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Physico-chemical and functional properties of deoiled rice bran and its utilization in the development of extruded product

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Abstract
Deoiled rice bran was investigated for proximate composition and functional characteristics to assess its capability as protein and fibre source. The presence of anti-nutritional factors such as oxalates, tannins, polyphenols and phytates in rice bran is one of the major drawbacks, which restrict its direct utilization in the diet. However, for effective utilization of bran for human nutrition, the elimination of these undesirable constituents is required. Processing treatments such as extrusion cooking can be used for elimination of undesirable components. Deoiled rice bran was incorporated with cereal base by an extrusion process to obtain a functional, ready-to-eat breakfast cereal. The carbohydrate content of deoiled rice bran was improved after extrusion processing, but the protein content was reduced in the extruded product of deoiled rice bran, which can be related to the denaturation of proteins. The extrusion process improves some functional and nutritional properties of deoiled rice bran which are valuable to industrial applications and have potential as food ingredient for the betterment of consumer health.

Keywords: Functional properties, antinutritional properties, extrusion, rice bran, oxalate content

Introduction
Rice bran is an important, highly nutritious by-product of rice milling industry, enriched in fiber, proteins, fats or oils and important antioxidants such as vitamin E and gamma oryzanol [1]. The use of rice bran is gaining importance in many studies due to the fact that, during the milling process of rice, large amounts of the grain's outer layers are removed, raising the concentration of nutrients in the bran and exposing it an important source of nutrients for human consumption [2-6]. However, deoiled rice bran, after extraction of oil known to contain high levels of beneficial compounds such as dietary fibre, antioxidants, micronutrients like oryzanols, tocopherols, tocotrienols, phytosterols. All these micronutrients are rich source of vitamin E and have antioxidant activity [7]. Due to the presence of significant levels of micronutrients such as oryzanol, tocotrienol and phytosterols, rice bran possesses unique properties that render its suitability for the production of value added products in neutraceuticals and pharmaceutical industry [1, 8]. The incorporation of dietary fiber into the functional food have reported to decrease the risk of coronary heart disease, reduction of blood cholesterol levels and improvement of insulin sensitivity [9-12].

Anti-nutritional factors in rice bran limit their use in food industry. The undesirable constituents such as phytic acid, trypsin inhibitors, oxalates, tannins, polyphenols, heamagglutinin and lectins restrict the straight-away utilization of bran in the diet [13]. An extensive literature survey reveals that all these non-nutritional components are protein in nature, with the exception of phytate. To achieve effective utilization of brans for human nutrition, the elimination of these undesirable constituents is required. Processing treatments such as extrusion cooking, wet, dry, microwave heating and chemical methods can be used for elimination of undesirable components.

Extrusion cooking is a latest, continuous, high temp., short-time processing technology, gaining increasing popularity in the food and feed sectors due to significant reduction in energy consumption, more production and final products at lower prices [14]. Extrusion cooking process involves several shear forces inside the extruder barrel, chemical reactions and molecular modifications like starch gelatinization, denaturation of proteins, inactivation of several food enzymes and reduction of microbes [15, 16].

Therefore, considering the nutritional composition and associated health benefits of deoiled rice bran, the present investigation was intended to assess its physico-chemical and functional properties which would help in utilization of rice bran as a food ingredient for human consumption. Further the study on extrusion processing of deoiled rice bran would help to find its application in different food formulations.

Material and methods

All the reagents used in present work were of analytical grade and purchased from Merck. The deoiled rice bran was obtained from A. P. Solvex, Dhuri (Punjab, India).

Extrusion

Extrusion was done using twin-screw extruder of co-rotating type (G.L. Extrusion Systems Pvt. Ltd., Delhi) having barrel with electric band heaters, temperature sensor fixed on front die, 7.5 HP motor (400 V, 3ph, 50 cycles) with automatic cutter fixed on rotating shaft was used. Ingredient formulation was chosen on the basis of our previous studies using response surface methodology (17.73% deoiled rice bran, 10% corn flour and 72.27% rice flour) [7]. Extruder was kept running before extrusion process to stabilize the adjusted temperature 124±1°C and screw speed of 295±1 rpm. The moisture content of raw flours was adjusted to 13.94% to obtain the extruded snack product based on optimization [7]. The die diameter of 4mm was selected. The product was collected at the die end and stored in already labeled zipped pouches for further characterization.

Physico-chemical analysis

The chemical composition of deoiled rice bran as well as extruded product was determined according to the procedures as described by the AOAC [17].

Total energy (Cal/100g)

Energy was computed using the following formula:
1g of carbohydrates (C) provides (4 kcal) (C×4 = kcal of carbohydrate), 1g of protein (P) provides (4 kcal) (P×4 = kcal of protein) and1g fat (F) provides (9 kcal) (F×9 = kcal of fat).

Functional characteristics

The different functional properties of deoiled rice bran as well as extruded product were determined in terms of density measurements, water holding capacity, water solubility index and oil binding capacity.

Bulk density (BD) is the ratio of the mass of the sample to its container volume occupied. For bulk density measurement, an empty cylindrical container was filled with deoiled rice bran and its extruded product to a known volume. Tapping during the filling was done to obtain uniform packaging and to minimize the wall effect, if any. The filled sample was weighed and the bulk density was calculated from mass (gm) occupied per unit volume (cm^3) [18].

True density (TD) is defined as the ratio of mass of the sample to its true volume. It was determined by the toluene displacement method in order to avoid absorption of water during experiment [19, 20]. Approximately 1 g of ground extruded as well as un-extruded sample was added to a 10 ml cylinder containing toluene and the rise in toluene level was measured. The net volumetric displacement was recorded from the graduated scale of the cylinder. It was calculated from weight of ground sample (gm) to the rise in volume in toluene (cm^3).

Water holding capacity (WHC) of the both samples was determined according to the method of Deshpande and Poshadri. Approximately 5 g of fine ground and sieved sample was weighed and allowed to rehydration over night in 35 ml of water, after draining, it was reweighed and water holding capacity was calculated [18].

Water absorption index (WAI) and water solubility index (WSI) were determined according to the standard method developed for cereals by Anderson and colleagues. A fine 2.5 g of ground sample was suspended in 30 ml distilled water at room temperature for 30 min with simultaneous stirring and then centrifuged at 3000 x g for a time period of 15 min. The supernatant liquid was decanted into an evaporating dish of known weight. The WAI was the weight of gel obtained after removal of the supernatant liquid per unit weight of original dry solids. The WSI was measured as the ratio of the weight of dry solids in the supernatent to the original weight of sample [21].

Oil binding capacity (OAC) was determined according to the method of Lin *et al.* (1974) with some modifications. A suspension of 5g sample (dry weight) was mixed with 75 ml oil in pre weighed centrifuge tubes. The contents were stirred for 1 min with a thin brass wire to disperse the sample in the oil. After a holding period of 30 min, the tubes were centrifuged for 15 min at 3000 x g. After centrifugation, the separated oil was removed. Triplicate determinations were carried out and the mean was calculated. The oil binding capacity was calculated from the weight of residual sample to the original weight of the sample [22].

Results and Discussion

Physico-chemical Analysis

The chemical composition of deoiled rice bran and its extruded product is presented in Table 1. It can be seen that deoiled rice bran is a rich source of proteins (12.09%) and fiber (11.52%). In comparison of deoiled rice bran and extruded product, it can be found that all the components like moisture content, crude fat, crude fiber, protein content varied during extrusion. The variation may be due to the fact that extrusion process involves high heat and high shear which leads to reduction in moisture content, protein and fiber content. The decreased moisture content of extruded product may increase the storage stability. The reduction in protein content may also be attributed to the denaturation of the proteins at high temperature during extrusion cooking process. Total carbohydrates included both starch and fiber, was found for extruded product than deoiled rice bran.

Table 1: Nutritional composition of deoiled rice bran and its extruded product.

Parameter	Deoiled Rice bran	Extruded Sample
Moisture Content (%)	12.32	6.48
Ash Content (%)	8.38	2.72
Fat Content (%)	0.4	0.8
Protein Content (%)	12.09	10.09
Crude Fiber (%)	11.52	3.49
Total carbohydrate (%)	55.3	76.42
Total energy (calorific value)	273.16	353.24

Functional characteristics

The different functional properties of deoiled rice bran as well as its extruded product were provided in Table 2. The bulk density is a key factor in determining the food product packaging requirements in the food industry. It is generally affected by the particle size and density of the flour. The deoiled rice bran had lesser bulk density than that of its extruded product (Table 2). Literature studies revealed that bulk density of bran can be correlated with degree of milling and is found to be significantly increased as the degree of milling increased. When all particles are small, the bulk density of the powder is higher and vice versa [23].

True density (TD) for deoiled rice bran was found to be 0.9 g/ml whereas, for extruded product, it was found to be 0.6 g/ ml. The lesser true density may be due lesser availability of void space in the extruded product which was made up of rice flour, corn flour and deoiled rice bran.

The water holding capacity (WHC) is an important parameter as it defines the ability of how much liquid can be absorbed by any food product. It is highly affected by the starch content as well as that of protein and fiber. It is easier to rehydrate a product with more air spaces or air cells as water can easily impregnate and diffuse through these cells. The extruded product was found to have higher water holding capacity in comparison to deoiled rice bran. It was expected that extruded product lost most of the water due to excess heat in extrusion cooking. Therefore, they were expected to have a better WHC [24].

Table 2: Functional Properties and anti-nutritional properties of deoiled rice bran and its extruded product.

Parameter	Deoiled Rice bran	Extruded Sample
Bulk density (g/ml)	0.64	0.75
True density (g/ml)	0.9	0.6
Water holding capacity (%)	136.38	686.24
Oil binding capacity (%)	278.9	315.2
Water absorption index (g/g)	2.38	6.15
Water solubility index (%)	16.28	12.92

Oil absorption capacity (OAC) denotes the amount of oil which can be bound to matrices in a particular food system and used as the index of hydrophobicity of the food. Oil absorption capacity in extruded product was found to be more than deoiled rice bran. However, higher absorption of oil may be attributed to presence of less fat [18]. Abdel-Aal et al. (1992) observed that extrusion conditions had little effect on oil absorption capacity when rice flour and faba bean protein concentrate blend was used [25] and other researchers [26] who reported that the FAC of the extruded flours were similar to that of the un-extruded rice flours.

WAI is an indicator of the ability of feed material flour to absorb the water, depends on availability of hydrophilic groups which bind water molecules, and on the gel forming capacity of macro molecules. It is the weight of gel obtained per g of dry product and can be used as an index of gelatinization. However increasing temperature and moisture had a positive influence on WAI [27]. In the present study, extruded product was found to have higher water absorption index than un-extruded deoiled rice bran as shown in Table 2. The higher value of WAI in the gelatinized sample was due to the presence of undamaged long polymer chains [28].

The water solubility Index (WSI) is related to the quantity of water soluble molecules, and is associated to dextrinization. In other words, WSI can be used as an indicator of the degradation of molecular compounds, and measures the starch degradation resulted from extrusion cooking. Water solubility index is not only due to starch content but also due to water-soluble components like protein which are present in raw material [29]. Deoiled rice bran was having the higher water solubility index (16.28%) than its extruded product (12.92%).

Conclusion

Present study results reflect that deoiled rice bran is a rich source of proteins, fiber and offers all the nutritional and neutraceutical benefits. In view of the overall proximate composition and functional characteristics, deoiled rice bran can be explored for a variety of food formulations like weaning foods, baked foods and ready-to-eat extruded products etc. So it can be concluded that the process of extrusion cooking clearly improves the nutritional quality of deoiled rice bran which are valuable in food applications.

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