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Baking and Sensory Characteristics of Bread Made With High-Protein Rice Flour

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ABSTRACT

Prevalence of celiac disease increased the consumption of gluten-free cereals and its products. Rice flour which was gluten-free and hypo allergic has been made into versatile bakery products. Most of the gluten-free cereal flours contain carbohydrates, lack of fiber and protein which is in wheat flour. Gluten-free bread which is made from rice flour has decreased baking characteristics and shelf-life due to the absence of protein functionality in rice flour. Hybridized rice contains high levels of protein (12.04/100g) and fibre (4.2g/100g) can be used as an ingredient in bread to balance the protein functionality. The aim of the present inventions was to increase the nutritional profile of bread by adding high-protein rice flour along with flaxseed to basic white pan bread. Enrichment of flax seed to rice bread leads to increased air cell distribution, high loaf volume, high specific volume, decreased firmness which is similar to control wheat pan bread. The replacement of high-protein rice flour ranges from 100%, 95%, 90%and 85% with incorporation of flaxseed flour at 0%, 5%,10% and 15% were used and evaluated the baking characteristics. The study revealed that the rice flour and flaxseed flour at 85% and 15% levels showed highest loaf volume (475 ml) and specific volume (2.636 ml/g). The result indicated that the volume of bread increased as the content of the flaxseed flour was increased in the bread dough. The white pan bread at 85% rice flour and 15% flaxseed flour was achieved lowest baking loss (7.87) and firmness (265.753g).

Key words: *High-protein rice, Flax seed, Rice bread, Baking characteristics, Sensory analysis*

INTRODUCTION

Celiac disease is a genetic disorder which affects the gastrointestinal system and damage the lining of the small intestine[2] as a result of prolamins fraction consumption in wheat, rye and barley[1]. Celiac disease reduces nutrient absorption of iron, calcium, vitamins A, D, E, K and folate which in turn leads to anemia, calcium deficiency etc[3]. Prevalence of celiac disease is increasing day-by-day all over the world. In India, Celiac disease has been recognized in northern region, primarily in children, since 1960s[5]. Previous findings determine that the Celiac disease in children was one in 300 school children and one in 100 adults in northern India[6,7].

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Reports of Celiac disease from southern part of India are scarce[8].Wheat flour has been replaced by rice flour for celiac disease consumers.

Most of gluten-free products are made from rice flour[2], which have lower protein and fiber content in comparison with wheat products[11]. Hybridized jeeraga samba rice contains high levels of protein (14.0g/100g), dietary fibre (16.88g/100g), magnesium (309.1mg/100g), iron (43.33mg/100g) and calcium (442.8mg/100g) can be used as an ingredient in bread to balance the protein functionality and good source of minerals.

Flaxseed (*Linum usitatissimum*) has been used from ancient time as a bakery ingredient for its medicinalproperties[14]. According to USDA, Flaxseed is classified as a functional food[14,15] because of its high fiber content 27.3/100 g, protein 18.3/100 g, potassium 813 mg/100 g, linolenic acid, n-3 fatty acid 22.8/100 g and lignan content 6.1 to 13.3 mg/g.[15] Flaxseed ingestion has reduced risk for cardiovascular disease[14,17,18] and helps in management of diabetes and hypercholesterolemia[19]. Flaxseed is the richest sourceof lignan (secoisolariciresinol diglucoside), a phytoestrogen[16,20] and supplementation to the diet offers an alternative to hormone therapy[21]. According to the Council on Scientific Affairs, high amounts of insoluble fiber content in flax seed prevents constipation by promoting gut motility. Linolenic acid in flax seed fortified spaghetti remained stableduring processing and cooking. Also during baking, lignancontent in flaxseed remained stable in bakery[22] and dairy products[23]. Flaxseed lignan content was unaffectedin ryebread, graham buns and muffins[23] by bakingand also during storage at temperature of -25°C. Similarly, flaxseed lignan was stable under high-temperature pasteurization, fermentation and milk renneting[23.]

Therefore, the current study was undertaken to develop gluten free rice bread with high-protein rice flour and flaxseed flour and study the effect of various levels of high-protein rice flour and flaxseed flour on baking qualities and sensory characteristic of gluten free bread.

MATERIAL AND METHODS

Raw Materials

The white pan breads were prepared by the replacement of high-protein jeeraga samba rice flour for refined wheat flour. The high-protein jeeraga samba rice was purchase from a Udha Agro Farm, Thanjavur. The flax seed, yeast, margarine, salt, sugar and milk powder were procured from local Thanjavur Consumer Co-operative Warehouse, Tamil Nadu.High-protein rice flour and flaxseed flour was prepared by milledin a mini flour mill (Make: A1 Flour Mill, Bangalore) to attain a minimum particle size. Flour samples were prepared and packed in bags and stored at ±4^{0}C till further testing.

High-protein Rice Bread Preparation

Rice flour, flaxseed flour, sugar, yeast, margarine, salt, skimmed milk powder and water were added as shown in formula Table1.The control bread samples were prepared from 100% high-protein rice flour and the experimental bread was prepared by substituting high-protein rice flour ranges from 100%, 95%, 90% and 85% with incorporation of flaxseed flour at 0%, 5%,10% and 15%respectively of the total composite flour weight.

Table 1: Formulation of gluten free bread with high-protein rice flour and flaxseed flour

Ingredients	Control	Incorporation of Flaxseed Flour		
		5%	10%	15%
Rice Flour(g)	100	95	90	85
Flax seed flour(g)	-	5	10	15
Sugar(g)	30	30	30	30
Yeast(g)	2	2	2	2
Margarine(g)	6	6	6	6
Salt(g)	2	2	2	2
Milk Powder(g)	5	5	5	5
Water (ml)	100	100	100	100

All the ingredients were mixed by straight-dough mixing method with the variable mixing speed at low speed for 2 minutes followed by medium speed for 3 minutes and high speed for 5 minutes. After mixing, the bread mix was transferred into the bread pans and fermented at ±30^{0}C for the period of 30 minutes. After fermentation, the samples were baked at 165^{0}C for 20 minutes followed by cooling at room temperature. The prepared breads samples were packed in polyethylene bags and stored at room temperature ±30^{0}C for the quality assessment.

Loaf Volume, Specific Volume and Baking Loss

Loaf volume was evaluated by rapeseeds displacement method (AACC Method 10-05.01). In this method, aluminium container was used to measure the loaf volume using mustard seeds. Seeds were filled into the aluminum container of known volume until the bottom. Bread volume was placed inside the container and filled till the top with mustard seeds. The extra seed, which equals the loaf volume of bread, was measured using graduated cylinder. The specific volume of the bread(AACC Method 55-50.01) was calculated using the below equation:

$$\text{Specific volume (cm3 /g)} = \frac{\text{loaf weight}}{loaf volume}$$

Baking loss was evaluated by measuring initial weight of batter and final weight of breadafter drying in room temperature for 2 hours.

Crumb and Crust Colour

Color of bread crust and crumb were analyzed by Hunter Lab next generation Color flex EZ spectrophotometer (Hunter associates laboratory, Reston, VA, USA). The calibration of colorimeter was carried out using a standard white and black plate. Color values L, a, b were measured. The dimensions "L" indicate lightness to darkness, "a" indicates redness to greenness and "b" indicates yellowness to blueness.

$$\Delta E = \sqrt{L^{*2} + a^{*2} + b^{*2}}$$

Firmness of Bread

Firmness of bread was determined using the Stable Micro Systems texture analyzer (TA-XT plus) which consists of 30 kg load cell and diameter (36 mm) cylindrical probe. The texture analyzer was set at a pretest speed (1 mm/s) and posttest speed(1.7 mm/s).(74-10A[25].

Air Cell Distribution

Air cell distribution of bread was estimated by capturing scan copy of bread in Laser jet scanner and analyzing with Image J Software. Image was converted to 8-bit and thresholding of image was done to visualize the pores. Number of pores were analyzed for control and bread with different flax seed concentration[27].

Sensory Analysis

Sensory analysis of bread was carried out in 9-point hedonic scale with 25 numbers of trained panelist (female judges 16 and male judges 9) of food technology [26.] Panel members were asked to give score for different parameters such as color, appearance, taste, texture, and overall acceptability. Panelists evaluated the sample coded with different specific code for each parameter: 9=extremely like, 8=like very much, 7=like moderately, 6=like slightly, 5=Neither like nor dislike, 4=dislike slightly, 3=dislike moderately, 2=dislike very much, 1=extremely dislike.

Statistical analysis

The data were interpreted using analysis of variance (ANOVA test) in SPSS software. The significant level wasestablished at $p<0.05$.Mean was found by LSD.

RESULTS AND DISCUSSION

The composite flour was prepared for bread with high-protein rice flour and flaxseed flour.

Flaxseed was added in the composite flour at 5%, 10% and 15% to improve the baking characteristics and acceptability of bread. Baking characteristics such as specific volume, loaf volume and baking loss were measured. The crumb and crust colour and firmness of the bread were analyzed.

Baking Characteristics

The effect of high-protein rice flour and flax seed flour on the baking characteristics of rice breads are presented in Table 2. It can be seen from the result that loaf volume (LV) was higher (475 ml) for the bread made at 15% incorporation of flaxseed flour with 85% high-protein rice flour. Marpalle *et al.*[28], reported that 5 % flaxseed addition produced loaf volumes that were not different from the control in wheat bread. Loaf volume is the key characteristics of bread which determines the acceptance of bread[28]. In this study there was no significant difference between 5%and 10% of flaxseed flour with 95% and 90% high-protein rice flour($p<0.05$) in loaf volume, whereas control and 15% incorporation of flaxseed flour with 85% high-protein rice flour were significantly different.

Table 2: Effect of high-protein rice flour incorporated with flax seed flour on loaf volume, specific volume and baking loss

Rice Bread	Loaf Volume (ml)	Specific Volume(ml/g)	Baking loss (%)
Rice flour = 100%	350±5.024a	1.964±0.025a	13.76±0.693a
Rice flour = 95% Flaxseed flour = 5 %	405±5.252b	2.135±0.027b	9.63±0.530b
Rice flour = 90% Flaxseed flour = 10%	410±4.987b	2.201±0.056b	7.38±0.328c
Rice flour = 85% Flaxseed flour = 15%	475±1.755c	2.636±0.032c	7.87±0.340c

Mentes *et al.*[30], reported that 10% flaxseed bread had higher loaf and specific volumes compared to the control in wheat bread. Similarly, the specific volume was high for flaxseed at 15% followed by 10%,5% and control. There was no significant difference between 5%and 10% concentration ($p<0.05$) in specific volume whereas control and 15% concentration were significantly different. Specific volume (SV) is interlinked with oven spring[28]. Bread made with 15%flax seed flour and 85% high-protein rice flour had slightly higher loaf and specific volumes compared to the control.

Baking loss (BL) measures the loss of moisture during baking which was CO_2 entrapped in bread during the yeast growth[34]. Baking loss was high for control (13.76%) followed by 5% (9.63%), 10% (7.38%) and 15% (7.87%).incorporation of flaxseed flour. Baking loss was decreased with addition of flax seed flour, which indicates the holding of moisture by the flax seed mucilage substances[35].There was no significant different between 10% and 15% concentration ($p<0.05$) whereas significant difference was showed in control and other incorporation levels.

Color of crumb and crust of the white pan bread prepared by using composite flour containing high-protein rice flour incorporated with flaxseed flour was analyzed and results are presented in the Table 3. The color value revealed that the crumb and crust colour was decreased (60.763±0.05a to 55.045±0.03d and 62.5960±0.345a to 38.9652±0.552d) with increase in flax seed level. This result indicated that there was increase in darkness of color in crumb and crust in experimental bread. Marpelle *et al.*[28], reported that color variation was due to maillard reaction due the protein in flax seed and sugar in high-protein rice.Similarly, ΔE of flaxseed flour reduced bread crumb and crust color values was observed by Garden[31]. and it was related to phenolic compoundsin flaxseed.

Table 3: Effect of high-protein rice flour incorporated with flax seed flour on crumb color of bread

Rice Bread	L	a	b	ΔE
Rice flour = 100%	58.25±0.05a	3.17±0.01a	17.11±0.16a	60.763±0.05a
Rice flour = 95% Flaxseed flour = 5%	55.29±0.34b	3.01±0.02b	13.05±0.62b	56.462±0.44b
Rice flour = 90% Flaxseed flour = 10%	53.27±0.75c	3.43±0.05c	13.38±0.07c	54.996±0.05c
Rice flour = 85% Flaxseed flour = 15%	53.11±0.67c	4.48±0.04d	13.81±0.02d	55.045±0.03d

Marpalle *et al*.[28], reported that the crumb and crust L and b values decreased with increasing flaxseed flour from 0 to 15% in wheat bread formulations[28]. There was significant differences in crumb of bread made at 10% and 15% addition of flax seed flour whereas crust of bread at different level of flax seed flour were not significantly different.

Table 4: Effect of high-protein rice flour incorporated with flax seed flour on crust color of bread:

Rice Bread	L	a	b	ΔE
Rice flour = 100%	56.45±0.03a	6.96±0.06a	25.43±0.01a	62.5960±0.345a
Rice flour = 95% Flaxseed flour = 5%	55.69±0.05b	6.47±0.40b	22.61±0.02b	60.5902±0.179b
Rice flour = 90% Flaxseed flour = 10%	47.91±0.67c	6.24±0.02c	20.29±0.16c	52.5393±0.597c
Rice flour = 85% Flaxseed flour = 15%	34.05±0.23d	7.26±0.03d	17.42±0.01d	38.9652±0.552d

Firmness of Bread

The result was showed that addition of flax seed flourat 15%with 85% high-protein rice flour decreases the firmness (265.752g) and its leads to reduce the retogradation of rice bread. Reduction of retrogradation was due to higher percent of fat in flax seed flour. According to Beatriz[9], addition of oilseeds above 15% leads to rancidity, change in sensory quality and absorption of moisture[32]. The result was observed that the incorporation of flaxseed in high-protein rice flour bread decrease in firmness indicated that increase in softness of the rice bread. There were significant differences between the incorporation level ($p<0.05$) from 5, 10 and 15% of flaxseed flour.

Table 6: Effect of high-protein rice flour with flax seed flour on firmness of bread:

Rice Bread	Firmness (g)
Rice flour = 100%	1821.190±3.601
Rice flour = 95% Flaxseed flour = 5 %	480.521±1.758
Rice flour = 90% Flaxseed flour = 10%	276.145±1.755
Rice flour = 85% Flaxseed flour = 15%	265.752±3.074

Air Cell Distribution

Air cell distribution determined using Image J Software revealed that increase in number of pores in bread up to 10% level of incorporation of flax seed flour. Further decrease in number of pores may be due to interaction of fatty components present in flax seed flour with starch. There was significant different between control, 5%,10% and 15% incorporation level of flax seed flour.

Table 7: Effect of high-protein rice flour incorporated with flax seed flour on air cell distribution of bread:

Rice Bread	Air Cell Distribution
Rice flour = 100%	227.66±4.93a
Rice flour = 95% Flaxseed flour = 5 %	491±1.73b
Rice flour = 90% Flaxseed flour = 10%	520.6±1.15c
Rice flour = 85% Flaxseed flour = 15%	393±6.08d

Sensory Evaluation

From the result of sensory evaluation, it was revealed that overall acceptability was high at 15% incorporation of flax seed flour which was nearer to control. Color scale of bread was increasing with increase in incorporation of flax seed in high-protein rice flour.

Table 5: Mean sensory scores of rice bread prepared with high-protein rice flour and flaxseed flour

Rice Bread	Color	Appearance	Texture	Taste	Overall
Rice flour = 100%	6.3±0.57a	3.3±0.57a	4.3±0.57a	4.3±0.57a	5±1.67a
Rice flour = 95% Flaxseed flour = 5 %	5±1.04b	5.3±1.09b	4±1.04b	4±1.02b	4.6±0.57b
Rice flour = 90% Flaxseed flour = 10%	4.3±0.57c	5±1.29c	4.3±1.46c	3.6±2.60c	5±1.46c
Rice flour = 85% Flaxseed flour = 15%	6.3±2.08d	6±1.73d	5±3.6d	5±2.08d	6±2.44d

Increase in color darkness was supported by Koca[29] and Naz *et al.*[33], observed that breads exceeding15% flaxseed supplementation in wheat flour resulted in lower scores for texture, crumb color, grain, and volume and crust color. Taste, appearance and texture attributes were higher acceptability score at 15 % level and it was comparable with control. Significant difference was not found between control, 5%,10% and15% incorporation of flax seed levels in sensory evaluation.

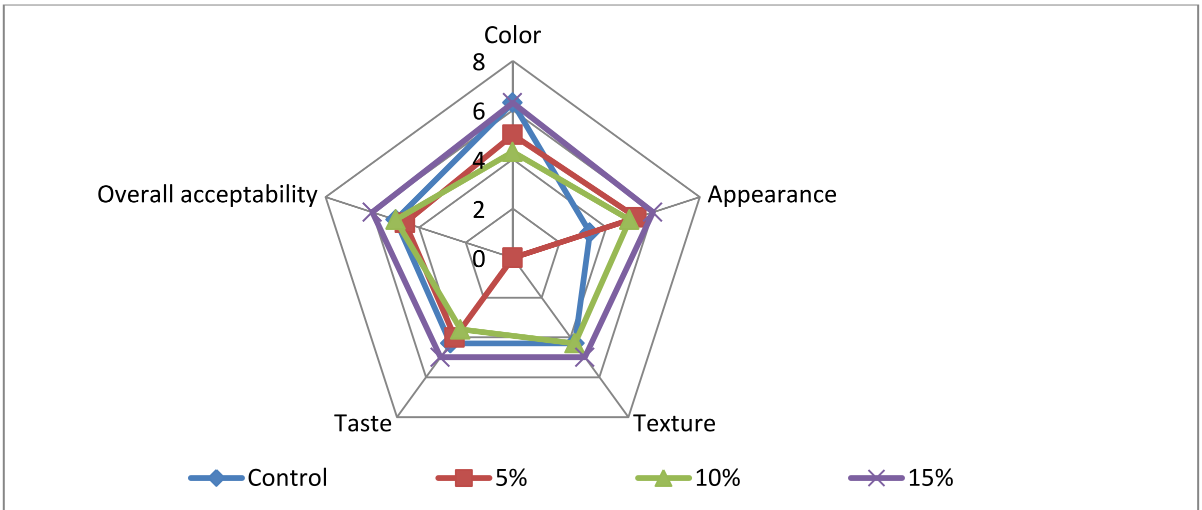

Fig. 1: Effect of high-protein rice flour incorporated with flax seed flour on sensory characteristic of bread

CONCLUSION

Rice Bread made from high-protein rich rice flour and flax seed flour will serve as a perfect alternative to gluten free diet. As rice flour lacks gluten, bread made from rice flour alone has increased firmness and retrogradation. Thus, incorporation of flax seed flour at 15% level improves the baking characteristic reduces hardness and improves the shelf life of bread.

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