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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Preparation of Fiber and Mineral Enriched Defatted Rice Bran Supplemented Cookies

Mian K. Sharif[1], Masood S. Butt[1], Faqir M. Anjum[1] and Haq Nawaz[2]
[1]National Institute of Food Science and Technology, University of Agriculture, Faisalabad-38040, Pakistan
[2]Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad-38040, Pakistan

Abstract: Microwave stabilized defatted rice bran was supplemented in commercial straight grade wheat flout @ 10, 20, 30, 40 and 50% supplementation level to prepare fiber and mineral enriched cookies. Cookies were analyzed for physical analysis, dietary fiber, mineral content (Na, K, Ca and Mg) and sensoric attributes to find out the most suitable compositions for commercialization. Overall, rice bran supplementation improved dietary fiber content and mineral profile of the cookies. On the basis of physical analysis and sensoric attributes, it was concluded that defatted rice bran can be substituted upto 10 to 20% in wheat flour to prepare rice bran supplemented cookies without adversely affecting quality attributes.

Key words: Rice bran, cookies, dietary fiber, minerals

INTRODUCTION

"Cookie" is chemically leavened product, also known as "biscuit". Generally the term biscuit is used in the European countries and cookies in the USA. Biscuits and biscuit like products have been made and eaten by man for centuries (Hosney, 1986). Cookies are ideal for nutrient availability, palatability, compactness and convenience. They differ from other baked products like bread and cakes because of having low moisture content, comparatively free from microbial spoilage and long shelf life of the product (Wade, 1988).

Rice is one of the leading food crops of the world, the staple food of half of the world's population. At least 90% of world's rice farmers and consumers are in Asia where it provides upto 75% of the dietary energy and protein for 2.5 billion people (Juliano, 1985; 1994). Rice is the 2nd leading cereal crop in Pakistan and is being processed in well established rice industry but unfortunately its byproducts primarily rice bran (5-8%) is going to waste which is a valuable source of nutrients (Kestin *et al.*, 1990). During 2007-08, rice was cultivated on an area of 2515 thousand hectares and yield was 5563 thousand tons (GOP, 2008). Total estimated available quantity of rice bran worked out was 0.5 million tons.

Rice bran is an excellent source of total dietary fiber ranging from 20-51% (Saunders, 1990). Rice bran fiber has laxative effect with increments of increased fecal output and stool frequencies (Tomlin and Read, 1988). Defatted Rice Bran (DFRB) is rich in proteins, minerals and vitamins. Possible health benefits of consumption include increased faecal bulk and reduced blood cholesterol (Abdul and Yu, 2000). The rice bran supplementation to wheat flour enhanced the contents of proteins, lysine and dietary fiber proportionately to the level of substitution.

Nutritional and functional properties of rice bran are well suited for baked products like cookies, muffins, breads, crackers, pastries and pancakes (Barber *et al.,* 1981). The fullfat and defatted rice brans were blended in wheat flour @ 5, 10 or 15% to prepare cookies. There was improvement in spread of cookies with the addition of fullfat rice bran. In contrast, decrease in spread after supplementation of defatted rice bran. Cookies supplemented with either type of rice bran were acceptable upto 10% supplementation level (Sekhon *et al.,* 1997). In another study, cookies were successfully prepared from stabilized rice bran at levels of 20% (Carroll, 1990). In a similar study, stabilized fullfat rice bran upto 20% level and un-stabilized fullfat or stabilized defatted rice bran upto 10% was found suitable in various food products (Singh *et al.*, 1995). Dry heat and extrusion stabilized rice bran was supplemented in wheat flour at 5-20% levels for the preparation of cookies (Sharma and Chauhan, 2002). The present study was designed to utilize rice industrial by-product i.e. rice bran for value addition. After oil extraction, defatted rice bran was supplemented in wheat flour to prepare fiber, mineral and protein enriched cookies for their allied health claims.

MATERIALS AND METHODS

Procurement and stabilization of rice bran: Rice industrial by-product i.e. rice bran was obtained from Reem Rice Mills, Sheikhupura-Pakistan. Freshly milled rice bran was stabilized by microwave heating. For the purpose, raw rice bran was adjusted to 21% moisture content and microwave heat treatment was given for 3 minutes (Ramezanzadeh *et al.,* 2000).

Preparation of defatted rice bran: Rice Bran Oil (RBO) was extracted by slurring with four volumes of hexane at room temperature for 1 hour, to get defatted rice bran.

Preparation of rice bran supplemented cookies: Defatted rice bran was supplemented in wheat flour @ 10, 20, 30, 40 and 50% level to prepare rice bran supplemented cookies (Table 1) according to method given in AACC (2000).

Analysis of rice bran supplemented cookies

Physical analysis: Rice bran supplemented cookies were analyzed for width, thickness and spread factor by following the respective procedures (AACC, 2000).

Width (W): Six cookies were placed horizontally (edge to edge) and rotated at 90° angle for reading.

Thickness (T): Six cookies were placed one another to compute thickness.

Spread factor (SF): It was calculated according to the following formula: $SF = (W/T \times CF) \times 10$
Where; CF= Correction factor (1.0 in this case)

Total dietary fiber: Dietary fiber content of supplemented cookies was determined by using Megazyme TDF Test Kit (AACC Method 32-05 and AACC Method 32-21). Total Dietary Fiber (TDF) was determined on duplicate samples of dried and defatted material. Samples were cooked at 100°C with heat stable α-amylase for 30 min for gelatinization, hydrolysis and depolymerization of starch; incubated at 60°C for same time interval with protease to solubilize and depolymerize proteins and amyloglucosidase to hydrolyze starch fragments to glucose; treated with four volumes of ethanol to precipitate soluble fiber and remove depolymerized protein and glucose from starch. The residue was filtered; washed with 78% ethanol, 95% ethanol and acetone; dried and weighed. One duplicate was analyzed for protein and the other incubated at 525°C to determine ash. TDF content was determined from the weight of the filtered and dried residue after deducting the weight of the protein and ash.

Mineral analysis: Rice bran supplemented cookies were analyzed for Na, K, Ca and Mg after wet digestion through Flame Photometer-410 (Sherwood Scientific Ltd., Cambridge) and Atomic Absorption Spectrophotometer (Varian AA240, Australia) by following procedures of AOAC (2006).

Sensory evaluation: Cookies were evaluated for color, flavor, taste, texture, crispness and overall acceptability by trained taste panel using 9-Point Hedonic Score System (Meilgaard *et al.,* 2007) with following individual scores: liked extremely-9, liked very much-8, liked moderately-7, liked slightly-6, neither liked nor disliked-5, disliked slightly-4, disliked moderately-3, disliked very much-2 and disliked extremely-1, to find out the most suitable composition of cookies for commercialization.

Table 1: Treatments used for preparation of rice bran supplemented cookies

Treatments	Wheat flour (%)	Stabilized defatted rice bran (%)
T_0	100	-
T_1	90	10
T_2	80	20
T_3	70	30
T_4	60	40
T_5	50	50

T_0 (100% commercial straight grade flour) acts as control, cookies with 0% DFRB
T_1 = Cookies with 10% DFRB T_2 = Cookies with 20% DFRB
T_3 = Cookies with 30% DFRB T_4 = Cookies with 40% DFRB
T_5 = Cookies with 50% DFRB

Statistical analysis: Complete Randomized Design (CRD) was applied and data obtained for each parameter was subjected to statistical analysis to determine the level of significance (Analysis of Variance technique) as described by Steel *et al.* (1997). Duncan's Multiple Range Test (DMR) was used to determine significant differences. All the statistical analyses were done by using Minitab software (Minitab V-15). Significant difference was defined as $p < 0.01$.

RESULTS AND DISCUSSION

Physical analysis of defatted rice bran supplemented cookies: Physical analysis of cookies is important from both consumers as well as manufacturers point of view. The spread of the cookies should be according to the specifications set by the manufacturers. Too much elasticity in the gluten and dough will spring back to give thicker cookies due to smaller diameter. Similarly, in case of too little elasticity, dough may flow after molding, resulting in thin cookies with large diameter. Mean squares (Table 2) alluded that supplementation of various levels of defatted rice bran has significant ($p<0.01$) effect on width, thickness and spread ratio of cookies whereas storage and interaction was found to be non-significant. The data regarding means for effect of various treatments on width of cookies (Table 3) showed a decreasing trend with the proportionate increase of bran supplementation. The results elucidated that T_0 (cookies with 0% DFRB) exhibits maximum width 44.15 mm, followed by T_1 (41.25 mm) and T_2 (39.58 mm) while minimum width (36.53 mm) was observed in T_5 (cookies with 50% DFRB). However, there were non-significant differences among the treatments during 60 days storage (Table 4). The results pertaining to means for thickness of cookies (Table 3) revealed increasing trend with proportionate increase of defatted rice bran in commercial straight grade flour. The results explicated that T_5 (cookies with 50% DFRB) exhibited maximum thickness (10.34 mm) followed by T_4 (9.95 mm) and T_3 (9.43 mm) while minimum thickness (9.23 mm) was measured in T_0 (cookies with 0% DFRB).

Table 2: Mean squares for thickness, width and spread ratio of rice bran supplemented flour cookies

SOV	df	Width	Thickness	Spread ratio
Treatments	5	67.5369**	2.0897**	158.43**
Storage	2	0.3243^{ns}	0.0359^{ns}	0.0616^{ns}
TxS	10	0.0087^{ns}	4.9963x10^{-4ns}	0.0158^{ns}
Error	72	0.1138	0.0214	0.6908
Total	89			

**Highly significant at P = 0.01; ^{ns}Non-Significant;
Treatments (T); Storage (S).

Table 3: Means for effect of treatments on physical analysis of defatted rice bran supplemented flour cookies

Treatments	Width	Thickness	Spread ratio
T_0	44.15^a	9.23^c	47.80^a
T_1	41.25^b	9.39^c	45.55^b
T_2	39.58^c	9.40^c	41.47^c
T_3	39.11^d	9.43^c	38.86^d
T_4	37.49^e	9.95^b	38.30^{de}
T_5	36.53^f	10.34^a	37.67^e

Means carrying same letters in a column for each factor do not differ significantly (p<0.01)

Table 4: Means for effect of storage on physical analysis of defatted rice bran supplemented flour cookies

Storage (days)	Width	Thickness	Spread ratio
0	39.83	9.62	41.54
30	39.65	9.56	41.62
60	39.57	9.53	41.66

The thickness of cookies remained unaffected during 60 days storage (Table 4).

The statistics regarding the effect of rice bran substitution on spread factor of cookies are presented in Table 3. There was a decreasing trend in the spread ratio of cookies with the proportionate increase of supplementation. The spread factor of cookies, prepared from different treatments ranged from 37.67-47.80. The maximum value (47.80) for spread ratio was observed in T_0 (cookies with 0% DFRB) whereas minimum (37.67) in cookies prepared from 50% defatted rice bran supplementation. Rice bran replacement upto 10-20% was found to be appropriate in cookies. On spread ratio, there were non-significant variations during two months storage (Table 4). The results of present study are quite close to the observations reported earlier by numerous researchers. Wheat flour was supplemented with 5-25% defatted soy flour samples. Increasing levels of defatted soy flour reduced diameter and increased thickness of cookies resulting in a significantly reduced spread ratio (Grover and Singh, 1994). The fullfat and defatted rice brans were blended in wheat flour @ 5, 10 or 15% to prepare cookies. Spread of cookies decreased with the addition of rice bran (Sekhon *et al.,* 1997). Cookie spread decreased with the addition of the various rice brans (Sudha *et al.,* 2007); however, the decrease was more pronounced in flours containing defatted bran. Stabilized fullfat rice bran upto a level of 20% and stabilized defatted rice bran upto a 10% level was considered suitable for use in various bakery products (Singh *et al.,* 1995).

Dietary fiber of defatted rice bran supplemented cookies: Recently the importance of consuming dietary fibre has increased owing to its relation with the reduction of blood cholesterol levels and incidence of colon cancer. There have been different approaches to escalate the dietary fiber content of the baked products; presently concerned with rice bran. Mean squares for dietary fiber content of different treatments of cookies revealed significant variation due to supplementation of defatted rice bran (Table 5). In defatted rice bran supplemented cookies, maximum dietary fiber (11.01%) was observed in T_5 (cookies with 50% DFRB) followed by T_4 (cookies with 40% DFRB) and T_3 (cookies with 30% DFRB) i.e. 9.32 and 7.63%, respectively; whereas lowest dietary fiber content (2.56%) was found in cookies prepared from straight grade wheat flour (Table 6). Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with partial fermentation in the large intestine (CAC, 1998). These plant food materials include non-starch polysaccharides such as celluloses, some hemi-celluloses, gums and pectins as well as resistant starches (DeVries, 2001). The WHO recommendation for total dietary fiber intake is above 25 g/day (WHO, 2003). Additional daily intake of 10g fiber appeared to lower the risk of coronary death by 17% (Morris *et al.,* 1977; Khaw and Barrett, 1987). The total dietary fiber content in stabilized rice bran ranges from 25 to 40% depending on the product (Carroll 1990). Rice bran's fiber comprised of a relatively low proportion of soluble fiber (7 to 13%) and the rest is insoluble fiber (Anderson *et al.,* 1990). Fiber supplementation has been used to enhance the fiber content of array of foods. Traditionally, fiber supplementation has focused on the use of milling by-products of cereal grains like wheat, corn, sorghum and other grains and now has been introduced in cookies, crackers, snack foods, beverages and many other cereal-based products (Matz, 1991; Hesser, 1994; McKee and Latner, 2000).

Mineral analysis of defatted rice bran supplemented cookies: These are inorganic materials present in ash when food or any living organism is cremated. The mean squares for mineral content (Table 5) depicted that blending of defatted rice bran, significantly improved the mineral content of the cookies. Sodium (Na) is essential in the regulation of water content of the body and in maintenance of osmotic pressure of body fluids. The means for mineral content in supplemented

Table 5: Mean squares for dietary fiber and mineral analysis of defatted rice bran supplemented flour cookies

SOV	df	Dietary fiber	Minerals Na	K	Ca	Mg
Treatments	5	29.989**	3876.877**	55178.08**	7732.022**	34891.56
Error	12	0.1037	43.93233	125.9768	32.72592	63.91906
Total	17					

**Highly significant at P = 0.01

Table 6: Means for dietary fiber and mineral content of defatted rice bran supplemented flour cookies

Treatments	Dietary fiber (%)	Minerals (mg/100 g) Na	K	Ca	Mg
T_0	2.56^f	196.51^a	44.55^f	54.95^f	10.64^f
T_1	4.25^e	177.30^b	117.04^e	82.08^e	68.29^e
T_2	5.94^d	158.08^c	189.53^d	109.22^d	125.93^d
T_3	7.63^c	138.87^d	262.03^c	136.35^c	183.58^c
T_4	9.32^b	119.65^e	334.52^b	163.49^b	241.22^b
T_5	11.01^a	100.44^f	407.01^a	190.60^a	298.87^a

cookies (Table 6) represented that maximum Na content (196.51 mg/100 g) was observed in T_0 (cookies with 0% DFRB) followed by T_1 (177.30) and T_2 (158.08) whilst the lowest value (100.44 mg/100 g) was found in T_5 (cookies with 0% DFRB). Potassium (K) participates in certain enzyme systems in the body and controls acid balance along with sodium to maintain fluid balance. Maximum K content (407.01 mg/100 g) was observed in T_5 (cookies with 50% DFRB) followed by T_4 (334.52) and T_3 (262.03) while the lowest value (44.55 mg/100 g) was found in T_0 (cookies with 0% DFRB). Calcium (Ca) is essential for teeth formation and also helps in muscle contraction, maintenance of cell membranes, clotting of blood and normal functioning of nerves, muscles and heart. It participates in the activation of many enzymes. The highest value for Ca (190.60 mg/100 g) was recorded for T_5 (cookies with 50% DFRB) followed by T_4 (163.49) and T_3 (136.35); the minimum value (54.95 mg/100 g) was in T_0. Magnesium (Mg) is essential in the formation of bones and teeth and synthesis of proteins. It is also involved in maintenance of muscle functions, release of energy from muscle glycogen and conduction of nerve impulse. The magnesium content of rice bran supplemented cookies ranged from 10.64 to 298.87 mg/100 g. It is obvious from the results that defatted rice bran supplementation significantly improved the mineral contents of the cookies, except for sodium, with proportionate increase of supplementation.

Sensory evaluation of defatted rice bran supplemented cookies: Sensory evaluation is usually performed towards the end of the product development or formulation cycle and is carried out to assess the reaction of judges towards the product and they rate the liking on a scale. Mean squares for sensory evaluation of cookies (Table 7) showed that sensoric attributes differed significantly due to treatments and storage, however, all quality attributes showed non-significant differences due to the interaction of treatments and storage.

In baking, color serves as a cue for the doneness of foods and is correlated with changes in aroma and flavor. The results pertaining to mean score for the color of defatted rice bran supplemented flour cookies (Table 8) revealed that in defatted bran supplemented cookies, T_3 (7.48) ranked at the top due to excellent appearance, followed by T_4 (7.47) as compared to control (6.65). Treatments prepared form 30 to 40% defatted rice bran substitution were acceptable by the judges for this trait. By the progressive increase in supplementation, color of cookies turned towards darker, leading to lower acceptance (Sudha *et al*., 2007). There was a declining trend in color score during storage. The maximum score (7.26) was assigned to fresh cookies that decreased to 6.86 and 6.43, after 30 and 60 days, respectively (Table 9). The deterioration in color of cookies was possibly due to the absorption of moisture from the atmosphere and oxidation of fats. Color changes are might be due caramelization, dextrinisation of starch or Maillard reaction involving the interaction of reducing sugars with proteins. There is natural trend of color fading with progressive storage which affects the appearance (Manley, 2002). These results are in close agreement with the findings of Elahi (1997) who observed a gradual decrease in color of biscuits made from composite flour during storage.

Perceptions of flavor are synthesis of taste and smell impressions, along with texture and are even influenced by appearance. Means for flavor of cookies (Table 8) revealed that T_4 (cookies with 40% DFRB) and T_2 (cookies with 20% DFRB) were liked by the judges and obtained maximum scores i.e., 7.45 and 7.10, respectively; whereas T_5 (5.98) got minimum score. As a whole, the maximum score (7.19) was obtained by fresh cookies (0 day), that was gradually decreased (6.84 and 6.54) after 60 days storage (Table 9). It has

Table 7: Mean squares for sensoric attributes of defatted rice bran supplemented flour cookies

SOV	df	Color	Flavor	Taste	Texture	Crispness	Overall acceptability
Treatments	5	4.3269**	3.6601**	3.2393**	4.6557**	5.2263**	2.8054**
Storage	2	5.1145**	3.1716**	2.9323**	4.0340**	4.9946**	4.2157**
TxS	10	0.0156ns	0.0032ns	0.0055ns	0.0095ns	0.0078ns	0.0117ns
Error	72	0.0828	0.0829	0.0824	0.0867	0.0828	0.0808
Total	89						

**Highly significant at P= 0.01; ns Non-Significant; Treatments (T); Storage (s).

Table 8: Means for effect of treatments on sensoric attributes of defatted rice bran supplemented flour cookies

Treatments	Color	Flavor	Taste	Texture	Crispness	Overall acceptability
T_0	6.65bc	6.78b	6.87c	7.58a	7.67a	6.78c
T_1	6.57c	6.85c	6.83c	7.33b	7.02b	7.05b
T_2	6.81b	7.10b	6.90bc	7.32b	7.10b	7.28a
T_3	7.48a	7.06b	7.10b	7.05c	6.72c	6.77c
T_4	7.47a	7.45a	7.42a	6.82d	6.80c	6.78c
T_5	6.12d	5.98d	6.02d	6.01e	5.87d	6.00d

Means carrying same letters in a column for each factor do not differ significantly (p = 0.01)

Table 9: Means for effect of storage on sensoric attributes of defatted rice bran supplemented flour cookies

Storage (days)	Color	Flavor	Taste	Texture	Crispness	Overall acceptability
0	7.26a	7.19a	7.16a	7.38a	7.27a	7.15a
30	6.86b	6.84b	6.87b	7.03b	6.87b	6.78b
60	6.43c	6.54c	6.53c	6.65c	6.45c	6.40c

been observed that during storage of cookies, moisture absorption results in deterioration of flavor due to oxidation of fat (Wade, 1988; Sharif *et al.,* 2005) and stailing (Setser, 1996). The development off-flavor as a result of oxidation of fats is particularly related to the presence of moisture, further accelerated by metal ions and light (Manley, 2002).

The taste is a sensation perceived by the tongue and influenced by the texture, flavor and composition of the foods. Means for taste (Table 8) unveiled that the judges ranked T_4 (7.42) at the top position followed by T_3 (7.10) and T_2 (6.90), whereas T_5 (6.02) was placed at the bottom. Statistically, T_3 and T_2; T_0 and T_1; showed non-significant variations with each other. Maximum scores (7.16) were assigned to fresh cookies, which were gradually decreased (6.87 and 6.53) after 30 and 60 days storage (Table 9). The decrease in cookies score was might be due to the rancidity of fats during storage.

Food texture is extremely important to the consumer. Yet, unlike color and flavor, texture is used by the consumer not as an indicator of food safety but as an indicator of food quality. The mean values for texture of cookies (Table 8) explicated that judges placed T_0 (7.58) at top, followed by T_1 (7.33) and T_2 (7.32). Highest mean score (7.38) was obtained by fresh cookies (0 day), that was decreased (6.65) during 60 days storage (Table 9). The declining trend in quality score for texture was might be due to absorption of moisture from the atmosphere that has inverse correlation with texture (Sharif *et al.,* 2005).

The quality score in response to crispness of the cookies has been presented in Table 8. Means for crispness of cookies alluded that T_0 got the maximum score (7.67) followed by T_2 (7.10) whereas minimum score was obtained by T_5 (5.87). Collectively, the maximum score (7.27) was obtained by the fresh cookies that decreased significantly (6.45) after 60 days storage (Table 9). Deterioration during storage can manifested itself by changes in physical and chemical characteristics, referred to as spoilage mechanism. In case of physical changes, loss of crispiness occurs due to moisture uptake as biscuits are hygroscopic in nature (Wade, 1988; Manley, 2002).

Overall acceptability was determined on the basis of quality scores obtained from the evaluation of color, taste, flavor, texture and crispness of the cookies. The means regarding overall acceptability of cookies are presented in Table 8. It is evident from the results that T_2 (cookies with 20% DFRB) was more appealing (7.28) for judges followed by T_1 (cookies with 10% DFRB), T_0 (cookies with 0% DFRB) and T_4 (cookies with 40% DFRB) i.e. 7.05, 6.78 and 6.78, respectively. As a whole, the maximum scores were obtained by fresh cookies, which gradually decreased from 7.15 to 6.40 during 60 days storage (Table 9). The decrease in overall acceptability was due to decrease in color, flavor, taste, texture and crispness scores. These results were in close agreement with those of observed in earlier studies (Pasha *et al.*, 2002; Butt *et al.*, 2004; Sharif *et al.*, 2005). Cookies are considered better for supplemented flours due to their wide consumption, relatively long shelf-life, ready-to-eat form and excellent eating quality (Tsen *et al.*, 1973). Cookies with high sensoric attributes have been produced from blends of millet/pigeon pea flour (Eneche, 1999), raw rice and wheat (Singh *et al.*, 1989), blackgram and wheat (Singh *et al.*, 1993), chickpea and wheat (Singh *et al.*, 1991), wheat, fonio and cowpea (McWatters *et al.*, 2003) and soybean, chickpea or lupine with wheat (Hegazy and Faheid, 1990). Similarly, cookies with high sensory ratings have been produced from blends of wheat flour and rice bran.

Conclusion: From the present research work, it was concluded that replacement of wheat flour with defatted rice bran upto 10-20% is possible without adversely affecting physical and sensory characteristics of cookies. Rice bran supplementation significantly improved the dietary fiber, mineral and protein content of the cookies. Moreover, cost of production was also reduced with proportionate increase of supplementation.

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