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Textural and sensory qualities of muffins prepared with fermented rice bran

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ABSTRACT

Rice is one of the most popular cereal grains in the world. Rice bran, a by-product of the rice milling process, contains an abundance of nutrients including protein, fiber, vitamin B complex, vitamin E, and other nutraceuticals. However, rice bran is underutilized in the food industry. In this project muffins were prepared with varying concentrations (2.5%, 5.0%, 7.5%, 10.0%, 15.0%, 20.0%, and 25.0%) of 60 mesh (250 µm) fermented rice bran (60 mFRB) and 80 mesh (180 µm) fermented rice bran (80 mFRB). A cappuccino muffin formulation was used as flavor for all the samples. The control sample was prepared without the fermented rice bran for comparison. Initial taste evaluations using student panelists demonstrated muffins incorporated with 80 mFRB were too dense, unacceptable, and discontinued for further study while the muffins prepared with 60 mFRB were found to be acceptable. The sensory qualities (texture, color, mouthfeel, aroma) and overall consumer acceptability of the muffins with 2.5%, 5.0%, 7.5%, and 10.0% 60 mFRB have lower firmness values in comparison to the control representing a softer texture. Three out of five sensory panelists considered muffins with 20.0% and 25.0% 60 mFRB to be acceptable in terms of color, texture, mouthfeel, and aroma. Hence, this project demonstrates that fermented rice bran products can be used in the preparation of breakfast food products like muffins. This innovative ingredient formulation concept can be useful in creating successful commercial bakery products that will provide protein, fiber and other nutrients.

* Breeanna Williams is a 2013 graduate of the University of Georgia with a major in Food Science and a minor in Nutrition Science. This paper is based on research conducted with the Department of Food Science at the University of Arkansas during her internship in 2012 funded through the Masterfoods USA, IFT Foundation.
† Navam Hettiarachchy is the faculty mentor and a University Professor in the Department of Food Science.
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MEET THE STUDENT-AUTHOR

Breeanna Williams

I am from Stone Mountain, Georgia. I attended Southwest DeKalb High School and graduated in the top 10% of my class in May, 2009. I am a senior at The University of Georgia majoring in Food Science with a minor in Nutrition Science. I am a recipient of both the Zell Miller Scholarship and the USDA Multicultural Scholars Program.

This year, I will serve as the Community Service Chair for both the Food Science Club and Minorities in Agriculture, Natural Resources, and Related Sciences. I was privileged to conduct this research at the University of Arkansas in Fayetteville through a 10-week food science research program funded by Masterfoods USA, IFT foundation. I would like to thank Dr. Navam Hettiarachchy for her guidance during this project and the opportunity to participate in this Summer Research Internship. We would like to thank Dr. Eswaranandam Satchithanandam for technical help and providing procedures for analysis.

INTRODUCTION

Rice is one of the most widely consumed cereal grains in the world and is grown in over 100 countries. It is also responsible for almost 25% of the world's food grain production (Wadsworth and Hui, 1992). Although rice is a staple food for two-thirds of the world population, the United States' per capita rice consumption is not large compared to world standards (Batres-Marquez et al., 2009). Because of the noted health benefits provided by rice and rice components, an increase in rice consumption may be helpful in improving the health of many Americans. A part of the rice grain, the aleurone layer that forms a major part of the rice bran contains a large amount of the nutritious components found in rice. A study by Kennedy and Luo (2012) states that rice consumption is associated with a lower BMI, smaller waist circumference and tricep skinfolds, and low serum insulin measures.

Rice bran can be identified as the brown, powdery material that is separated from rice during the milling of rough rice. It contains nutrients such as tocopherols, beta-glucan, and pectin and is composed of approximately 20% oil, 15% protein and 50% carbohydrate (Hernandez, 2000). In addition to such qualities, rice bran can be a food ingredient that contains protein that can be cleaved into active protein fragments called peptides. Researchers have found that the peptides from rice bran exhibit anti-obesity and anticancer properties (Kannan et al., 2009). The high quality protein generated peptides tend to reduce hypertension and oxidative stress, both of which are risk factors for cardiovascular diseases (Kannan et al., 2008).

The nutritional and functional properties of rice bran have contributed to the success of rice bran as an additive in baked goods such as cookies, crackers, pancakes, muffins, and breads (Barber et al., 1981). Although in recent years rice bran has been used in baked goods, not all products show improvements in sensory qualities and consumer acceptability when rice bran is incorporated. A decrease in cookie spread and bread volume has been observed while muffin volume increased (Sekhon et al., 1997). Even though there has been some research done investigating the effect of fermented cowpea flour addition on the rheological and baking properties of wheat flour, applications of fermented rice bran have not been utilized fully (Hallén et al., 2004). Co-/by-products like rice bran from rice processing when used as ingredients in the food products have excellent health benefits as well as an economical advantage.

Muffins are a popular breakfast item in the United States and are suitable products for incorporating rice bran to improve nutritional value with health benefits. Fermented rice bran is being utilized rather than rice bran that has not been fermented to possibly reduce the amount of leavening agents used during the baking process. An acceptable fermented rice bran muffin product is capable of increasing fiber and protein intake that may assist in creating a more balanced and healthier human diet. Hence, the objectives of this study were 1) to incorporate defatted and fermented rice bran at varying levels and prepare muffins and 2) to study the physiochemical properties and sensory characteristics of muffins made with rice bran.

MATERIALS AND METHODS

Materials. Heat stabilized de-fatted rice bran (HDRB) was obtained from Riceland foods (Stuggart, Ark.). All-purpose flour, unsalted butter, salt, sugar, baking powder, milk, cinnamon, vanilla extract, chocolate chips, instant coffee, eggs and canola cooking spray were purchased from local grocery stores. Xanthan gum was purchased from Danisco USA, Inc.

Preparation of Fermented Heat Stabilized De-fatted Rice Bran. Fermented HDRB was prepared by a patent pending and proprietary procedure by Hettiarachchy (2009). The post fermented rice bran is dried, ground, and sieved through 60 and 80 mesh sizes to prepare the 60 mesh (250 µm) fermented rice bran (60 mFRB) and 80 mesh (180 µm) fermented rice bran (80 mFRB).

Preparation of Muffins. The dry ingredients including all-purpose flour (64.3 g), sugar (41.4 g), baking powder (2.5 g), cinnamon (0.7 g), and salt (0.7 g) were homogenously mixed in a bowl using a metal whisk. In a separate bowl, instant coffee (2.8 g) was dissolved into milk (60.5 g) and added to the dry ingredients. To this mixture, melted butter (15.1 g), a beaten egg (13.9 g) and vanilla (1.1 g) and chocolate chips (11.7 g) were added. The muffin batter was poured into a greased mini-muffin tin tray until three-quarters full and baked at 185 °C for 17-20 minutes. To prepare the treatments, muffins were prepared by adding FRB at 2.5%, 5.0%, 7.5%, 10.0%, 15.0%, 20.0%, and 25.0% of the total weight of ingredients. The 20.0% and 25.0% rice bran muffins contain more milk, vanilla extract and xanthan gum, 90.8 g, 1.6 g, and 0.01 g, respectively. Muffins were cooled to ambient temperature before being evaluated for texture and color, and sensory analysis.

Physiochemical Properties of Muffins. The color of the muffin crumb was measured using a Minolta Chroma Meter (CR -300 Osaka, Japan) by calculating the L*, a*, and b* values. The L* value is the lightness variable, with values ranging from 100 (white) to 0 (black). The a* value measures the color of the sample, positive values being more red and negative values more green. The b* value also measures the color of the sample, positive values being more yellow and negative values more blue. Six samples were measured and the mean and standard deviation of the values were calculated.

Textural Properties of Muffins. Textural properties of muffins, firmness and springiness were determined using texture profile analysis with a TA-XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, N.Y.). The TA-XT2 Texture Analyzer was calibrated using a 5-kg weight. A 5-mm cylinder probe with a radius edge was used. The muffin sample was compressed at a constant rate of 1.0 mm/s to 25% of the original thickness. In this experiment, muffin firmness is defined as the force in grams, kilograms, or Newtons required to compress the muffin by 25%. To determine muffin springiness, the force after 30 seconds was recorded ($F_{30\ sec}$), then divided by the maximum force (F_{max}) and that quotient was then multiplied by 100% according to Eq. 1:

$$\left(\frac{F_{30\,sec}}{F_{max}}\right) \times 100 = \%\ \text{recovery} \qquad \text{Eq. 1}$$

A value closer to 100% indicates a more spring-like muffin.

Sensory Analysis. A group of five volunteer panelists evaluated color, texture, mouthfeel, and smell of muffins on a 5-point scale, with 5 being desirable for a trait. Muffins prepared for sensory analysis included chocolate chips.

Data Analysis. The values were analyzed using student's *t* test with a P value < 0.05. Color was measured six times to calculate its mean value and standard deviation. Firmness and springiness were measured three times to calculate its mean value and standard deviation.

RESULTS AND DISCUSSION

The color, firmness, springiness, and overall consumer acceptability of muffins prepared with fermented rice bran were analyzed in this study.

Evaluation of Textural Quality. Texture analysis calculations for firmness confirmed that all 80 mFRB treatments are firmer than the control and all 60 mesh muffin treatments except for the 60 mesh 25% (Table 1). Firmness of the control was determined by the texture analyzer to be 90.1 ± 10.5 g and the springiness was 41.3 ± 6.3%. Firmness in the muffin with 15% 80 mFRB was 243.5 ± 47.3 g and springiness was 28.1 ± 4.4%. During the textural analysis, it was also observed that the leavening agents used in the muffins, yeast and baking powder, created several air pockets in the crumb structure of both muffin treatments. The textural and color quality of the muffins was influenced by the air pockets formed. Xanthan gum was added to the 20% and 25% 60 mesh muffin treatments to achieve a more desirable texture considering the increase in amount of rice bran added.

The firmness of 60 mesh muffin treatments with less than 25% was lower than the firmness of all 80 mesh muffin treatments. The reason for this could be due to finer bran produced from 60 mFRB in comparison to

80 mFRB. A study by Chin et al. (2009) suggested that increased yeast level resulted in decreased bread density. This study also investigated the correlation between aeration and rheology of breads and suggests that there is a linear proportional relationship between bread density and bread firmness. This supports the findings of a less firm muffin with 60 mFRB compared to muffins with 80 mFRB. Hence, a lighter, fluffier crumb texture was found in the muffins in comparison to the control treatment (0% fermented HDRB).

As the percentage of 60 mFRB increased, muffin firmness also increased. Firmness of the muffins with no more than 20% 60 mFRB, although higher than the control, was lower when compared to firmness measurements for muffins with 80 mFRB. The springiness for most of the 60 mFRB muffin treatments is statistically similar to the control, while the springiness of 80 mFRB muffin treatments is lower than that of the control. Since springiness values closer to 100 represent a muffin that is most likely to be a spring (textural quality), it is evident that the fermented rice bran added to the muffins has an effect on the texture of the muffins.

Evaluation of Color. The color measurements were taken only for the 60 mFRB muffins while the 80 mFRB muffins were discontinued. The lightness variable, L* of several of the muffin treatments were higher than the control sample, although L* values of muffins with 10.0 and 20.0% 60 mFRB were similar to the control (Table 2). The a* value measures the color of the sample, where the positive values denote more redness while the negative values denote green. The a* value for the control (0 %) was 5.8 ± 0.2. All muffins with 60 mFRB have a* values that are statistically similar to the control. The b* value for the color of the sample denotes yellow to blue, where positive values are more yellow and negative values are more blue. The b* value for the control (0%) was 14.9 ± 0.4. All muffin treatments except for 20% 60 mFRB have a higher b* value than the control. There was no significant difference in a* values of the treatments compared to the control. However, there was a significant difference in b* values among the muffin treatments and the control (Table 2).

Analysis of Sensory Data. The most preferred muffin sample was the control which did not contain any HDRB. However, 2 of 5 panelists preferred muffin samples with 10% HDRB and 20% HDRB (Fig. 1). All the 5 panelists said they would recommend the product to family and friends. Four of the 5 panelists responded with confidence that they would be willing to purchase a similar product with HDRB in a commercial setting if reasonably priced. These results show that with further testing and adjustments to the formulation, it is possible to incorporate HDRB into a bakery product such as a muffin to provide protein, fiber, and other nutrients.

CONCLUSIONS

The results of this study show that incorporation of fermented rice bran in breakfast muffin formulations is a possibly feasible and applicable idea. Yeast fermented rice bran adds dietary fiber to the muffin which makes it a healthy breakfast that is sought by the health conscious consumers. The muffins prepared with 60 mFRB appealed sensory panelists and had some textural qualities similar to a regular muffin.

ACKNOWLEDGMENTS

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Table 1. Textural properties of muffins as measured by a texture analyzer.†

HDRB‡ Level %	Firmness (g)	Springiness %
Control (0)	90.1 ± 10.5d§	41.3 ± 6.3a
60 mesh 2.5	65.8 ± 9.9f	37.4 ± 1.4a
60 mesh 5.0	66.3 ± 1.8f	33.7 ± 2.9a
60 mesh 7.5	81.0 ± 8.8e	38.8 ± 4.0a
60 mesh 10.0	78.0 ± 7.3e	32.1 ± 2.6a
60 mesh 15.0	103.0 ± 7.2d	37.7 ± 2.3a
60 mesh 20.0	123.4 ± 62.0c	28.9 ± 14.3b
60 mesh 25.0	156.1 ± 38.9c	40.1 ± 3.0a
80 mesh 2.5	130.1 ± 17.9c	23.9 ± 3.6b
80 mesh 5.0	189.5 ± 33.4b	24.0 ± 1.1b
80 mesh 7.5	148.8 ± 14.0c	28.7 ± 2.7b
80 mesh 10.0	233.3 ± 27.6a	22.2 ± 2.8b
80 mesh 15.0	243.5 ± 47.3a	28.1 ± 4.4b

† Mean of three measurements ± standard deviation ($P < 0.05$).
‡ HDRB = heat stabilized de-fatted rice bran.
§ Values within a column represented with different letters are significantly different from each other.

Table 2. Color properties of muffins as measured by a chroma meter.†

HDRB‡ Level %	L*§	a*	b*
Control (0)	41.4 ± 0.7b¶	5.8 ± 0.2a	14.9 ± 0.4b
60 mesh 2.5	46.0 ± 0.6a	6.0 ± 0.1a	17.2 ± 0.8a
5.0	43.5 ± 5.7a	5.7 ± 0.2a	16.6 ± 0.5a
7.5	42.5 ± 0.2a	6.1 ± 0.1a	16.8 ± 0.3a
10.0	41.4 ± 1.4b	5.4 ± 0.2a	15.2 ± 0.8a
15.0	43.9 ± 0.7a	5.9 ± 0.2a	16.6 ± 0.4a
20.0	41.2 ± 0.8b	5.3 ± 0.3a	13.4 ± 0.6b
25.0	43.9 ± 0.7a	5.8 ± 0.3a	15.9 ± 1.5a

† Values are mean of six measurements ± standard deviation ($P < 0.05$).
‡ HDRB = heat stabilized de-fatted rice bran.
§ The L* value is the lightness variable, with values ranging from 100 (white) to 0 (black). The a* value measures the color of the sample, positive values being more red and negative values more green. The b* value also measures the color of the sample, positive values being more yellow and negative values more blue.
¶ Values within a column represented with different letters are significantly different from each other.

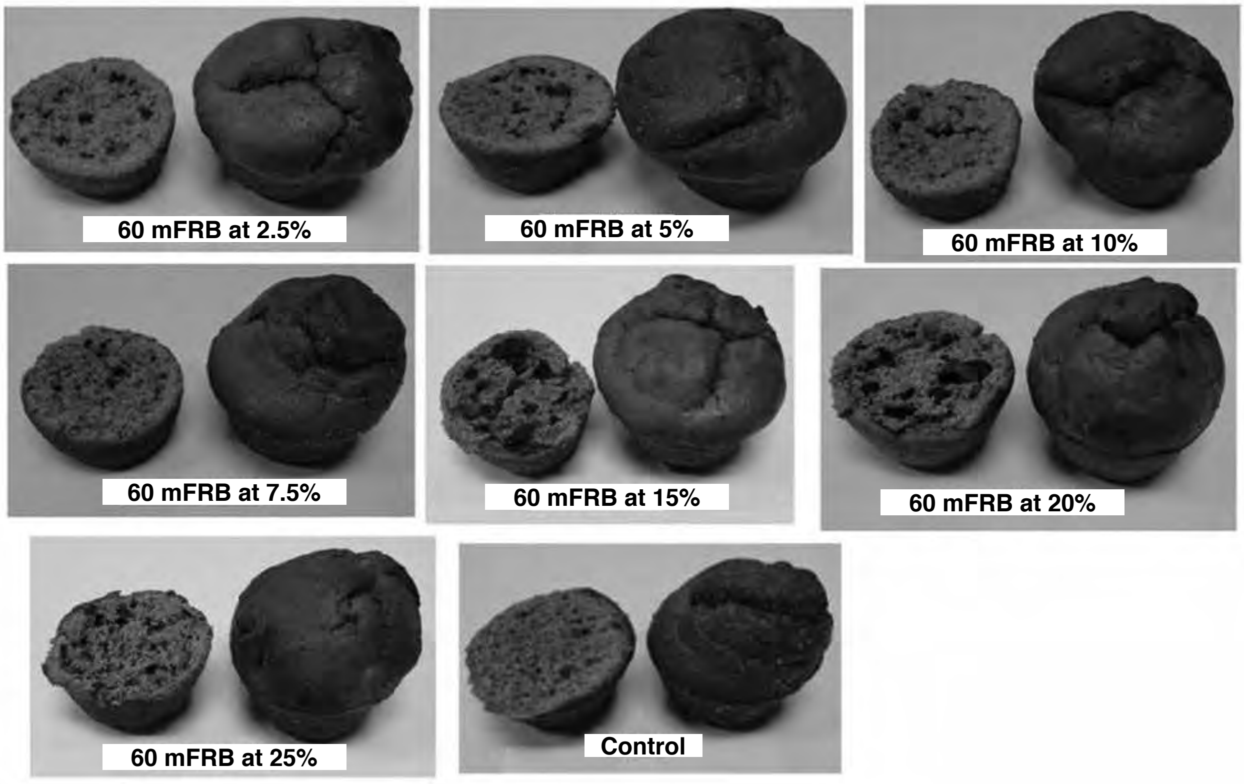

Fig. 1. Muffins prepared with 60 mesh fermented rice bran (mFRB) at varying concentrations and control sample; whole muffin and transverse section.