was lower than in broad beans (Akpınar *et al.*, 2001; Yoshida *et al.*, 2008), higher than peas (Yoshida *et al.*, 2007) and higher than soy bean (Yoshida *et al.*, 2003).

The percentage of PUFA was increased in germinated mung bean, peanut, red, brown, Barrio and white rice whereas, in other legume and rice samples, PUFA was decreased after germination.

Similarly, Hahm *et al.* (2008) found that PUFA was decreased in germinated sesame seeds. Linoleic acid (C18:2) was the most common PUFA found in all germinated sample. In germinated legumes, linoleic acid was decreased after germination except in germinated mung beans where the level was increased. This result is similar to Hahm *et al.* (2008) who found in germinated sesame seeds the level of linoleic acid was decreased after germination. Among the germinated rice, linoleic acid was increased after germination except in germinated black rice where slight decreased was found after germination. The amount of linoleic acid found in germinated legumes was lower than that found in broad beans (Yoshida *et al.*, 2008), lower than peas (Yoshida *et al.*, 2007) and lower than soy beans (Yoshida *et al.*, 2003).

#### **Conclusion**

This study reveals that germination in both legume and rice samples increases the moisture content and decrease the ash content in all germinated samples. Carbohydrate content was increased in germinated mung and kidney beans while in other germinated samples, the carbohydrate content was decreased. These changes can be beneficial to diabetes patients as they need to consume less carbohydrate in their diet intake. Protein and fat contents were decreased in all germinated legume and rice samples. Total dietary fibre was decreased in germinated kidney and mung bean while in other germinated samples, total dietary fibre was increased. The changes of fat and total dietary fibre can be beneficial to patients with coronary disease and obesity problems. Germination has increased SFA in all legume samples while in rice samples, SFA content varies (increased in germinated black, red and brown but decreased in germinated Barrio and white rice). MUFA was increased in germinated kidney, soy bean and Barrio rice, while in other germinated samples, MUFA decreased. The percentage of PUFA increased in germinated mung bean, peanut, red, brown, Barrio and white rice whereas, in other legume and rice samples, PUFA was decreased following germination.

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