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Influence of rice flour on wheat flour based low-gluten flat bread: Functional and bread parameters characterization

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Abstract
The present study was undertaken to develop low-gluten flat-bread from the rice and wheat flour. Composite flour was prepared by blending wheat flour with rice flour in the ratio of 48:52. Functional properties, bread parameters, and organoleptic properties were evaluated and the results revealed that water absorption capacity and oil absorption capacity increased with increase in rice flour incorporation while as gluten content, loaf volume, specific volume decreased. Overall acceptability for flat bread was awarded highest score indicating 52% rice flour addition showed increase in bread quality parameters without affecting its quality attributes.

Keywords: Influence, flour, low-gluten, parameters, characterization

Introduction
A small segment of the world population suffers from dietary wheat intolerance. The responsible pathogenic factor has been traced to the gliadin fraction of gluten. The need for non-gluten, low sodium, or low protein breads could be satisfied by using rice flour in yeast leavened breads. Rice (*Oryza sativa* L.) is one of the leading food corps in South East Asia including India, and the production of rice in this part of the world is much higher than that of wheat. Rice is one of the most important crops in the world in addition to wheat and maize and more than 650 million metric tons of paddy rice is produced worldwide per year (InterRice 2009). Among the chemical components of rice grains, amylase and protein contents are very important factors influencing the eating quality of rice. Also the moisture content, low molecular weight sugar and mineral content affect the palatability of rice. Rice has properties such as the absence of gluten, low levels of sodium, protein, fat and fibre, and a high amount of easily digested carbohydrates, which are desirable for certain special diets. In countries where rice production is more suitable than wheat or corn because of climatic conditions, it is highly desirable to partially substitute rice flour for wheat flour in bread and bakery products. The manufacture of bread from rice without gluten presents considerable technological difficulty because gluten is the most important structure forming protein for making bread. Gluten-free breads can be made from cassava, maize, potato, or rice starch Onyango *et al.* (2011) [19]. If it is possible to make consumer acceptable rice bread from these broken grains, it would not only utilize effectively the broken grains to convert it to a value added product, but also would be a better alternative for gluten allergic patients. Celiac disease is a digestive disorder which damages the villi, tiny hair like projections in the small intestine that absorb nutrients due to an immunological reaction to gluten (Crockett, 2009; Barada *et al*., 2010) [6, 2]. Flatbreads are the most primitive type of bread prepared by humans because the ingredients were readily available and simple; flour, water, and sometimes salt were used and without any specialized tools, kneaded into pliable dough before being shaped by hand and baked. Flatbreads could be eaten at every meal, due to the ease of making them, and they also functioned as plates with other foods being served on top of them or the flatbreads could be ripped into pieces and used as an implement to facilitate eating other parts of the meal. Of great importance, among the people of India and the Middle East, forms of flatbreads are also found in Europe, Africa, Southeast Asia, and the Americas (Parimala and Sudha, 2015) [20]. The consumption of Indian flatbreads has also spread to Western countries where their popularity is increasing due to their versatility (Mir *et al*., 2014) [17]. In India, there are several forms of flatbreads such as chapati, parotta, puri, and tandoori roti, which are consumed as part

of the daily diet. Indian flatbread is made from wheat flour and water, with or without the addition of yeast or other leavening agents and ingredients such as salt. Therefore, the objectives of this study were to evaluate the feasibility of preparing rice-wheat premix bread with qualities consistent with rice-wheat bread and to analyze the keeping time of premix with no reduction of bread quality.

Materials and Methods

Materials

Wheat flour (*Triticum aestivum* L.) and rice broken was obtained from local market of Srinagar Kashmir. Rice broken was milled in an ASR RM 209 modern rice mill. The rice broken were pulverized to pass through a 200-µm sieve and was stored for further analysis.

Preparation of wheat flour and rice flour blend

Blended flour was prepared by replacing wheat flour with rice flour at 48% as per the preliminary trials and sensory evaluation by the expert panellists.

Functional properties of flour:

Water absorption capacity (WAC): WAC of the flours was determined by the method of Sosulski *et al.* (1976) [26]. One gram of sample mixed with 10 mL distilled water and allow to stand at ambient temperature (30±2 °C) for 30 min, the centrifuged for 30 min at 3,000 rpm or 2000 × g. WAC was examined as per cent water bound per gram flour.

Oil absorption capacity (OAC): OAC was determined by the method of Sosulski *et al.* (1976) [26]. One gram of sample mixed with 10 mL soybean oil (Sp. Gravity: 0.9092) and allow to stand at ambient temperature (30±2 °C) for 30 min, the centrifuged for 30 min at 300 rpm or 2000 × g. OAC was examined as percent oil bound per gram flour.

Falling number

The slurry of 7 g of sample with 25 mL of water was used to determine the falling number values (sec) on the Falling Number AB apparatus according to AACC (2005) procedure.

Gluten content

The wet and dry gluten contents were estimated using the method described in AACC (2005) and calculated using equations (1) and (2), respectively;

$$Wet\ gluten\ (\%) = \frac{Weight\ of\ wet\ gluten}{Weight\ of\ flour\ sample} \times 100$$

$$Dry\ gluten\ (\%) = \frac{Weight\ of\ dry\ gluten}{Weight\ of\ flour\ sample} \times 100$$

Preparation of flatbread

Flat bread was prepared using wheat and rice flour. All the ingredients which included wheat flour: rice flour (48:52), water (60-70 mL approximately), leavening agent (1.725 g) were put together and mixed to obtain a smooth and elastic dough. The dough was allowed to rest in an incubator at a temperature of 37 ºC and relative humidity of 85 % for 30 minutes. Thereafter dough was moulded and glazed with milk, followed by baking in an electric deck oven. After baking, the flatbread was cooled at room temperature and then subjected to analysis.

Physical evaluation of flatbread

Weight: The weight of the loaves was obtained following the method of Feili *et al.*, (2013) [7]. Flat breads were placed on the weighing balance that have previous zero and the weight values were recorded for each sample**.**

Height: The method according to Mcwatters *et al.*, (2003) [16] was used for determination of height of flatbread. The height was measured using Vernier Caliper (Diginatic/Mitutoya, Japan) by placing six flatbreads on top of each other, followed by triplicate reading recorded by shuffling of flatbreads.

Loaf volume: Sorghum seed displacement method was used to determine loaf volume according to the method described by Feili *et al*., (2013) [7]. An empty container was used for the test, sorghum seeds were poured into an empty container until full and the sorghum seeds were measured in a graduated cylinder and marked as V1. Each sample of bread was placed same empty container and sorghum seeds were poured till the bread sample was covered and the container was full. The sorghum seeds were collected and measured in a graduated cylinder as V2. The volume of bread sample was determined by using the formula (3);

$$\text{Loaf volume (mL)} = V1 - V2 \qquad (3)$$

Specific Volume Index: Specific volume of bread samples were measured by the rapeseed displacement method as described by See *et al*., (2007) [23]. The specific volume was calculated by dividing volume/weight (cc/g).

Sensory evaluation

Flatbread prepared from wheat-rice composite flour was assessed for consumer acceptance. Bread samples from composite flour of wheat and rice were compared to bread from control (100% wheat flour). Flat breads were subjected to sensory analysis on a 5-point hedonic scale by a panel comprising of 10 semi-trained members. The panel evaluated the flat breads for sensory parameters including colour, flavour, appearance, texture and overall acceptability. Potable water was used by the panellist for rinsing mouth before each sample.

Statistical analysis

The data obtained was statistically analysed using SPSS software (version 21). All the tests were carried out in triplicate and data is reported as mean±standard deviation. The difference between the means was determined by Duncan's multiple range test ($p < 0.05$).

Results and Discussions

Water absorption Capacity (WAC): Table 1 presented the functional properties of flour samples. The WAC of blended flour (80.24 ±3.15) was observed to be highest than control wheat flour (79.5±3.21). The result suggested that that addition of rice flour to wheat flour affected the amount of water absorption. The increase in WAC in blended flour upon addition of rice flour may be because of higher starch content in rice flour. Jan *et al.* (2021) [10] reported that higher the starch content of feed material, higher will be the WAC of flat bread due to greater exposure of hydrophilic groups of starch to water molecules there by allowing a better moisture penetration into flat breads. Similar observation was reported by Delgado-Nieblas *et al*. (2014). The increase in the WAC has always been associated with increase in the amylose leaching and solubility, and loss of starch crystalline structure. The flour with high water absorption may have more hydrophilic constituents such as polysaccharides.

Oil absorption capacity (OAC): The OAC ranged between 47.3 to 55.2% among all the flours. The blended flour had the highest OAC (49.21±2.14) as compared to wheat flour (47.3±2.04). It is clear that the OAC of blended flour increased with increase in the proportion of rice flour. The possible reason for increase in the OAC of blended flour after incorporation of rice flour could be attributed to the presence of non-polar side chain, which might bind the hydrocarbon side chain of the oil among the flours (Jan *et al*., 2021) [10]. Similar findings were observed by Kaushal *et al*. (2012) [12]. However, the flours in the present study are potentially useful in structural interaction in food specially in flavor retention, improvement of palatability and extension of shelf life particularly in flat breads or other bakery items where fat absorption is desired (Aremu *et al*., 2007) [1]. The major chemical component affecting OAC is protein which is composed of both hydrophilic and hydrophobic parts. Non-polar amino acid side chains can form hydrophobic interaction with hydrocarbon chains of lipids (Jitngarmkusol *et al*. 2008) [11].

Table 1: Functional properties of composite flours

Parameters	Wheat Flour	Rice flour	Flour blend
Water absorption capacity (%)	79.5±3.21^a	81.2±4.12^b	80.24 ±3.15^b
Oil absorption capacity (%)	47.3±2.04^a	55.2±2.24^c	49.21 ± 2.14^b

Results are expressed as means ± standard deviation.
Values followed by different letter in a row differ significantly ($p<$ 0.05).

Falling number

The results of falling number are depicted in Table 2. Falling number which indicates α-amylase activity was significantly ($p<$ 0.05) higher in flour blend (526±4sec) and lower in wheat flour (492±3sec) possibly due to the incorporation of rice flour. Falling number indicates flour quality. More the falling number low will be the amylase activity and vice versa. According to AACC (2005), high falling number (above 300 s) indicates minimal enzyme activity and sound quality of wheat flour. A low falling number (below 250 s) indicates substantial enzyme activity and sprout-damaged wheat or flour. Even after reconstitution, all flour samples falling number were above 300, thus indicated minimal enzyme activity and sound quality of wheat flour (Kaushik *et al*., 2015) [13]. The present study indicated that flour blend had higher falling number depicted sound quality of flour.

Gluten content

Table 2 shows the gluten properties of composite flours. The wheat flour recorded significant ($p\leq$ 0.05) high value of gluten content viz, wet gluten (25.8±1.12%), dry gluten (13.7±0.29). The gluten level was significantly ($p\leq$ 0.05) reduced by increasing level of rice in wheat flour. Addition of rice to wheat flour was reported to cause decrease in gluten content and hence affect baking quality of the flour. The wet and dry gluten contents of blended flour were markedly lower than wheat flour possibly due to the incorporation of Rice flour. Rice flour is gluten-free with major storage proteins of glutelins (65–85%) while prolamins are present in smalller amount (Marco and Rosell, 2008) [14].

Table 2: Gluten properties and Falling number of composite flours

Parameters	Wheat flour	Rice flour	Flour blend
Falling number (sec)	492±3.00^a	578±5.00^c	526±4.00^b
Wet Gluten (%)	25.8±1.12^c	0.00±0.01^a	6.58±0.19^b
Dry Gluten (%)	13.7±0.29^c	0.00±0.01^a	1.12±0.02^b

Results are expressed as means ± standard deviation.
Values followed by different letter in a row differ significantly ($p<$ 0.05).

Bread weight: The results illustrated that loaf weight of low-gluten flat bread (56.51±2.41 g) was significantly affected by incorporation of rice flour and was observed to be higher in comparison to wheat flour bread (50.2±2.32 g). Higher loaf weight has positive economic effects on bread at the retail end (Table 3). Increase in rice flour composition in flat bread increased the loaf weight due to the higher water holding capacity of rice flour than wheat flour hence enhancing the water absorption (Matos and Rosell, 2013) [15]. Also, the presence of hydroxyl groups allows more water interaction through hydrogen bonding thus increasing the level of hydration and eventually more loaf weight. The result is in line with the findings of Islam *et al*. (2012) [9] who reported increase in loaf weight in composite flour.

Loaf volume: Loaf volume determines the baking performance and it is influenced by the quantity and quality of gluten in the flour. The addition of rice flour to wheat flour negatively affected loaf volume of flat bread which reduced from 97±3.12cm^3 to 88±3.05 cm^3. Decrease in loaf volume of bread was due to inclusion of rice flour, which reduced the wheat gluten and consequently weakened the gluten network in the dough. This agreed with previous works of Mubarak (2001) [18] who also obtained a decrease in the volume of bread in pigeon pea, lupin seed, and mango flour supplemented bread.

Specific volume index: Specific volume is a quality indicator of bread that indicates dough expanding ability and oven spring (Giannou and Tzia, 2007) [8]. With the incorporation of rice flour, specific volume decreased significantly ($p<$ 0.05). According to Ragaee *et al.* (2011) [21], partial replacement of wheat flour with grains including cellulose, barley, and oat resulted in a decrease in the volume of bread loaves. This might be supported by the fact that replacing wheat flour with rice flour causes gluten dilution, which affects the proper gluten matrix development throughout the mixing, fermentation, and baking processes. Sankhon *et al.* (2013) [22] found similar outcomes in wheat bread incorporated varying concentrations of locust bean flour.

Bread height

The effect of rice flour on quality of bread by analysing various physical properties is shown in Table 3. Results depicted that with the addition of rice flour, height of flat bread decreased significantly due to low air entrapment. The height of control flat breads was observed to be higher (8.75±1.15) in comparison to rice-wheat blended bread (8.59±1.19). This decrease in bread height could be due to the low gluten content in the blends (Bhatt and Gupta, 2015) [3].

Table 3: Physical properties of low gluten flat bread

Parameters	Control	Flat bread
Bread Weight (g)	50.2±2.32^{a}	56.51±2.41^{b}
Bread Height (mm)	8.75±1.15^{a}	8.59±1.19^{b}
Loaf volume (cm^3)	97±3.12^{b}	88±3.05^{a}
Specific volume index (cm^3/g)	1.93±0.05^{b}	1.55±0.01^{a}

Results are expressed as means ± standard deviation.
Values followed by different letter in a row differ significantly ($p < 0.05$).

Sensory evaluation

Results related to sensory characteristics of appearance, colour, texture, flavour and overall acceptability of low gluten flat bread (LGFB) are depicted in Table 4. The sensory score of LGFB samples with 52% rice flour substitution was better than control flat bread made from 100% wheat flour. With the incorporation of rice flour, the colour scores increased significantly ($p < 0.05$) possibly due to the bright and white colour of rice flour and was found to be higher (4.3±0.17) than control flat bread (3.5±0.02.). Maillard reaction takes place when reducing sugars and protein react together and provide brown color to the baked goods (Shafi *et al.*, 2017) [24]. The sensory score in terms of flavour decreased (3.9±0.08) upon incorporation of rice flour LGFB recorded the non-significant ($p < 0.05$) difference in flavour with rice flour substitution level. The scores for texture and appearance varied significantly ($p < 0.05$) from (3.9±0.09) to (4.1±0.12) and (3.8±0.04) to (4.2±0.13) respectively. Appearance implies visual characteristics of baked product that includes its size as well as the texture and shape (Singh *et al.*, 2019) [25]. The highest score for appearance, colour, as well as texture was recorded for LGFB containing 52% substitution level in comparison to control flat bread Overall acceptability (OAA) varied significantly ($p < 0.05$) from 3.85±0.06 to 4.12±0.15. OAA described as the average value of all the sensory characteristics. Singh *et al.*, (2019) [25] indicated that 52% rice flour incorporated wheat based flat bread was found most feasible for the development of low-gluten flat bread with desired quality attributes and overall acceptability (OAA).

Table 4: Sensory evaluation of Low-gluten flat breads

Parameters	Appearance	Colour	Flavour	Texture	Overall acceptability
Control	3.8±0.04^{a}	3.5±0.02^{a}	4.2±0.13^{b}	3.9±0.09^{a}	3.85±0.06^{a}
Flat bread	4.2±0.13^{b}	4.3±0.17^{b}	3.9±0.08^{a}	4.1±0.12^{b}	4.12±0.15^{b}

Results are expressed as means ± standard deviation.
Values followed by different letter in a row differ significantly ($p < 0.05$).

Conclusion

The study showed that rice flour could be used as substitute for wheat flour for making low-gluten flat bread. The most acceptable preparation of alternate flour based bread was selected on the basis of bread making and sensory quality of bread after incorporation of rice flour with 52% substitution. It was found that wet and dry gluten contents, loaf volume and specific volume decreased whereas, overall acceptability was found to be increased with increase in rice flour incorporation in low-gluten flat bread. Hence it can be concluded, that rice flour could be used as a substitute of wheat flour due to lack of gluten without affecting bread making quality adversely.

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