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Studies on physico-chemical, functional, pasting and morphological characteristics of developed extra thin flaked rice

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Abstract Paddy (*Oryza sativa* L.) is among major staple food cereal crops of the world. The whole grain has higher percentage of vitamins, minerals and fiber as compared to milled rice grain. The present study was undertaken to study the physicochemical, functional, pasting and morphological characteristics of paddy (Gurjari variety) and its processed products were obtained during flaking. The major dimensions were highest for extra thin flaked rice (ETFR) with 17.08 mm length and 8.50 mm breadth at the expense of thickness found to be lowest 1.16. Thousand kernel weight (TKW), bulk density (BD), true density (TD) and porosity (POR) of ETFR were lowest as compared to other products. Frictional properties did not show any significant difference ($p < 0.05\%$) except for angle of repose. Significant difference was observed in chemical and functional properties of ETFR with exception to water absorption index (WAI) and water solubility index (WSI). Optical parameters L^*, a^* and b^* values of EFTR were found to be 73.72, 0.39 and 9.60, respectively significantly different from brown and roasted paddy. Peak and final viscosity was highest for brown rice (4419 cP, 6351 cP) and lowest for roasted rice (1058 cP, 1525 cP). Morphological changes occurring due to disintegration of starch granules within ETFR were clearly visible within its matrix caused by high mechanical force and temperature.

1. Introduction

Paddy (*Oryza sativa* L.) is a semi aquatic, annual grass which can be grown under a broad range of climatic conditions. India is major paddy producer with an annual production of about 159.20 MMT during 2013–14 and contributes to one-fifth of the global rice production (FAOSTAT, 2015). Paddy grain consists of husk, bran and endosperm, the latter used as a rice kernel (Marshall and Wadsworth, 1994; Deepa et al., 2008). Processing of paddy before its consumption is important for

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Nomenclature

List of symbols

L	length
B	breadth
T	thickness
D_e	geometric mean diameter
R_e	aspect ratio
S_p	sphericity
$\mathcal{E}$	porosity
Φ	angle of repose
μ	static coefficient of friction
ρb	bulk density
ρt	true density

the removal of hull to get brown rice. Further milling eliminates bran and germ from the rice kernel forming white or polished rice (Buggenhout et al., 2013). Traditionally hand pounding of paddy grains removed their hull (Manay and Shadaksharaswamy, 2001) and were consumed after boiling or in the form of either thick flaked rice or puffed rice, and have a relatively higher nutritional content than white rice due to presence of aleurone layer.

Presently various rice based, ready to eat food products are available in the market. Rice a gluten free diet can be utilized as a best substitute for celiac patients (Prasad et al., 2010). Flaked rice is obtained after processing of paddy and its further processing yields flaked rice of very low thickness with relatively lower weight and whiter color than normal flaked rice. The physical properties have important role in designing various food processing equipments for harvesting, threshing, conveying, drying, handling, aeration and storage (Sahay and Singh, 2007; Mohsenin, 1970). Flaked rice is rich source of carbohydrates, protein, vitamin, minerals, phytochemicals, and essential amino acids with exception to lysine (Bhattacharya, 2011 and Maisont and Narkrugsa, 2009). The phytochemical content of flaked rice viz. γ-oryzanol has many health benefits as it lowers down the total blood cholesterol and decreases risk of heart disease (Berger et al., 2005).

Flaked rice generally consumed as breakfast item, snacks and savory is specific to particular regions in India (Kumar and Prasad, 2013). Roasting carried out in fine sand at high temperature for short period of time is known as dry heat parboiling (Chitra et al., 2010; Bhattacharya and Mahanta, 2010) that involves gelatinization of starch. Conversion of starch into the resistant starch is necessary for carrying out the flaking process. The resistant starch functions as the potential source of pre-biotic food material that can be used as a source of dietary fiber for enriching breakfast cereal (Maisont and Narkrugsa, 2009). Dietary fiber (roughage) generally remains unaffected during digestion, helps in nutrient absorption within small intestines and is a valuable ingredient for the growth of beneficial gut micro flora that have key role in the synthesis of vitamin B-complex (Fuentes-Zaragoza et al., 2011).

Flaked rice is a precooked product and is consumed with soaking either in milk or in curd. The pasting properties are important for viscosity measurements of different starch laden products. Viscosity of brown rice depends on both amylose and amylopectin content (Chen, 1995) with higher former content lowering down the viscosity whereas the latter's higher content increases the same (Miles et al., 1985). Roasting and flaking of paddy are responsible for partial gelatinization of the starch granule that gets ruptured even at low water absorption resulting in lower swelling power of roasted and flaked rice compared to brown rice (Ghiasi et al., 1982).

The physical properties such as dimensional (shape, size, volume and surface area), gravimetric (bulk density, true density and porosity) and frictional (angle of repose and static coefficient of friction on different surfaces) properties of different grains are important in designing and manufacturing different equipments required during its transportation and storage (Corre et al., 2007). In present era, working people from urban regions mostly depend on refined food products lacking essential nutrients and fiber. The flaked rice is easily digestible and serves as nutritionally rich traditional food item with improved nutritional attributes. Present study focuses on the development of extra thin flaked rice (ETFR) along with the changes occurring in its physico-chemical, functional, morphological and pasting properties.

2. Materials and method

2.1. Material preparation

The "Gurjari" paddy grains used for present research work were procured from Anand Agriculture University (Gujarat). The grains were hulled and roasted by using paddy dehusker (Indosaw Industries (P) Ltd., Ambala, India) and roaster (custom made Lab Scale Roaster), respectively. The obtained brown rice and roasted rice were employed for the estimation of physicochemical and functional properties. Paddy grains (500 g) taken for dehulling yielded brown rice that along with roasted rice were kept in polyethylene bags and stored under refrigerated conditions for further analysis.

2.1.1. Preparation of extra thin flaked rice

ETFR was prepared at Balatripura Agro Industries, Ahmadabad, Gujrat. The process of product development is depicted in flow diagram (Fig. 1). Raw paddy was soaked in the water for 7–8 h at room temperature to increase its moisture content up to 30 ± 2%. This was followed by complete removal of water from soaking tank and the soaked paddy was conveyed through a bucket elevator to the paddy roaster (roller speed = 13 rpm by means of 5HP electric motor) operated at higher temperature for a short period of time in fine sand (178–180 °C for 28 s.). The process results in drying of husk with its internal moisture content in the range of 17–20% yielding roasted paddy that was immediately conveyed to the rice flaking machine operating at 900 rpm by a 15 HP electric motor. The machine resulted in the formation of flaked rice (with thicker dimensions) that was passed through another set of rollers (roller pressure of 145 ± 5 kg/cm^2 and temperature 75 ± 5 °C) present in extra thin flaking machine, yielding product with reduced thickness further cleaned in a cleaning machine to separate any brokens from ETFR.

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