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Middle infrared stabilization of individual rice bran milling fractions

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ABSTRACT

The aim of this study was to determine the composition and hydrolytic deterioration behavior of rice bran fractions which were obtained individually from different rice whitening mills. Additionally, stabilization of these bran fractions individually with middle infrared radiation and its effects on the contents of tocopherols and γ-oryzanol were investigated. FFA content of the crude and stabilized bran fractions that were obtained from the last whitening and polishing steps was higher either in the beginning or in the end of the storage compared to the others obtained in the first steps of whitening. Stabilization at 700 W infrared (medium-wave) power for 7.0 min provided 90 days of shelf life without a notable change in FFA content of rice bran fraction which was obtained from the first whitening step. Total tocopherol and γ-oryzanol contents of stabilized rice bran fractions were higher than their crude counterparts.

1. Introduction

Although the awareness and demand for whole grain cereals have been increased in recent years, white rice has still been preferred to brown rice due to the shorter cooking time and accustomed and appealing taste and flavor. Therefore, rice bran, which constitutes approximately 7–8.5% of the weight paddy milled, occurs as a by-product of milling process and mainly utilized as feed (Malekian et al., 2000). However, rice bran is a considerable source of protein, dietary fiber, B vitamins, essential unsaturated fatty acids, minerals and phenolic compounds (Kahlon, 2009; Malekian et al., 2000; Tuncel & Yılmaz, 2011). Additionally, it contains notable amounts of naturally occurring antioxidants of which the tocopherols, tocotrienols and γ-oryzanol have received the most interest. Gamma-oryzanol, which is a unique mixture of the ferulic acid esters of triterpene alcohols and plant sterols, has shown to have a cholesterol reducing effect in both humans and experimental animals (Gerhardt & Gallo, 1998; Rong, Ausman, & Nicolosi, 1997). Nevertheless, the use of rice bran in human diet is restricted due to the rancidity problem which is mainly caused by lipases. Paddy rice and brown rice are relatively stable in terms of rancidity because the lipolytic enzymes are located primarily in seed coat (tegmen), while most of the oil is stored in the aleuron layer and germ (Saunders, 1985). Hydrolytic deterioration starts with the milling operation which disrupts the physical separation between the lipase enzymes and their substrates. Besides, lipoxygenases are the other cause of the deterioration, although to a lesser extent compared to lipases (Malekian et al., 2000). Extrusion is one of the most common methods of rice bran stabilization in the literature (Sharma, Chauhan, & Agrawal, 2004; Shin, Godber, Martin, & Wells, 1997). However, it has several drawbacks, which make the process uneconomical, such as large capital investment and high operating and equipment costs (Malekian et al., 2000). On the other hand, successful results for rice bran stabilization with infrared radiation have been reported recently (Yılmaz, Tuncel, & Kocabıyık, 2014). It was shown that the free fatty acid (FFA) content of rice bran stabilized with short wave infrared radiation remained almost constant for 6 months (Yılmaz et al., 2014). Besides, infrared (IR) radiation offers many advantages including versatility, simplicity of the required equipment, fast response of heating, easy installation and low capital cost (Chua & Chou, 2003). IR processing is mentioned as a low cost approach mainly because the radiative energy is directly transferred from the heating element to the material without heating the surrounding air (Chua & Chou, 2003). Although it is not a pure spectrum and includes some wavelengths overlap eachother, IR radiation is classified into 3 regions, namely, near-IR (NIR), medium-IR (MIR), and far-IR (FIR) corresponding to the spectral ranges of 0.78–1.4, 1.4–3, and 3–1000 μm, respectively (Sakai & Hanzawa, 1994). The preference of the wavelength of IR radiation is considerably important in food processes not only because it affects the temperature and the emissivity of the emitter, but also it affects the absorbtion intensity of the radiative energy by food components. For instance, the level of radiation which is reflected back by the materials with a rough surface is 50% for NIR and less than 10% for FIR region (Krishnamurthy, Khurana, Jun, Irudayaraj, & Demirci, 2008).

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White rice is produced from brown rice (cargo, dehulled whole grain) by removing the bran and germ. The whitening process applies pressure to the rice grain, which generates heat, causes cracking and results in low head rice yield. Therefore, brown rice is passed through 2–4 whitening machines, which is so called multi-break systems, connected in series to avoid overheating. Typically, there are 2 types of whitening machines; abrasive type and friction type. In abrasive-type milling, rice kernel passes between a moving abrasive surface and stationary screen while in friction-type machines, kernels are forced against eachother. Friction-type whiteners apply more pressure to the grain compared to abrasive-type whiteners and are therefore less preferred (IRRI, 2014). The number, type and the order of location of these machines may vary depending on the kernel variety, shape and the required rice specifications. In this study, one of the most common whitening systems was performed. Usually, the whitening process ends up with a polishing step, which provides a shiny, smooth and dust-free final product and also cools the rice. In this polishing step, rice grains are gently polished by friction generally in a humidified atmosphere. Totally, the composite rice bran is produced with different mills and under current practices, these bran fractions are combined and the total mixture is named as "rice bran".

In the studies carried out so far, it has been clearly established that many bioactive components such as tocopherols and γ-oryzanol are concentrated in the bran portion of paddy and the amount of these compounds decreases as the milling progresses (Butsat & Siriamornpun, 2010; Rohrer & Siebenmorgen, 2004; Tuncel & Yılmaz, 2011). However, there is still lacking information about the distribution of these components within the bran. From the industrial point of view, the composition and the deterioration behavior of these bran fractions are considerably important since the stabilization procedure is essential to serve rice bran back into human diet and has to be performed immediately after the milling procedure. Fractionation of rice bran also allows the selective use of rice bran fractions which reduces the amount of material that needs to be processed and leads to obtain higher concentrations of the components of interest.

The aims of the present study are; to designate the differences among the composition of rice bran fractions that were obtained individually with different mills, to compare the hydrolytic deterioration behavior of bran fractions by monitoring FFA content, to investigate the possibility of stabilizing these fractions with medium wave IR radiation, and to determine the effect of medium wave IR radiation on the contents of γ-oryzanol and tocopherols.

2. Experimental

2.1. Chemicals

Gamma-oryzanol standard (99% purity) was kindly supplied by Oryza Oil & Fat Chemical Co. Ltd. (Aichi, Japan). Tocopherol standards (Cat. No. 613424) were purchased from Merck (Darmstadt, Germany). Megazyme (Megazyme International, Bray, Co. Wicklow, Ireland) enzyme kit (α-amylase, protease, and amyloglucosidase) was used for dietary fiber analyses. All chemicals and solvents were of analytical grade (Sigma Aldrich, St. Louis, MO, USA, and Merck GmbH, Darmstadt, Germany).

2.2. Material

Freshly milled rice bran samples (rice variety of Baldo) were procured from a commercial milling factory in Çanakkale, Turkey. The multi-break milling system consists of 3 abrasive-type mills (Mill 1, 2 and 3) and a friction-type water-mist polisher (Fig. 1) (Bühler Technologies GmbH, Ratingen, Germany). Approximately 1 ton of paddy underwent this multi-break milling treatment to achieve homogeneous and representative sampling. Rice bran fractions 1 and 2, which constitute approximately 50% and 30% of the composite bran, respectively, were collected from abrasive-type mill 1 and 2 individually by intermittent operation, while the brans come out of abrasive-type mill 3 and friction-type water-mist polisher were obtained in combined form and named as bran fraction 3 (Fig. 1). Although it is not totally incorrect, rice bran fractions 1, 2 and 3 do not necessarily represent the outer, middle and inner bran layers, respectively, due to the fact that the commercial abrasive-type milling machines do not remove the bran layer by layer, however, gently scrape the bran away piece by piece as the milling progresses. Samples were immediately transported to the laboratory, sieved (20-mesh) and stabilized. Crude and stabilized bran samples were divided into two portions and placed in zip-lock aluminum bags. One portion was stored at room temperature for 3 months to monitore FFA levels at every 15-days of intervals and the other portion was stored at −18 °C for the chemical analyses.

2.3. Stabilization

A laboratory-type IR stabilization system, which was schematically shown in our previous study (Yılmaz et al., 2014), was used to stabilize the rice bran fractions. It is a closed chromium chamber consisted of two medium wave IR emitters (Heraeus-Noblelight, 600 mm, 230 V, 1000 W, Hanau, Germany). The chamber has a loading unit which enables the bran to spread out uniformly and in the form of a thin layer (thickness ~ 0.5 cm) on the belt. Distance between the emitters and the sample (belt) was maintained constant at 15 cm throughout the experiments.

Rice bran stabilization was employed at 500, 600 and 700 W IR power for 3.0, 5.5 and 7.0 min for all rice bran fractions individually. IR stabilization at 600 and 700 W for longer than 7.0 min caused browning/burning and therefore further process times were not evaluated. Stabilization procedure was replicated 2 times and totally 54 stabilization trials (3 rice bran fraction, 3 IR power, 3 process time, 2 replication) were performed.

2.4. Free fatty acid determination

FFA content of rice bran fractions was measured titrimetrically according to the AOCS method (Ca5a-40) with minor modifications (AOCS, 1997). Five gram (dry weight basis) of rice bran was suspended in 40 mL of diethylether:ethanol (50:50, v/v) mixture for 10 min at room temperature on an orbital shaker and centrifuged for 5 min at 4 °C. The clear supernatant was titrated with 0.05 N KOH. The results were expressed as percentage of oleic acid equivalents.

2.5. Proximate analyses

Moisture content was determined according to the air-oven method (No: 44–19) at 135 °C immediately after the arrival of bran samples to the laboratory (AACC, 2000). Crude fat, protein and ash contents were determined by official standard methods (No: 30-10, 46-12 and 08-01, respectively) (AACC, 2000). Soluble, insoluble, and total dietary fibers were determined using the enzymatic–gravimetric method (No: 32-07) (AACC, 2000). Phytic acid content was measured spectrophotometrically (No: 986.11) (AOAC, 2000). All measurements were performed in triplicate and expressed as dry weight.