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Processing of commercial rice bran for the production of fat and nutraceutical rich rice brokens, rice germ and pure bran

A.S. Bhatnagar, D.S. Prabhakar, P.K. Prasanth Kumar, R.G. Raja Rajan, A.G. Gopala Krishna*

Department of Lipid Science & Traditional Foods, CSIR-Central Food Technological Research Institute, Mysore 570020, India

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ABSTRACT

Successive sieving of commercial rice bran on the basis of particle size was performed and different fractions were obtained of which the rice brokens and rice germ fractions contained fat 33 g/kg and 207 g/kg, oryzanol 400 mg/kg and 874 mg/kg, total tocols (tocopherols and tocotrienols) 16.5 mg/kg and 87.8 mg/kg, and total phytosterols 128.7 mg/kg and 769.6 mg/kg respectively, thus indicating that these fractions are a good source of fat and nutraceuticals. The residual fat (6 g/kg) from commercial defatted rice bran contained high oryzanol content of 4.8 g/100 g, indicating that commercial defatted rice bran as a source of oryzanol. The fat from pure rice bran fraction of commercial rice bran decreased in the color value (48.5%) indicating that sieving could also improve the quality of crude rice bran oils.

1. Introduction

Rice bran is an important byproduct from rice milling industry, which is obtained while milling and polishing of brown rice in to white rice (polished rice). Rice bran contains about 12–18% oil, which has health beneficial nutraceuticals such as tocopherols, tocotrienols, phytosterols, squalene, oryzanol and phospholipids (Gopala Krishna, 2002). The polished rice contains lower amounts of fat, tocopherols, tocotrienols and oryzanol compared to brown rice (Sakina & Gopala Krishna, 2004). The histochemical studies of an intact rice grain suggest that it consists of epicarp, mesocarp, endocarp, testa, aleurone, germ and starchy endosperm. The various parts of rice grain other than endosperm constitute rice bran. Most of the fat is present in aleurone layer. The aleurone layer gets shattered during milling process and evenly distributes between the other layers (Sastry, Ramakrishna, & Raghavendra Rao, 1977). Rice bran layer contains significant concentrations of high-value components of interest for pharmaceutical and nutraceutical applications. Rice bran is a good source of antioxidants including vitamin E and oryzanol, high quality oil and protein, and cholesterol-lowering waxes and anti-tumor compounds like rice bran saccharide. (Rebecca, Alicia, Na, Zhimin, & Lima, 2007).

Gopala Krishna, Prabhakar, and Sen (1984) studied the effect of degree of milling on the tocopherol content in rice bran from four varieties of Indian rice and found that an increase in the degree of milling of rice from 2, 3 and 5%, changes tocopherols content in bran (Gopala Krishna et al., 1984). Studies on the fractionation of the rice bran layer and quantification of vitamin E, oryzanol, protein, and rice bran saccharide on two American varieties of rice have also been reported (Rebecca et al., 2007). Based on the studies on thirteen American varieties of rice, it has been reported that vitamin-E levels in rice germ is five times greater than in rice bran and gamma-oryzanol levels in rice bran is five times greater than in rice germ (Yu, Nehus, Badger, & Fang, 2007). A study on the extraction and determination of oryzanol in rice bran from mixed local varieties found in Malaysia has also been reported (Azrina, Maznah, & Azizah, 2008). Two American varieties of rice have been studied and a rapid procedure for analyzing rice bran tocopherol, tocotrienol and γ-oryzanol contents has been developed (Chen & Bergman, 2005). One Korean variety of rice has also been studied and the changes in nutraceutical lipid components like tocols (i.e. tocopherol + tocotrienol), phytosterol, oryzanol, octacosanol, and squalene at different degrees of milling have been reported (Tae-Yeoul et al., 2006).

All the above-mentioned studies indicated that rice bran and its various fractions are a rich source of nutraceuticals, namely

Abbreviations: CRB, commercial rice bran; RB, rice brokens; RG, rice germ; PRBC, pure rice bran coarse; PRBF, pure rice bran fines; Total tocols, tocopherols and tocotrienols; Total PS, total phytosterols; FFA, free fatty acids; USM, unsaponifiable matter.

* Corresponding author. Tel.: +91 821 2514153; fax: +91 821 2517233.
E-mail addresses: aggk_55@yahoo.com, gopalakrishnaag@yahoo.com (A.G. Gopala Krishna).

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oryzanol, tocols (tocopherols & tocotrienols), phytosterols, etc. These nutraceuticals are distributed within the different fractions of rice bran. Vigorous mechanical processing (disc shellers/rubber roller shellers) involved during raw rice milling often contributes to the incorporation of substances other than pure rice bran such as broken rice pieces and rice germ. These fractions can be separated easily by simple physical means such as successive sieving on the basis of particle size. These broken rice pieces and rice germ are rich in fat and nutraceuticals and hence have the potential to be used as natural food supplements and contribute to the nutraceutical enrichment and value addition to various processed food products. Therefore, the effect of sieving of commercial rice bran on the physico-chemical characteristics and nutraceuticals content in different fractions have been studied and reported in this study.

2. Materials and methods

2.1. Commercial rice bran samples and chemicals

Rice husk, brown rice and commercial rice bran obtained from IR-64 variety paddy were procured from M/s Sri Ranganatha Rice Mills, Mysore. Three samples of commercial rice bran and three different types of commercial rice bran i.e., steamed rice bran; fibrous rice bran and defatted rice bran were obtained from M/s Habib Agro Industries, Mandya, India. All three samples of commercial rice bran as well as steamed, fibrous and defatted rice bran from M/s Habib Agro Industries belonged to mixed local varieties of paddy like IR-64, Sona-Masoori and others. Standard α-tocopherol and cholesterol were procured from Sigma Chemical Co., St. Louis, USA. All other chemicals and reagents used were of analytical grade.

2.2. IR-64 variety paddy

Rice husk, brown rice and commercial rice bran – A (CRB-A) obtained from IR-64 variety paddy were investigated for moisture content and fat content. The extracted fat from brown rice, rice husk and CRB-A were investigated for appearance, oryzanol and fatty acid composition.

2.3. Sieve analysis

The sieve analysis of the bran was carried out using test sieves (Grainburo standard wire cloth test sieve, make; Prem Engineering Commercial Corporation, Delhi, India) having aperture of 710, 600 and 300 microns (μm) of IS460 Part I, 1985 specification.

Commercial rice bran – B (CRB-B) and commercial steamed, fibrous and defatted rice bran: Three sets of 150 g each of CRB-B, steamed, fibrous and defatted rice bran were taken and sieved through 300 μm aperture size sieve and the passed out material collected. The parent bran and sieved bran were analyzed for moisture and fat content. The fats extracted from parent bran and sieved bran were analyzed for oryzanol and color.

Commercial rice bran – C and D (CRB-C and CRB-D): CRB-B and CRB-D were fractionated on the basis of particle size by successive sieving through sieves of different aperture sizes (710 μm, 600 μm and 300 μm). Three sets of 500 g each of CRB-B and CRB-D were passed successively through 710 μm, 600 μm, 300 μm aperture size sieves and the residues (Ist, IInd and IIIrd fractions) obtained and the passed out material (IVth fraction) through 300 μm aperture size sieve were also collected. The CRB-C and its sieved fractions were analyzed for fat content. The fats extracted from CRB-C and its fractions were analyzed for free fatty acid value (FFA) and oryzanol. The CRB-D and its sieved fractions were analyzed for bulk density and fat content. The extracted fats from CRB-D and its fractions were analyzed for color, FFA, oryzanol, unsaponifiable matter (USM), Total tocols, Total phytosterols (Total PS) and fatty acid composition. The schematic presentation of successive sieving of CRB is given in Fig. 1.

2.4. Moisture analysis

Moisture content of the samples was determined by using AOCS Method No: Ca 2c-25, 1998 (Firestone, 1998) and expressed as g/100 g.

2.5. Fat extraction

Rice husk, brown rice and all the different types of commercial rice bran and their fractions obtained through sieving were subjected to fat extraction by Soxhlet method using hexane as the extraction solvent. The fat content determined was expressed as g/kg.

2.6. Physicochemical characteristics

Bulk density of the rice bran was determined gravimetrically by weighing 100 ml quantity of rice bran placed in a graduated measuring cylinder (Borosil) and expressed as g/ml.

Free fatty acid value (FFA) and unsaponifiable matter (USM) of the oil was determined by using AOCS Method No: Ca 5a-40, 1998 and AOCS Method No: Ca 6a-40, 1998 respectively (Firestone, 1998).

Color of the oil was determined by using a lovibond tintometer (model-F, The Tintometer Ltd, Salisbury, UK.) in the transmittance mode in 1-inch cell and expressed as Lovibond units.

Oryzanol content of the oil was determined by spectrophotometric method (Gopala Krishna, Hemakumar, & Sakina, 2006) by dissolving 0.01 g of the sample in 10 ml of hexane and reading the absorbance at 314 nm in a 1 cm cell (double beam uv-visible recording spectrophotometer model UV-1601, Shimadzu corporation, Kyoto, Japan). Oryzanol content (g/100 g) was calculated by using the formula: [(A/W) × (100/358.9)], Where, A = absorbance of the sample, W = weight of the sample in gram/100 ml, $358.9 = E^{1\%}{}_{1\ cm}$ for oryzanol.

Total tocols (tocopherols + tocotrienols) content of the oil was determined by using reverse phase HPLC according to AOCS Method No: Ce 8-89, 1998 (Firestone, 1998).

Total phytosterols content (Total PS) of the oil was determined by the procedure given by Raja Rajan and Gopala Krishna (2009) and Searcy and Bergquist (1960) with minor modifications. The sterol concentration in the sample was quantitated from a standard curve generated with standard cholesterol (30–200 μg) as 10% solution in coconut oil and expressed as mg/kg (Raja Rajan & Gopala Krishna, 2009; Searcy & Bergquist, 1960).

2.6.1. Fatty acid composition

Fatty acid methyl esters (FAME) of the oil samples were prepared by transesterification, using methanolic KOH according to the method of AOCS Method No: Ce 1-62, 1998 (Firestone, 1998). The FAME were analyzed on a gas chromatograph (Model GC-15A, Shimadzu corporation, Kyoto, Japan), equipped with a hydrogen flame ionization detector (FID). Separation was performed using a S.S. column (3m × 1/8″dia mm i.d.), coated with 15% diethylene glycol succinate (DEGS) on chromosorb w/HP 80–100 mesh as the stationary phase. The fatty acids in the samples were identified based on retention time of reference standards and expressed as relative area%.

2.7. Statistical analysis

All samples were taken in triplicate and analysis carried out in duplicate making six determinations and mean ± standard deviation value reported. The data were analyzed using the statistical