



Processing Raw Rice Bran to Potential Functional Food for Human Consumption

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10.18805/ajdfr.DR-2233

ABSTRACT

Background: Rice bran despite its nutritious value is largely underutilized. It is partly used for edible oil extraction and as animal feed or discarded as garbage. The present study was carried out with the objective of developing rice bran into a functional food ingredient for human consumption.

Methods: The collected rice bran was exposed to four different treatments that included application of edible acid for activation of phytase, followed by drying at different temperatures to inactivate lipase. Standard biochemical methods were used to analyze the nutrients, anti nutrients and acid value.

Result: Processing led to the reduction of phytic acid up to 43.6% and acid value up to 85.2% in comparison to raw rice bran (control) together with observation of absence of microbial load. Moreover, the processing led to the development of potential functional product with the better retention of ash, fiber, phenolic compound and crude protein content of the raw rice bran. The organoleptic evaluation revealed that the processed product can be utilized as ready-to-cook food ingredient, which might help to improve nutrition.

Key words: Acid value, Phytic acid, Potential functional food, Processing, Rice bran.

INTRODUCTION

Rice holds a central role as the primary cereal in Asia, serving as a fundamental dietary staple for the majority of the population. Its significance extends globally, contributing to over 21% of the world's caloric needs and comprising up to 76% of the caloric intake for people in Southeast Asia (Zhao *et al.*, 2020). The milling process of paddy produces a primary product of rice (endosperm) accounting for 70% of the yield. Additionally, it generates by-products in the form of 20% husk, 8% bran and 2% germ (Van Hoed *et al.*, 2006). Rice bran consists of the pericarp, aleurone and sub-aleurone layers, seed coat, a portion of the germ and a small amount of the starchy endosperm (Kumari *et al.*, 2018). It is a rich and natural source of various essential nutrients, including protein (1416%), fat (12-23%), crude fiber (8-10%), carbohydrates, vitamins, minerals, vital unsaturated fatty acids and phenolic compounds. Moreover, rice bran contains significant quantities of natural antioxidants like tocopherols, tocotrienols and γ -oryzanol, which are recognized for their cholesterol-lowering effects and their potential to reduce the risk of diseases associated with oxidative stress, such as cancer, cardiovascular issues, inflammation, *etc.* (Rashid *et al.*, 2015). It is also an excellent source of vitamins E and B (Adanse *et al.*, 2022). Rice bran is considered a functional food due to its high content of bioactive compounds like fiber, antioxidants, vitamins and essential fatty acids. These components contribute to various health benefits, such as improved cardiovascular health, better digestive function and reduced inflammation (Alauddina *et al.*, 2017). Even though rice bran is packed with valuable components such as oil, protein, fiber and

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How to cite this article: Baruah, D., Das, P., Nath, T., Neog, B. and Barooah, M.J. (2025). Processing Raw Rice Bran to Potential Functional Food for Human Consumption. Asian Journal of Dairy and Food Research. 1-6. doi: 10.18805/ajdfr.DR-2233.

Submitted: 14-05-2024 **Accepted:** 26-11-2024 **Online:** 06-02-2025

various functional compounds, it remains underutilized, despite its exceptional nutritional advantages and promising applications in the food industry. Currently, India processes only 5 million tonnes out of the 9.8 million tonnes of rice bran, which represents just half of its total potential, with the remainder being used directly as cattle feed (Kumar *et al.*, 2022). It is due to the presence of high amount of phytic acid which makes some minerals unavailable and instability during storage. The instability of rice bran is caused by the presence of lipase enzyme in the outer layers of the rice kernel. The lipases play a key role in breaking down triglycerides into glycerol and free fatty acids. However, these free fatty acids are harmful

compounds that make rice bran unsuitable for human consumption due to its lowered pH and rancid flavor. A few studies on rice bran exposed the possibility of utilization of it as human food (Van Hoed *et al.*, 2006). However, considering lack of safe and cost-effective method to process large volume of rice bran for human consumption, the present study was carried out. The objective of the study was to develop a method for preparation of stabilized rice bran that has the potential of a functional food, such that the otherwise lost nutrients of rice bran can be utilized for preventing malnutrition in the population, which is still a challenge in developing countries. Functional food can be defined as a foodstuff that provides a health benefit beyond basic nutrition, demonstrating specific health or medical benefits, including the prevention and treatment of disease (FAO, 2001).

MATERIALS AND METHODS

The study was conducted during the year 2021-2022. Rice bran of the variety *Mahsuri* was collected from the milling unit of the Department of Agricultural Engineering, Assam Agricultural University, Jorhat. Just after milling, the rice bran was collected in food grade polyethylene bags and carried immediately to be vacuum packed and stored at ambient condition till further processing.

The rice bran sample which was not processed at all was analyzed as Control. The second lot of rice bran (500 g) was treated with 0.2% citric acid solution (1250 ml) for 18 hrs at ambient condition (26°C), followed by drying half of the amount at 40°C (T1) and the rest at 80°C (T3). The third lot (500 g) was treated with a solution (1250 ml) of 0.2% citric acid containing 0.005% phytase (Anfotal Nutritions Pvt. Ltd., New Delhi India) for 18 hrs at ambient condition (26°C) maintaining hygiene and then dried half of the amount at 40°C (T2) and the rest at 80°C (T4). Drying was done using dehydrator till the products were free flowing. The products were powdered using a mixer grinder and then stored at 4°C in a food grade plastic container until analysis.

The percentage moisture content, total ash, crude fat and crude protein were determined based on the official methods of analysis (AOAC, 2000). The acid value of crude fat was determined by the method given by Cox and Pearson (1962). The crude fiber content was determined by the method given by Maynard, (1970). Carbohydrate was determined by difference. The total phenol was estimated

by using Folin-Ciocalteu reagent (Iqbal *et al.*, 2005). The phytic acid content was also determined by the method given by Wheeler and Ferrel (1971). Nutrient agar and potato dextrose agar was used as media to check the bacterial and fungal growth, respectively. Both the media were prepared by mixing the nutrient agar and potato dextrose agar separately in water in a conical flask and then heating them in a microwave oven until they are dissolved properly. Then, the mouth of the conical flask was sealed by non-absorbent cotton plug. These were then autoclaved for sterilization. After that, 1 g of the sample was dissolved in 10 ml of sterile water and mixed thoroughly by vortexing and serial dilution was formed. (FSSAI, 2014).

Three food items were prepared traditionally with and without processed rice bran (T3) which were subjected to organoleptic evaluation. The items made were “kheer” (50g rice + 5g T-3), “khichdi” (50g rice and dal mixture (1:1) + 5g T-3) and “Soup” (11g soup powder + 1.1g T-3). The rice bran processed product (T3) was added at the rate of 10%, w/w of the main ingredients because it would replace the lost nutrients of the cereals if these were polished up-to 10%. The organoleptic evaluation was carried out by 20 semi-skilled people and the mean score for each of the sensory attributes of the three items were calculated.

The rice product processed through only T-3 (with 22.2% reduction in PA) was used for organoleptic evaluation because it was devoid of phytase treatment. Due to lack of certified phytase to be used for human food in the local market, the rice product developed through T-4 (where phytase for animal feed was added) was not used, though this product was found to contain the least amount of phytic acid.

All the analysis were done in triplicate and the average was calculated. The experiments were done in completely randomized design (CRD). The data were analyzed by one-way analysis of variance (ANOVA) using Microsoft excel (2007). The standard error of the mean difference, S.E(d) was calculated. The treatment means were compared among themselves by calculating critical difference (CD at $P < 0.05$).

RESULTS AND DISCUSSION

Moisture content (fresh basis)

The moisture content on fresh basis in the processed rice bran products ranged from 0.31% (T3, T4) to 2.80% (T1). However, the same in control was found to be 9.33% (Table 1).

Table 1: Moisture (%), fresh weight basis), crude fat, crude protein, total ash, crude fiber and total carbohydrate content (all in %, dry weight basis) of the processed rice bran products.

Treatments	Moisture (%)	Crude fat (%)	Crude protein (%)	Total ash (%)	Crude fibre (%)	Total carbohydrate (%)
Control	9.33 ^a	16.46 ^a	14.54	10.16	9.65 ^a	49.19
T1	2.80 ^b	16.51 ^a	14.55	10.09	9.54 ^a	49.30
T2	2.73 ^b	16.53 ^a	14.56	10.15	9.50 ^a	49.26
T3	0.31 ^c	17.53 ^b	14.55	10.08	8.80 ^b	49.04
T4	0.31 ^c	17.59 ^b	14.54	10.08	8.88 ^b	48.91
S.Ed(±)	0.06	0.06	-	-	0.15	-
C.D	0.15	0.13	-	-	0.33	-

The moisture content of raw rice bran aligned with previous result reported by Sadawarte *et al.* (2007), who reported fresh rice bran moisture content within the range of 6.61%-12.4%, while the findings for processed rice bran are consistent with Irakli *et al.* (2021) who reported the same for heat-stabilized rice bran to be in the range from 2.76% to 8.3%. However, the lower moisture content observed for rice bran processed through T3 and T4 might be due to exposure of the same at 80°C. Moisture content varies according to the drying temperature; more the drying temperature less is the moisture content (Abasi *et al.*, 2009).

Crude fat content

The crude fat content in the processed rice bran products ranged from 16.51% (T1) to 17.59% (T4). However, the same in control was found to be 16.46% (Table 1)

The crude fat content was found to be comparable to the results of Moongngarm *et al.* (2012), who found it to be in the range of 15.85% -18.8%. The findings for processed rice bran were found to be comparable to the results of Nusrat *et al.* (2019), who reported the crude fat content of rice bran under various heat treatment to be in the range of 10.31%-22.34%. However, the significantly higher crude fat content of the processed rice bran dehydrated at 80°C (T3, T4) than those dehydrated at 40°C (T1, T2) might be due to reduction in other components (crude fiber) within the ingredients.

Crude fibre content

The crude fibre content in the processed rice bran products ranged from 8.80% (T3) to 9.54% (T1). However, the same in control was found to be 9.65% (Table 1).

The results of crude fiber in the present study were found to be comparable to the results of Saunders (1985), who found the crude fiber content of rice bran to be in the range of 8%-10%. Siswanti *et al.* (2019) also reported decrease in crude fiber content from 10.63% in raw rice bran to 6.45% in heat stabilized rice bran. The decreased content of crude fiber might be due to hydrolysis of the fiber structure, the part of which was lost during analysis when they were dissolved in acid and base.

Crude protein content

The crude protein content in the processed rice bran products ranged from 14.54% (T4) to 14.56% (T2). However, the same in control was found to be 14.54% (Table 1).

The results of crude protein content of untreated rice bran was found to be consistent with the results of Wiset-komolmat (2022), who reported a range of 12.04%- 15.2%,

whereas, the findings for processed rice bran were consistent with Zaghlol *et al.* (2018) who reported the protein content of untreated, microwaved and dry heated rice bran to be 14.17%, 14.80% and 15.06%, respectively.

Total ash content

The total ash content in the processed rice bran products ranged from 10.08% (T4) to 10.15% (T2). However, the same in control was found to be 10.16% (Table 1).

The data for total ash content aligned with the results of Ju and Vali (2005) who reported the total ash content of

Table 2: Total phenol content (mg GAE/100 g, dry weight basis) of the processed rice bran products.

Treatment	Total phenol (mg GAE/100 g)
Control	185.86
T1	185.63
T2	184.56
T3	184.32
T4	183.25
SE(d)	-
C.D	-

Table 3: Acid value (mg KOH/g of crude fat) of the processed rice bran products.

Treatment	Acid value(mg KOH/g)
Control	39.87 ^a
T1	21.08 ^b (47.12%)
T2	21.16 ^b (46.92%)
T3	5.90 ^c (85.2%)
T4	5.90 ^c (85.2%)
S.Ed(±)	0.08
C.D	0.18

*Data in parentheses shows percentage reduction in acid value compared to control.

Table 4: Phytic acid content (g/100 g, dry weight basis) of the processed rice bran products.

Treatment	Phytic acid (g/100 g)
Control	3.46 ^a
T1	2.79 ^b (19.36%)
T2	2.40 ^b (30.63%)
T3	2.69 ^b (22.2%)
T4	1.95 ^c (43.6%)
SE(d)	0.02
C.D	0.01

*Data in parentheses shows percentage reduction in phytic acid compared to control.

Table 5: Microbial load (both bacteria and fungi) analysis of processed rice bran products.

Dilution	T1	T2	T3	T4
Stock	Nil	Nil	Nil	Nil
10 ⁻¹	Nil	Nil	Nil	Nil
10 ⁻²	Nil	Nil	Nil	Nil
10 ⁻³	Nil	Nil	Nil	Nil

rice bran to range from 8% to 17%. Irakli *et al.* (2021) found the ash content of heat-stabilized rice bran to be between 8.94% and 9.0%. However, the results for processed rice bran in the present investigation (10.08-10.16%) slightly differed which could be attributed to differences in rice varieties, milling processes and processing methods employed.

Total carbohydrate content

The total carbohydrate content in the processed rice bran products ranged from 48.91% (T4) to 49.30% (T1). However, the same in control was found to be 49.19% (Table 1).

The result regarding the total carbohydrate content in the present study was found to be comparable to the result of Siswanti *et al.* (2019), who found the total carbohydrate content of heat stabilized rice bran to be in the range of 35.97%-50.03%.

Total phenol content

The total phenol content in the processed rice bran products ranged from 183.25 mg GAE/100 g (T4) to 185.63 mg GAE/100 g (T1). However, the same in control was found to be 185.86 mg GAE/100 g (Table 2).

The results for phenol content (Table 3) were found to be comparable with results of Ghasemzadeh *et al.* (2018), who found the total phenol content of rice bran to be in the range of 153.30mg GAE/100 g–771.15 mg GAE/100 g and Saji *et al.* (2019), who reported the range of total phenol content of rice bran to be 160.65 mg GAE/100 g - 222.94 mg GAE/100 g.

Acid value

The acid value of crude fat in the processed rice bran products ranged from 5.90 mg KOH/g fat (T4) to 21.16 mg

KOH/g fat (T2). However, the same in control was found to be 39.87 mg KOH/g fat (Table 3).

The results for acid value in the present study (Table 4) was found to vary significantly which aligned with the results of Wu *et al.* (2020), who found the acid value of rice bran oil with storage time 0, 1, 3, 5 and 10 days in the range of 4.31 -38.72 mg KOH/g on dry weight basis. The total decrease in acid value in T1 (47.12%) and in T2 (46.92%) in comparison to control might be attributed to the effect of citric acid as pH value 4 was sufficiently less than optimum for lipase. Meanwhile, the substantial reduction, up to 85.2%, in both T3 and T4 appears to be a result of the combined impact of citric acid and the elevated drying temperature (80°C). This combination effectively deactivated lipase enzymes, leading to the significant decrease in acid value. According to Aizono *et al.* (1973), lipase has an optimum activity at pH 7.5-8.0 and temperature 37°C.

Phytic acid content

The phytic acid content in the processed rice bran products ranged from 1.95 g/100 g (T4) to 2.79 g/100 g (T1). However, the same in control was found to be 3.46 g/100 g (Table 4).

The results of phytic acid in the present study (Table 5) were found to be comparable to the results of Moongngarm *et al.* (2012), who reported the same in rice bran to be in the range of 3.5 g/100 g -5.0 g/100 g on dry weight basis. Irakli *et al.* (2021) reported the phytic acid content of various heat stabilized rice bran to be in the range of 20.04 mg/g - 21.06 mg/g on dry weight basis. In the present study, the reduction of phytic acid content in comparison to control (from 19.36% in T1 to 22.2% in T3 and 30.63% in T2 to 43.6% in T4) might be due to action of endogenous and both endogenous and exogenous phytase, respectively.

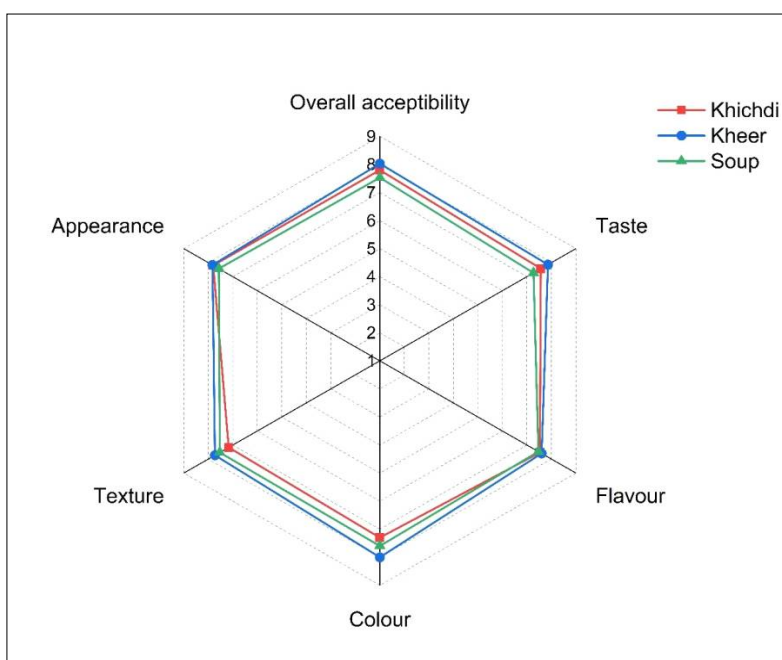


Fig 1: Radar plot of the sensory attributes of the three products prepared from T3.

Addition of phytase led to reduction of more phytic acid. During processing, citric acid was added to lower the pH to 4 from pH 6 in raw rice bran. This might have increased the activity of both endogenous and applied phytase. Ragab *et al.* (2000) reported that the phytase had an optimum activity at pH 5 and temperature 50°C.

Microbial load

Both bacterial and fungal growth were absent in the four differently processed rice bran products (Table 5). The observed absence of bacterial and fungal load might be due to the application of citric acid within the permissible limit (0.2% w/w) and due to very low moisture content of the treated bran samples.

Organoleptic evaluation

The mean score for the overall acceptability of the three items prepared from processed rice bran (T3) was found to be 8.03 (highest) for “kheer” followed by “khichdi” (7.80) and “soup” (7.53) (Fig 1). The earlier results of Sharif *et al.* (2009), involving preparation of cookies incorporating microwave-stabilized defatted rice bran into standard wheat flour at various levels of supplementation indicated that defatted rice bran could be effectively substituted for 10% to 20% of wheat flour without compromising their quality attributes.

CONCLUSION

The present study revealed that when compared with raw rice bran, pretreatment of rice bran with citric acid, followed by heat treatment can lead to development of a potential functional product being lower in phytic acid and acid value, together with retention of ash, fiber, phenolic compound and crude protein content. Thus, it can be concluded that the rice bran processed through present method might be having applicability against malnutrition prevailing in developing countries.

ACKNOWLEDGEMENT

We would like to offer sincere thanks to Assam Agricultural University, Jorhat, Assam, India for providing the necessary facilities.

Conflict of interest

Authors declare that they have no conflict of interest.

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