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Functional and physical properties of cookies enriched with dephytinized oat bran

B. Baumgartner*, B. Özkaya, I. Saka, H. Özkaya

Ankara University, Faculty of Engineering, Department of Food Engineering, Gölbaşı Campus, TR-06830, Gölbasi, Ankara, Turkey

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ABSTRACT

Oat bran is widely used for enrichment of health-oriented products due to their high dietary fiber (DF) and bioactive compounds contents. However, its high phytic acid (PA) content generally is overlooked. PA is an antinutrient which decreases bioavailability of minerals and proteins. Therefore, our aim was to produce oat bran cookies with low PA content. Oat bran was dephytinized with two different methods (fermentation and hydrothermal). Cookies were prepared by substitution of flour with dephytinized oat brans (0%, 7%, 14% and 21%) and evaluated in terms of physical characteristics, functional and sensory properties. Dephytinized oat brans supplemented cookies had significantly low PA content. Additionally, this supplementation enhanced DF content, phenolic compounds content and antioxidant activity of corresponding cookies much more than untreated bran. Oat bran and dephytinized oat bran addition has similar effects on cookies, resulted in higher spread ratios, harder texture and darker color. Their sensory evaluation scores are promising, especially fermented oat bran's. These results show dephytinized oat brans have a great potential use in bakery industry, does not have to be limited with cookies but also could be suitable for different types of baked goods.

1. Introduction

The importance of dietary fiber (DF) in human diet has been widely recognized during the past decades after establishing connection between low DF intake and several diseases including diabetes, coronary heart disease and certain cancer types (Burkitt and Spiller, 2001). Similar to other cereal brans, oat bran is also a good source of DF, especially in terms of soluble DF. There are many studies suggesting diets high in soluble fiber from whole oats may reduce the risk of heart diseases by lowering cholesterol (Anderson et al., 1991, 1990, 1984; Berg et al., 2003; Keenan et al., 2002; Tiwari and Cummins, 2011). Oat bran intake is also related with reducing diabetes symptoms (Tapola et al., 2005) and prevention and control of other chronic diseases such as stroke, cancer and obesity (Mäkeläinen et al., 2007; Murphy et al., 2004). These reported health promoting effects are mainly attributed to β-glucan, the soluble fiber content of oats. In addition to oat bran's high DF content, oat bran is also rich in phenolic compounds, which are associated with reducing risk of developing chronic diseases due to their high antioxidant power (Andreasen et al., 2001; Chen et al., 2004; Liu, 2003, 2004; Slavin, 2000).

There is a growing demand for different types of health-oriented food products in the food industry. Therefore, fiber enriched cookies can help fulfill this need, considering cookies are one of the most popular snacks around the world due to their ready to eat and easy to store nature, availability in different varieties and low cost. Oat bran has been used for enrichment of baked goods for ages because of their good flavor, long before their health benefits discovered. However, oat bran contains a quite amount of phytic acid (PA) like other cereal brans. PA is an antinutrient, which forms insoluble complexes with mineral cations (iron, magnesium, zinc and calcium) and proteins. Therefore, consumption of foods rich in PA impaired the bioavailability of these minerals and proteins (Lazstity and Lazstity, 1990; Reddy and Sathe, 2001; Stevenson et al., 2012; Zhou and Erdman, 1995). This can cause major problems for children, pregnant and lactation women, vegetarians, and vegans as well as people who suffer from anemia. Although some PA could be destroyed during baking, short baking time as in cookie baking process is not enough for effective PA destruction. Therefore, it is necessary to destroy PA of brans before their incorporation into foods to reveal true potential use of brans in baking industry.

There are several studies about fiber enrichment of cookies

* Corresponding author. Department of Food Engineering, Faculty of Engineering, Ankara University, Gölbaşı Campus, TR-06830, Gölbaşı, Ankara, Turkey.
E-mail address: bduman@ankara.edu.tr (B. Baumgartner).

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using different cereal brans including wheat bran, rice bran and oat bran (Bilgiçli et al., 2007; Chen et al., 1988; Khalil et al., 2015; Sharma and Chauhan, 2002; Silky and Tiwari, 2014; Sudha et al., 2007; Vitali et al., 2009). However, these studies did not focus on dephytinized brans and their effect on cookie quality or phytic acid contents of the related cookies. Our previous work has already showed dephytinization by hydrothermal and fermentation methods are both effective methods for degrading phytic acid of oat bran (Özkaya et al., 2017b). Therefore, the aim of this paper is to produce fiber enriched cookies with low phytic acid content and determine the influence of hydrothermal and fermentation dephytinized oat brans on bioactive compounds, texture, and sensory properties of related cookies.

2. Materials and methods

2.1. Materials

Flour (11.2% protein, 0.71% ash) and oat bran (14.3% protein, 3.95% ash) were purchased from local suppliers. Compressed baker's yeast was obtained from a commercial factory (Pakmaya Baker's Yeast Company) and stored in a refrigerator at a temperature at 4 °C until usage.

2.2. Dephytinization of oat bran

Oat bran was passed through the bran finisher (Buhler Type MLU-302). Bran slurries were prepared with cleaned oat bran and distilled water (1:15, w/v) and subsequently were dephytinized by two different methods. The slurries were mixed with 6% compressed baker's yeast, and fermented for 6 h at 30 °C for dephytinization by fermentation. In hydrothermal autoclaving treatment, the pH values of the slurries were adjusted to 4.0 with acetic acid, and the slurries were held at 120 °C for 0.5 h in an autoclave. These parameters were chosen according to our previous work (Özkaya et al., 2017b). At the end of both treatments, the aqueous slurries were filtered and the residual bran was rinsed five times with distilled water, and dried at 50 °C to moisture content of maximum 12%.

2.3. Chemical analysis

The protein and ash contents of the flour and bran samples were determined by AACC International Approved Methods 08–01.01 and 46–12.01, respectively (AACC International, 2010). Phytic acid and phytate phosphorus contents were measured by a colorimetric method according to Haug and Lantzsch (1983). Thiamine and riboflavin analyses were performed with slight modifications of AACC International Approved Methods 86–80.01 and 86–70.01, respectively (AACC International, 2010). The total, soluble, and insoluble dietary fiber contents were determined using the AOAC method 991.43 (AOAC, 2012). Extraction of phenolic compounds of samples was performed according to Adom and Liu (2002) with some adjustments described in our previous reports. After extraction, phenolic content was determined by the Folin-Ciocalteu spectrophotometric method while antioxidant activity was measured using 2.2-di-phenyl-2-picryl-hydrazyl (DPPH) according to the method described by Yu et al. (2002).

2.4. Baking

Wire-cut cookies were prepared according to AACC International Approved Method 10–54.01 (AACC International, 2010). The formula included 0.4 g of skim milk powder, 16.8 g of caster sugar, 0.5 g salt, 16 g of shortening, 0.6 g of high-fructose corn syrup (HFCS), 0.2 g of ammonium bicarbonate, 0.4 g of sodium bicarbonate, 40 g of flour or flour bran mixture (on 13%dry matter basis) and water. Bran was substituted with flour at rate of 0%, 7%, 14% and 21% and water calculated according to following formula,

$$(40 - \textit{flour or flour bran mixture}\ \ (g)) + 8.8.$$

Skim milk powder, caster sugar, salt and shortening were creamed using a Kitchen–Aid Professional. HFCS, ammonium bicarbonate and sodium bicarbonate dissolved in water, added to the mixture, and mixed to obtain homogeneous cream. Finally flour or flour-bran mixture added and mixed to form cookie dough. The dough was kneaded and sheeted to a uniform thickness of 6 mm and cut into circular shapes of diameter 60 mm. Baking was carried out at 205 °C for 11 min in an oven. The cookies were cooled at room temperature and stored in polyethylene bags until further analysis.

2.5. Evaluation of cookies

2.5.1. Physical characteristics

The thickness and diameter of cookies were measured with caliper according to the AACC International Approved Method 10–54.01 (AACC International, 2010). The measurement was carried out in samples cooled at room temperature. The spread ratio was calculated by dividing diameter (D) by thickness (T).

Breaking strength of cookies was determined by the three point break test according to Gaines (1991) using a texture profile analyzer (TA-XT plus, Stable Microsystems, UK) with a load cell of 5 kg, pre-test speed of 1.0 mm/s, test speed of 3.0 mm/s, post test speed of 10.0 mm/s, distance 5 mm and trigger force of 50 g.

2.5.2. Color measurement

Color parameters of the cookies were measured using Minolta CR-300 colorimeter (Minolta Inc., Tokyo, Japan) and CIE Lab scale. The total color difference (ΔE) of cookies was calculated using the following formula where L_0^*, a_0^* and b_0^* are color parameters of control cookies.

$$\Delta E = \sqrt{\left(L^* - L_0^*\right)^2 + \left(a^* - a_0^*\right)^2 + \left(b^* - b_0^*\right)^2}$$

2.5.3. Sensory evaluation

Cookie samples were presented in sealed containers with random 3-digit numbers to 9 semi-trained panelists. Each panelist rated sensory attributes of cookie samples by assigning a score on a 10-point hedonic scale ranging from 1 (dislike extremely) to 10 (like extremely) for color, appearance, texture, taste-odor and overall acceptability.

2.6. Statistical analyses

All data are expressed as the mean of triplicate measurements. The data were analyzed with SPSS software (V.22.0 for Windows, SPSS Inc., Chicago, IL) using two-way analysis of variance (ANOVA), followed by Duncan's post-hoc test to verify any significant differences between the group means. Differences were considered to be significant at $p < 0.05$.

3. Results and discussion

3.1. Chemical composition of dephytinized oat bran

PA and DF contents are illustrated in Fig. 1. PA content of oat bran