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Investigating the influence of rice flour incorporation on baking quality of wheat pretzels

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Abstract
Influence of 35% rice flour addition to wheat flour was investigated for chemical, functional and baking quality of pretzels. Results revealed that rice flour addition increased the lightness and true density while as emulsion activity, gelatinization temperature and least gelation concentration decreased. Farinographic characteristics indicated that water absorption capacity increased with decreasing mixing tolerance index. Pretzels developed with 35% rice flour addition showed increase in diameter, spread ratio of pretzels as well as fracturability.

Keywords: Broken rice, pretzels, rheology, spread ratio

Introduction

Rice (*Oryza sativa* L.) is the most cultivated cereal crop globally and is the staple food for most of the countries including India, China, Thailand, Philippines, etc. Globally, rice production amounts to approximately 508.7 million tonnes (FAO, 2020) [11]. It is the staple food for over half the world's population, mainly in Asian countries, where it provides a considerable proportion of the protein intake for millions of people (Muthayya *et al.*, 2014) [18]. For value addition, low grade rice has been used for extrusion cooking to manufacture expanded crunchy snacks (Gujral and Singh, 2002) [13]. Rice brokens, the by-product of rice milling industry has lower market price. Rice flour prepared out of rice broken can be used as an important ingredient for many ready to eat breakfast cereals and snacks. Consequently, rice based expanded snacks production enhances the price of broken rice and prepares a value added product for the market (Kanojia *et al.*, 2016) [15]. Rice flour has high puffing quality, low cost, attractive white colour, hypoallergenicity and ease of digestion (Cornejo and Rosell, 2015) [9]. Hence it is a better adopted ingredient in the extrusion industry. Furthermore, rice is one of the most important agricultural products in India, which is well suited and used as the main raw materials for developing extruded snack because of their high starch content and excellent expansion properties (Ryu, 2004) [24]. Extrusion of starchy foods results in gelatinization, partial or complete destruction of crystalline structure and molecular fragmentation of starch polymers (Gonzalez *et al.*, 2006; Perez *et al.*, 2008) [12, 23].

Pretzels are a very tasty, low calorie, nutritious, cooked and baked products usually made from wheat and are popular snack foods in many developed countries. The production and consumption of pretzel is increasing at a fast rate because consumers want alternatives to fried snack foods. At present, pretzel production is fully automized in the developed countries to meet the rising consumer demands and aspirations but no such product is available in India (Naik *et al.*, 2007) [20]. In the present study, partial replacement of wheat flour by rice flour is used for developing pretzels. However, rice flour is not able to form cohesive dough structure because of the absence of gluten protein (Cornejo and Rosell, 2015) [9]. Therefore, the present study has used wheat flour in combination with rice flour for pretzel production and to study its effect on baking quality.

Materials and Methods

Materials: Wheat flour (*Triticum aestivum*) 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 35% as per the preliminary trials and sensory evaluation by the expert panelists.

Instrumental color

Color values *viz*. luminosity (L*), redness (a*) and yellowness (b*) were measured using Hunter Lab Colorimeter (A60-1010- 615 Model Colorimeter, Hunter Lab, Reston VA). The colorimeter was calibrated against a standard white plate. Chroma values (*C*) and Hue angle (h°) were calculated from the color parameters $L*$, $a*$ and $b*$ using below equations.

$$Chroma\ (C) = \sqrt{a*^2 + b*^2}$$

$$Hue\ angle\ (h^{\circ}) = tan\ -1\ \frac{b*}{a*}$$

Beta-carotene

According to AACC (2005) [2], water saturated N-butanol was used to extract pigments in a stoppered conical flask from 5 g sample. The results were expressed as beta-carotene, mg/100g.

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) [2] procedure.

Functional Properties

Emulsion activity and stability

The emulsion activity (EA) and stability (ES) were measured by the methods described by Hussain *et al.* (2020). One gram of flour was dispersed in 10 mL of distilled water in a graduated tube. 10 mL of soyabean oil was added to the suspension followed by homogenization to form an emulsion. The emulsion was centrifuged at 2000 rpm for 5 min and EA was calculated as:

$$EA\ (\%) = \frac{H2-H1}{H1} \times 100$$

Where

H_1 is the initial height of the solution before centrifugation;
H_2 is the height of the emulsified solution

The emulsion was heated at 80°C for 30 minutes in a water bath followed by cooling to room temperature. The emulsion was centrifuged at 2000 rpm for 15 min and ES was calculated as:

$$ES\ (\%) = \frac{Ht}{H2} \times 100$$

Where

H_t is the height of emulsified layer after heating;
H_2 is the total height of the emulsified layer before heating

True density

The true density was determined using the toluene and displacement method. The volume of toluene (C_7H_8) displaced was found by immersing a weighed quantity of the flour in the toluene (Sacilik *et al.*, 2003) [25].

Gelatinization temperature

Gelatinization temperature was determined by Shinde, (2001) [28]. 1 g flour sample was weighed accurately in triplicate and transferred to 20 mL screw capped tubes. 10 mL of water was added to each sample. The samples were heated slowly in a water bath until they formed a solid gel. At complete gel formation, the respective temperature was measured and taken as gelatinization temperature.

Least gelation concentration

The least gelation concentration (LGC) was evaluated using of Coffman and Garcia (1977) with modification. The flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 30% (w/v) prepared in 5 mL distilled water was heated at 90°C for 1 h in water bath. The contents were cooled under tap water and kept for 2 h at 10±2°C. The least gelation concentration was determined as that concentration when the sample from inverted tube did not slip.

Rheological characteristics

Farinographic properties

Farinographic measurements were carried out following the test procedures of ISO 5530-1 (Nikolić *et al.*, 2013) [22] using a Brabender Farinograph (Duisburg, Germany). The following parameters were determined- water absorption capacity (%), dough development time (DDT) (min), dough stability (min) and mixing tolerance index (MTI).

Pretzel preparation

Pretzels were prepared according to the method described by Naik *et al.* (2007) [20] with slight modifications. Pretzels were prepared with wheat-rice flour blend (65:35), salt (2g), refined oil (3 mL), ammonium bicarbonate (0.4 g), compressed yeast (12 g), malt extract (2 g) and water (50 mL). All the constituents were mixed in a dough mixer for 7 min and the prepared dough was extruded through a hand operated vermicelli machine equipped with a sieve aperture of 4 mm. After passing through the extruder, the extruded dough threads were manually cut into 10-15 cm and shaped into oval rings, arranged on a tray and kept for proofing for 10 min. The product was cooked in 1% alkali (NaOH) solution at 81 °C for 15 s. Finally, the pretzels were baked at 236 °C for 6 min and then dried in an oven at 103 °C for 25 min. In case of control, instead of the blend flour, only wheat flour was used.

Product characteristics

Physical parameters: Diameter, thickness and spread ratio of pretzels were estimated as per AACC (2000) [1] methods.

Texture

A TA-XT2 Texture Analyser (Perkin Elmer Private Limited, Godalming, Surrey UK) with 5-kg load cell was used for fracturability of pretzels.

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 Discussion

Instrumental color

Table 1 presented the color values of flour samples. $L*$ value of flour blend was significantly ($p < 0.05$) higher (87.73±2.48) than wheat flour (87.62±2.43). Similarly, *a** (-0.084±0.02) and *b** (12.57±1.03) values of flour blend were significantly ($p < 0.01$) lower than wheat flour. The color values imply that flour blend is brighter and whiter in color than wheat flour possible due to the incorporation of rice flour. The intensity of yellow is dependent on the concentration of the beta carotene pigment (Woolfe, 1992) [29]. Since, flour blend contains less beta-carotene in our study as compared to wheat flour (Table 1), thus showed higher *L** and lower *a** and *b** values. Chroma and hue angle of the wheat, rice and flour blend were calculated from the Hunter *L a b* parameters. Chroma value of the wheat, rice flour and flour blend were 13.78±1.17, 11.63±0.86 and 12.57±1.05, respectively. The hue angle is another parameter frequently used to characterize colour in food products (Barreiro *et al.,* 1997) [5]. Calculated hue angle of the wheat, rice flour and flour blend were -89.62±2.72, -89.63±2.74 and -89.99±2.82. Wheat flour, rice flour and flour blend presented negative hue values that reflected yellow-greenish hue.

Table 1 Color and chemical properties of raw materials

Parameters	Wheat flour	Rice flour	Flour blend
Instrumental color			
Luminosity (*L**)	87.62±2.43^a	87.87±2.51^c	87.73±2.48^b
Redness (*a**)	-0.091±0.02^c	-0.074±0.02^a	-0.084±0.02^b
Yellowness (*b**)	13.79±1.17^c	11.64±0.87^a	12.57±1.03^b
Chroma (C)	13.79±1.17^c	11.63±0.86^a	12.57±1.05^b
Hue angle (°*h*)	-89.62±2.72^a	-89.63±2.74^b	-89.99±2.82^c
Chemical properties			
Beta carotene (mg/100g)	0.09±0.02^c	0.03±0.01^a	0.05±0.02^b
Falling number (sec)	493±4^a	581±5^c	524±4^b

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

Chemical properties

Falling number

The results of falling number are depicted in Table 1. Falling number which indicates α-amylase activity was significantly ($p < 0.05$) higher in flour blend (524±4 sec) and lower in wheat flour (493±4 sec) possible 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) [2] 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) [17]. The present study indicated that flour blend had higher falling number depicted sound quality of flour.

Beta carotene

Table 1 presented the beta-carotene of wheat flour, rice flour and flour blend. Beta-carotene was significantly ($p < 0.01$) higher in wheat flour (0.09±0.02 mg/100g) than flour blend (0.05±0.02 mg/100g). Naik and Sekhon (2014) [19] reported 4.82 ppm of beta-carotene in wheat flour.

Functional properties

Emulsion activity and stability

The results of emulsion activity (EA) and stability (ES) are depicted in Table 2. EA and ES are the surface active properties that aid in formation and stabilization of emulsion which is a mixture of two or more liquids that are normally immiscible (Bhat *et al.*, 2016) [6]. Emulsion activity was significantly ($p < 0.05$) higher in wheat flour (43.3±0.93%) and lower in flour blend (39.2±0.57%). Similar pattern was also noticed in emulsion stability. Proteins are surface-active and facilitate an oil-in-water emulsion because of their hydrophilic and hydrophobic side chains and their charge. The increase in the protein mass fraction in the solution resulted in an increase in the rate of diffusion of protein (Sanchez and Patino, 2005) [26], a higher protein mass fraction at the interface, and thus the higher emulsifying capacity. Flour blend showed lesser emulsifying activity than wheat flour due to incorporation of rice flour as rice flour contained more non-protein constituents, which may impair its emulsifying capacity.

True density

Table 2 shows the true density of wheat flour, rice flour and flour blend. True density was higher in flour blend (830±6) than wheat flour (720±6) possibly due to the incorporation of rice flour. The variation in true density is attributed to particle properties especially the hygroscopicity. Finer the particle, lower is the true density as the particles orient in a compact manner as compared to the coarser particles. The finer particles lead to a probable decrease in the inter particle voids, and hence greater surface contact with the surrounding particles (Shah *et al.*, 2016) [27]. Density is a useful parameter for the design of storage and transportation bins for grains.

Table 2: Functional properties of raw materials

Parameters	Wheat flour	Rice flour	Flour blend
Emulsion activity (%)	43.3±0.93^c	35.2±0.82^a	39.2±0.57^b
Emulsion stability (%)	37.42±0.87^c	28.61±0.77^a	33.7±0.24^b
True density (Kg/m^3)	720.00±6.0^a	940.00±7.00^c	830.00±6.00^b
Gelatinization temperature (°C)	59.21±0.37^c	57.56±0.21^a	58.17±2.78^b
Least gelation concentration (%)	8	6	6

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

Gelatinization temperature (°C)

The results of gelatinization temperature are listed in Table 2. The temperature at which the starch granules begin to swell rapidly and lose birefringence is known as the gelatinization temperature. Gelatinization temperature was found lowest in flour blend (58.17±2.78 °C) than wheat flour (59.21±0.37 °C) possible due to the higher starch content in rice flour which took lowest temperature for gelatinization (Chandra *et al.*, 2015) [7]. As rice flour took less time for gelatinization due to higher starch while wheat flour took more time due to lower starch content.

Least gelation concentration (LGC)

The results of least gelation concentration are presented in Table 2. The least gelation concentration which is defined as the lowest protein concentration at which gel remained in the inverted tube was used as index of gelation capacity (Chandra *et al.*, 2015) [7]. Flour formed gel quickly at a very low concentration (6%) than wheat flour which formed gel at a significantly ($p < 0.05$) higher concentration (8%). The lowest gel concentration of flour blend may be due to the incorporation of rice flour. Wheat flour contain high protein and lower starch content and the gelation capacity of flours is influenced by physical competition for water between protein gelation and starch gelatinization (Kaushal *et al.*, 2012) [16]. The lower the LGC, the better the gelating ability of the protein ingredient (Akintayo *et al.*, 1999) [4] and the swelling ability of the flour was enhanced (Kaushal *et al.*, 2012) [16]. Since wheat flour has higher protein content which competes with starch for water uptake thus affecting the gelation concentration of flour.

Rheological characteristics

Farinographic properties

Table 3 presented the farninographic results of wheat flour, rice flour and flour blend. The farinograph gives a measure of dough consistency during its formation. Water absorption is considered to be an important characteristic of flour. Flour blend showed significantly ($p< 0.05$) higher water absorption capacity (61.33±2.37%) than wheat flour (60.2±2.35%) due to the incorporation of rice flour. Higher water absorption is required for good bread characteristics which remain soft for a longer time. Naik and Sekhon (2010) reported a range of 48.66 - 62.12 g/100 g water absorption for different wheat flours whereas, Curic *et al.* (2007) [10] reported water absorption value of 60% for rice flour which is consistent with the present study. Flour blend showed significantly ($p< 0.05$) higher values (5.43±0.92 min) for dough development time than wheat flour (3.8±0.38 min). Dough development time (DDT) is the time from water addition to the flour until the dough reaches the point of the greatest torque. During the mixing phase, water hydrates the flour components and the dough is developed. Since DDT in flour blend was observed to be higher than wheat flour indicating that flour blend needed longer time to hydrate all the compounds than wheat flour. Additionally, the increase in DDT of flour blend is due to the increase in water absorption of the dough (Zaidul *et al.*, 2004) [30].

Stability values are usually indicators of flour strength and higher values represent stronger dough. This value, in general, gives some indication of the tolerance of the flour to mixing. Flour blend had minimum value of stability (3.1±0.45 min) than wheat flour (4.2±0.53 min). Strong gluten flour gives the highest stability value, thus wheat flour had the highest tolerance to mixing. Lower dough development time and higher dough stability of wheat flour indicated their good protein quality. Nemeth *et al.* (1994) [21] reported dough stability 1.5 to 5.0 minutes in Canadian, Australian and American wheats. The mixing tolerance index which is a measure of resistance of dough to deformation was reported to be higher in wheat flour (125.2±4.52 BU) whereas, flour blend and rice flour had 52.94±2.47 BU and 2.2±0.01 BU, respectively. The lower values indicated higher tolerance to over mixing. This indicated that rice flour and flour blend had the best tolerance for mixing and wheat flour the poorest. Nemeth *et al.* (1994) [21] in comparative study of Canadian, Australian and American wheats reported a range of 60-170 BU for mixing tolerance index.

Physical characteristics of pretzels

Thickness, diameter and spread ratio

The data regarding physical properties such as diameter, thickness and spread ratio of pretzels is presented in table 4. It was observed that the diameter of pretzels was higher (5.16±0.62 cm) than control (4.22±0.56 cm). Also there was simultaneous decrease in thickness. Control had 0.67±0.07 cm thickness and pretzels had 0.58±0.04 cm thickness. In comparison to control sample, spread ratio of pretzels was higher with 35% rice flour incorporation. This increase in spread ratio might be due to the lower protein and higher starch content. Further, decrease in crude fibre content increased the spreading of pretzels thus increasing the diameter with subsequent decrease in thickness of pretzels (Agrahar-Murugkar *et al*., 2014) [3].

Texture

The results of texture are presented in Table 4. Fracturability was found to be higher in pretzels (0.69±0.17 mm) as compared to control (0.50± 0.12 mm). The increase in fracturability might be becauce of the interaction of starch with other components of rice flour. Further, higher value of fracturability is desirable in extrudates (Kanojia *et al.*, 2016) [15].

Table 3: Farinographic properties of raw materials

Parameters	Wheat flour	Rice flour	Flour blend
Water absorption capacity (%)	60.2±2.35^a	62.8±2.42^c	61.33±2.37^b
Dough development time (min)	3.8±0.38^a	10.0±1.67^c	5.43±0.92^b
Dough stability (min)	4.2±0.53^c	1.3±0.09^a	3.1±0.45^b
Mixing tolerance index (BU)	125.2±4.52^c	2.2±0.01^a	52.94±2.47^b

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

Table 4: Physical and textural properties of pretzels

Parameters	Control	Pretzels
Physical characteristics		
Diameter (cm)	4.22±0.56^a	5.16±0.62^b
Thickness (cm)	0.67±0.07^b	0.58±0.04^a
Spread ratio	6.29±0.73^a	8.89±0.94b
Texture		
Fracturability (mm)	0.50± 0.12^a	0.69±0.17^b

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

Conclusion

Based on functional, rheological and baking quality, rice flour addition up to 35% level is suitable for pretzel production. Emulsion activity and least gelation concentration of 35% rice flour incorporation in wheat flour was found to be decreased which suggests its possible use for food thickening applications.

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