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Nutritional Composition and Stabilization of Local Variety Rice Bran BRRI-28

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ABSTRACT

Rice bran is a valuable by-product of the rice milling industry, a good natural source of many vital nutrients but has some limitations in food application. It is highly susceptible to rancidity caused by the inherent enzyme lipase and there is an unfounded fear that the rice bran may contain silica in an amount and make it unsuitable for human consumption. In the present investigation, cold treatment was used to extend the shelf life of local variety parboiled rice bran and was also directed to assess the nutritional composition and silica content. The rancidity in term of free fatty acid (FFA) was less increased 0.104 to 0.74 % (7 fold) in cold treated parboiled rice bran than untreated rice bran 0.104 to 2.90 % (28 fold) at the end of 3 months of storage period. The silica content was ranged from 0.34-0.71 % in different fractions of rice bran samples. The nutritional composition of the stabilized rice bran was analyzed that contained 6.54-9.48 % moisture, 7.24-10.63 % ash, 12.26-14.01% proteins, 23.53-27.86 % fats, 2.5-10.10 % fiber, 42.19-45.74 % carbohydrate and 456.54-486.00 Kcal/100g energy. The different fractions of rice bran contained 8 - 14 mg/100 g of Fe, 425 – 940 mg /100 g of Mg, 4.65 – 6.68 mg /100 g of Zn and 35 – 62 mg/ 100 g of Ca. The vitamin B_1 (Thiamin), B_3 (Niacin) and B_6 (Pyridoxine) content ranged from 14 – 24, 275 – 430 and 25 – 42 ppm respectively in different fractions of rice bran. Results indicated that cold treatment might effectively improve the self life of rice bran that contained a good amount of vital nutrients for health benefit and is useful in many food applications such as food supplement and edible oil extraction.

Keywords: *Rice bran, cold treatment, self life, rancidity, parboiled, nutritional composition.*

I. INTRODUCTION

Rice processing or milling produces several streams of material, including husks, milled rice, and bran. Rice bran, a by product of rice milling industry is an indispensable, less expensive abundantly available as soft and fluffy off-white powdery material, during the milling period. It constitutes 8 % of the weight of the whole grain that contains most of the nutrients (65 %). During milling process rice containing nutrients is completely removed with bran (Saunders 1990). Around 60 million metric tons of rice bran is produced worldwide each year. Current production of paddy is 40 million metric tons (MT) in Bangladesh which yields around 27 million MT of white, polished rice along with 3 million MT of crude rice bran (BBS 1999). Most of the rice bran is used as fuel for cooking purposes and or in boilers with husks but a good quality edible oil could be produced from it that could meet about 50 % of total consumption of the country. Bangladesh is deficit in edible oil and locally produced oil hardly meet 30 % of country's total needs. Over 10,000 million taka is necessary to meet the import bills of edible oil. Rice bran produced from slightly modified rice mills could substitute for a huge quantity of the imported edible oil every year.

Rice bran is an incredible source of the vitamins, minerals, amino acids, essential fatty acids, dietary fiber and more than 100 antioxidant nutrients that helps to fight against disease and promote good health (Fatemeh Malekean *et al.*2000). Lloyd et al (2000) reported that rice bran contained high amount of beneficial antioxidants including tocopherols and oryzanols. It is a rich source of B-vitamins and minerals such as phosphorus, potassium, iron, copper and zinc. The protein found in rice bran is reported approximately 12-15 % (Faiyaz *et al.* 2007).The amino acid profile of rice bran has been generally reported to be superior to cereal grain proteins (Farrell 1994). The protein of rice bran has relatively high nutritional value. The interesting characteristic of rice bran protein is that it is composed of high amount of lysine, an essential amino acid (Sudarat *et al.* 2005). Rice bran oil is an excellent cooking medium because of nutritional superiority, abundant micronutrients longer shelf life as well as stability at higher temperature, better taste flavour to food items (Sharma, 2002).
Apart from the nutritional benefits of rice bran it has anti nutritional factors. Lipases are enzymes present naturally in paddy which are become active and rapidly hydrolyzed the unsaturated fat into free fatty acids and glycerol. These fatty acids are oxidized by atmospheric oxygen and become rancid (Faiyaz *et al.* 2007). The rancid oil and their related products are toxic therefore are considered anti nutritional factors that

reduce the shelf life of the bran. This high instability is the problem to incorporating rice bran in food applications. Stabilization of rice bran can helps to overcome the problems. In view of these, the main objective of the present study is to determine the nutritional composition of local variety (BRRI-28) parboiled rice bran that has been stabilized by cold treatment. It also evaluated the shelf life of stability of the rice bran in terms of free fatty acid.

II. MATERIALS AND METHODS

The present experiment was carried out at Cereal Technology Laboratory, Institute of Food Science Technology (IFST), Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka 1205, Bangladesh.

Sample Collection and Preparation

Freshly milled rice bran of parboiled paddy, BRRI-28 variety was obtained from Rashid Agro Food Products Ltd at Poradah, Ballobpur, Kushtia, Bangladesh. The collected bran was processed within 1/2 h of collection to inactivate the endogenous lipase enzyme and denature the trypsin inhibitors. To achieve this objective the bran subjected to cold treatment. Before starting this experiment, the rice bran of the first, second, third and silky polishes have been screened through 80-mesh screen.

Stabilization of Rice Bran

To obtain parboiled rice bran, the BRRI-28 variety of paddy was soaked and steamed followed by drying and milling (Saunder 1990). The bran was then removed to yield parboiled white rice through 2-3 cycles polishing. All the fractions of rice bran were subjected independently to cold treatment for stabilization. For the cold treatment process, 500g of collected rice bran was placed in an airtight zip lock polythene covered bag, and kept under ice immediately after the milling process. Then it stored in refrigerator at -20^{o}C for further analysis. The same fraction of rice bran was also kept at room temperature for same period of time as a control (untreated bran).

Shelf-life of Rice Bran

The stored samples were assessed in triplicates for free fatty acid (FFA) content at 15 day intervals for a period of 90 days. FFA was determined by the titrimetric procedure by titrating against potassium hydroxide (1 mol L^{-1}) after extracting with hot neutral alcohol (AACC, 1983).

Proximate Composition

The proximate composition of all the fractions of BRRI-28 variety parboiled rice bran was carried out as follows:

Moisture Content

Moisture content was determined by oven-dry method as the loss in weight due to evaporation from sample at a temperature of 100 ± 2 ^{0}C. The weight loss in each case represented the amount of moisture present in the sample.

Moisture (%) = {(Weight of original sample – weight of dried sample)} × 100
/ (Weight of original sample)

Crude Protein

The crude protein content was determined following the micro Kjeldahl method (AOAC 2005). Percentage of nitrogen (N) was calculated using the following equation.

Nitrogen (%) = {(S-B) × N × 0.014 × D× 100} / (weight of sample × V)

Where D = Dilution factor, T = Titration value = (S-B), W = weight of sample, 0.014 = Constant value. Crude protein was obtained by multiplying the corresponding total nitrogen content by a conventional factor of 6.25. Thus crude protein (%) = % of N × 6.25.

Crude Fat

Crude fat was determined by the Soxhlet extraction technique followed by AOAC (2005). Fat content of the dried samples can easily extracted into organic solvent (petroleum ether) at 40-60^{0}C and followed to reflux for 6 h. Percentage of fat content was calculated using the following formula.

Crude Fat (%) = Weight of fat in sample × 100/ Weight of dry sample.

Ash Content

Ash content was determined by combusting the samples in a muffle furnace at 600^{0}C for 8 h according to the method of AOAC (2005).

Ash content (%) = Weight of Ash × 100/ Weight of sample

Acid Insoluble Ash (silica)

Acid insoluble ash was determined by adding 25 ml of dilute HCI to the ash and boiled for 10 minutes and then filtered, incinerate, cool and weight according to the method of AOAC (2005).

Crude Fiber

The bulk of roughage in food is referred to as the fiber and is called crude fiber. Milled sample was dried, defatted with ethanol acetone mixture and then the experiment was carried out using the standard method as described in AOAC (2005).

Crude Fiber (%) = (Weight of residue – weight of Ash) × 100 / Weight of sample.

Carbohydrate

The carbohydrate content was estimated by the difference method. It was calculated by subtracting the sum of percentage

of moisture, fat, protein and ash contents from 100% according to AOAC (2005).
Carbohydrate (%) = 100 – (moisture% + Fat % + Protein % + Ash %)

Total Energy

The total energy value of the food formulation was calculated according to the method of Mahgoub (1999) using the formula as shown in equation:
Total energy (kcal/100g) = [(% available carbohydrates X4.1) + (% protein X4.1) + (% fat X 9.3)]

Vitamin and Mineral

The vitamins thiamin (B_1), niacin (B_5) and pyridoxine (B_6) were analyzed according to the method of AOAC (1993). The minerals Fe, Mn, Zn and Ca were determined after acid digestion by using atomic absorption spectrophotometer according to the method of AACC (2000).

Statistical Analyses

Collected data obtained from various parameters of processed rice bran were subjected to statistically analysis using "SPSS (Version 12.00)" computer programmed to compute analysis of variance (ANOVA) techniques according to the method of Steel *et al*. (1997).

III. RESULTS

FFA in Rice Bran

The rate of free fatty acid formation in rice bran during their storage period has been shown in Figure1. The initial FFA content of parboiled rice bran (in all fractions of the variety) was around 0.104 % which was increased to 0.74 % (7 fold) by the end of the 90 days storage period under cold treatment. But in absence of any cold treatment, the rancidity in terms of FFA content of the parboiled rice bran was increased from 0.104 to 2.90 % (28 fold) during the 90 days storage period.

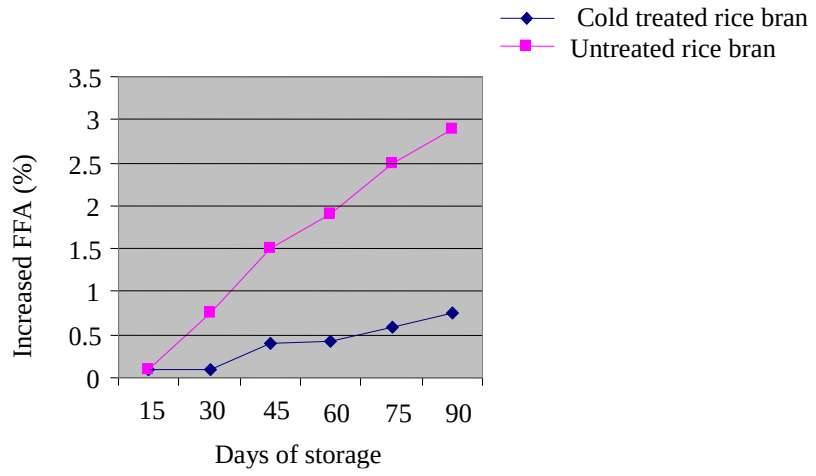

Figure 1. Storage stability of cold treated and untreated rice bran

Data represented as mean value of triplicate analysis

Silica in Rice Bran

The amount of silica existed in all rice bran has been presented in Figure 2. The acid insoluble ash in terms of silica content of all parboiled rice bran varied from 0.34 to 0.71%. It was highest (0.71%) in first polish followed by second polish (0.47%), third polish (0.35%) and silky polish (0.34%).

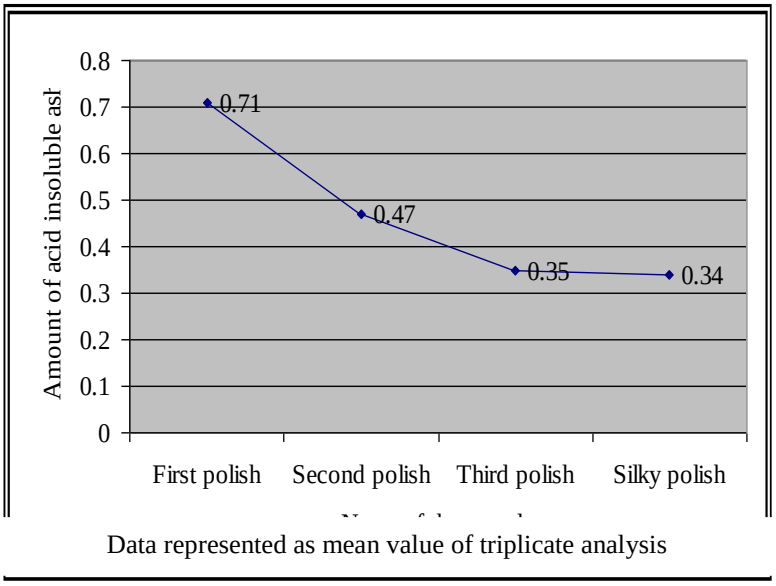

Fig. 2 Acid insoluble ash in rice bran

Proximate Composition of Rice Bran

Rice bran was chemically analyzed for their proximate compositions i.e. moisture, ash, crude protein, crude fat, crude fiber, crude carbohydrate and energy have been presented in Table 1. The moisture content of different fraction of parboiled rice bran was ranged from 6.54 to 9.48 %. The lowest and the highest moisture contents in parboiled rice bran were shown by the second polish (6.54%) and the silky polish (9.48%) respectively. The ash content of parboiled rice bran was ranged from 7.24 to 10.63 %. The bran of first polish showed the highest (10.63%) and silky polish showed the lowest amount (7.24%) of ash content. The protein content was highest (14.01%) in silky polish followed by second polish (13.60 %), third polish (12.97 %) and first polish (12.26%) . In the different fractions of parboiled stabilized rice bran, the fat content was ranged from 23.53 to 27.86 % where the lowest and the highest fat contents were showed by silky polish (23.53%) and third polish (27.86%) respectively (Table 1). The highest fiber content (10.10%) was observed in bran obtained from first polish and lowest (2.50%) in bran obtained from silky polish. The carbohydrate content of the parboiled rice bran ranged from 42.19 – 45.74 % (Table 1). The highest energy content was 486.00 Kcal in the bran of third polish followed by second (481.05 Kcal), silky (463.80 Kcal) and first polish (456.54 Kcal) respectively shown in table 1.

Table: 1. Proximate composition of stabilized rice bran

Name of the sample	Parameters tested (%)						
	Moisture	**Ash**	**Protein**	**Fat**	**Fiber**	**Carbohydrate**	**Energy(Kcal/100g)**
FP n = 6	9.23 ± .47 [a]	10.63 ± 0.11[a]	12.26± 0.15[a]	24.60± 0.10 [a]	10.10 ± .10 [a]	43.29 ± 0.31[a]	456.54 ± 8.54 [a]
SP n = 6	6.54 ± 0.14[b]	10.54 ± 0.10 [a]	13.60± 0.20 [b]	27.13± 0.15 [b]	9.56 ± 0.15 [a]	42.19 ± 0.10 [b]	481.05 ± 2.92 [bc]
TP n = 9	6.81 ± 0.63[b]	10.00± 0.16 [b]	12.97± 0.10 [c]	27.86± 0.17 [c]	6.03 ± 0.51[b]	42.37 ± 0.76 [b]	486.00 ± 3.41 [c]
SLP n = 9	9.48 ± 0.29[a]	7.24± 0.22[c]	14.01± 0.15 [b]	23.53± 0.21[d]	2.50 ± 0.11[c]	45.74 ± 0.54 [c]	463.80 ± 4.35 [a]

Data present as mean value ± standard deviation. Means in column with same superscript letters are not significantly different at P =0.05. FP, SP, TP and SLP represent first polish, second polish, third polish and silky polish of 80 meshes respectively.

Minerals in Rice Bran

A considerable amount of minerals were found in the rice bran of BRRI-28 variety, presented in Table 2. The major mineral iron, magnesium, zinc and calcium contents in first polish, second polish, third polish and silky polish of BRRI-28 rice bran were ranged from 8 ± 0.10 to 14 ± 0.21, 425 ± 4.5 to 940 ± 2.5, 4.65 ± 0.12 to 6.68 ± 0.06 and 35 ± 1.10 to 62 ± 0.70 mg/ 100 g respectively.

The highest amount of iron, magnesium, zinc and calcium were found in the second polish fraction and the lowest amounts were found in the silky polish fraction.

Table 2: Mineral content of stabilized rice bran.

	Mineral content of stabilized rice bran (mg/100 g)			
Name of Fractions	**Iron (Fe)**	**Magnesium (Mg)**	**Zinc (Zn)**	**Calcium(Ca)**
FP	13 ± 0.15^{a}	854 ± 3.5^{a}	6.4 ± 0.05^{a}	60 ± 0.75^{a}
SP	14 ± 0.21^{a}	940 ± 2.5^{b}	6.68 ± 0.06a	62 ± 0.70^{a}
TP	10 ± 0.25^{b}	684 ± 2.2c	5.45 ± 0.21b	45 ± 0.25b
SLP	8 ± 0.10^{c}	425 ± 4.5^{d}	4.65 ± 0.12^{c}	35 ± 1.10^{c}

Data presented as mean ± SD. Mean values in the same column with different superscript letters are significantly different ($p \leq 0.05$). FP, SP, TP and SLP represented the rice bran of first, second, third and silky polish of 80 meshes

Vitamins in Rice Bran

Vitamin contents of BRRI-28 rice bran are shown in Table 3. The major vitamins thiamin (B_1), niacin (B_3) and pyridoxine (B_6) present in the rice bran of first polish, second polish, third polish and silky polish fractions were ranged from 14 ± 1.0 to 24 ± 2.1, 275 ± 15 to 430 ± 25 and 25 ± 1.2 to 42 ± 1.6 ppm respectively. The highest amount of B_1, B_3 and B_6 vitamins were found in second polish fraction whereas the lowest amount of B_1, B_3 and B_6 vitamins were found in the silky polish fraction.

Table 3: Vitamin content of stabilized rice bran.

Name of Fractions	**Vitamin content of stabilized rice bran (ppm)**		
	Thiamin (B_1)	**Niacin (B_3)**	**Pyridoxine (B_6)**
FP	24 ± 1.5^{a}	390 ± 13^{a}	40 ± 1.5^{a}
SP	24 ± 2.1^{a}	430 ± 25^{b}	42 ± 1.6^{a}
TP	16 ± 2.5^{b}	305 ± 22^{c}	32 ± 2.1^{b}
SLP	14 ± 1.0^{c}	275 ± 15^{d}	25 ± 1.2^{c}

Data presented as mean ± SD. Mean values in the same column with different superscript letters are significantly different ($p \leq 0.05$). FP, SP, TP and SLP represented the rice bran of first, second, third and silky polish of 80 meshes.

Several different thermal methods were used for rice bran stabilization. But satisfactory results had not been achieved by all methods. Many methods had common drawbacks, such as damage of valuable components of rice bran; substantial

moisture removal and complete and irreversible inactivation of enzyme not achieved. To achieve proper stabilization every discrete particle of bran must have proper moisture content, depending upon time and temperature of the treatment (Fatemeh Malekean *et al.*2000). In the present investigation, we examined simpler methods of stabilizing rice bran, namely cold treatment which can be adopted at the domestic level. The simple cold treatment procedures can effectively check the rancidity in rice bran for a considerable period of storage and did not alter the nutritional profile of the bran and making it suitable for possible human consumption.

The FFA formation is a criterion to determine the lipase activity and evaluation of stability. The rate of free fatty acid formation in rice bran during their storage period has been shown in Figure1. The initial FFA content of parboiled rice bran (BRRI-28 variety) was around 0.104 %. This was increased to 0.74 % by the end of the 90-days storage period under cold treatment. The results pertaining to the determination of free fatty acid of parboiled rice bran were in conformity with the findings of Faiyaz *et al.* (2007) who found that during storage of the cold-treated parboiled rice bran of jaya variety, the initial FFA value of around 0.25 % increased to around 0.83 % at the end of 90 days. The stabilization by the cold-treated process was able to maintain the FFA value below 1 % and was suggested that the result is preferable for human consumption, because it was known that free fatty acid range from 1-3 % in any food is consumable (Faiyaz *et al.* 2007). In the absence of any cold treatment, the rancidity in terms of FFA content during 90 days storage period increased from 0.104 to 2.90 % in the case of rice bran from parboiled BRRI-28 variety (Figure 1). Thus the increase of FFA content was to the extended of 28-fold in the untreated parboiled rice bran, whereas it was found much lower increase namely 7.0 - fold in the cold treated rice bran. The extent of rancidity in terms of FFA was significantly lower in cold treated rice bran than untreated bran. This could be attributed to the partial inactivation of lipase enzyme during parboiling. The development of FFA causes the deterioration of rice bran quality with time. The deterioration is due to the conversion of oil in the presence of water to FFA and the reaction is catalyzed by enzyme lipase in the bran.

Acid insoluble ash was analyzed to determine the amount of silica. The amount of silica existed in all rice bran has been presented in Figure 2. From this figure, it has been observed that all of the fractions of stabilized BRRI-28 variety contain very low amount of silica that is consumable. The acid insoluble ash content in all parboiled rice bran varied from 0.34-0.71%. The acid insoluble ash content of 1st polish was found to be highest (0.71%) followed by 2nd polish (0.47%), 3rd polish (0.35%) and silky polish (0.34%). The silica content of rice bran derived from husk may presumably help in bone formation when used as a dietary supplement (R. Jugdaohsingh.2007).

Rice bran was chemically analyzed for their proximate compositions that have been presented in Table 1. In terms of moisture content, first polish and silky polish were significantly different from second polish and third polish but no significant difference was existed between first and silky polish and also between second polish and third polish. The result was in agreement with Banerjee (1995) who found 8.2 g/100g moisture in rice polish. Malik *et al.,* (1979) also obtained 7.4 g/100g in rice polish. Other investigators (Anjum *et al*., 2007; Hamid *et al*., 2007; Sharif *et al*., (2005) also found closely similar results.

The bran of silky polish showed lower amount (7.24%) of ash content and it was statistically ($p \leq 0.05$) different from the other entire samples. On the other hand the bran of first polish showed higher amount (10.63%) of ash content and it was significantly ($p \leq 0.05$) different from the bran of third and silky polish , but not from the bran of second polish (Table 1). The higher content in ash contributed to their minerals contents (Juliano and Bechtel 1985). The protein content was highest (14.01%) in silky polish followed by second polish (13.60 %), third polish (12.97 %) and first polish (12.26%); which were significantly ($p \leq 0.05$) different from each other. In the different fractions of parboiled stabilized rice bran, the fat content was also observed significantly ($p \leq 0.05$) different among the fractions. The lowest and the highest fat contents were showed by silky polish (23.53%) and third polish (27.86%) respectively (Table 1), and were similar to that reported by Narasinga Rao (1988). The fiber content in bran of first polish and second polish were significantly ($p \leq 0.05$) higher than in both bran of the third and silky polish .The highest fiber content (10.10%) was observed in bran obtained from first polish and lowest in bran obtained from silky polish (2.5%).

The carbohydrate content of the analyzed rice bran ranged from 42.19-45.74 % (Table-1). The major carbohydrates in rice bran are cellulose, hemicellulose and starch (Juliano and Bechtel 1985). The carbohydrate content was significantly ($p \leq 0.05$) higher in rice bran of silky polish and lower ($p \leq 0.05$) in the bran of first polish than the carbohydrate in bran of each of the second and third polish but the content was not significantly ($p \leq 0.05$) different in the bran of the second and third polish. The lower amount of carbohydrates content in rice bran might be due to the absence or lower fragments of starch content in the bran. The highest energy content was 486.00 Kcal in the bran of third polish followed by second (481.05 Kcal), silky (463.80 Kcal) and first polish (456.54 Kcal) respectively shown in Table 1.

The results pertaining to proximate composition of processed rice bran were in conformity with the findings of Farrell (1994) who found protein 11-17 %, fat 11-18 %, fiber 10 % and ash 9 %. Similarly Pomeranz and Oryl (1982), and Holland et al. 1991 reported that bran had protein 13.2-17.3 %, crude fiber 9.5-13.2 % and ash 9.2-12.2 % on dry weight basis. Like wise the existing study is also fully in conformity with the findings of Warren and Farrell (1990) reported that the crude protein ranged from 13.4 - 17.4 %, fat 20.4 - 23.4 % and ash 10.5 % among several cultivars of rice bran grown in Australia. The present study is also in concordance with the findings of Saunders (1990), Malik and Chughtai (1979) who illustrated that the stabilized and parboiled rice bran had moisture 12 %, protein 13 %, fat 16 %, crude fiber 9 % and ash 10 %. Later on Al-Jassar and Al-Mustafa (1996) showed normal level of

protein 12.56 % and fat 15.15 % in rice bran. The results in the present study were also in agreement with the findings of Rosniyana A. *et al.* (2009) reported that on average rice bran has approximately 438 Kcal/100gm of energy, 5 % moisture, 13-15 % protein, 19-30 % fat and Sudarat *et al.* (2005) reported that rice bran contain 7.27 % water, 8.21 % ashes, 10.87 % proteins, 26.28 % fat.

The minerals content in the different fractions of rice bran are presented here in Table 2. The present results indicated that a considering amounts of minerals were present in the rice bran and the same finding was also observed by Bor *et al.* (1991). Iron was one of the major mineral constituents of bran obtained in varied amounts on the basis of different milling fractions due to degree of severity during milling for the separation of bran. The highest iron content was found 14 mg/100 g in the fraction of second polish and the lowest was found 8 mg/100 g in the fraction of silky polish. Magnesium, zinc and calcium showing the similar pattern that indicated the contents were found 940, 6.68 and 62 mg/ 100 g respectively highest in the fraction of second polish and were found 425, 4.65 and 35 mg/ 100 g respectively lowest in the fraction of silky polish. Except magnesium the minerals contents in bran were not significantly different between the first and second polish whereas the contents were significantly higher ($p \leq 0.05$) than the contents of the third and silky polish respectively (Table 2). The magnesium content in bran of all fractions was significantly different from each other. The gradually decreasing amounts of minerals contents in bran of the different fractions due to polishing the brown rice to get the bran fractions in the present study are in agreement with the earlier findings as reported by FM Anjum *et al.* (2007).

Vitamin contents of rice bran are shown in Table 3. Rice bran is also a rich source of vitamins particularly thiamin, niacin and pyridoxine. Except niacin, the vitamin contents in bran were not differed significantly ($p \leq 0.05$) in both the fractions of first and second polish. The niacin content in the bran of second polish was significantly ($p \leq 0.05$) higher than the contents of all other fractions. On the other hand, the thiamin and pyridoxine contents in the bran of second polish were significantly ($p \leq 0.05$) higher than the contents of third and silky polish respectively. The variation of vitamin content reflects the degree of polishing to get the different fraction of the rice bran (Hammond 1994).

IV. CONCLUSION

The present study indicated that rice bran is rich in protein, fat, minerals and vitamins. It has been evidenced that a simple cold treatment procedure has been arrested the lipase action and enhanced the keeping quality of rice bran. Undesirable and anti-nutritional factor like lipase was inactivated and minimized on processing of rice bran that might extent the storage period. Shelf life of processed rice bran was increased more than 90 days. It can be assesses that both significant and non-significant differences existed in various nutrients like protein, fat, mineral, vitamins, carbohydrate and fiber among different fractions of BRRI-28 variety parboiled rice bran. It can be said that all of the nutrients in rice bran were significantly effective and can be useful in food application as edible oil extraction and food supplement.

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