Effect of Processed Rice Bran Supplementation on the Quality of Chapaties

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Abstract

Raw rice bran (RRB) was mixed with 20% water or 20% solution of 1% acetic acid or 1% calcium hydroxide and cooked by passing through an extruder cooker (130±2°C for 10-15 s) to prepare Processed Rice Bran (PRB). PRB exhibited improvement in bulk density and storage stability (90 days). The chapaties were prepared by supplementation of PRB (0-30%) to whole wheat flour. Crude protein increased from 11.23 to 12.83%, fat 1.98 to 9.47%, crude fiber 2.11 to 3.79% and ash 1.4 to 5.21% in chapaties supplemented with PRB. The sensory quality improved for chapaties supplemented with 15% PRB. The biological value of PRB supplemented chapaties increased by 6, 11 and 13% which contained 5, 10 and 15% PRB, respectively. The chapaties containing PRB exhibited higher nutritional attributes such as PER, net protein utilization (NPU) and biological value. The processed rice bran can be used up-to 15% for the preparation of high nutritive chapaties in order to over come malnutrition problems in Pakistan. This will also help to utilize the rice bran and release pressure on wheat to some extent.

Keywords: rice bran, true digestibility (TD), protein efficiency ratio (PER), net protein utilization (NPU), chapaties

Introduction

Rice (*Oryza sativa*) is the 2nd largest amongst the staple food grain crops in Pakistan. Rice export is the major source of foreign exchange earnings of Pakistan in recent years. Pakistan produces good quality of rice. Rice was cultivated on an area of 2571 thousand hectares during the year 2011-12. Rice production for the year 2011-12 is estimated at 6160 million tons (GOP, 2012). Rice bran is produced about 8-10% as byproduct of rice milling industry. Thus, rice bran is abundantly available. According to an estimate about 500-600 million tons of rice bran was available during the season.

Rice bran is nutritionally rich. It is a rich source of dietary fiber and minerals (Sharif et al., 2009; Sairam et al., 2011). Rice bran has many health benefits. It is laxative and has stool bulking ability (Tomlin and Read, 1988), low in saturated fat (Cornelius, 1980), beneficial in reducing the risk of cardiovascular disease and colon cancer (Marshall and Wadsworth, 1994), increases fecal bulk and reduces blood cholesterol (Abdul and Yu, 2000).

Rice bran is under utilized for human consumption in Pakistan. It is mostly utilized for animal and poultry feed. Wheat is mainly consumed in the form of chapaties. Some of wheat is used in baked foods such as bread, cookies, cakes and pastries (Ahmad et al., 2002) and chapati is prepared mostly at homes by house wives. A number of studies have been reported for the preparation of bread, cookies, muffins and cakes by using rice bran (Carroll, 1990; Sekhon et al., 1997; Shaheen et al., 2005 and Sharif et al., 2009). Recently, Yadav et al., (2012) studied the possibility of utilizing defatted rice bran (DRB) for chapati making. However, there is lack of information about efficacy study for the rice bran utilization for human diet. To make it practically feasible for the general public to use rice bran in chapati, it is better to explore the potential of full fat rice bran (FFRB) for chapati. Therefore, the present study was under taken to utilize the FFRB and efficacy study of chapati was conducted to determine the nutritional potential of rice bran. It will ultimately improve the health status of people in Pakistan.

Materials and Methods

Raw Material

Rice bran of Basmati 385 was collected from Reem Rice Mills (Pvt.) Limited, Muridke, Sheikhupura, Pakistan. Rice bran contained crude protein 13%, crude fat 12.93%, crude fiber 7.65%, ash 10.34% and nitrogen free extract 56.08%.

Processing of Rice Bran

The processing of rice bran was carried out to inactivate the anti-nutritional factors. Samples of Rice bran (RRB: Raw Rice Bran; PRB: Processed Rice Bran) were prepared according to Shaheen et al., (2004). The rice bran was packed in air impermeable plastic bags with Free Oxygen Absorber (FOA) following the procedure of Hirokazu and Takao, (2000) and stored at room temperature for further study.

Chemical Evaluation

Samples were analyzed for crude protein, crude fat, crude fiber, total ash and NFE according to their respective methods as described in AACC (2000). Starch in rice bran was determined by dinitro silicic (DNS) acid through spectrophotometer at 550nm absorbance (AOAC 2000).

Bulk Density

The bulk density of rice bran was determined according to Egan et al., (1981). Rice bran was filled in a cylinder (volume 50 mL) and weighed. Bulk density was calculated as weight per unit volume.

Preparation of Chapati

The whole wheat flour was supplemented with PRB at 0, 5, 10, 15, 20, 25 and 30% levels. The chapaties were prepared according to Haridas Rao et al. (1986). The dough was prepared by mixing 200g of flour for three minutes in a mixer (National Mfg. Co., Lincoln, Nebraska). A portion of dough weighing 80g was rounded and turned into chapaties. The chapaties were baked on a hot plate (210°C for 2 minutes). Sensory evaluation of chapaties was performed according to Meilgaard et al., (2007).

Biological Evaluation of Chapaties

The composition of diets containing chapaties was as follows: T1 (wheat flour chapati = 73.5%), T2 (5% rice bran chapati (RBC) = 72%), T3 (10% RBC = 70.5%), T4 (15% RBC = 69%), T5 (casein = 10.7%) and T6 (non protein diet). The feeding trials were conducted according to Thomus Mitchell balance methods with modification by Eggum (1976). The colony of weanling albino rats (three weeks age) was maintained at Pakistan Council of Scientific and Industrial Research (PCSIR) biological experimental station. The rats were fed on basal diet for a period of one week and randomly divided into 6 groups comprising of 4 rats each. The diets were prepared such a way that 10% protein was available from each diet. All groups were fed ad-libitum for a period of 10 days. The feed consumption (feed intake) and body weight of rats was recorded on daily basis.

$$\text{Protein Efficiency Ratio (PER)} = \left(\frac{\text{Gain in weight}}{\text{Protein intake}}\right)$$

True Digestibility (TD) =

$$\left(\frac{\text{Nitrogen intake - (Fecal N - Metabolic N)}}{\text{Protein intake}}\right)\times 100$$

Net Protein Utilization (NPU) was determined according to Miller and Bender (1955).

$$\text{NPU\%} = \left(\frac{\text{B - Bk + Ik}}{\text{I}}\right)\times 100$$

Where B = Body N of test group, Bk = Body N of protein free group, I = N intake of test group, Ik = N intake of protein free group.

Biological Value (BV%) =

$$\left(\frac{\text{Net protein utilization}}{\text{True digestibility}}\right)\times 100$$

Statistical Analysis

The data was subjected to statistical analysis according to Steel et al. (1997).

Results and Discussion

Bulk Density and Starch Contents of Rice Bran

The results showed statistically significant differences among different rice bran samples with respect to bulk density. However, non-significant differences were observed for starch content. The processing of rice bran exhibited an increase in bulk density from 0.39 to 0.91 g cm^{-3}. The starch contents of rice bran samples ranged from 15.05 to 16% (Table 1).

Rice bran contains 10-20% starch but its quantity varied due to amount of breakage and degree of milling (Saunders, 1990). Marshall and Wadsworth (1994) showed that rice bran contained 15.8% starch. In the present investigation, rice bran was moistened with 20% water. Thus starch granules also absorbed water. On extrusion cooking, it was found to be gelatinized and rice bran was coated with a thin starchy film by giving PRB a crispy structure and protective layer. This encapsulated starch layer can prevent the rice bran from moisture and atmospheric oxygen. The starch modification by extrusion assured the availability of proteins and B-complex vitamins particularly thiamine as 78% of the original thiamine was present in rice bran (Saunders, 1990). Each treatment gave a specific structure to PRB. The crumbs produced by PRB (acid or alkali) were fewer firms as compared with raw rice bran.

Texture and Color of Rice Bran

The texture of raw rice bran showed fluffy appearance while the processed rice bran samples had crumble look (Table 1). It may be due to increase in Bulk density of rice bran. The color of RRB was brown, PRB-I was lemon yellow while PRB-II and PRB-III exhibited off white color after 90 days of storage. The change in color was due to the reason that treated rice bran was extruded. Jiaxun (2001) observed that acid stabilized parboiled rice bran could maintain its stability up to 6 months storage at ambient conditions.

Chemical Composition of Chapati

Chemical composition of chapaties supplemented with PRB-II (T_1-T_7) was analyzed. PRB-II was selected because it has less toxic factors (Shaheen et al., 2004). The analysis of variance revealed statistically significant ($P \leq 0.01$) differences in chemical composition of chapaties (Table 2). There was an increase in protein and fat contents of chapaties supplemented with PRB. The protein content showed non-significant differences among chapaties prepared from 0, 5 and 10% PRB supplementation. The increase in fat contents may be due to the presence of higher amount of fat content in PRB-II (13.25%). The crude fiber content of chapaties increased from 2.11 to 3.79% by the addition of PRB. The increase in crude fiber contents of chapaties may be attributed to higher amount of crude fiber present in PRB. The ash content of chapaties increased progressively with the addition of PRB in WWF (Table 2). The NFE contents decreased with the addition of PRB. The

Table 1 Characteristics of processed rice bran (PRB).

Treatment	Starch (%)	Bulk density (g cm^{-3})	Color after 90 days storage	Structure
S1	15.25	0.39c	Brown	Fluffy powder
S2	16.00	0.82b	Lemon-yellow	Crumbles
S3	15.50	0.85ab	Off-white	Crumbles
S4	15.05	0.91a	Off-white	Crumbles
Mean Square	0.470^{NS}	0.198**	-	-

Mean values sharing similar letters in a column are not significantly different. NS = Non significant, ** = P<0.01
S1 = RRB (Raw Rice Bran). S2 = PRB-I (20% moist with water and extruded). S3 = PRB-II (20% moist with 1% solution of acetic acid and extruded). S4 = PRB-III (20% moist with 1% sol. of calcium hydroxide and extruded).

Table 2 Chemical composition of chapaties supplemented with processed rice bran (PRB-II).

Treatment	Crude protein	Crude fat	Crude fiber	Ash	NFE
	(------------------	----------	%	----------	------------------)
T 1	11.23c	1.98g	2.11f	1.41f	83.27a
T 2	11.38c	3.11f	2.38e	2.16e	80.97ab
T 3	11.63bc	4.48e	2.77d	2.67d	78.45bc
T 4	11.84ab	5.75d	2.93cd	3.85c	75.63cd
T 5	12.43ab	6.96c	3.18bc	3.92c	73.51de
T 6	12.56ab	8.26b	3.43b	4.62b	71.13ef
T 7	12.83a	9.47a	3.79a	5.21a	68.70f
Mean Square	1.533**	22.963*	1.026**	5.634**	106.166**

Mean values sharing similar letters in a column are not significantly different. * = $P<0.05$, ** = $P<0.01$
T1 = Control, T2 = 5% PRB, T3 = 10% PRB, T4 = 15% PRB, T5 = 20% PRB, T6 = 25% PRB, T7 = 30% PRB

decrease may be attributed to the fact that PRB contained more protein, fat, fiber and mineral contents which decreased NFE contents.

Lysine is the limiting amino acid in wheat (Kent and Evers, 1994). Rice bran, a by-product of rice milling industry is a good source of protein, energy, minerals and vitamins (B-complex and tocopherols) etc. (Dale, 2000). The chapaties with PRB supplementation exhibited higher crude protein, crude fat, crude fiber and ash as compared with chapaties of wheat flour. The addition of PRB increased the nutritive value of chapaties. Gulzar et al. (2010) reported ash 0.6-1.43%, fat 1.18-1.43%, crude fiber 0.10-0.15%, carbohydrate 75.68-76.53% and protein content 10.30-11.72% in different wheat varieties. Anjum et al. (2005) found that crude protein content in whole wheat chapati was 11.85%. Yadav et al., (2012) observed that chapati supplemented with 20% defatted rice bran (DRB) was acceptable and exhibited higher ash (2.1%) and total dietary fiber (4.3%) contents than control chapati.

Sensory Evaluation of Chapaties

The statistical results indicated differences in sensory attributes of chapaties prepared from PRB supplementation (Table 3). The scores for color were non significant in chapaties prepared from 0 to 25% PRB-II supplementation (T_1 to T_6). Chapati is a staple diet of South Asian countries. A light brown and creamy color of chapati is liked by the consumers.

The scores for flavor and taste of chapaties increased with the addition of PRB. The differences in flavor of 10 and 15% PRB supplemented chapaties were non-significant. The scores for taste improved by 5.6, 8.8 and 12.7% in the chapaties prepared from 5, 10 and 15% PRB supplementation, respectively. The highest scores for flavor and taste were attained by T_4. The scores for texture and feel to touch of chapaties prepared from 0 to 15% PRB supplementation showed non-significant differences among one another. The scores for texture were significantly higher for chapaties of T_4. The judges assigned significantly higher scores to fold-ability of chapaties prepared from 10% PRB supplementation. The scores for breakability of chapaties for T_1 was significantly higher followed by T_4, T_3 and T_2 but the differences among these chapaties were non significant.

Total scores (TS) of chapaties prepared from PRB supplemented at levels of 5, 10 and 15% increased progressively. On the basis of the above results, the chapaties prepared from 0 to 15% (T_1, T_2, T_3 and T_4) were more accepted by the panel of judges. Kennedy (1996) observed that with the addition of rice bran fiber (RBF) the color of bakery products became darker and tenderness decreased as in this study the scores for texture of chapaties decreased above 15% replacement. Likewise Prakash (1996) showed that incorporation of roasted rice bran (5-20%) in traditional foods had great impact on color but some impact on aroma, taste and overall acceptability and little effect on texture. Sharif et al. (2003) observed that rice bran oil (RBO) is effective in extending the shelf life of product due to its natural antioxidants. Lima et al. (2002) indicated that FFRB supplementation in bakery

Table 3 Sensory attributes of chapaties supplemented with processed rice bran.

Treatment	Color	Flavor	Taste	Texture	Feel to touch	Fold-ability	Break-ability	Total Scores
T 1	7.41ab	6.25b	7.81b	6.78a	7.15a	7.33ab	6.81a	49.54a
T 2	7.53a	7.13b	8.25ab	6.81a	7.50a	7.65a	6.23ab	51.10a
T 3	7.88a	8.11a	8.50ab	6.75a	7.32a	7.81a	6.18ab	52.55a
T 4	8.07a	8.75a	8.80a	6.91a	7.27a	7.35ab	6.75a	53.90a
T 5	7.40ab	6.54b	7.19b	5.75b	6.25b	6.88b	6.00abc	46.01b
T 6	7.28ab	6.18b	6.53c	5.64b	6.11b	6.51b	5.32bc	43.57b
T 7	6.52b	5.17c	6.14c	5.54b	6.04b	6.42b	5.18c	41.01b
Mean Square	0.721*	5.684**	3.145**	1.046*	1.084**	0.873*	1.201*	67.378**

Mean values sharing similar letters in a column are not significantly different. * = $P<0.05$, ** = $P<0.01$
T1 = Control, T2 = 5% PRB, T3 = 10% PRB, T4 = 15% PRB, T5 = 20% PRB, T6 = 25% PRB, T7 = 30% PRB

products gave better texture. Sekhon et al., (1997) also reported that rice bran could be added to the extent of 5-10% in different food products.

Biological Evaluation of Chapaties

The chapaties accepted by the panel of judges were biologically evaluated by feeding young albino rats. The results revealed statistically significant (P<0.01) differences for weight gain, feed consumed, PER, TD, BV and NPU values of PRB supplemented chapaties (Table 4). The rats fed on casein diet gained maximum weight (88 g) followed by diet of chapaties containing 15% PRB supplementation (82 g). The rats fed on 100% whole wheat flour chapaties possessed the lowest weight gain (63 g). It is evident from the results that supplementation of 15% PRB increased the weight gain of rats comparable to the weight gain of casein diet.

The average feed intake (feed consumed) data indicated that rats consumed more feed which contained 15% PRB supplemented WWF chapaties (Table 4). The supplementation of 5, 10 and 15% PRB increased the PER values by 39, 44 and 49%, respectively. The true digestibility (TD), biological value (BV) and net protein utilization (NPU) of chapaties increased with the addition of PRB and was maximum (89, 67 and 64%, respectively) for chapaties prepared from 15% PRB (T_5). It indicated an improvement in protein retention due to PRB supplementation. It might be due to improvement of limiting amino acids (Saunders, 1990).

The best response in terms of chemical analysis, sensory and biological evaluation was obtained with 15% PRB supplementation. Rice bran has better amino acids profile than wheat (Saunders, 1990) and processing of rice bran improved its nutritional value (Dale, 2000). The feeding trial of rats exhibited that toxic factors of rice bran were removed on processing as the feeding values of PRB (5-15%) were improved. The improvement in weight gain, feed consumption, PER, TD, BV and NPU are certainly due to high nutritional value of rice bran protein and better quantity and quality of other constituents such as fat in rice bran (Saunders, 1990 and Sharma 2002).

The digestibility of rice bran protein is 73% (Saunders, 1990) and wheat flour is 67-94% (Chandra and Ramanatham, 1987). The better growth (weight gain) and feed efficiency also showed better PER, TD, BV and NPU. The weight gain was correlated with PER (Zombade and Ichhponani, 1983). Protein concentrate of rice bran had better digestibility and NPU than other cereal proteins (Ledesma et al., 1990). Rasool et. el. (2005) observed an increase in feed efficiency, NPU, BV, net protein retention (NPR) and PER values in diets containing oilseed enriched chapaties. Singh et al. (1995) indicated that stabilized FFRB could be used up to 20% level in various food products. Rice bran may be utilized (10-20%) for human consumption due to excellent nutraceutical properties (Lima et al., 2002).

Among the various problems emerging out as a consequence of population growth, the problem of food particularly of good quality protein is reaching to its critical level affecting adversely the health and vitality of the people. As chapati is the main

Table 4 Nutritional attributes of albino rats fed on diets containing supplemented with Processed Rice Bran (PRB).

Treatment	Wt. gain /group	Feed consumed/ group	Protein efficiency ratio	True digestibility (%)	Biological value (%)	Net protein utilization (%)
T 1	83a	329c	2.53a	94a	78a	73a
T 2	63d	385c	1.30c	85b	54c	49d
T 3	70c	388b	1.81b	86b	61c	54c
T 4	73c	391b	1.87b	88ab	65bc	58c
T 5	82ab	423a	1.94b	89ab	67b	64b
Mean Square	292**	2555**	0.57**	36.9**	232**	259**

Mean values sharing similar letters in a column are not significantly different at ** = P<0.01
T1 = Control, T2 = 5% PRB, T3 = 10% PRB, T4 = 15% PRB, T5 = 20% PRB, T6 = 25% PRB, T7 = 30% PRB

and major source of protein and energy for the people of Asian sub continent. Rice bran is a good source of protein and energy. Thus it seems feasible to supplement the wheat flour with Processed Rice Bran.

Conclusions

The chapaties containing PRB exhibited higher nutritional attributes such as PER, net protein utilization (NPU) and biological value. The results of the present study suggest that processed rice bran can be incorporated in whole wheat flour up to 15% for the preparation of high nutritive chapaties in order to over come malnutrition problems. The chapaties made from this flour will not only possesses better sensory attributes but also have better nutritional quality. This will also help to utilize the rice bran and release pressure on wheat to some extent.

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