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Utilization of waste defatted rice bran in formulation of functional cookies and its effect on physiochemical characteristic of cookies

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Abstract
Utilization of waste product is the recent trend for increasing the nutritional value of products. Rice bran is a waste by-product obtained during polishing of un-milled rice Supplementation of rice bran can improve their nutritional value of food. In the present study, cookies were prepared from wheat flour with supplementation of microwave stabilized defatted rice bran @ 5, 10, 15 and 20 percent. Cookies were subjected for physical analysis, proximate composition and sensoric attributes to find out the most suitable compositions for commercialization with high nutritional value. Average width and spread factor of cookies increased proportionally with increase in level of rice bran. Sensory score of cookies decreased significantly with increase in level of rice bran. Highest scores for overall acceptability of supplemented cookies were recorded at 10 percent level of substitution. The result of the nutritional analysis of functional cookies shows it is more nutritious than traditional cookies. The moisture, ash, protein, fat and fiber content of cookies increases with the supplementation of rice bran from 3.14% to 7.28%, 0.69% to 2.55%,11.23% to 13.84%, 14.27% to 17.03%, 0.16% to 9.5% respectively, whereas carbohydrate content and energy value decreases from 70.51% to 49.16% and 455.39Kcal to 397.89Kcal. The result reveal that from overall acceptability rating, treatments T2 (10%RB) obtained the highest score at $p \geq 0.05$. Although, defatted rice bran can be incorporated into cookies upto 15% as a functional ingredient to increase the nutritional value of conventional cookies.

Keywords: deffated rice bran, cookies, proximate composition, dietary fiber

1. Introduction

Rice (Oryza sativa L.) is a staple food for more than half of the world's population [1]. The global rice production in year 2016 stood at 481.04 million tons [2] and India ranks second amongst the top rice growing counties in the world. Rice bran (RB) constitutes around 10% of total weight, obtained as a by-product of rice milling from outer layer of the brown (husked) rice kernel [3]. Each year 90% of the rice bran produced in the world is utilized cheaply as a feed stock for cattle and poultry and the remainder is used for extraction of rice bran oil [4, 5]. In recent trend, extensive researches have been conducted for the utilization of underutilized, waste and non-conventional food resources to increase nutritional value of food products [6]. Defatted rice bran is a by-product obtained as rice bran meal after the extraction of oil from rice bran [7]. Defatted rice bran (DFRB) is considered as a waste product of rice milling and is often disposed off or utilized as a low-cost animal feed ingredient. RB is reported to have 10-15% protein, 20-29% oil, 20-27% fibers, substantial amount of vitamins, minerals and array of bioactive compounds include phenolic compounds, α, β, γ, δ-tocopherol, tocotrienols, γ-oryzanol with potent antioxidant activities [8, 9, 10, 11, 12]. Previous studies demonstrated that the bioactive components of RB have the ability to improve the human health and to treat oxidative stress related diseases and cancer [13, 14]. In spite of a unique nutritional value and nutraceutical properties, it is under-utilized in food product development [15, 16]. Developing new flour from underutilized indigenous plant will solve the problem of nutritional scarcity and improve the economical viability. DFRB being high in protein, dietary fiber and bioactive compounds, it has a potential in the development of value-added foods that would increase the nutritional quality of processed foods. Application of rice bran for the enriching the various snacks such as bread, cakes, noodles, pasta, and ice creams has been successfully carried without significantly affecting the functional and textural properties. However, fortification could possibly influence the physical and chemical, functional properties of flour [17]. The present study was undertaken to investigate potential of defatted rice bran for the formulation of functional cookies that have high nutritional value and to analyze the effect of this change on sensory and physiochemical characteristic of cookies.

2. Materials and Methods

2.1 Raw material

Raw material required for the preparation of cookies were the wheat flour, sugar, sodium bicarbonate, hydrogenated fat was purchased from local market of Allahabad. Defatted rice bran from parboiled rice was obtained from rice mill situated in Mauiama, Pratapgarh district, Uttar Pradesh.

2.2 Stabilized Rice Bran

Fresh mill bran was stabilized by microwave heating maintained at temperature of 120 ºC for 10 minutes to inactivate lipase enzyme. The stabilize rice bran was allowed to cool to room temperature and was packaged in air tight bags and stored for further analysis as describe by Iqbal [18].

2.3 Preparation of composite flour
Composite flour is prepared by substituting the wheat flour with rice bran in the ratio of 100:0, 90:10, 85:15, and 80:20 as shown below:

Treatments
T1 - Biscuit made by 100% wheat flour
T2 - 10% rice bran + 90 % wheat flour.
T3 - 15 % rice bran + 85% wheat flour.
T4 - 20% rice bran + 80% wheat flour

2.4 Composite biscuit production
First a known weight of hydrogenated fat and powdered sugar was creamed together until light and fluffy appearance is formed. Then all-purpose composite flour and baking soda and egg were added to the creamed paste while mixing for 2 min at low speed to firm dough. The dough was then rolled out to 2.5mm thickness in a baking tray and cut into round in shape having 5cm diameter with a cookie cutter. The biscuits were placed in greased aluminum trays and baked in a preheated oven at 150ºC for 4min, according to the methods of AOAC (19).

2.5 Physical analysis
Rice bran supplemented cookies were analyzed for width, thickness and spread factor by following the procedure of AOAC [19].

Width (W)
Six cookies were placed horizontally (edge to edge) in a row and taking their average diameter using digital vernier caliper with 0.01 mm accuracy.

Thickness
Six cookies were placed one another and taking their average thickness using digital vernier caliper with 0.01 mm accuracy.

Spread factor (SF)
The spread factor (SF) were calculated using relationship between spread ratio, width, and thickness and correlation factor as shown in the formula given below:
$SF=(W/T\times CF)\times 10$ $CF=1$

2.6 Proximate Analysis
Proximate composition includes moisture content; total ash, crude protein, fat, carbohydrate and crude fiber were determined using AOAC method (19).

2.7 Sensory Evaluation
Sensory evaluations of composite cookies conducted in Department of Food Science and Technology, using 9-point hedonic score system. The cookies were presented to 20 semi trained panelist coded with different number. The trained judges evaluated the cookies for color, flavor, taste, texture, crispness and overall with individual scores from liked extremely-9 to disliked extremely-1.

2.8 Statistical Analysis
All tests were conducted in triplicate and were analyzed by one-way analysis of variance (ANOVA) and least significant difference at $p<0.05$ was calculated by Tukey's test.

3. Results
3.1 Proximate composition of Flour
The chemical composition of raw flours is presented in Table 1. The chemical composition of the composite flours affects both physico-chemical properties and nutritional quality of their products. Rice bran powder contained significantly higher contents of protein, fat, ash and fiber than did wheat flour. The result of present study indicates that proximate composition of DFRB found to be higher than FRB. There have been seen that defatting markedly increases the nutrients content of the rice bran [20, 21]. Previous studies reported that defatted rice bran is a rich source of fiber and protein [22]. Therefore, rice bran incorporated food products would be rich in protein, fiber, bioactive compounds and may contribute to health benefits like lowering of blood cholesterol [23, 24], decreases the incidence of artherosclerosis disease [25], maintain blood glucose level and increase satiety [26].

Table 1: Chemical composition of raw flour (%)

Nutrients	Wheat Flour	Rice Bran	Defatted Rice Bran
Moisture (g/100g)	13.67±0.35	8.3±0.05	11.3±0.03
Protein (g/100g)	11.00 ±0.03	13.5±0.035	15.6±0.08
Fiber (g/100g)	4.51±0.015	25.8±0.08	34.9±0.25
Fat (g/100g)	1.25 ±0.005	20.15±0.11	2.20±0.01
Ash (g/100g)	0.53 ±0.00	8.23±0.01	9.86±0.05

3.2 Physical Analysis
The result of the physical analysis of the cookies produced from wheat flour and rice bran blends is shown in Table2. In consistent with previous study reported physical properties of cookies such as width, thickness, and spread factor were affected significantly ($p<0.05$) with increasing the level of rice bran. This study found that width and spread factor of functional cookies decreased and thickness increased with increasing the level of substitution. The width of cookies decreased from 44 to 38.5mm with increased in the level of substitution attributed to the high fiber content of composite flour. Fiber lowers the water absorption capacity of dough, mixing tolerance, tenacity and extensibility of dough [27]. Similar to previous study found thickness of cookies increased with proportionate increase of defatted rice bran, this attributed to the better binding capacity of fiber and protein content of composite flour [28]. The spread factor of cookies prepared from different treatments ranged from 47.5 to 40.8. This reduction in the spread factor of the biscuits attributed to the protein and fiber content as it binds water and restricts the spread of the cookies.

Table 2: Effect of rice bran substitution on physical characteristic of cookies

Treatments	Width (mm)	Thickness (mm)	Spread Ratio
T_0 (0%)	44 ±0.38	9.25 ±0.07	47.5±0.45
T_1 (5%)	43.2 ±0.45	9.32 ±0.1	46.3 ±0.55
T_2 (10%)	40.05 ±0.42	9.39 ±0.07	42.6 ±0.61
T_3 (15%)	39.39 ±0.31	9.4 ±0.08	41.9±0.53
T_4 (20%)	38.5 ±0.38	9.42 ±0.09	40.8±0.43

3.3 Sensory Analysis

The mean value for overall sensory quality of cookies showed a decreasing trend with proportionate increase of rice bran supplementation (Table 3). Sensory rating of cookies for color shows that control treatment T_0 (7.9) ranked at top due to excellent color followed by T_1 (7.2) & T_2 (6.9). Color score of T and T2 are not significantly different at 0.05% and were comparable to the control (29). Figure 1 illustrated that the mean score of color declined from 7.9 to 5.1. With increasing level of substitution the color of cookies turned from light brown to dark brown, leading to lower acceptance [30]. Browning colour of bakery product like bread, cookies might be due to caramelization, dextrinisation of starch or due to the non enzymatic reaction (Maillard reaction) between reducing sugar molecules and lysine protein [31, 32, 33]. Taste is the most important sensory attribute for the acceptance of product. Taste score of cookies T2 (7.2) with 10% RB was not significant different to the control T0 (7). However further increase of RB substitution produced bitter flavor in the products. The similar trend of result found in Sharma and Chauhan [34] study reported that flavour response decreased with increase supplementation of bran in the cookies and increased a bran flavor of cookie. Similar to this study Carroll [35] found that a high level (20 percent) of rice bran in muffins affects overall appearance, volume, taste and texture. Mean score of texture decreased from 7.1 to 5.32 with increasing level of substitution from 0 to 20% RB. Texture attribute of treatment T_2 was highest and gives crunchy texture to cookies. The hardness of flour is known to reflect the extent of protein-starch interaction in the flour [36]. Overall acceptability was determined on the basis of quality scores obtained from the evaluation of color, flavor, and texture of the cookies. The treatment T_2 (10% RB) had highest scores for the entire sensory attributes than other treatment. Hence it is concluded from the results that supplementation of DFRB at 10 percent is more suitable for production of rice bran supplemented cookies.

Table 3: Sensory attributes of cookies incorporated with different levels of defatted rice bran

Treatments	Colour	Taste	Texture	Flavor	Overall acceptability
T_0 (0%)	7.9	7^{b}	6.5^{ab}	7.78	7.03
T_1 (5%)	7.2^{a}	6.8^{ab}	6.8^{b}	7.55	6.87
T_2 (10%)	6.9^{a}	7.2^{b}	7.1^{b}	6.8	7.28
T_3 (15%)	5.9	6.3	5.84	6.14	6.78
T_4 (20%)	5.1	5.4	5.32	5.0	5.18

Means carrying same letters in a column for each factor do not differ significantly ($p<0.05$)

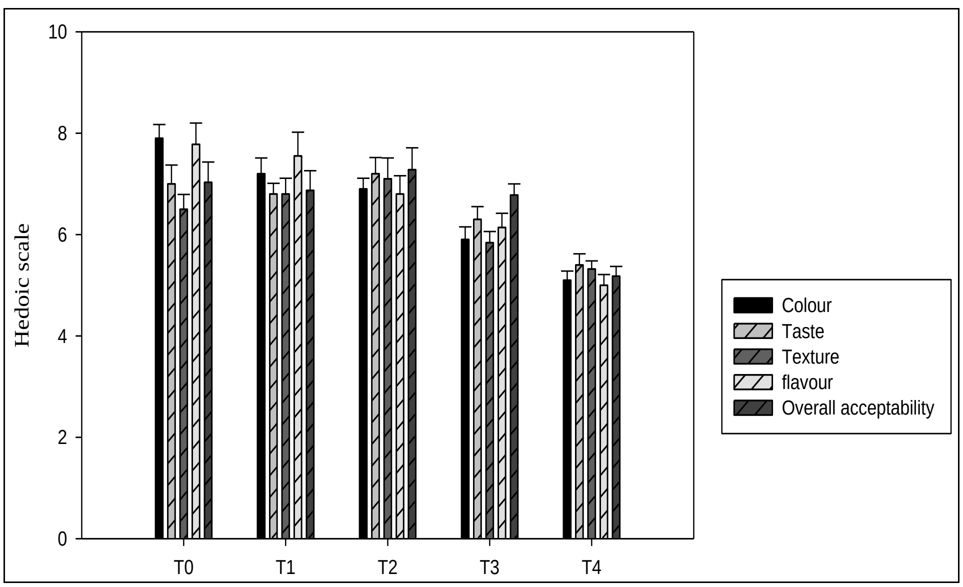

Fig 1: Sensory score of cookies

3.4 Proximate composition

The proximate compositions of rice bran fortified cookies were depicted in Table 4 and found with supplementation all attributes of proximate composition of cookies increased except carbohydrate and energy. The moisture content of composite cookies increased with the increase in supplementation this is could be due to the fact that rice bran contains more cellulose and other non starch polysaccharides that hold moisture several times higher to its weight and retain in baked products [37]. A high level of moisture content indicates short shelf life of composite cookies it as they encourage microbial growth leads to spoilage [38]. Protein content was also affected significantly due to addition of various levels of rice bran. The highest protein content (13.84 percent) was found in T4 followed by 13.77, 12.75, 12.07, and 11.23, for T3, T2, T1, and T0, respectively. In consistent with previous studies found that the protein and fiber content of cookies increased with the increase in supplementation [35]. The increase in protein and fiber content may be ascribed to the higher protein and fiber content of rice bran. There is no significant effect of rice bran on fat content of composite cookies this is might be due to defatted rice bran is used for composite cookies. However, with increased level of rice bran, the fat % increased from 14.27% to 17.03%. As shown in Figure 6 the carbohydrate content decreases from 70.51% to 52.67%. This variation is due to lower carbohydrate content of rice bran flour than refined wheat flour. The calorific value of cookies decreased from 455.39Kcal to 409.89Kcal with increase levels of RB. In terms of nutritional point of view lower calorific value of composite cookies is desirable for health benefits in different therapeutic condition. The lower calorific value of composite cookies attributed to their lower fat % and higher complex carbohydrate content.

Table 4: Effect of rice bran substitution on proximate composition of cookies

Treatments	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)	Energy (Kcal)
T_0 (0%)	3.14	0.69	11.23	14.27^a	0.16	70.51	455.39
T_1 (5%)	5.88^a	2.13^a	12.07^a	15.23^a	5.97	58.92	420.13
T_2 (10%)	6.15^a	2.34^a	12.75^{ab}	16.12^{ab}	7.73^a	54.33	414.48
T_3 (15%)	7.19^b	2.75^b	13.77^b	16.25^b	7.88^a	52.67	410.39
T_4 (20%)	7.28^b	2.55^{ab}	13.84^b	17.03^{bc}	9.5	49.16	397.89

Means carrying same letters in a column for each factor do not differ significantly ($p<0.05$)

4. Conclusion

Rice bran is a waste product of rice processing industries and its fortification in food is the economical way to enrich the nutritional value of various processed foods. This study demonstrated that DFRB have high nutritional value and can be used as a nutrient rich source in the preparation of various bakery products such as cookies. It is possible to formulate high fiber cookies by incorporating DFRB upto 15% without much affecting the sensory characteristic of cookies. However, from overall acceptability rating, treatments T2 (10%RB) obtained the highest score at $p\geq0.05$. This study concluded that fortification of wheat flour with rice bran will improve the nutritional quality and render health benefits to consumers.

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