EFFECTS OF COOKING ON THE DIETARY FIBER AND PHENOLIC CONTENTS OF SELECTED BEANS AND ITS COMBINATIONS

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ABSTRACT

This study aimed to determine the effects of cooking on the dietary fiber and phenolic contents of chickpea (Cicer arietinum L), kidney bean (Phaseolus vulgaris L), mung bean (Vigna radiata L. R. Wilczek) and its combinations. The beans were cooked using an automatic rice cooker and combinations of beans were done by mixing each of the homogenized beans flour in the ratio of 1:1 (w/w) and 1:1:1 (w/w/w). Resulted showed cooking affects the dietary fiber and total phenolic content (TPC) of beans and its combinations to various extents. Comparing with the raw form, cooking significantly reduced (p<0.05) the insoluble dietary fiber (IDF) of mung bean and chickpea. Combinations of cooked kidney bean, mung bean and chickpea (KMC) resulted in a significantly higher (P<0.05) yield of IDF than all individual beans studied. Cooking causes a reduction or increment in the phenolic contents of beans and its combinations. This study suggests the possibility of using the beans combinations method to increase the dietary fiber and TPC.

KEYWORDS: Legumes, Beans, Dietary fiber & Total Phenolic Content

INTRODUCTION

Dietary fiber is the edible portion of plants that is resistant to enzymatic digestion and absorption by the intestinal tract. Dietary fiber can be categorized into the soluble dietary fiber (SDF) or insoluble dietary fiber (IDF), according to its digestibility in the small intestine. SDF dissolves in water and turns to gel during digestion. The gel forming characteristic allows the food to be slow down while digestion and this indirectly contributes many health benefits such as reducing postprandial blood glucose, serum cholesterol and insulin levels (Jenkins et al., 2000). Meanwhile, IDF is unable to be digested and are poorly metabolized in the small intestine (Englyst et al., 2007). IDF have passive water-holding characteristics that can reduce the risk of constipation, diverticular disease and hemorrhoids (Anderson et al., 2009).

Phenolic compounds are a large group of phytochemicals found in the plant kingdom that act as a natural antioxidant in the prevention of several diseases such as atherosclerosis, diabetes mellitus, cardiovascular disease and cancer. The phenolic compounds can range from simple, low-molecular-weight, single aromatic-ringed compounds to large and complex tannins and derived polyphenols (Crozier et al., 2009).

Legumes are among the earliest food crops cultivated through the world. Beans are distinctive among a diverse and broad class of legumes (Uebersax, 2006). It has contributed as an important food category for humans for thousands of years and is typically incorporated in various forms of most traditional diets around the world.
Beans are considered as a nutrient-dense food because of its distinctive nutritional compositions such as dietary fiber, protein, antioxidants, minerals and omega-3 fatty acids (Darmadi-Blackberry et al., 2004; Mitchell et al., 2009). Besides, the low glycemic index characteristic of beans are especially useful in mixed-meal settings, in which beans combined with a high glycemic index food such as white rice able to produce a glycemic response that is intermediate between the high and low glycemic index foods (Winham et al., 2007).

Recently, researchers have focused public’s attention on the dietary fiber and phenolic content of foods as there have been some evidence that diet low in dietary fiber and phenolic content are linked with diseases development. People rarely eat raw beans as it contains anti-nutritional factors which can adversely affect enzyme activity, digestibility, nutrition, and health. Generally, food processing can affect the dietary fiber and phenolic content of beans (Guillon & Champ, 2000) and cooking is one of the common ways that people use in processing the beans.

Previous studies have demonstrated that high level of legumes intake has health-protective effects and disease-reversal benefits. Certain health products claiming their products are high in dietary fiber and phenolic content because they applied bean combinations method. However, there are no published data to support these claims. The purpose of this study is to determine the dietary fiber and phenolic content of selected raw and cooked beans and its combinations.

MATERIALS AND METHODS

Samples

Chickpea (*Cicer arietinum L*), kidney bean (*Phaseolus vulgaris L*) and mung bean (*Vigna radiata* L. R. Wilczek) were purchased from hypermarket in Selangor, Malaysia. The beans in good condition (without broken, molded, mechanically damaged and wrinkled) were homogenized to a particle size less than 0.5 mm using a blender (Panasonic, Malaysia). The beans flour was sieved before being stored at 4 ºC.

Cooking

Beans in good condition were initially washed with tap water before being cooked with an automatic rice cooker (Panasonic SR-E18A, Malaysia). Cooking time was defined according to the method described by Williams et al. (1983), whereby the beans were cooked until soft as determined by pressure felt between the fingers. The ratio of beans to cooking water was set according to Jood et al. (1998), which was 1: 3 (w/v). A few beans were taken out from the rice cooker and pressed between fingers to test the degree of softness after 30 min of cooking. If the beans were not soft, the process of cooking was continued for another 10 min or until the beans were soft. At the end of cooking, the water was drained off and the cooked beans were freeze-dried and homogenized to a particle size less than 0.5 mm using a blender (Panasonic, Malaysia). The beans flour was sieved before being stored at 4 ºC.

Bean Flours Combination

The combinations of beans flours was done by mixing each of the homogenized beans flour in the ratio of 1:1 (w/w, for the combinations of two types of beans) and 1:1:1 (w/w/w, for the combinations of three types of beans).

Preparation of Organic Extract

The organic extract was prepared according to the method of Huang and Yen (2002) with a slight modification. About 1 g of the bean flour was mixed with 15 ml methanol (80%, v/v) and incubated at room temperature with continuous stirring for 2 hours. Then, the mixture was centrifuged for 10 min at 4000 rpm. The supernatant obtained was assayed for
phenolic determination.

**Determination of Dietary Fiber**

AOAC Official method 991.43 (1995) with slight modification was used for dietary fibers determination. This method is an enzymatic-gravimetric method that utilized three different enzymes (heat-stable α-amylase, protease, and amyloglucosidase) under different incubation conditions in order to remove starch and protein components. For IDF determination, the enzyme digest was filtered, and the residue was washed with warm water, dried and weighed whereas, for SDF determination, combined filtrate and washes were precipitated with alcohol, filtered, dried and weighed. Lastly, the values obtained in IDF and SDF were sum up to become the total dietary fiber (TDF).

**Determination of Total Phenolic Content (TPC)**

TPC determination was analyzed based on the method of Marathe et al. (2011). This is an oxidation-reduction colorimetric method, whereby exactly 600 µl of extracted samples was pipetted into a test tube. Next, 300 µl of 1 N Folin-Ciocalteu reagent and 600 µl of 2.0 % sodium carbonate solution were added and the mixture was allowed to stand in a dark for 30 minutes. Then, the absorbance of the mixture was measured against blank solution at the wavelength 750 nm using spectrophotometer (Shimadzu, Australia).

**Statistical Analysis**

All the analyses were performed in triplicate and the results are expressed as the mean ± standard deviation. The data were analyzed by one-way analysis of variance (ANOVA) accompanied with Turkey’s post hoc using Statistical Package for Social Science (SPSS) version 21. The level of significant was set at \( p < 0.05 \).

**RESULTS AND DISCUSSIONS**

**Dietary Fiber of Raw Beans and its Combinations**

The dietary fiber of raw beans and its combinations are shown in Table 1. The IDF, SDF, and TDF for individual beans studied were in the range of 20.52–26.61 g/100 g, 1.20–2.45 g/100 g and 22.08–27.81 g/100 g, respectively. The amount of IDF (26.61 g/100g) and TDF (27.81 g/100g) in mung bean was significantly higher (\( p < 0.05 \)) than the chickpea. The differences might be attributed to the seed size. Beans with a smaller seed size will have a higher dietary fiber contents than those beans with a larger seed size because of the greater proportion of seed coat to cotyledon (Wang et al., 2003). Hence, the small seed size mung bean has greater dietary fiber contents than larger seed size beans such as chickpea and kidney bean. The results in the current study contrary with the data of Mallillin et al. (2008), who reported the IDF of kidney bean was the highest and the SDF of kidney bean was the lowest, as compared with mung bean and chickpea. Variation in the SDF and IDF may be due to the differences in the variety of beans, environmental planting conditions and extraction method used (Martin-Cabrejas et al., 2006; Wang et al., 2008).

After bean combinations, the IDF, SDF and TDF were in the range of 20.74–23.96 g/100 g, 2.3- 2.50 g/100 g and 23.05-26.46 g/100 g, respectively. Among the bean combinations studied, KM contains the highest amount of IDF, SDF, and TDF whereas KC has the lowest. Multiple comparisons of results showed that combinations of raw beans do not enhance the amount of IDF and SDF than its individual form. Conversely, certain beans in combination were able significantly increased its TDF value. The TDF content in chickpea was significantly lower (\( p < 0.05 \)) than MC and KMC.
Effects of Cooking on the Dietary Fiber of Beans and its Combinations

The dietary fiber of cooked beans and its combinations are shown in Table 1. After being cooked, the IDF, SDF, and TDF for individual beans studied were in the range of 14.49-26.30 g/100 g, 1.40-2.02 g/100 g, and 15.88-28.31 g/100 g, respectively. Cooked kidney bean has the highest amount of IDF (26.30 g/100g) and TDF (28.31 g/100g) whereas mung bean has the highest amount of SDF (2.02 g/100g). Meanwhile, cooked chickpea has the lowest amount of IDF (14.49 g/100g), SDF (1.40 g/100g) and TDF (15.88 g/100g). Current findings agree with Mahadevamma et al. (2004), who reported that cooking affects the dietary fiber of beans. As compared with their raw forms, cooking significantly reduced (p<0.05) the IDF of mung bean and chickpea. A similar finding was reported by Khanum et al. (2000), in which the IDF of vegetables reduced after being cooked with a pressure cooker and an open-pan method. The reductions of IDF could be due to the conversion of IDF into digestible carbohydrates.

For cooked bean combinations, the IDF, SDF, and TDF were in the range of 15.73-23.03 g/100 g, 1.73-2.36 g/100 g, and 17.46-24.95 g/100 g, respectively. Combinations of three types of beans studied (KMC) resulted in the highest amount of IDF (23.03 g/100g) and TDF (24.95 g/100g) whereas KM has the highest amount of SDF (21.80 g/100g). Multiple comparisons of results demonstrated that IDF, SDF and TDF contents of certain cooked beans combinations were significantly higher than individually cooked beans. As compared with individually cooked beans, the IDF content in KMC were significantly higher (p < 0.05) than all individual beans studied. Besides, the IDF and TDF contents in KM were significantly higher (p < 0.05) than mung bean and chickpea. Also, it was observed the amount of SDF in KM was significantly higher (p < 0.05) than the chickpea.

<table>
<thead>
<tr>
<th>Samples</th>
<th>IDF (G/100g)</th>
<th>SDF (G/100g)</th>
<th>TDF (G/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw</td>
<td>Cooked</td>
<td>Raw</td>
</tr>
<tr>
<td>Kidney bean</td>
<td>25.21 ± 0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.30 ± 0.87&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.45 ± 0.66&lt;sup&gt;ab&lt;/sup&gt;</td>
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<tr>
<td>Mung bean</td>
<td>26.61 ± 0.22&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>17.36 ± 0.61&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.20 ± 0.05&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chickpea</td>
<td>20.52 ± 0.26&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.49 ± 0.67&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.56 ± 0.41&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
<tr>
<td>KM</td>
<td>23.96 ± 0.12&lt;sup&gt;ad&lt;/sup&gt;</td>
<td>21.80 ± 0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.50 ± 0.02&lt;sup&gt;acd&lt;/sup&gt;</td>
</tr>
<tr>
<td>KC</td>
<td>20.74 ± 0.74&lt;sup&gt;ac&lt;/sup&gt;</td>
<td>19.13 ± 0.40&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>2.31 ± 0.13&lt;sup&gt;bde&lt;/sup&gt;</td>
</tr>
<tr>
<td>MC</td>
<td>22.22 ± 0.69&lt;sup&gt;bcdef&lt;/sup&gt;</td>
<td>15.73 ± 0.27&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.42 ± 0.35&lt;sup&gt;bcdef&lt;/sup&gt;</td>
</tr>
<tr>
<td>KMC</td>
<td>23.48 ± 0.60&lt;sup&gt;def&lt;/sup&gt;</td>
<td>23.03 ± 0.58&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.40 ± 0.08&lt;sup&gt;bdef&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Mean values in the same column with different letters (a-f) are significantly different at the level of p<0.05. Mean values in the same row with symbol (*) are significantly different at the level of p < 0.05. KM: combinations of kidney bean and mung bean, KC: combinations of kidney bean and chickpea, MC: combinations of mung bean and chickpea, KMC: combinations of kidney bean, mung bean and chickpea.

TPC of Raw Beans and its Combinations

The TPC of raw beans and its combinations are displayed in Table 2. The TPC for individual beans studied was in the range of 0.48-1.04 mg GAE/g, being highest in kidney bean and lowest in mung bean. The results obtained in the
current study was in agreement with Marathe et al. (2011), who reported the phenolic content of beans varied in the range of 0.33 to 6.38 mg GAE/g.

After the beans being combined, the TPC was in the range of 0.80-0.85 mg GAE/g, being highest in MC and lowest in KM. It was observed that all types of beans in combinations studied (KM, KC, MC, and KMC) were significantly higher (p< 0.05) than mung bean. These suggest combinations of beans able to increase the phenolic content.

Effects of Cooking on the TPC of Beans and its Combinations

The TPC of raw beans and its combinations are shown in Table 2. The TPC for individually cooked beans was in the range of 0.57-1.20 mg GAE/g, being highest in kidney bean and lowest in mung bean. Current results contradicted with the findings of Gujral et al. (2013), who reported the TPC for chickpea was the lowest and TPC for kidney bean was the highest, after being cooked. Variation in the TPC may be due to the differences of cooking conditions. Gujral et al. (2013) soaked the beans before cooked whereas, in the present study, the beans only wash with running water before cooked. As evidenced by Ranilla et al. (2009), soaking of beans prior cooking significantly affected the total phenolic contents and antioxidant capacity of beans.

After the cooked beans being combined, the TPC was in the range of 0.61-1.08 mg GAE/g, being highest in KM and lowest in KC. It was observed the TPC in KMC and KM were significantly higher (p<0.05) than chickpea and mung bean, after being cooked. Also, the TPC in cooked MC was significantly higher (p < 0.05) than cooked mung bean.

The findings in the present study agree with the data published by Turkmen et al. (2005), who reported that cooking causes a reduction or increment in the phenolic contents of vegetables and legumes. After the process of cooking, the TPC in chickpea, KC, and MC were significantly reduced (p < 0.05), as compared with its raw form. The reduction of TPC could be due to phenolics breakdown during cooking (Crozier et al., 1997). Meanwhile, cooking raised the phenolic contents of the kidney bean, mung bean, KM, and KMC. The TPC in kidney bean and KM were significantly increased (p < 0.05) to various extents. The increment of TPC could be due to the increased level of free flavonols as a result of heat treatment (Stewart et al., 2000).

Table 2: TPC of Raw and Cooked Beans and its Combinations

<table>
<thead>
<tr>
<th>Samples</th>
<th>TPC (mg GAE/g)</th>
<th>Raw</th>
<th>Cooked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney bean</td>
<td>1.04 ± 0.02a</td>
<td>1.20 ± 0.04a*</td>
<td></td>
</tr>
<tr>
<td>Mung bean</td>
<td>0.48 ± 0.01b</td>
<td>0.57 ± 0.07b*</td>
<td></td>
</tr>
<tr>
<td>Chickpea</td>
<td>0.88 ± 0.05c</td>
<td>0.71 ± 0.03c*</td>
<td></td>
</tr>
<tr>
<td>KM</td>
<td>0.80 ± 0.03ad</td>
<td>1.08 ± 0.01ad*</td>
<td></td>
</tr>
<tr>
<td>KC</td>
<td>0.84 ± 0.01cde</td>
<td>0.61 ± 0.09cde*</td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>0.85 ± 0.02cdef</td>
<td>0.76 ± 0.02cdef*</td>
<td></td>
</tr>
<tr>
<td>KMC</td>
<td>0.84 ± 0.03cdef</td>
<td>0.95 ± 0.06cdef*</td>
<td></td>
</tr>
</tbody>
</table>

Mean values in the same column with different letters (a-f) are significantly different at the level of p < 0.05. Mean values in the same row with symbol (*) are significantly different at the level of p < 0.05. KM: combinations of kidney bean and mung bean, KC: combinations of kidney bean and chickpea, MC: combinations of mung bean and chickpea, KMC: combinations of kidney bean, mung bean and chickpea.
CONCLUSIONS

Combinations of raw beans do not enhance the IDF and SDF levels than its individual form. After the process of cooking, the IDF and SDF of certain cooked beans combinations were significantly higher than individually cooked beans. Certain bean combinations yielded a greater amount of TDF and TPC than individual beans either in raw or cooked form. This study suggests the possibility of using the beans combinations method to increase the dietary fiber and TPC.

REFERENCES


