Improved quality and storage of rice flour (MR 220) by rice bran
[Peningkatan mutu dan tahap penyimpanan tepung beras (MR 220) menggunakan dedak beras]

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Key words: improvement, rice bran, nutritional, storage stability

Abstract
Rice flour of variety MR 220, was developed by dry milling. Different levels of stabilised rice bran (10, 20, 30 and 40%) were incorporated for the development of rice bran flour. Chemical and nutritional evaluations were conducted on all samples. Results from chemical analyses indicated higher percentage in fat, protein, minerals, vitamins and dietary fibre in flour incorporated with rice bran than the control sample. The developed flour had higher oryzanol and tocopherol values than the control. Each developed rice flour was vacuum packed in bag laminated with oriented polypropylene/polypropylene and kept at ambient temperature for storage study. At 24 weeks storage period, samples incorporated with 40% rice bran packed in OPP/PP/vacuum bag, had the lowest increase in free fatty acid (FFA) values (13%). Results indicated that the addition of rice bran might influence the development of FFA in the samples and this might be due to the naturally occurring antioxidant in the rice bran which improved the shelf life of rice flour.

Introduction
Products that are discarded or used for animals feeds, such as the by-products of milling industries, are nowadays largely applied to foods (Camire 1990). Cereal residues are one important source of dietary fibre and rice bran is in this group. Rice bran is a nutritionally valuable by-product obtained from the outer layers of rice kernel during milling process. Industrial processing of rice bran into edible products is attractive due to the abundance of rice bran as a by-product in the milling industry and the recognition of its commercial potential (Anderson and Guraya 2001).

Rice bran contains 14–16% crude fibre, of which 3–4% is lysine (Shih et al. 1999), and is therefore of high nutritional value. Rice bran contains several components that are associated with health benefits. Research indicates that rice bran lowers blood cholesterol levels. It offers an advantage over other brans in that it can be tolerated by people who are gluten intolerant, or allergic to protein gluten, which is found in most cereal grains (Hammond 1994). Rice bran also increases faecal output and stool frequency, where both effects are significantly greater than observed for wheat bran fed at a similar intake of indigestible fibre (Saunders 1990). Studies also reported that rice bran is an effective stool-bulking agent. The oryzanol present in the rice bran is reported to have a function similar to vitamin E in promoting growth, facilitating capillary growth in the skin and improving blood circulation along with stimulating hormonal secretion (Luh et al. 1991).
Improved rice flour using rice bran

Stabilised or food grade rice bran is normally finely granulated, light tan in colour, and possesses a relatively bland flavour with a nutty, toasted overtone (Bor et al. 1991). At present, food grade rice bran is not much being marketed in large quantities in Malaysia. However, this situation may change in the future with increased attention paid today to the positive physiological benefits from consumption of rice bran food products.

Hammond (1994) described a method of processing rice bran into products, such as milk replacers, a slow-release carbohydrate products, fibre in health foods, and ingredients in cosmetics and pharmaceuticals. One of the potential application of stabilised rice bran is the use in composite flour for production of nutritious products or nutritional improvement. Stabilised rice can be easily incorporated into rice flour which can be used in different Malaysian food items. Its application includes baked goods, bread, biscuits, cakes, cookies and extruded foodstuffs.

The shelf life of stabilised rice bran is estimated to be about 6 months (Rosniyana et al. 2005). This would be expected to increase in cases where bran is a minor component of a product mix (Saunders 1990). The naturally occurring antioxidants (oryzanol, tocopherols and tocotrienols) improve the shelf life of many foods containing fat. Accordingly, studies were carried out to investigate the shelf life of rice flour incorporated with different levels of rice bran, namely 10, 20, 30 and 40%. Apart from that, chemical and nutritional contents of rice bran were also determined. These findings are useful as these properties will be related to the quality attributes of food products prepared from rice bran.

Materials and methods

Preparation of stabilised rice bran
Stabilised rice bran was produced by parboiling process as stated by Rosniyana et al. (2005). To obtain parboiled rice bran, the paddy (100 kg) was initially soaked (2 h) and steamed (20 min) followed by drying and milling. The hull was then removed, followed by removal of bran to yield parboiled white rice and bran. Parboiled rice brans were dried at 60 °C to reduce the moisture content to less than 5%. This bran was used for the development of rice bran flour.

Production of rice flour
Stabilised rice bran was sieved through a 50-mesh sieve. Rice (MR 220) was processed into flour by dry milling method using air isolating type grinding machine. Rice bran flours, containing 0, 10, 20, 30 and 40% rice bran replacing rice flour, were prepared by gradual mixing of rice bran and rice flour in a rotary mixer. Production of rice bran flours (1 kg) at different levels of rice bran was prepared in triplicates.

Storage study and sampling
Samples of each rice bran flour were packed in bags laminated with oriented polypropylene/polypropylene (OPP/PP) and polypropylene (PP). The samples were also vacuum packed in OPP/PP bag. The samples were stored at ambient temperature and samples were evaluated every two weeks. The chemical analysis of free fatty acid (FFA) values of each sample was determined during the storage period.

Chemical analysis
Samples of rice bran flour were taken and analysed for moisture, protein, crude fibre, fat, ash, phosphorous, potassium, sodium, calcium, iron, thiamine, niacin and riboflavin. Moisture, protein, fat, free fatty acid and ash were determined using standard AOAC methods (AOAC 1990). Protein was determined by Kjeldahl nitrogen method using Kjeltec system 1026 (Tecator 1978). Fat was determined by Soxhlet extraction and ashing was done at 550 °C to constant weight. Crude fibre was determined by Weende method using fibertec system (Tecator 1978). Minerals, vitamins and
dietary fibre were analysed by an accredited company Edtech Associates Sdn. Bhd. according to the method by AOAC (1993). Each analysis was carried out in duplicate. Carbohydrate was calculated by subtracting the values of moisture, protein, crude fibre, fat and ash, from 100.

**Experimental design and data analysis**

For this study, each developed rice bran flour was carried out in two replicates. All determinations were statistically analysed by the analysis of variance and mean values are presented. The Duncan Multiple Range Test was used to detect the differences between treatments (Gomez and Gomez 1984).

**Results and discussion**

**Chemical and nutritional composition**

The proximate and nutritional compositions of rice flour with different levels of rice bran are shown in Table 1. Replacement of rice bran resulted in an increase of fat content. The maximum value for fat content was noted in 40% rice bran flour (13.9%). It is evident from the means for fat content that the treatments differed significantly with each other. Studies by Goffman and Bergman (2002) had indicated that rice bran is high in fat content ranging 16–22%. As rice bran is rich in fat content, a significant increase in percentage of fat was observed as the levels of rice in the rice flour were increased.

The protein content of analysed samples varied from 8.85 ± 0.45 to 10.58 ± 0.75%. With the exception at level of 10% rice bran, treated rice flours were significantly higher in protein content than the control rice flour. According to Anderson and Guraya (2001), the range of protein content present in rice bran is 14–16%.

Table 1. Proximate composition, mineral composition, vitamin composition and selected phytochemical of rice bran flour at different percentages of rice bran

<table>
<thead>
<tr>
<th>Percentage of rice bran (%)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>7.47 ± 0.25b</td>
<td>8.8 ± 0.15a</td>
<td>8.9 ± 0.75a</td>
<td>8.6 ± 0.45a</td>
<td>7.1 ± 0.75b</td>
</tr>
<tr>
<td>Fat</td>
<td>0.34 ± 0.15e</td>
<td>3.4 ± 0.45d</td>
<td>6.3 ± 0.15c</td>
<td>8.7 ± 0.25b</td>
<td>13.9 ± 0.15a</td>
</tr>
<tr>
<td>Protein</td>
<td>8.85 ± 0.45d</td>
<td>9.05 ± 0.75d</td>
<td>9.31 ± 0.50c</td>
<td>9.61 ± 0.25b</td>
<td>10.58 ± 0.75a</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>1.41 ± 0.15d</td>
<td>1.6 ± 0.25d</td>
<td>3.5 ± 0.75c</td>
<td>5.5 ± 0.45b</td>
<td>7.7 ± 0.15a</td>
</tr>
<tr>
<td>Ash</td>
<td>0.7 ± 0.75d</td>
<td>1.1 ± 0.15d</td>
<td>2.2 ± 0.15c</td>
<td>3.6 ± 0.15b</td>
<td>4.7 ± 0.15a</td>
</tr>
<tr>
<td>Calcium</td>
<td>5.1 ± 0.75e</td>
<td>14 ± 0.05d</td>
<td>22 ± 0.15c</td>
<td>25 ± 0.75b</td>
<td>31 ± 0.75a</td>
</tr>
<tr>
<td>Iron</td>
<td>1.1 ± 0.15d</td>
<td>1.7 ± 0.75d</td>
<td>4.0 ± 0.75c</td>
<td>5.5 ± 0.15b</td>
<td>7 ± 0.25a</td>
</tr>
<tr>
<td>Magnesium</td>
<td>28.55 ± 2.25e</td>
<td>99.35 ± 1.25d</td>
<td>220.45 ± 2.15c</td>
<td>291.45 ± 2.25b</td>
<td>360.75 ± 2.25a</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.8 ± 0.05d</td>
<td>0.44 ± 0.25d</td>
<td>1.3 ± 0.15c</td>
<td>1.7 ± 0.05b</td>
<td>2.2 ± 0.75a</td>
</tr>
<tr>
<td>Potassium</td>
<td>72 ± 2.75e</td>
<td>183 ± 1.25d</td>
<td>382 ± 0.75c</td>
<td>560 ± 0.75b</td>
<td>590 ± 1.25a</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>84 ± 1.25e</td>
<td>232 ± 3.05d</td>
<td>506 ± 2.25c</td>
<td>642 ± 2.25b</td>
<td>742 ± 1.15a</td>
</tr>
<tr>
<td>Thiamine (mg)</td>
<td>0.2 ± 0.05d</td>
<td>0.33 ± 0.25c</td>
<td>0.69 ± 0.55b</td>
<td>0.80 ± 0.05a</td>
<td>0.95 ± 0.75a</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>0.01 ± 0.01c</td>
<td>0.03 ± 0.05c</td>
<td>0.09 ± 0.01b</td>
<td>0.12 ± 0.05a</td>
<td>0.13 ± 0.05a</td>
</tr>
<tr>
<td>Pyridoxine (mg)</td>
<td>0.60 ± 0.05c</td>
<td>0.72 ± 0.01c</td>
<td>1.4 ± 0.25b</td>
<td>1.3 ± 0.05b</td>
<td>2.2 ± 0.05a</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>3.0 ± 0.45e</td>
<td>5.3 ± 0.45d</td>
<td>10 ± 0.55c</td>
<td>13 ± 0.75b</td>
<td>31 ± 0.55a</td>
</tr>
<tr>
<td>Dietary fibre/g</td>
<td>3.1 ± 0.05e</td>
<td>4.1 ± 0.25d</td>
<td>7.1 ± 0.55c</td>
<td>8.8 ± 0.55b</td>
<td>11 ± 0.25a</td>
</tr>
<tr>
<td>Soluble fibre (g)</td>
<td>0.2d ± 0.05d</td>
<td>0.25 ± 0.05d</td>
<td>0.55 ± 0.05c</td>
<td>0.71 ± 0.05b</td>
<td>0.9 ± 0.05a</td>
</tr>
<tr>
<td>Tocopherol (g)</td>
<td>0.08 ± 0.05e</td>
<td>0.65 ± 0.05d</td>
<td>0.55 ± 0.25c</td>
<td>0.55 ± 0.45c</td>
<td>0.55 ± 0.45c</td>
</tr>
<tr>
<td>Ferulic acid ester (g)</td>
<td>–</td>
<td>0.2 ± 0.05c</td>
<td>1.8 ± 0.05c</td>
<td>1.8 ± 0.05c</td>
<td>1.8 ± 0.05c</td>
</tr>
</tbody>
</table>

Means values in the same row with different letters are significantly different (p < 0.05)
Similar observation was reported by Prakash and Ramanathan (1995) and they stated that protein concentrate prepared from rice bran gave a good nutritional quality in weaning food. Saunders (1990) reported that rice bran protein has relatively high nutritional value (3.8) and higher lysine content but a lower glutamic acid content than wheat. With a better balance of essential amino acids which was reported by Landers and Hamaker (1994), results suggested that the rice bran may be utilised to improve the nutritional value of rice flour. Reports by Hamada (2000) also indicated that addition of rice bran improved lysine content of developed products.

Crude fibre was present in the range of 1.41% to 7.7%. Besides rice flour at 10% level, there was a significant difference in crude fibre content between the rice bran incorporated flour and the control flour. Skuarray et al. (1988) reported that stabilised bran contained 62% crude fibre and the result suggested that rice bran contributed to the crude fibre content in the rice flour. High value for crude fibre may be due to the relatively high hemicellulose and pentosan in the flour incorporated with rice bran.

The minerals were present in varied amount. The major minerals in the product was phosphorous followed by potassium and magnesium. The level of iron at 5.5 mg/100 g (30% sample) was of considerable nutritional significance (Tee et al. 1997). All the rice bran incorporated rice flour had significantly higher mineral content as compared to the control sample indicating that the developed products offer a nutritional added value. The result indicated that increase addition of rice bran resulted in increase in mineral contents. Carroll (1990) observed that incorporating bran would significantly increased the minerals content of the finished products. Other study by Hammond (1994) reported that rice bran is a concentrate source of meal, the minerals can be concentrated to produce nutrient mixture.

The developed flour had varied amount of vitamin content. An appreciable amount of niacin was present in the samples analysed (3.0–31 mg/100 g samples). The developed flour had reasonable pyridoxine (0.60–2.2 mg/100 g samples) contents. Except for control and at 10% rice bran which contained 0.2 mg and 0.33 mg thiamine per 100 g sample respectively, the levels of thiamine in the flour ranged from 0.69 to 0.95 mg/100 g. Riboflavin was present in the range of 0.01–0.13 mg/100 g sample. Result showed that the vitamin contents increased significantly with the increasing levels of rice bran. Similar observation was reported by Juliano (1993) which stated that the major proportion of vitamins in rice is located in the bran and this content was significantly reduced during milling of rice to produce milled rice.

With the exception of control flour and 10% rice bran flour, all the other flours are high fibre product (containing more than 6% total dietary fibre) based on the definition of Codex Alimentarius draft table of conditions for nutrient content (Codex Alimentarius Commission 2001). Flour at the level of 40% rice bran had the highest total dietary fibre of 11%. Studies suggested that rice bran can be incorporated in food products as a source of dietary fibre and nutritional quality improvement. Rice bran was reported containing 25.3 g of dietary fibre per 100 g which can meet the recommended dietary fibre intake.

Two phytochemicals namely tocopherol and oryzanol were found in varied amount. The analysed samples had oryzanol and tocopherol contents in the range of 0.2–0.9 g/100 g and 0.08–3.1 g/100 g respectively. The amount of tocopherol and oryzanol detected were significantly different among samples. Studies by Rong et al. (1999) had indicated that rice bran has the richest source of oryzanol (nearly 1 g/100 g). Hence, addition of rice bran resulted in an increase in oryzanol content and the result showed significant increase.
Development of FFA values in stored rice bran flour

One of the main parameters to determine during storage of rice flour is the broken of fat by lipase into free fatty acid (FFA). The effect of storage on FFA development in stored flour is presented in Figure 1. The initial value of FFA in stored rice flour (control sample) was 28.8%. With progress of storage, FFA values increased in all control samples with sample packed in OPP/PP/Vacuum had the lowest value (42.1%). According to Pearson (1976), flour containing 30% FFA values are considered unsuitable for use. Hence result indicate that storage of flour may lead to deterioration of flour by hydrolysis of fat to FFA.

The effect of incorporated of rice bran in rice flour during storage is shown in Figure 2. The initial FFA value in the 20% rice bran was in contrast to 3.7% and 2.8% for the 30% rice bran flour and 40%

Figure 1. Free fatty acid values of rice flour during storage

Figure 2. Free fatty acid values of rice bran flour with 20, 30 and 40% rice bran during storage
Improved rice flour using rice bran

There was an increase in FFA values during storage. Rice flour with 40% rice bran showed minimum increase of FFA followed by rice flour with 30% rice bran and 20% rice bran. It is evident from the results that by increasing the percentage of rice bran, the FFA values decreased and the onset of rancidity is delayed.

It is suggested that the tocopherols, tocotrienols and oryzanols present in rice bran act as natural antioxidant. Rong et al. (1999) had reported the significant levels of these nutritionally components in rice bran. Rice bran flours have extended shelf life since these components are extremely stable against the onset of rancidity and oxidative deterioration.

Storage of rice bran flour by ordinary packaging material lead to rapid deterioration due to moisture absorption. Study showed that rice bran flour kept in OPP/PP/Vacuum had the lowest free fatty acid values during storage. Moisture content of bran was increased in PP (control) storage due to free exchange of air with atmosphere (Prabhakar 1987). In OPP/PP/Vacuum storage, exchange of air was restricted and hence moisture was reduced considerably. Results indicated that storage of rice bran sealed in bags made of impervious materials and depletion of oxygen are essential in protecting stabilized bran against deterioration by the action of moisture and oxygen. Thus oxidative rancidity of stabilized rice bran during storage could be controlled by application of vacuum-packed technique.

Conclusion
The chemical composition of developed rice bran flour with different levels of rice bran showed considerable variations. Incorporation of rice bran also contributed to differences in mineral and vitamin contents in the developed products. Rice bran flour was a nutritious product as it contains substantial amount of protein, vitamins, minerals, and dietary fibre. With addition of rice bran it was found that the shelf life of the developed rice flour was extended to more than six months as the process of rancidity was reduced. The presence of natural antioxidant in the bran helps in preventing the deterioration of fat.

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