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Nutritional content and storage stability of stabilised rice bran – MR 220

(Kandungan pemakanan dan kestabilan penyimpanan dedak beras yang telah distabilkan – MR 220)

A. Rosniyana*, M.A. Hashifah* and S.A. Shariffah Norin*

Keywords: nutritional quality, rice bran, storage

Abstract

The nutritional composition of rice bran at 4% and 8% milling degree was stabilised by either autoclaving or parboiling process. The rice bran was autoclaved with commercial retort at 120 °C for 20 min. For the production of parboiled rice bran, the harvested paddy was soaked for 2 h, steamed for 20 min then dried and milled. The values of fat, fibre, ash, most minerals and vitamins in parboiled bran were generally higher than treatment by autoclave technique. The free fatty acid levels for both parboiled and autoclaved rice bran were below the 10% permissible level for 4 months and 6 months respectively for the product packed in oriented polypropylene/polypropylene packs, either vacuumed or without, and stored in ambient temperature room condition. The storage of rice bran by polypropylene packs, as control packaging material, led to rapid production of free fatty acids. These findings indicate that rice bran can be stored without risk of deterioration for a substantial time prior being used for the production of many health-related food products.

Introduction

Rice bran is the outer brown layer, including the rice germ that is removed during milling of brown rice to produce milled rice (Saunder 1990). The outer brown layer is actually composed of a number of botanical entities, including several sublayers within the pericarp and the aleurone layer. A variable quantity of subaleurone of endosperm material show up in the bran fraction, depending upon severity of milling.

Breakage of white rice kernel during milling also results in small fragments of endosperm becoming part of the bran fraction. The amounts of starch and other nutrients in the bran are functions of milling degree and extent of kernel endosperm breakage during milling. Rosniyana et al. (2005) indicated that the chemical composition and physico-chemical properties of rice bran produced at different milling degree showed considerable variations.

On average, rice bran has 20–30% total dietary fibre, mostly the insoluble (Skuarray et al. 1988). It also acts as an excellent source of B vitamins and minerals. Possibilities of using rice bran-based products for human food have been explored. Processed bran preparations are currently being marketed for use as additives and as a source of fibre in various foods at home (Carroll 1990). Rice bran is used with milk to prepare rice bran milk, a nutritional high protein drink.

*Food Technology Research Centre, MARDI Station Bukit Raya, P.O. Box 1, 06707 Pendang, Kedah, Malaysia
Authors' full names: Rosniyana Ahmad, Hashifah Mohd Ali and Shariffah Norin Syed Abdullah
E-mail: rosa@mardi.gov.my

One of the problems to incorporating rice bran in food products is its high instability due to the presence of lipase, which catalyzes the splitting of the oil-fraction into free fatty acids and glycerols, thus reducing its shelf life (Fernando and Hewavitharana 1990). Stabilisation of rice bran helps to overcome this problem.

Methods proposed to stabilize rice bran are based on altering the moisture content, temperature or pH to destroy the activity of the lipase (Prabhakar 1987). These processes involve heat treatment, low temperature storage and chemical treatment (Prakash and Ramanatham 1995). Heat resistance of enzymes responsible for bran deterioration is evaluated as function of temperatures and time of treatment and moisture content of bran (Randall et al. 1985). Conditions are optimally combined to achieve irreversible inactivation of enzymes.

The main objective of this paper is to describe the nutritional composition of rice bran at 4% and 8% milling degree, that has been stabilised by either autoclaving or parboiling process. The study also evaluated the storage stability of rice bran in terms of free fatty acid values.

Materials and methods

Production of rice bran

Rice bran was obtained from milling of paddy with the 2-tonne capacity rice mill at MARDI station, Bukit Raya, Kedah. The paddy variety, MR 220 was obtained from MARDI station at Tanjung Karang.

A sample of 1,000 kg at 14% moisture content was dehusked by a rubber roll huller (model Satake, Japan). The mixture comprising brown rice and paddy was separated by a paddy separator. Brown rice (approximately 750 kg) obtained from the paddy separator was milled by a horizontal abrasive whitener (model Satake, Japan). The bran was produced from brown rice that was milled at either 4% or 8% milling degree (MD). These brans were produced through adjustments of a steel weight-load and flow rates (Wahid et al. 1997).

Milling degrees at 4% and 8% were chosen for the purpose of the study as earlier study (Rosniyana et al. 2005) had indicated that rice bran produced at 4% was the most nutritious compared to brans produced at other milling degrees. Rice bran milled at 8% MD is commonly produced in commercial milling (Bor et al. 1991).

Stabilisation of rice bran

Rice bran and paddy were subjected to stabilisation process by autoclaving and parboiling respectively. Rice bran was autoclaved by using commercial retort at 120 °C for 20 min. These parameters were selected based on a preliminary study which indicated the optimum condition to inactivate lipase in the bran. To obtain parboiled rice bran, the paddy was initially soaked (2 h) and steamed (20 min) followed by drying and milling (Saunder 1990). The hull was then removed, followed by removal of bran to yield parboiled white rice and bran. Autoclaved and parboiled rice brans were dried at 60 °C to reduce the moisture content to less than 5%. Both treatments at each MD were performed in triplicates.

Storage study and sampling

The dried rice brans were packed in laminated bags made of oriented polypropylene/polypropylene (OPP/PP) and polypropylene (PP) which acts as a control packaging material. To study the effect of packaging technique, the samples were also vacuum packed in OPP/PP bag and compared with samples which were packed in non-vacuum OPP/PP bag.

Unstabilised rice bran (control sample) was also packed in similar packaging materials and techniques. All samples were stored under ambient temperature. The unstabilised rice brans were evaluated every day while the stabilised rice brans were evaluated every 2 weeks. These samples were evaluated for free fatty acids values and moisture contents.

Chemical analysis

Samples of stabilised rice bran were 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, ashing was done at 550 °C to constant weight, and 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. (Pulau Pinang) according to the method by AOAC (1993). Each analysis was done in duplicate. Carbohydrate was calculated by subtracting the values of moisture, protein, crude fibre, fat and ash, from 100.

Experimental design and data analysis

Each stabilisation process and experimental condition was done in three 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 composition

Proximate compositional values for the stabilised bran are presented in *Table 1*. The chemical composition of stabilised bran is predominantly (75%) carbohydrate, fat and protein. Others are crude fibre, ash and water. The proximate constituents and their levels are comparable with that shown by Saunder (1990). The proximate content of rice bran varies depending on the amount of breakage and degree of milling and this has been discussed in the earlier paper (Rosniyana et al. 2005).

The protein content was significantly higher in bran obtained from rice milled at 4% MD. The protein content which varied from 13.6% to 15.10% was comparable for bran stabilised by both techniques. These results were in agreement with that observed by Prakash and Ramanatham (1995). Normally, protein of rice bran has higher lysine content and lower glutamic acid content with a better balance of essential amino acids with an amino acid score of 80% lysine and 90% threonine (Prakash and Ramanatham 1995).

The fat content of the analysed rice bran ranged from 19.5–30.5%. These values were significantly higher in parboiled rice bran than in autoclaved rice bran. The fat content was higher (p <0.05) in parboiled rice bran milled at 4% MD but was the same with autoclaved rice bran milled at 8% MD. The fat content in parboiled rice bran was similar to that reported by Narasinga Rao (1988).

The soaking and steaming process actually hardens the kernel, such that almost no endosperm breakage occurs during milling (Saunder 1990). Hence, fat is higher in parboiled bran due to the absence of

Table 1. Proximate composition of stabilised rice bran

Composition (%)	Autoclaved rice bran		Parboiled rice bran	
	4%	8%	4%	8%
Moisture	5.13 ± 0.05a	4.96 ± 0.15a	5.02 ± 0.2a	5.60 ± 0.10a
Protein	14.69 ± 0.25a	13.60 ± 0.55b	15.10 ± 0.35a	13.60 ± 0.15b
Fat	19.50 ± 0.01c	19.40 ± 0.75c	30.45 ± 0.25a	25.50 ± 0.10b
Carbohydrate	45.20 ± 0.75b	47.14 ± 0.25a	25.91 ± 0.75d	34.42 ± 0.75c
Crude fibre	7.80 ± 0.15b	7.25 ± 0.75b	12.68 ± 0.25a	9.80 ± 0.10c
Ash	7.68 ± 0.0b1	7.65 ± 0.05b	10.84 ± 0.75a	11.08 ± 0.75a

Mean values in the same row with different letters are significantly different (p <0.05)

broken starch fragment. A study by Bera (1992) showed that three major fatty acids present in the rice bran are palmitic, oleic and linoleic which make up more than 90% of the total fatty acids.

The carbohydrates ranged from 25.9–47.1%. The major carbohydrates in bran are cellulose, hemicellulose and starch (Juliano and Bechtel 1985). The carbohydrate content in autoclaved bran (45–47%) was significantly higher than those obtained from parboiled rice (25–34%). The lower carbohydrates in parboiled rice bran might be due to the absence or lower starch fragments in the bran. At 8% MD, brans contained significantly higher carbohydrate from both stabilised techniques as compared to brans produced at 4% MD.

Ash was present in the range of 7.7–11.1%. The high content in ash contributed to its mineral contents (Juliano and Bechtel 1985). The ash contents showed significant difference between treatments but insignificant difference between MD of the same treatments. Higher values of ash contents in parboiled rice bran were due to the contributory effect of parboiling which resulted in less endosperm contaminants during milling.

The minerals were present in varied amounts *(Table 2*). Results indicated that rice bran was a source of minerals and the same finding was also observed by Bor (1991). Phosphorus was one of the major mineral constituents of bran (1,180–1,830 mg). These values were significantly higher in bran produced at 8% MD. Also present in decreasing order were potassium, magnesium, calcium, sodium and iron. Analysis of the six minerals showed the levels for all minerals except phosphorus were significantly (p <0.05) higher in parboiled rice bran compared to autoclaved bran.

Retention of phosphorus and iron was higher in bran produced at 8% MD, but calcium, magnesium, sodium and potassium were comparable at 4% MD. Results suggested that the concentration of minerals in bran varies with the degree of milling and techniques (Saunder 1990). Hegested et al. (1990) indicated that the low sodium and high potassium content can perhaps be useful supplement in diets for hypertension.

Rice bran is also a rich source of B-complex vitamins (*Table 3)*, particularly thiamine and pyridoxine. Riboflavin and niacin contents, however, appear to be on a lower side. Except for thiamine, the vitamin contents differed significantly in both treated rice brans. Parboiled rice bran had significantly higher riboflavin, pyridoxine and niacin than autoclaved rice bran. The variation in vitamin content reflects the degree of milling and possible hull contamination (Hammond 1994).

The ranges for soluble and total dietary fibre for both parboiled and autoclaved rice bran are shown in *Tables 3*. The amount present can meet the recommended dietary fibre intake of an adult which is about 25 g a day (WHO 1990). Parboiled rice had the highest dietary fibre (23.5%) and the value

Table 2. Mineral composition of stabilised rice bran

Composition (mg/100 g)	Autoclaved rice bran		Parboiled rice bran	
	4%	8%	4%	8%
Calcium	54 ± 0.05b	55 ± 0.15b	62 ± 0.7a	61 ± 0.75a
Iron	14 ± 0.75d	19 ± 0.75c	23 ± 0.15b	30 ± 0.25b
Magnesium	823 ± 0.25d	845 ± 0.15c	952 ± 0.25a	940 ± 0.25b
Sodium	24 ± 0.25b	25 ± 0.15b	28 ± 0.05a	28 ± 0.75a
Potassium	1170 ± 0.25c	1200 ± 0.75b	1350 ± 0.75a	1340 ± 0.25a
Phosphorus	1180 ± 0.05b	1830 ± 0.25a	1710 ± 0.25b	1800 ± 0.15a

Mean values in the same row with different letters are significantly different (p <0.05)

Table 3. Vitamin composition and selected phytochemicals of stabilised rice bran

Composition (mg/100 g)	Autoclaved rice bran		Parboiled rice bran	
	4%	8%	4%	8%
Thiamine	2.4 ± 0.25a	2.3 ± 0.05a	2.4 ± 0.75a	2.2 ± 0.05a
Riboflavin	0.25 ± 0.05c	0.27 ± 0.75b	0.30 ± 0.75a	0.29 ± 0.05a
Pyridoxine	3.4 ± 0.75d	3.7 ± 0.05c	4.2 ± 0.15a	4.0 ± 0.75b
Niacin	30 ± 0.25c	36 ± 0.25b	37 ± 0.75a	37 ± 0.05a
Dietary fibre (g)	23.3 ± 0.05a	22.4 ± 0.75a	23.5 ± 0.15a	20 ± 0.25b
Soluble fibre (g)	2.1 ± 0.75a	1.9 ± 0.05a	2.2a	2.0 ± 0.75a
Tocopherol	4.8 ± 0.75d	6.0 ± 0.75a	5.6 ± 0.25b	5.3 ± 0.25c
Oryzanol (Ferulic acid ester)	1.1 ± 0.25c	0.9 ± 0.05c	2.2 ± 0.15a	1.9 ± 0.25b

Mean values in the same row with different letters are significantly different (p <0.05)

showed insignificant difference with that of autoclaved rice brans. However, significant difference was observed between brans produced at 4% and 8% MD. Dietary fibre in rice bran includes cellulose, hemicellulose and pentosan which are all insoluble (Thompson and Weber 1981). It also contains 2% soluble dietary fibre.

Phytochemicals analysed were tocopherol and oryzanol. The analysed samples contained oryzanol in the range of 0.9–2.2 g/100 g. These results were in general agreement with the work by Rong et al. (1999). It was reported that at this level of 1 g/100 g rice bran oil was considered the richest source of these compounds. Results indicated that the amount of tocopherol and oryzanol detected were significantly different among the analysed samples.

Storage study

Changes in free fatty acids as function of storage time are presented in *Figure 1*. The initial free fatty acid values (FFA) of bran from unstabilised sample was 2.25% and increased to 27.0–30.1% after 8 days of storage. Similar observation was reported by Bhandari (1981). He stated that within 7 days, the level of FFA is found to rise up to 10% and increases to 25% within a month. In another report by Azeemoddin and Thirumala Rao (1984), the development of FFA with time prior to food application

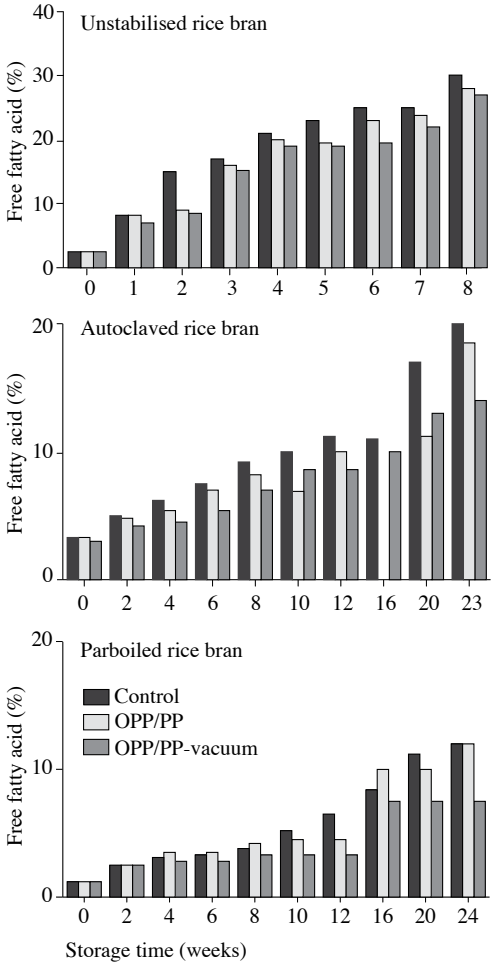

Figure 1. Free fatty acid values of unstabilised rice bran, autoclaved rice bran and parboiled rice bran during storage

causes deterioration of the bran quality with time. The deterioration is due to the conversion of oil in the presence of water to FFA and the reaction is generally catalysed by enzyme lipase in the rice bran.

After 4 months of storage, the FFA content of the autoclaved rice bran samples in the sealed packaging bags under ambient conditions, increased from 3.3% to 12.4, 10.2 and 9.8% (PP, OPP/PP and OPP/PP-vacuum respectively) (*Figure 1*). The FFA in stabilised bran was lower than unstabilised rice bran caused by the thermal inactivation of lipolytic enzyme (Mishara and Mukhejee 1992). Moist heat temperature with the temperature at the boiling point of water will instantaneously inactivate the enzyme. Other study had indicated that heat treatment of rice temperature at 110 °C for 20 min is considered to be the optimum in keeping the FFA content of the treated rice bran below 10% for 60 days (Chakraverty and Devadattam 1987).

From the results, the stabilisation by parboiling process was able to maintain the FFA value below 10% for 6 months when kept in OPP/PP-vacuum. It was suggested that the localisation of the lipase in the peripheral testa-cross layer of the rice grain might explain the efficient heat inactivation of paddy as compared to that of rice bran as reported by Juliano and Bechtel (1985). Peroxidase activity is totally inactivated during steaming step of parboiling (Barber et al. 1884). Results also indicated that oxidative rancidity is still a cause for concern, and is best addressed by an optimal combination of processing conditions, packaging and storage.

The initial moisture content of control samples was 4.6% and increased to 13.5–18.5% after a storage period of 8 days *(Table 4)*. Studies clearly indicated that the moisture content played a major role in hydrolysis of rice bran oil and in the growth of lipase-producing insects, moulds and micro flora in the bran as reported by Viakatmath et al. (1972).

The moisture contents stored in sealed packaging material went up from 4.9% to 9.7–10.8% for autoclaved bran and 5.0% to 7.6–8.8% for parboiled rice brans (*Tables 5* and *6*). The moisture content of unstabilised rice bran increased from 4.6% to 13.5–18.5% after 9 days of storage. Chakraverty and Devadattam (1992) found out that the moisture content of bran showed an increase in PP (control packaging) storage due to free exchange of air with atmosphere. 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 were essential in protecting stabilized bran against deterioration by the action of moisture and oxygen.

Conclusion

Study indicated that rice bran was rich in fat, protein, mineral, vitamin, tocopherol and oryzanol. As parboiled rice bran had significantly higher in the nutritional contents than autoclaved rice bran, it is recommended to use parboiled rice bran in food application which will produce more nutritious products. Study showed that the storage of rice bran could be extended to 4 months and 6 months by the process of autoclaving and parboiling respectively. The extension of storage period was probably the denaturizing of lipase during thermal processing. The study also found that the application of packaging technique would also give an important role in arresting the oxidative rancidity.

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Table 4. Moisture contents (%) of unstabilised rice bran during storage

Packaging materials	Storage period (day)								
	0	1	3	4	5	6	7	8	9
PP	4.6 ± 0.2	8.8 ± 0.5	10.5 ± 0.2	12.8 ± 0.4	13.5 ± 0.4	14.7 ± 0.4	16.8 ± 0.5	17.5 ± 0.2	18.5 ± 0.5
OPP/PP	4.6 ± 0.4	8.2 ± 0.4	9.8 ± 0.5	11.8 ± 0.5	12.5 ± 0.2	13.8 ± 0.5	14.5 ± 0.5	14.8 ±0.4	15.5 ± 0.2
OPP/PP-vacuum	4.6 ± 0.5	7.5 ± 0.2	8.8 ± 0.4	11.0 ± 0.5	11.5 ± 0.4	11.8 ± 0.4	13.0 ± 0.2	13.1 ± 0.4	13.5 ± 0.2

Table 5. Moisture contents (%) of autoclaved rice bran during storage

Packaging materials	Storage period (week)									
	0	2	4	6	8	10	12	16	20	24
PP	4.9 ± 0.5	6.3 ± 0.5	7.9 ± 0.4	8.0 ± 0.2	8.4 ± 0.2	8.6 ± 0.4	9.3 ± 0.5	9.7 ± 0.5	9.5 ± 0.2	10.8 ± 0.5
OPP/PP	4.9 ± 0.4	5.9 ± 0.5	7.5 ± 0.5	7.8 ± 0.5	7.8 ± 0.4	8.3 ± 0.5	8.8 ± 0.4	9.4 ± 0.2	8.8 ± 0.4	10.7 ± 0.2
OPP/PP-vacuum	4.9 ± 0.2	5.5 ± 0.5	6.8 ± 0.4	6.8 ± 0.2	7.1 ± 0.5	7.3 ± 0.5	7.9 ± 0.2	8.5 ± 0.5	8.1 ± 0.5	9.7 ± 0.4

Table 6. Moisture contents (%) of parboiled rice bran during storage

Packaging materials	Storage period (week)									
	0	2	4	6	8	10	12	16	20	24
PP	5.0 ± 0.4	6.6 ± 0.5	7.3 ± 0.4	7.9 ± 0.2	8.2 ± 0.4	8.3 ± 0.5	8.2 ± 0.5	8.1 ± 0.4	8.1 ± 0.4	8.8 ± 0.2
OPP/PP	5.0 ± 0.5	6.2 ± 0.4	7.6 ± 0.2	7.7 ± 0.2	7.9 ± 0.5	8.1 ± 0.2	8.0 ± 0.4	7.9 ± 0.5	7.9 ± 0.2	8.7 ± 0.4
OPP/PP-vacuum	5.0 ± 0.2	5.3 ± 0.2	5.9 ± 0.5	6.3 ± 0.5	6.3 ± 0.2	6.7 ± 0.5	6.9 ± 0.4	7.0 ± 0.2	7.1 ± 0.5	7.6 ± 0.5

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Abstrak

Zat pemakanan dedak beras pada darjah pengilangan 4% dan 8% telah distabilkan dengan proses pengautoklafan dan *parboiling*. Dedak beras diautoklafkan dengan menggunakan retort pada suhu 120 °C selama 20 minit. Untuk menghasilkan dedak beras secara *parboiling,* padi direndam selama 2 jam dan dikukus selama 20 minit sebelum dikeringkan dan dikisar. Nilai lemak, serabut, abu, kebanyakan galian dan vitamin pada dedak dari proses *parboiling* adalah lebih tinggi daripada yang diproses secara pengautoklafan. Kandungan asid lemak bebas di dalam dedak daripada kedua-dua proses di bawah aras 10% yang dibenarkan, selepas disimpan 6 bulan (*parboiling*) dan 4 bulan (pengautoklafan) di dalam bungkusan OPP/PP, sama ada divakum atau tidak, pada suhu ambien. Penyimpanan dedak beras di dalam bungkusan PP, sebagai kawalan, menghasilkan asid lemak bebas dengan cepat. Kajian ini menunjukkan dedak beras boleh disimpan tanpa sebarang kerosakan untuk tempoh yang agak lama sebelum digunakan untuk menghasilkan produk makanan kesihatan.

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