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Whole rice bran stabilization using a short chain organic acid mixture

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ABSTRACT

Rice bran stabilization reduces normal peroxidase, lipoxygenase and auto-oxidation enzymatic activities. Depending on the stabilization treatment, lipolytic enzymes may be reversibly inhibited through partial or permanent denaturation. For effective rice bran stabilization, the treatment should inactivate the lipolytic enzymes and minimize decomposition of bioactive components. The objective of this study was to evaluate the effects of an acetic and propionic acid mixture on the proximal composition, colorimetric profile, gross energy, lipid acid and lipid oxidation products (K_{232}, K_{270}) in rice bran during storage. Whole rice bran treated with organic acids and stored for 120 days exhibited lower quality. However, no major proximal composition alterations were observed during storage or related to organic acid use. Furthermore, organic acids yielded the highest gross energy values, lower lipid acidity increases, less primary (K_{232}) and secondary (K_{270}) lipid oxidation product formation, and maintenance of the yellow color (value 'b') after storage for 120 days. This study shows that applying an acetic and propionic acid mixture conserves the bran well, which primarily supports its use for treating animal feed.

1. Introduction

Rice (*Oryza sativa* L.) is vital for food security in much of the world's population and is considered the world's third largest crop, behind only corn and soybean. Rice production is directed to human consumption, and only the surplus and by-products are used for animal nutrition. Whole rice bran is a by-product of the rice polishing process and is characterized as the peripheral layer of the rice grain. It contains the aleurone and germ layers with small quantities of broken endosperm, which comprises approximately 10% of the total rice grain (Pourali et al., 2009). Whole rice bran is an energetic food comprising 2521 kcal kg^{-1} of metabolizable energy for birds, 3111 kcal.kg^{-1} of metabolizable energy for swine, 89.34% dry matter, 13.13% protein, 14.49% lipids, 8.07% crude fiber, 0.11% calcium and 0.24% phosphorus (Rostagno et al., 2011).

When the aleurone layers are removed from the endosperm during the rice polishing process, the lipid fraction, which is mostly in the germ, comes into contact with lipolytic enzymes, mainly lipases. Lipases are in the whole bran and break the fatty acid and glycerol ester links, increasing the rate of free fatty acid production, which results in hydrolytic rancidity (Naz et al., 2004). Whole rice bran is also highly susceptible to oxidation, typically through peroxidases, lipoxygenases and autoxidation processes. The bran quality is compromised due to the degradation processes, and so is difficult to use for oil extraction and animal feed (Zhang et al., 2007).

Several whole rice bran stabilization methods (enzyme inactivation) have been reported in the literature. Sharma et al. (2004) used a thermal treatment; Brunschwiler et al. (2013) used microwave heating; Mujahid et al. (2005) used extrusion; and Amarasinghe et al. (2009) used cooling and acidification. The studies were performed to facilitate the use of rice bran in foods; otherwise, the bran must be immediately submitted to an oil extraction process without the potential for storage and use in animal feed.

Bran stabilization reduces enzymatic activity mainly in lipases, peroxidases and lipoxygenases, thus maintaining the nutritional quality of the entire rice bran (Brunschwiler et al., 2013). Lipolytic enzyme inactivation with chemical products, such as hydrochloric acid, acetic acid and propanol, has also been studied (Prakash, 1996). According to Suhr and Nielsen (2004), 3 Liters per ton of bran is effective for maintaining quality for greater than 30 days of

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storage. Depending on the stabilization treatment, lipolytic enzymes may be reversibly inhibited, which partially or permanently denatures these proteins. For effective rice bran stabilization, the treatment should inactivate lipolytic enzymes and minimize bioactive component decomposition (Kim et al., 2014).

Therefore, the objective of this study was to evaluate the effects of applying an acetic and propionic acid mixture on the rice bran proximal composition, colorimetric profile, gross energy, lipid acidity and lipid oxidation products (K_{232}, K_{270}) relative to the storage time.

2. Materials and methods

2.1. Preparation, conditioning and storage of samples

The whole rice bran used in this study was derived by polishing rice grains produced in the city of Pelotas, State of Rio Grande do Sul, southern Brazil. After applying the acid mixture (acetic and propionic) to the samples, the storage and quality were assessed at the Laboratory of Postharvest, Processing and Quality of Grains of DCTA-FAEM-UFPEL.

Whole rice bran was obtained from the processing of about 10,000 kg of rice grains, which can generate about 1000 kg of bran. A 50 kg whole rice bran sample was collected and divided into two 25 kg samples. One of the samples was treated with a mixture (2% based on bran weight) of acetic acid P.A. and propionic acid P.A. (1:1 m/m), and a sample without the acid mixture was the control (no treatment).

The organic acid mixture was applied by spraying the bran layer, which was 2 cm thick and spread on an impermeable polyethylene film. After the treatment, the treated rice bran and control were conditioned in low density polyethylene bags 10 μm thick with a 30 kg capacity. The samples were stored in a storage chamber at 18 °C, which was controlled by a thermometer and protected from light. To simulate a semi-hermetic storage system, the experimental methodology included an opening in the packages for bran aeration every 30 days of storage. Silos and grain warehouses use a similar process with regular airings to avoid anaerobiosis of the environment and reduce temperature non-uniformities from internal convective currents (Paraginski et al., 2014).

Whole rice bran was stored for 120 days, and every 30 days, bran samples were collected to evaluate the quality parameters. The samples were prepared for evaluation through grinding in a laboratory mill (Perten 3100, Perten Instruments, Huddinge, Sweden) to obtain flour with uniform particle size (70 mesh).

2.2. Proximate composition

The rice bran moisture content during the storage period was determined using a drying oven at 105 ± 3 °C with natural air circulation for 24 h following recommendations from the American Society of Agricultural Engineers (ASAE, 2000); the content was expressed as a percentage of wet weight. The fat content was determined following the method 30-20 from the American Association of Cereal Chemists (AACC, 1995). The nitrogen content was determined using the AACC method 46-13 (AACC, 1995), and the protein content was determined using a 6.25 nitrogen to protein conversion factor. The ash content was determined using the AACC method 08-01 (AACC, 1995). The total carbohydrate content was determined using the difference.

Table 1
Proximal composition of whole rice bran submitted to different storage times and with the use of a mixture of acetic and propionic acid.

Proximate composition												
Storage period (days)	Moisture		Fat		Protein		Ash		Total carbohydrate	
	Control	Acid	Control	Acid	Control	Acid	Control	Acid	Control	Acid
Initial	A 11.23 ± 0.22 ab	A 12.06 ± 0.95 ab	A 21.60 ± 0.34 ab	A 21.60 ± 0.34 a	A 14.63 ± 0.22 ab	A 14.63 ± 0.22 a	A 11.84 ± 0.05 a	A 11.84 ± 0.01 a	A 40.70 ± 0.20 b	B 39.87 ± 0.38 bc
30	A 11.92 ± 0.64 a	A 12.73 ± 0.17 a	A 21.20 ± 0.63 ab	A 22.00 ± 0.07 a	A 15.23 ± 0.35 ab	A 15.38 ± 0.62 a	A 11.66 ± 0.25 a	A 11.59 ± 0.07 a	A 39.99 ± 0.46 bc	B 38.30 ± 0.23 c
60	B 11.13 ± 0.36 ab	A 12.53 ± 0.65 b	A 22.80 ± 0.75 a	A 23.94 ± 1.41 a	A 15.79 ± 0.15 a	A 14.68 ± 1.39 a	A 11.72 ± 0.19 a	A 11.27 ± 0.38 a	A 38.56 ± 0.36 c	A 37.58 ± 0.95 c
90	B 11.58 ± 0.36 ab	A 12.49 ± 0.19 ab	A 19.56 ± 0.81 b	A 20.71 ± 2.07 a	A 15.86 ± 1.29 a	A 14.75 ± 0.43 a	A 12.00 ± 0.06 a	A 11.28 ± 1.47 a	A 41.00 ± 0.63 b	A 40.77 ± 1.04 ab
120	A 10.49 ± 0.38 b	A 11.15 ± 0.55 b	A 20.07 ± 1.17 b	A 20.57 ± 1.49 a	A 13.84 ± 0.66 b	A 14.13 ± 1.01 a	A 11.71 ± 0.17 a	A 11.85 ± 0.20 a	A 43.89 ± 0.59 a	A 42.30 ± 0.81 a

The mean values of three replicates ± standard deviation followed by different lowercase letters in the same column differ by Tukey test ($p \leq 0.05$) test as a function of storage time. For each parameter, different uppercase letters in the rows denote differences by t test ($p \leq 0.05$) within the pairs due to the use of organic acid.