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# Stabilization of rice bran using microwave: Process optimization and storage studies

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ABSTRACT

The study was aimed to stabilize raw rice bran obtained from freshly milled paddy of PB-1121 variety and conducted in two stages; to understand the effect of microwave power (2, 4, 6 W/g) and exposure time (1, 3, 5 min) in controlling the lipase activity during short term storage so that an optimum treatment combination for stabilizing the rice bran for its subsequent long term storage for at least three month could be devised. Free fatty acid (FFA) content, the primary indicator of lipase activity, was significantly ($p < 0.05$) affected by microwave treatment. Keeping in view the FFA content, oil yield, visible oil quality, moisture and protein content; treatment combination of 4 W/g + 5 min was found to be optimum in stabilizing the treated rice bran. The bran stabilized by optimized microwave treatment and bran obtained using traditional parboiling stabilization process (Sela) was compared. Microwave treated rice bran could be stored safely for a period of three months without any loss of nutritional quality as well as with high oil quality (FFA – 3%, PV – 7.63 meq/kg, TBA – 0.071 mg MDA/kg). The oil yield from the parboiled rice bran is significantly higher (23%) than microwave treated rice bran (21%).



## 1. Introduction

Rice bran is a major co-product of rice milling process accounting for 5–8% of milled rice (Sereewatthanawut et al., 2008). It is a natural source of protein (14–16%), fat (12–23%), crude fiber (8–10%), carbohydrates, vitamins, minerals, essential unsaturated fatty acids and phenolics (Kahlon, 2009; Malekian et al., 2000). Additionally, rice bran had remarkable contents of naturally occurring antioxidants such as tocopherols, tocotrienols and γ-oryzanol known to have hypocholesterolemic effect and helps lowering incidences of oxidative-stress related diseases such as cancer, cardiovascular disorders, inflammation, aging and obesity (Amarasinghe et al., 2009). Nevertheless, the single most restrictive factor for its use as a food ingredient is its instability during storage. This instability is attributed to the activity of lipases enzyme present in outer layers of the rice kernel which is primarily responsible for the hydrolysis of triglycerides into glycerol and free fatty acids. Besides, lipoxygenase and peroxidase are also the key enzymes responsible for the deterioration of rice bran although to a lesser extent (Orthoefer, 2005). The free fatty acids formed are harmful compounds which render the rice bran unsuitable for human consumption on account of reduced pH, rancid flavor and soapy taste yield (Lai et al., 2005; Yilmaz et al., 2014). Increase in the free fatty acid occurs within hours and reaches 5–7% within the first 24 h (Ramezanzadeh et al., 1999). Rice bran with an excess of 5% and rice bran oil with excess of 10% FFA is considered unfit for human consumption (Tao et al., 1993).

To prevent rice bran from becoming rancid, lipase activity must be arrested by some stabilization process immediately after the milling process (Ju and Vali, 2005). Several stabilization prepositions has been employed such as chemical

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stabilization or refrigeration (Anil Kumar et al., 2006), hydrothermal treatment (Pradeep et al., 2014), steaming (Azrina et al., 2008; Thanonkaew et al., 2012), extrusion (Sharma et al., 2004; Shin et al., 1997), microwave heating (Nordin et al., 2014; Ramezanzadeh et al., 2000), ohmic heating (Dhingra and Chopra, 2014; Lakkakula et al., 2004; Loypimai et al., 2009) and infrared radiations (Yilmaz et al., 2014). Moist heat treatments (steam retorting, extrusion cooking) are being extensively used for rice bran stabilization. However, these treatments are associated with several drawbacks such as less flexibility, inconsistency in results, high operating and equipment costs; which make them uneconomical (Malekian et al., 2000).

Microwaves, infrared radiations and ohmic heating have offered an alternative energy source for stabilization of rice bran. But compared with other heat treatments, microwave heating is efficient, economically superior, shorter in processing time and has little effect on the nutritional value of bran. The advantageous effect of microwave heating in stabilizing the rice bran has been confirmed by many researchers (Nordin et al., 2014; Ramezanzadeh et al., 2000; Zigoneanu et al., 2008). Against this background, the present study was proposed to stabilize the rice bran with the following objectives: (i) Optimization of microwave heating (power density and time of exposure) for stabilization of rice bran and (ii) Storage studies of rice bran stabilized by microwave heating and parboiling (traditional stabilization process).

## 2. Materials and methods

### 2.1. Optimization of microwave heating

#### 2.1.1. Research material

Rice bran obtained from milling of PB-1121 rice variety was used for stabilization. PB-1121 is variety of basmati rice developed by ICAR-Indian Agricultural Research Institute, New Delhi, India; known for its extraordinary kernel length (8.2 mm) and high kernel elongation ratio (2–2.5). The variety has been adopted widely by the farmers across India for cultivation and export. Freshly milled rice bran was collected from a commercial rice mill and cleaned using BS sieve no. 20 (750 μm aperture) to remove broken pieces of rice, husk and other foreign material from the same. Subsequently, rice bran was packed in air tight double-layered polythene bag and stored at −20 °C to prevent hydrolysis of fatty acids by lipase activity until the day of sample preparation.

#### 2.1.2. Microwave treatment

Stored bran was equilibrated to room temperature and subjected to moisture content determination. The final moisture content was adjusted to 21% (w.b.) by adding calculated amount of water (Ramezanzadeh et al., 2000) with continuous mixing at medium speed in a blender to evenly distribute the water. Post conditioning, bran sample was placed in a glass petridish followed by spreading evenly to a thickness of 0.5 cm and exposing to the requisite microwave power density (2, 4 and 6 W/g) for a predetermined time of exposure (1, 3 and 5 min) using a domestic convective-microwave oven (Model: WP700L17-3 Padmini, India) operating in pulsed mode at 2450 MHz and having 700 W maximum power output. The power density and exposure time levels were selected on the basis of preliminary trials. The microwave treatments were namely; $T_1$ (2 W/g, 1 min), $T_2$ (2 W/g, 3 min), $T_3$ (2 W/g, 5 min), $T_4$ (4 W/g, 1 min), $T_5$ (4 W/g, 3 min), $T_6$ (4 W/g, 5 min), $T_7$ (6 W/g, 1 min), $T_8$ (6 W/g, 3 min) and $T_9$ (6 W/g, 5 min). The temperature of microwave heated bran samples observed to vary between 93 and 108 °C; thus samples were cooled to room temperature (25–30 °C and 30–40% rh), packed in zip-lock polyethylene bags and stored at room temperature to study their stability during storage of four weeks. Untreated raw rice bran was used as a control.

#### 2.1.3. Rice bran analysis

*2.1.3.1. FFA content.* FFA content, the primary indicator of lipase activity was determined by AOCS official method Ca 5a-40 (AOCS, 2004). FFA was calculated as oleic acid and expressed as percentage of the total lipids.

*2.1.3.2. Moisture content, protein content and oil yield.* Moisture content of bran was determined by keeping 5 g sample at 135 °C for 3 h (AACC, 2000).

Protein content was determined using macro Kjeldhal AACC method 46-10 (AACC, 2000).

The oil yield was analyzed using solvent extraction AACC method 30-10 (AACC, 2000).

### 2.2. Storage studies of parboiled and microwave treated rice bran

#### 2.2.1. Research material

The bran stabilized by optimized microwave treatment (4 W/g + 5 min) and by parboiling (Sela) was compared. Sela is the traditional parboiling process (boiling at 70 °C for 20 min and steaming) being used for stabilization of rice bran by commercial rice millers in north India. Bran of freshly milled parboiled rice (variety PB-1121) was collected from a commercial rice mill. Both microwave treated (MTRB) and parboiled rice bran (PRB) samples were stored at room temperature (25–30 °C; 30–40% rh) for a period of three months using HDPE (50 μm) zipper-top bags. Untreated rice bran (URB) was served as a control throughout the storage period.

#### 2.2.2. Proximate analysis of rice bran

Proximate composition of rice bran samples was determined using AACC International methods (AACC, 2000): moisture, method 44-15A; ash, method 08-01; protein, method 46-08; crude fat, method 30-10 and crude fiber, method 32-10. The percentage of NFE was determined by subtracting percentages of other nutrients (except moisture) from 100.

$$\text{NFE}\,(\%) = 100 - (\%\,\text{Ash} + \%\,\text{Crude protein} + \%\,\text{Crude fat} + \%\,\text{Crude fiber})$$

#### 2.2.3. Oil quality analysis

*2.2.3.1. Free fatty acid (FFA) content.* The FFA content was determined by AOCS official method Ca 5a-40 (AOCS, 2004).

*2.2.3.2. Peroxide value (PV).* The peroxide values were analyzed as per method of Amarasinghe et al. (2009) and expressed in meq/kg.

*2.2.3.3. Thiobarbituric acid (TBA) number.* Thiobarbituric Acid (TBA) number was determined by the method developed by Ohkawa et al. (1979) and expressed as mg MDA/kg.