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# Effect of enrichment with hemicellulose from rice bran on chemical and functional properties of bread

Guohua Hu[a,*], Shaohua Huang[b], Shuwen Cao[b], Zhengzhi Ma[a]

[a] College of Life and Environment Science, Shanghai Normal University, Guilin Road 100#, Shanghai 200234, PR China
[b] College of Life Science, Nanchang University, Nanjing East Road 235#, Nanchang 330047, PR China

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ABSTRACT

This paper examines the use of the defatted rice bran hemicellulose B (RBHB), and insoluble dietary fibre (RBDF), as two functional ingredients added to bakery products. The results show that the RBHB from defatted rice bran had high water-binding and swelling capacity. RBHB exhibited high fat binding capacity. However, RBHB was found to be low viscous. Addition of 1%, 2% and 3% RBHB preparation reduced loaf volume significantly and increased the firmness of the breads. Sensory evaluations revealed that breads with 1%, 2%, 3% RBHB and 2%, 4% RBDF were overall acceptable. This confirms that the RBHB and RBDF preparation from defatted rice bran has great potential in food applications, especially in development of functional foods including functional bakery products.



## 1. Introduction

Rice is a staple food for more than half of humanity. According to the Association of Japanese Agricultural Scientific Societies (1975), every continent on the planet produces rice except Antarctica. The major rice growing countries are China, India, Indonesia, Bangladesh, Thailand, Burma, Vietnam, Japan and the Philippines. Rice bran is a by-product obtained from outer rice layers and is a good source of protein, mineral, and fatty acids, and dietary fibre content (Mccaskill & Zhang, 1999). Also rice bran is used for the enrichment of some foods, due to its high dietary fibre content. Since the middle of the 1970s, the role of dietary fibre in health and nutrition has stimulated a wide range of research activities and caught public attention. Accumulating evidence favours the view that increased intake of dietary fibre can have beneficial effects against diseases, such as cardiovascular diseases, gastrointestinal disease, decreasing blood cholesterol, diverticulosis, diabetes and colon cancer (Burton, 2000; Cara et al., 1992; Chen & Anderson, 1986; Cummings, 1985; Dukehart, Dutta, & Vaeth, 1989; Spiller et al., 1980; Wrick et al., 1983). In view of the therapeutic potential of dietary fibre, more fibre incorporated food products are being developed. Addition of dietary fibre to a wide range of products will contribute to the development of value-added foods or functional foods that currently are in high demand. In addition to the physiological benefits provided by high-fibre foods, studies have shown that fibre components can give texture, gelling, thickening, emulsifying and stabilising properties to certain foods (Dreher, 1987; Sharma, 1981).

In China, not much work has been done on rice bran and its dietary fibre. Rice bran is mostly burnt off at the rice mills and very little is used in animal feed. By understanding functional properties of dietary fibre, one can increase its use in food applications and aid in developing food products with high consumer acceptance. We systematically studied the chemical constituents and functional properties of dietary fibre from rice bran (Hu & Huang, 1998, 2003; Hu, 2001; Hu, Yang, Ma, & Zhou, 2007). Rice bran hemicellulose B (RBHB) had been reported to have many biological activities including decreasing blood cholesterol and preventing colon cancer (Guohua et al., 2007). The objective of the paper is to study the functional properties of RBHB and rice bran insoluble dietary fibre (RBDF) and to develop an acceptable food enriched with high content fibre from defatted rice bran.

## 2. Materials and methods

### 2.1. Materials

Defatted rice bran from Shanghai, PR China. Milled rice bran was then passed through a 600 mm sieve to achieve appropriate particle sizes. Defatting was immediately carried out using of Soxhlet apparatus utilising n-hexane as a solvent. The dry defatted rice bran was then kept in a sealed container in a desiccator until further treatment was performed. The other raw materials used

* Corresponding author. Tel.: +86 21 64322933; fax: +86 21 64322142.
*E-mail address:* hgh114226@sina.com (G. Hu).

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were wheat flour, granulated yeast, water, and salt obtained from a local market in Nanchang, PR China.

### 2.2. Extraction of RBHB and RBDF preparation

Hemicellulose B was prepared from rice bran after lipids were removed with organic solvents and extracted with sodium hydroxide as described by Siegel (1968). The defatted rice bran was digested with protease (60 °C, 3 h), followed by digesting with amyloglucosidase (60 °C, 2 h) to remove protein and starch. Twenty volumes of 4% NaOH were then added to extract hemicelluloses at room temperature for 18 h under $N_2$ flow, followed by filtration. The filtrate was then neutralised with 5% acetic acid. After centrifugation, the filtrate was dialysed under running tap water for three days. After dialysis, four volumes of 95% ethanol were then added to the filtrate. The precipitate was oven-dried overnight (60 °C, 16 h) in an air oven and then weighed. The insoluble dietary fibre (RBDF) was prepared from defatted rice bran after protein and starch were removed with some enzyme as described by Prosky et al. (1985) with some modifications. Five kilograms of defatted rice bran was soaked with 50 L of deionised water for 12 h and treated with proteinase, and amyloglucosidase according to the method of Prosky et al. (1985). After filtration, the residue was washed with deionised water and alcohol (95%). The residue was oven-dried overnight (60 °C, 16 h) in an air oven and then weighed.

### 2.3. Determination of crude protein, moisture, ash, oil, and dietary fibre

The recommended methods of the Association of Official Analytical Chemists (AOAC, 1984) were adopted to determine the levels of crude protein, moisture, ash, and oil. Nitrogen content was determined using the Kjeldahl method (Kjeldahl, 1883) and multiplied by a factor 6.25 to determine the crude protein content. Moisture content was determined by drying the samples at 105 °C to a constant weight. Ash was determined by the incineration of 1.0 g samples placed in a muffle furnace, maintained at 550 °C for 5 h. Crude fat was determined by the Soxhlet method. Crude fat was obtained by exhaustively extracting 5.0 g of each sample in a Soxhlet apparatus using petroleum ether (boiling point range 40–60 °C) as the extractant. Dietary fibre content of the defatted samples was determined by decomposing starches with acids and proteins, with base, and then filtering (Nielsen, 1998). Starch was obtained by difference. All results were expressed on a dry weight basis.

### 2.4. Functional properties of RBHB and RBDF preparation

The water-binding capacity (WBC) was determined according to the method described by Sosulski, Humbert, Bui, and Jones (1976) and Auffret, Ralet, Guillon, Barry, and Thibault (1994), although some modifications were made. Samples (300 mg) were weighed and left to stand for 1 h in distilled water (10 ml) at room temperature (25 °C) before being centrifuged for 20 min at 14,000*g*. The residues were left for 30 min, dried overnight at 110 °C, and weighed. The swelling capacity measurement was made using 0.15 mol/L NaCl, as described by Guillon, Barry, and Thibault (1992). WBC and SC were expressed as ml of water held per gram of sample. Fat binding capacity (FBC) was measured using a method adapted from Lin, Humbert, and Sosulski (1974). A 4 g of sample was added to 20 ml of corn oil in a 50 ml centrifuge tube. The content was then stirred for 30 s every 5 min and, after 30 min, the tubes were centrifuged at 1600*g* for 25 min. The free oil was then decanted and absorbed oil was then determined by difference. The fat binding capacity was expressed as ml of absorbed oil per gram of sample. Viscosity of the dietary fibre was determined using the method of Frost, Hegedus, and Glicksman (1984). RBHB solution (2%, w/w) was prepared by slowly adding an appropriate amount of dietary fibre preparation to distilled water and mixing at high speed in a blender for 1 min. The solution was allowed to sit at room temperature for 24 h to come to equilibrium and entrapped air to escape before viscosity measurements were made. The viscosity was measured using a NDJ viscometer (NDJ-1 Model, 60 r/min, Shanghai Hengping instrument Co., LTD.). The measurement was performed at room temperature.

### 2.5. Baking performance

A simple formulation was used to reduce additional effects of other ingredients consisting of wheat flour, water, sugar, butter, dry active yeast and sodium chloride. Baking tests were carried out by adding 1%, 2%, 3% RBHB preparation and 2%, 4%, 6% RBDF to bread formulations. The control baking tests no added fibre was carried out. Loaf volume was determined using the volume displacement method. Husked rice was used as medium displacement. The volume of the container used was determined by filling the container with rice, the bread was then placed inside the container, followed by the rice. The rice that was not required to fill the container was used to express volume of the loaf (ml). Firmness or texture of 1 day old bread was determined using an Instron universal testing instrument with a 50 kg load cell. The texture was measured by adjusting the portion of the compression plunger until it barely touched the surface of the bread at the centre of the slice. The plunger was then lowered at a constant speed until it compressed the bread to a predetermined degree (percentage of compression). The resulting peak force was measured in kilograms. Sensory evaluations of the breads were conducted by 20 panellists, consisting of Department of Food Science staff and students, using a nine-point hedonic scale for six attributes (colour, taste, odour, softness, chewiness and overall acceptability) where nine is like extremely and one dislike extremely. Five coded samples were served and water was provided for rinsing between samples.

### 2.6. Statistical analysis

All results were subjected to statistical analyses. Mean and standard deviation (SD) was calculated (Steel & Torrie, 1960). Mean values of all data were obtained from triplicate determinations. Values expressed are mean ± SD. Significance of differences between control and treated samples was evaluated using Duncan's multiple range test at 5% level.

## 3. Results and discussion

### 3.1. Functional properties of RBHB and RBDF

The chemical composition of RBHB and RBDF preparations used in this study is presented in Table 1. As illustrated, RBHB

**Table 1**
Proximate analysis of RBHB and RBDF.

| Components | Percentage (%)[a] | |
|---|---|---|
| | RBHB | RBDF |
| Crude fat | 0.59 ± 0.01 | 2.88 ± 0.05 |
| Crude protein | 2.69 ± 0.03 | 8.35 ± 0.09 |
| Moisture | 10.31 ± 0.12 | 10.98 ± 0.18 |
| Ash | 3.17 ± 0.04 | 4.21 ± 0.10 |
| Starch | 0.3[b] | 10.85[b] |
| Total dietary fibre | 82.94 ± 0.36 | 62.73 ± 0.45 |

[a] Values are mean ± SD, $n = 3$.
[b] Values were obtained via gravimetric procedure.

**Table 2**
Functional properties of dietary fibre from defatted rice bran.

| Samples | Water holding capacity (ml/g)[a] | Swelling capacity (ml/g)[a] | Fat-binding capacity (ml/g)[a] | Viscosity[a] (2%, cps) |
|---|---|---|---|---|
| RBHB | 5.20 ± 0.12 | 6.08 ± 0.20 | 4.96 ± 0.08 | 7.8 |
| RBDF | 5.11 ± 0.14 | 5.93 ± 0.17 | 4.35 ± 0.09 | |

[a] Values are mean ± SD, $n = 3$.

preparation contained a high amount of dietary fibre (82.94%), 0.59% fat, 2.69% protein and 3.17% ash. RBDF preparation contained high content dietary fibre (62.73%), 2.88% fat, 8.35% protein, 10.85% starch and 4.21% ash. These fibres had many desirable properties, including high water-holding capacity and swelling capacity. Table 2 shows the water-binding capacity, swelling capacity and fat binding of RBHB and RBDF preparations from defatted rice bran. RBHB and RBDF had high WBC and SC, namely 5.20, 6.08 and 5.11, 5.93 ml/g, respectively. The results suggested that RBHB was able to bind more water. WBC and SC have been widely studied in food functionality, due to its importance in foods. Table 2 also shows that RBHB and RBDF exhibited FBC (4.96 and 4.35 ml/g, respectively) than FIBERX reported (a commercial fibre from sugar-beet, 1.29 ml/g, Azizah & Yu, 2000). RBHB exhibited higher FBC than dietary fibre from rice bran reported (4.54 ml/g, Azizah & Yu, 2000). RBHB was found to be low viscous, and the viscosity of 2% solution (w/w) was 7.8 cps.

### *3.2. Sensory evaluations of breads supplemented with dietary fibre*

Table 3 summarises loaf volume and firmness of dietary fibre-supplemented breads. All dietary fibre-supplemented breads had significantly lower loaf volume and firmer texture than control bread (no added fibre). Pomeranz, Shogren, Finney, and Bechtel (1977) suggested that added fibre reduces loaf volume by diluting gluten content and changing crumb structures, which in turns impairs carbon dioxide retention. Table 4 shows sensory scores for colour, taste, odour, texture and overall acceptability of dietary fibre-supplemented breads. Colour, taste, texture and overall acceptability were not found to be significantly different ($P < 0.05$) than control bread (no added fibre) when 1–3% RBHB fibre preparation was added to the breads. Darkness of the crumb was directly related to increased fibre content. Odour ratings were significantly different for dietary fibre-supplemented breads and control. Bread with 2–6% added RBDF was commented to have a nutty rice flavor, which is typical of the brans. The scores for softness and chewiness of the breads were all at acceptable values. Panellists also commented that the breads were comparable to high-fibre breads currently available in the market. The 6% RBDF added bread received the lowest score. Sensory evaluations revealed that breads with 1%, 2%, 3% RBHB and 2%, 4% RBDF were overall acceptable. This confirms that the RBHB and RBDF preparations from defatted rice bran have great potential in food applications, especially in development of functional foods including functional bakery products.

**Table 3**
Effect of dietary fibre-supplementation on properties of bread.

| Type of dietary fibre | Level of fibre added[a,b] (%) | Loaf volume (ml)[a,b] | Firmness (kg)[a,b] |
|---|---|---|---|
| Control | 0 | 480.7 ± 7.0a | 0.13 ± 0.01a |
| RBHB | 1 | 470.6 ± 5.3a | 0.14 ± 0.02a |
| | 2 | 460.1 ± 3.6b | 0.15 ± 0.02a |
| | 3 | 453.5 ± 6.3b | 0.18 ± 0.01b |
| RBDF | 2 | 467.2 ± 5.2b | 0.21 ± 0.03b |
| | 4 | 378.7 ± 2.9c | 0.35 ± 0.03c |
| | 6 | 296.0 ± 3.4d | 0.48 ± 0.05d |

[a] Values are mean ± SD, $n = 3$.
[b] Means within a column bearing the same letter are not significantly different at 5% level as determined by the Duncan multiple range test.

**Table 4**
Sensory scores of dietary fibre-supplemented breads[a].

| Type of breads | Colour | Taste | Odour | Softness | Chewiness | Overall acceptability |
|---|---|---|---|---|---|---|
| Control | 8.05a | 7.82a | 7.16a | 8.13a | 7.72a | 7.68a |
| 1%RBHB | 7.98a | 7.45ab | 6.32b | 8.07a | 7.49ab | 7.36ab |
| 2%RBHB | 7.95a | 7.30ab | 6.20b | 7.94a | 7.31ab | 7.27ab |
| 3%RBHB | 7.15b | 6.84b | 6.09bc | 7.76a | 7.00b | 7.02b |
| 2%RBDF | 7.12b | 6.99b | 6.01bc | 6.82b | 7.10b | 7.05b |
| 4%RBDF | 6.77bc | 5.83c | 5.96bc | 5.97c | 6.28c | 6.62b |
| 6%RBDF | 6.39c | 5.37c | 5.42c | 5.62c | 5.93c | 5.97c |

[a] Means within a column having the same letter are not significantly different at 5% level, as determined by the Duncan multiple range test.

**Table 5**
Composition of dietary fibre in the end products.

| Type of breads | Dietary fibre (%)[a] |
|---|---|
| Control | 1.87 ± 0.03 |
| 1%RBHB | 2.53 ± 0.02 |
| 2%RBHB | 3.19 ± 0.15 |
| 3%RBHB | 3.87 ± 0.05 |
| 2%RBDF | 2.80 ± 0.12 |
| 4%RBDF | 3.89 ± 0.13 |
| 6%RBDF | 4.98 ± 0.09 |

[a] Values are mean ± SD, $n = 3$.

### *3.3. Determination of dietary fibre in end products*

Table 5 summarises dietary fibre content of the breads. The end products received high content dietary fibre (3.87%) for the 3% RBHB added bread. Results indicated that contents of dietary fibre in the end products were less than expected amounts. Some dietary fibre may be hydrolysed by enzyme from the yeast used or lost due to the high baking temperature (200 °C). According to Varo, Laine, and Koiivistoinen (1983), some of the water-soluble fibre, especially from RBHB, may be lost during cooking. Nevertheless, an appreciable amount of dietary fibre remained in both RBHB and RBDF-incorporated breads and this may contribute to health benefits, for example increasing faecal bulk and lowering of plasma cholesterol.

## 4. Conclusion

The results show that the RBHB and RBDF from defatted rice bran had high water-binding and swelling capacity. RBHB exhibited high fat binding capacity. Addition of dietary fibre was found to reduce loaf volume and increased firmness of the breads, as indicated by the Instron measurements. Sensory evaluation revealed that the breads incorporated with RBHB (1–3%) and RBDF (1–4%) were acceptable to the panellists. In addition, analysis showed that appreciable amounts of dietary fibre remained in both RBHB and RBDF-incorporated fibre and this may contribute to health benefits, such as decreasing blood cholesterol and preventing colon cancer. This confirms that the RBHB and RBDF preparation from defatted rice bran has great potential in food applications.

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