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*Full Length Research Paper*

# Effect of fat-replacement through rice milling by-products on the rheological and baking behaviour of dough

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**Baking market is deriving the new technique to produce low fat foods due to high demand from the health conscious individuals. Fat replacement is largely focused on the fat rich food such as biscuit, cookies and cake etc. Rice bran and broken rice are the two major by-products of rice milling industry that contain important chemical properties such as moisture, hardness score, protein, fiber and ash. The known percentages of rice bran and broken rice powder were mixed separately with wheat flour. The impact of substitution on the rheological behaviour, such as the dough development time, dough strength, dough stability, dough softening, force required to blow bubble in dough, elongation of bubble, swelling index and peak viscosity was studied by Farinograph and Alveograph. The results showed that mixing and baking behaviours are strongly linked to the enzyme treatment and the particle size of rice products. The results are promising and elaborate the competency of rice bran and broken rice as an excellent economical and health stimulating, future substitute for fat replacement in the soft-dough biscuits.**

**Key words:** Rice milling by-products, dough development behavior, farinograph, alveograph, fat replacement, end quality impact.

## INTRODUCTION

High fat intake is associated with various health disorders such as obesity, diabetes, cancer, high blood cholesterol, and coronary heart diseases (Alexender, 1995). A wide variety of ingredients are now introduced as fat replacers to capture the market of low caloric food products (Akoh, 1998; Keetles et al., 1996), particularly, cereal, vegetable fruit, nuts and olive commercial wastes containing reasonable amount of functional ingredients, which not only provide water holding and ion exchange capacity but also reduce uptake of fat with minimal effects on physicochemical and sensorial properties (Jimenez et al., 2000).

Fat is one of the principal ingredients that affect the biscuit's texture as compared to the sugar or flour (Champagne, 1996). Generally, the increase in fat content resulted in more friable and reduced crispy texture, while the reduction in fat produced hard chewy texture with low moisture content (Kruger and Hatcher, 1995). Fat mimetic is a vast group of substances that includes carbohydrates, proteins or structured lipids that provide 0 to 4 kcal/g energy, contributing parallel functional and sensorial properties. Carbohydrate-based fat mimetics are the most common additives that include modified starches, gums, dietary fibers, ß-glucans, polydextroses and maltodextrins etc (Chrastil, 1992). The pasting and mixing characteristics of dough have been optimally modified by incorporation of soluble and insoluble fibers in chapatti (Yadav et al., 2009). Replacement of 50% of the fat by the soluble ß-glucans

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and amylodextrins derived from oat flour produced cookies that were not significantly different from their full-fat counterparts, however, higher substitution adversely affected the overall quality of biscuits (Kumar and Sharma, 2004).

Rice is one of the major consuming crops in South and Southeast Asia (Gustavsson et al., 2011). Rice bran is brown powder, highly nutritious milling waste of the rice industry. In Pakistan, approximately 6.9 million tons of rice are produced annually while bran and broken rice commercially wasted as 10 and 3% respectively. An estimated global production of rice bran is 27.3 million ton while Pakistan produced 450 to 500 thousand tons annually (GOP, 2004, 2009). Rice-based fat substitutes are able to mimic fat, providing better mouth feel and texture perception in view of their two major properties; firstly, the rice starch granule is about the same size as that of the homogenized fat globule (Gaines, 1991) and secondly, it is modified starch and forms gel with uniform distribution of small air bubbles that contributes to the soft texture of the biscuit (Keetles et al., 1996). The rice is more competent in gel formation because of the fact that amylose molecules leach out from starch granules easily during its gelatinization process that forms the three dimensional structure on cooling (Maache-rezzoug et al., 1998). Rice-based fat substitutes are less explored in spite of the fact that its components show better water solubility, water holding capacity and gelling strength (Yackel and Cox, 1992). Some of the rice proteins are considered valuable fat substitutes because of their functional properties with tasteless, colourless, and hypoallergenic character (Yang et al., 2003). The hydrolysate of rice contains approximately 90% maltodextrin with DE 2-3, while 10% protein with the significant blend of essential amino acids and a small amount of fat and minerals (O'Brien et al., 2003; Inglett et al., 1994). Rice bran is rich in fibers, proteins, starches, high quality edible oils, oryzanol, ferulic acids and non starch polysaccharides that are responsible for its valuable nutraceutical properties. Rice bran contain 12 to 32% oil (Akoh, 1998), which is rich in unsaturated fatty acids such as oleic acid, linoliec acid and antioxidants which makes it suitable for frying (Ring, 1985); other cereal by products such as oat mill waste contains 2.2 to 7.8 g/100 g β-glucan. Patsioura et al. (2011) described an efficient method for the isolation of β-glucan from oat mill. It can be used for the replacement of fat in yogurt similarly to produce alternative milk products for lactose intolerant and high cholesterolemic patients (Webster, 2002; Lazaridou et al., 2007).

Several nutritional studies on the rice bran ingredients such as bran oil is known for lowering blood cholesterol, risk of cardiovascular disorders and arthrosclerosis etc. (Sanchez et al., 1995). Fibers, the non-starch polysaccharides, proteins and lipids make rice bran an ideal fat substitute as these components are the known fat replacers; moreover, defatted rice bran has good water holding capacity which is the prerequisite of fat replacer (Bobalik and Taranto, 1980). Gamma oryzanol is a mixture of ferulic acid esters and sterols besides its antioxidant and nutritional value; it can be useful in baking as ferulic acid is known to increase the baking performance of dough. The ferulic acid cross links arabinose and galactose (Sanchez et al., 1997), making the network much stronger and sustainable. It is also possible that during mixing of dough, arabinose units of rice bran cross link in the presence of indigenous ferulic acid and form higher molecular weight polysaccharides; this cross linking may also affect the rheological behavior of dough and sensory attributes of the end product. The digestibility may be altered in view of the new bonds created because of the cross linking.

The present study is therefore based on the substitution of treated and untreated rice bran and broken rice powder for fat in biscuits and to explore the new potentials in making industrially oriented nutraceutical baked products.

## MATERIALS AND METHODS

Rice bran, of particle size (80 mesh) was obtained from Matco Rice Mills, Karachi, using the Satake FM-18 polisher mill, broken rice was provided by Habib-ADM Ltd. Karachi. The refined wheat flour was supplied by Madina Flour Mills, Karachi, and all the baking ingredients were purchased from grocery store, University of Karachi. α-amylase (EC 3.2.2.1) and trypsin (EC 3.4.21.4) were purchased from Merck, Germany, while the sodium hydrogen phosphate and sodium dihydrogen phosphate were supplied by the Sigma-Aldrich, Germany. The vacuum oven (OV-11/12, Korea) was used for low temperature drying. Brabender Farinograph E (CW Brabender Duisbery, NJ, USA) and Alveograph NG consistograph (Chopin 50-54 France) were used to study the rheological characteristics. An Inframatic 9200 NIR (near infrared reflectance) analyzer (Perten, Springfield, IL) was used for compositional analysis. All other chemicals and solvents were used for analytical grade.

### Physiochemical analysis

The ICC/AACC method (2005) was used to determine the moisture (44-45A), total protein (39-11), hardness score (39 to 70A), fiber (32-05) and ash (08-01).

### Stabilization of rice bran

The rice bran (1 kg) was freshly obtained and stabilized by heating in the microwave oven (Dawlance-DW180G) for 2 min with 1400 W power input, and frequency of 2450 MHz. Microwave treatment deactivated the lipase activity responsible for the rancidity of oil referred to as untreated rice bran. Furthermore, untreated rice bran was separately treated with protease enzyme to convert it to treated rice bran as given in Figure 1.

### Untreated broken rice

Broken rice was grounded using Anex TS-630CS and sieved to get powder of mesh size 80. Rice flour was defatted with hexane for 1 h at room temperature and centrifuged at 3000 g for 10 min.

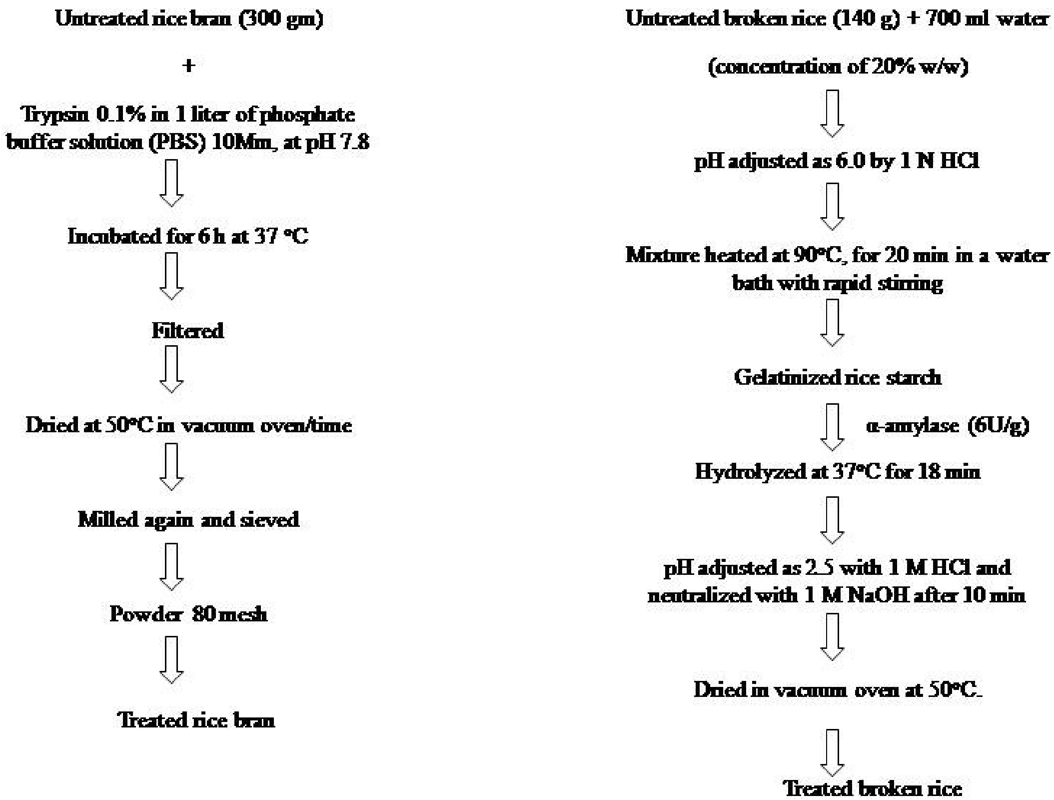


**Figure 1.** Flow diagram for enzyme treatment to obtain treated rice bran and broken rice powder.

Supernatant was discarded while residue was dried for 30 min at room temperature referred to as untreated rice bran. For amylase enzyme, the treated broken rice was prepared as shown in Figure 1.

### Farinograph properties

Rice bran and broken rice powder addition served as fat substitutes. The mixing properties of wheat dough were evaluated by Farinograph using a 50 g bowl, following the AACC Method 54-21. Briefly, a known amount of refined wheat flour, on the basis of moisture was taken in the bowl with the known amount of fatreplacers according to the formulation given in the preparation of cookies. The water was added from the burette during mixing to give a dough consistency of 500 Brabender units (BU). The mixing was performed for 20 min and the following parameters were derived from the resulting Farinogram such as water absorption (WA), dough development time (DDT), dough stability (DS), Farinograph quality number (FQN) and the degree of softening. The results are reported as the average value of triplicate measurements in Table 2.

### Alveograph properties

Rice bran and broken rice powder affects the extensibility and elasticity of dough that was determined by Alveograph NG Consistograph following the method of AACC 2000 (54-30A). Wheat flour dough (250 g) formulated in accordance with the recipe was given in preparation of cookies. All the ingredients were mixed with 2% salt solution. Prepared dough sheeted and cut into five patties of 4.5 cm diameter. It was incubated for 20 min and then subjected to Alveograph, where blown air expands the dough till break down. Parameter evaluated for dough expansion was maximum length of bubble (L), maximum power to blow the bubble (P), swelling index (G) when the bubble breaks and baking power (W) were represented as the mean of five measured values in Table 2.

### Preparation of cookies

The cookies were formulated by 46 g flour, 0.21 g salt, 18 g icing sugar, 0.14 g lecithin, 5 g egg, 0.03 g condensed milk flavor and 6 ml distilled water. The control recipe contains 23 g of shortening (Kisan Ghee). Equal amount of shortening was replaced in the recipe by treated and untreated rice bran such as 2.3 g (10%), 4.6 g (20%) and 6.9 g (30%), similarly, treated and untreated broken rice powder was replaced by 2.3 g (10%) and 11.5 g (50%). The dough was prepared in the Hobart N-50 mixer at slow speed for 7 min. The firm dough obtained was sheeted to 20 mm width and cut into 4.5 cm diameter. The cookies were baked in the preheated oven at 205°C for 8 min, cooled to room temperature (24°C) for 20 min, sealed in polypropylene pouches separately and stored at 15°C in the refrigerator till further use.

### Sensory evaluation

The cookies were analyzed by twenty panellists according to the Hedonic scale (Table 3), taking into consideration the attributes such as the surface-color, appearance, texture, taste and mouth feel. Each attribute was examined using 10 point Hedonic scale,

**Table 1.** Effect of rice bran and broken rice powder on chemical composition of substituted wheat flour.

| Variety | Substitution (%) | Moisture (%) | Hardness score | Protein (%) | Fiber (%) | Ash (%) |
|---|---|---|---|---|---|---|
| **Untreated substitute** | | | | | | |
| Rice Bran | Control | 13.6±0.35$^{a}$ | 44.1±0.8$^{b}$ | 9.7±0.00$^{e}$ | 3.2±0.20$^{g}$ | 1.3±0.20$^{j}$ |
| | 10 | 13.2±0.21$^{a}$ | 45.2±0.7$^{c}$ | 9.7±0.04$^{e}$ | 7.8±0.35$^{h}$ | 1.5±0.13$^{j}$ |
| | 20 | 13.1±0.10$^{a}$ | 45.5±0.5$^{c}$ | 9.7±0.05$^{e}$ | 8.1±0.41$^{h}$ | 1.9±0.25$^{k}$ |
| | 30 | 13.1±0.14$^{a}$ | 45.1±0.3$^{bc}$ | 9.2±0.06$^{f}$ | 12.4±0.32$^{i}$ | 2.1±0.01$^{k}$ |
| Broken Rice powder | 10 | 13.5±0.07$^{a}$ | 45.5±0.4$^{c}$ | 9.8±0.07$^{e}$ | 3.1±0.23$^{g}$ | 1.3±0.12$^{j}$ |
| | 50 | 13.1±0.07$^{a}$ | 46.2±0.2$^{cd}$ | 9.5±0.07$^{g}$ | 3.2±0.45$^{g}$ | 1.3±0.14$^{j}$ |
| **Treated substitute** | | | | | | |
| Rice bran | 10 | 13.8±0.08$^{a}$ | 45.5±0.5$^{c}$ | 9.7±0.00$^{e}$ | 7.9±0.23$^{h}$ | 1.4±0.12$^{j}$ |
| | 20 | 13.6±.0.04$^{a}$ | 45.4±0.6$^{c}$ | 9.8±0.06$^{e}$ | 8.3±0.35$^{h}$ | 1.8±0.13$^{jk}$ |
| | 30 | 13.3±0.07$^{a}$ | 45.1±0.5$^{bc}$ | 9.8±0.07$^{e}$ | 12.3±0.45$^{i}$ | 2.1±0.14$^{k}$ |
| Broken rice powder | 10 | 13.4±0.06$^{a}$ | 47.2±0.2$^{d}$ | 9.3±0.00$^{f}$ | 3.2±0.52$^{g}$ | 1.3±0.12$^{j}$ |
| | 50 | 13.4±0.02$^{a}$ | 45.5±0.3$^{c}$ | 9.3±0.07$^{f}$ | 3.1±0.24$^{g}$ | 1.2±0.11$^{j}$ |

Each value expressed as mean± S.D. (*n=3*); mean with different small letters within a column are significantly different calculate by LSD method ($P<0.05$); $^{a}$mean within a column is not significantly different ($P>0.05$).

except texture and taste on the basis of 20 point scale, representing number 1 as the most unacceptable while 10 shows highly acceptable.

#### Statistical analysis

All the tests were conducted in triplicate and were analyzed by one-way analysis of variance (ANOVA). The data were analyzed applying Minitab software, Windows version. The linear correlation coefficient between the matching parameters of the samples were calculated, using formula $r=\sigma xy/\sigma x\sigma y$, where r is correlation coefficient, $\sigma xy$ represents standard deviation or covariance of two data sets, $\sigma x$ shows standard deviation of x value and $\sigma y$ is standard deviation of y value.

## RESULTS AND DISCUSSION

It was observed that after the enzyme treatment of both rice bran and broken rice, they both showed higher absorption of water due to the increase in the surface area. In the case of treated rice bran digestion, it caused low molecular weight protein production while treated broken relates with amylodextrins from starch in accordance with the earlier findings of Sébastien et al. (2004). Chemical composition was not drastically affected by the addition of rice bran and broken rice. Moisture of composite flour insignificantly effected. Hardness that indicates the frequency of starch protein interactions remained unchanged, suggesting that interactions were not facilitated during the initial dry mixing of ingredients. Most of the composite flour mixes; protein content also remains unchanged except 50% untreated broken rice powder and 10% treated rice powder. Fiber and ash contents were significantly higher in blends with untreated and treated rice bran responsible for alterations in dough behaviour while negligible effect on the fiber and ash content was observed in untreated and treated broken rice powder (Table 1).

Heating and tryptic treatment of bran was linked with firm and harder texture. The bran was affected in two ways: firstly, the lipase was degraded and deactivated for stabilizing rice bran oil; secondly, the bran proteins were converted into reduced molecular sizes to be microparticulated during the mixing and baking process in order to obtain fat. The microparticulated proteins are the engineered, denatured and aggregated spheroidal protein particles of 0.1 to 0.3 µm in diameter (the size is equivalent to that of the fat globules) having similar functional properties as those of fat globules. Fats are responsible for the creamy, lasting and smooth mouth feeling in the products. Recent developments have introduced a variety of microparticulated protein-based fat replacers in diverse food systems; protein hydrolysates are documented to have increased water holding, foaming and emulsifying capacities, and so they are helpful in product development (Stojceska and Butler, 2008; Ring, 1985). The proteins from broken rice powder are known to form fine gel on heating in the presence of enough water, which is the property that helps in fat replacement. Protein contents are directly related to the WA of flour that takes part in developing gluten network (Ma et al., 2007).

The Farinograph curve shows that there was negligible change in WA of the enzyme treated and untreated samples and the gluten network therefore remained almost unchanged, this may be due to the fact that bran consists of 7.8% crude fibre (Shih et al., 1999) out of which 2.1% pentosans also form the network and support the dough strength. As the quantity of untreated rice bran increased in wheat flour, dough strength decreased

**Table 2.** Rheological properties of dough by partial substitution of rice bran and broken rice powder (treated and untreated).

| Variety | Substitution (%) | Farinograph | | | | | Alveograph | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | WA (%) | ST (min) | DDT (min) | DS (FU) | FQN | P (mm) | L (mm) | G (mm) | W ($10^4$ J) |
| **Untreated substitute** | | | | | | | | | | |
| | Control | 60 | 1.3 | 1.5 | 105 | 26 | 74 | 38 | 18 | 95 |
| Rice bran | 10 | 59.2 | 0.6 | 1.7 | 115 | 52 | 60 | 37 | 18 | 95 |
| | 20 | 61 | 1.2 | 1.9 | 117 | 29 | 59 | 35 | 18 | 70 |
| | 30 | 59.2 | 1.3 | 1.8 | 118 | 30 | 54 | 33 | 18 | 60 |
| Broken rice powder | 10 | 59.1 | 2.4 | 1.5 | 151 | 33 | 40 | 43 | 18 | 58 |
| | 50 | 59 | 1.3 | 1.9 | 119 | 42 | 30 | 78 | 20 | 64 |
| **Treated substitute** | | | | | | | | | | |
| Rice bran | 10 | 59.6 | 1.4 | 1.9 | 115 | 33 | 72 | 44 | 18 | 116 |
| | 20 | 58.3 | 1.1 | 1.7 | 119 | 31 | 65 | 40 | 18 | 104 |
| | 30 | 59.6 | 1.3 | 1.8 | 117 | 31 | 56 | 38 | 18 | 95 |
| Broken rice powder | 10 | 63 | 1.4 | 1.3 | 128 | 31 | 56 | 56 | 18 | 95 |
| | 50 | 60 | 1.2 | 1.4 | 148 | 31 | 45 | 68 | 19 | 91 |

WA = Water absorption; ST = Stability; DDT = dough development time; DS = Degree of softening; FQN = farinograph quality number; P(mm) = force required to blow bubble; L(mm) = elongation of bubble; G = Alveograph swelling index; W = baking power.

**Table 3.** Sensory qualities of cookies determined by Hedonic scale.

| Variety | Substitution (%) | Color (10) | Appearance (10) | Texture (20) | Taste (20) | Mouth feel (10) | Total score (70) |
|---|---|---|---|---|---|---|---|
| **Untreated substitute** | | | | | | | |
| | Control | $9.2±0.76^a$ | $8.5±0.52^c$ | $18.5±0.92^f$ | $17.2±0.62^j$ | $8.0±0.61^n$ | 61.4 |
| Rice bran | 10 | $9.0±0.89^a$ | $6.8±1.07^d$ | $15.0±0.89^g$ | $15.1±0.99^k$ | $7.1±1.09^o$ | 53 |
| | 20 | $7.8±0.87^b$ | $5.8±0.95^e$ | $14.8±0.68^{gh}$ | $14.9±0.96^k$ | $6.3±0.71^p$ | 49.6 |
| | 30 | $7.3±1.11^b$ | $4.9±0.62^e$ | $11.2±1.16^h$ | $13.1±1.44^l$ | $5.1±0.89^q$ | 41.6 |
| Broken rice powder | 10 | $9.2±0.98^a$ | $8.0±0.74^c$ | $17.1±0.82^i$ | $17.1±0.99^j$ | $7.7±1.23^n$ | 59.1 |
| | 50 | $9.2±0.64^a$ | $7.9±0.83^c$ | $14.2±1.13^h$ | $17.2±0.70^j$ | $7.1±0.77^o$ | 55.6 |
| **Treated substitute** | | | | | | | |
| Rice bran | 10 | $9.1±0.85^a$ | $7.1±0.68^d$ | $15.8±1.21^j$ | $15.2±1.36^k$ | $7.2±1.03^o$ | 54.4 |
| | 20 | $8.8±1.50^a$ | $6.8±0.68^d$ | $14.9±0.70^g$ | $14.8±0.68^k$ | $6.7±1.10^{op}$ | 52.0 |
| | 30 | $7.8±1.17^b$ | $6.5±0.63^d$ | $11.5±1.32^h$ | $12.1±1.21^m$ | $6.3±0.95^{po}$ | 44.2 |
| Broken rice powder | 10 | $9.1±0.68^a$ | $8.1±0.82^c$ | $17.5±0.97^i$ | $17.3±1.05^j$ | $7.9±0.75^n$ | 59.9 |
| | 50 | $9.2±0.66^a$ | $8.0±0.74^c$ | $14.9±0.93^g$ | $17.4±0.80^j$ | $7.6±0.99^n$ | 57.1 |

Each value is expressed as mean ± S.D. (n= 20 panelists); mean with different small letters within a column are significantly different calculate by LSD method ($P<0.05$).

continuously; it neither consists of free pentosans nor the glutenin/gliadin, which are the major components responsible for providing strength. However, amylolytic treatment also decreased the dough stability slightly. The other values did not change significantly.

The values of water absorption (WA %), dough development time (DDT), dough stability (ST), dough softness (DS) and Farinograph quality number (FQN) obtained by Farinograph curve are given in Table 2. WA is associated with a number of factors including the protein and non-starch polysaccharides (NSP) contents in the dough and higher water absorption is attributed to higher protein and fiber contents especially higher molecular weight proteins and NSP (Yackel and Cox, 1992). Addition of bran reduced the strength of the gluten network for two reasons: firstly, bran itself has no gluten

**Table 4.** Correlation coefficients between rheological characteristics of the bran dough and sensory characteristics of cookies.

| Parameter | Color | Appearance | Texture | Taste | Mouth feel |
|---|---|---|---|---|---|
| **Untreated rice bran** | | | | | |
| WA (%) | 0.10 | 0.09 | 0.36 | 0.32 | 0.16 |
| ST (min) | 0.45 | 0.09 | 0.03 | 0.00 | 0.24 |
| DDT (min) | 0.81 | 0.89 | 0.73 | 0.76 | 0.78 |
| DS | 0.78 | 0.95 | 0.89 | 0.92 | 0.86 |
| FQN | 0.36 | 0.01 | 0.11 | 0.13 | 0.12 |
| P | 0.80 | 0.96 | 0.95 | 0.97 | 0.91 |
| L | 0.98 | 0.95 | 0.93 | 0.93 | 0.99 |
| G | - | - | - | - | - |
| W | 1.00 | 0.89 | 0.82 | 0.82 | 0.94 |
| **Treated rice bran** | | | | | |
| WA (%) | 0.30 | 0.00 | 0.32 | 0.39 | 0.06 |
| DS(min) | 0.03 | 0.33 | 0.01 | 0.07 | 0.39 |
| DDT(min) | 0.22 | 0.50 | 0.20 | 0.12 | 0.55 |
| Softness | 0.22 | 0.50 | 0.20 | 0.12 | 0.55 |
| FQN | 0.68 | 0.87 | 0.66 | 0.60 | 0.90 |
| P | 0.97 | 1.00 | 0.97 | 0.95 | 0.99 |
| L | 0.88 | 0.98 | 0.87 | 0.83 | 0.99 |
| G | - | - | - | - | - |
| W | 0.93 | 1.00 | 0.92 | 0.88 | 1.00 |

A = water absorption, ST = Stability, DDT = dough development time, DS = Degree of softening FQN = farinograph quality number, P(mm) = force required to blow bubble, L(mm) = elongation of bubble, G = Alveograph swelling index ,W = baking power (n = 3).

and secondly, the bran also compete with gluten for water uptake, resulting in less water availability for proteins to form gluten network and thus providing a week dough (Keetles et al 1996). The ST also declined with the addition of the untreated and treated broken rice and rice bran but increased on tryptic digestion.

Dough's elasticity and strength as measured by Alveograph is shown in Table 2; maximum resistance of the dough which is measured as pressure required to blow the bubble was used to predict the dough volume (Yackel and Cox, 1992) and is related to the elasticity of the dough expressed as (P) while elongation of dough (L) also indicates elasticity which predicts the spreadibility. The baking power (W) shows the deformation energy and measures the strength of the dough based on the protein content of the flour and the index of swelling being denoted by (G). Power to blow the bubble (P) increased with the addition of untreated broken rice and treated broken rice, which indicates the improved visco-elastic properties of dough. The elongation of dough (L) increased by increasing the quantity of treated rice bran while it was decreased with the addition of other replacers because of lack of elastic gluten in untreated broken rice and rice bran; however, proteolytic treatment and mixing provided favourable chances for rebuilding of the protein molecules with better elasticity. Interestingly, baking powder (W) increased by the addition of the untreated and treated rice bran which also increased in dough strength and the effects of rice bran were also observed earlier in the reports of Ozen and Hamit (1997). The index of swelling (G) as shown by Alveograph was improved by addition of the untreated and treated rice bran due to the presence of fiber. The blended wheat flour with rice bran are suitable for baking of biscuits, loaf volumes in the bread.

Generally, the overall sensory quality of biscuits decreased with increased bran substitution as compared to the control (Table 3). However, for the attribute of taste, which is the most important of all the sensory attributes, biscuits with 10 and 20% fat replaced by the treated and untreated bran were comparable to the control recipe. The slight bitter taste was observed in the products consisting of bran while there was no adverse effect on the biscuit's quality when substituted with broken rice up to 50% and the products were more close to the control. Colour and appearance is the most prominent factor for the consumer acceptability. The treated and untreated broken rice powder, colour and appearance were equivalent to the control recipe, while bran recipe gets dark colour and unacceptable appearance except 10% substitution. Biscuit prepared with broken rice powder was highly acceptable in terms of taste and mouth feel for 10 and 50% substitution oftreated broken rice and 10% untreated rice bran.

The correlation of rheological and sensorial properties mentioned in Table 4 shows that DDT and DS are highly correlated with all sensory characters of the untreated rice bran while insignificant in the case of treated rice bran. Alveographic properties like P, L, and W are strongly correlated with the sensorial properties of untreated and treated rice bran while FQN values of both untreated and treated rice bran are not competent to evaluate the sensory attributes.

## Conclusion

The present study shows that low caloric cookies may be prepared by using 10% substitution untreated and treated rice bran or 50% of the untreated and treated broken rice powder. The products were acceptable in view of the good sensory scores. The biscuits are nutritionally superior as the caloric values were reduced; the nutritive indexes of various nutrients were therefore raised and the cost of biscuits also reduced by 10% approximately. Tryptic treatment increased the acceptability of texture and mouth feel which are both attributes of biscuits. Briefly, it may be reported that nutraceutical biscuits improved nutritive indexes and reduced fat may be produced using protease treated rice bran or amylase treated broken rice powder.

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