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Quality improvement of rice-based gluten-free bread using different dietary fibre fractions of rice bran

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ABSTRACT

Gluten-free (GF) breads are often characterised by low nutritional quality as they are mainly starch based and contain low amounts of vitamins, minerals and in particular dietary fibre. The objective of this study was to improve the physical, nutritional and sensory quality and shelf life of rice-based GF bread by adding different fractions of rice bran, containing different amounts of protein, fat, dietary fibre (DF) and different ratios of insoluble (IDF) to soluble (SDF) DF.

As a first step, recipe parameters (content of HPMC, egg albumen and emulsifier) of GF bread with 10% rice bran addition were optimised. An amount of 3% HPMC, 1.5% emulsifier and 2% egg albumen provided acceptable structural and textural quality of GF bread. The main trials demonstrated that addition of rice bran, in particular when containing a high amount of SDF, produced better bread colour, higher specific volume, softer crumb firmness and improved porosity profile. All rice bran containing GF breads had higher protein and DF content and the ratio of IDF to SDF was improved substantially depending on the dietary fibre fraction of rice bran. Sensory acceptance was increased and shelf life extended, again when selecting a rice bran source with high SDF content.

1. Introduction

There is an increasing interest in gluten-free (GF) products as the prevalence of coeliac disease is increasing. Its mean prevalence is estimated to be 1–2% of the world population (Reilly and Green, 2012). Therefore, a major challenge for the food industry is to develop GF products with high nutritional value for wellbeing. However, still the majority of the commercial GF bread products are of lower quality when compared to wheat bread products. The major defects in basic GF bread are that they often present poor quality with a crumbling texture, dry and friable crumb, lack of flavour and mouth feel, poor colour, and other post baking defects (Gallagher et al., 2004). From a nutritional viewpoint, most gluten-free breads are low in protein and dietary fibre. In recent studies, various technological parameters and formulations have been extensively investigated to improve not only quality but also the nutritional value of GF bread by either using different raw materials (Schoenlechner et al., 2010; Sciarini et al., 2010; Torbica et al., 2010) or adding various additives (Sciarini et al., 2011) like hydrocolloids (Sabanis and Tzia, 2011), emulsifiers (Nunes et al., 2009) or proteins (Crockett et al., 2011; Marco and Rosell, 2008; van Riemsdijk et al., 2011). Although some studies on the use of dietary fibre in GF bread have been performed in recent years (Hager et al., 2011; Sabanis et al., 2009), research data on this topic is still limited and not sufficient to explain the effects of fibre addition on the functional and sensory quality of GF bread. Besides its well documented health benefits, dietary fibre addition contributes to the modification and improvement of texture, sensory characteristics and shelf-life of foods (due to its water binding capacity, gel forming ability, fat mimetic, textural and thickening effects), but most of this information has been learned from gluten-based food systems. In order to better understand the effects of using or adding whole-grain, various bran fibres, or other sources of dietary fibre to GF dough systems, further detailed research is necessary.

Rice flour is well accepted and one of the most used cereal grain flours for the production of GF products due to its bland taste, white colour, high digestibility, and hypoallergenic properties (Marco and Rosell, 2008). However, GF breads based on rice flour require polymeric substances that mimic the viscoelastic properties of gluten to provide structure and retain gas (Torbica et al., 2010). Hydroxypropyl methylcellulose (HPMC) is such a compound that could improve volume and texture of rice-based GF breads in terms

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of gas retention and water absorbing characteristics (Marco and Rosell, 2008; Sabanis and Tzia, 2011). Regarding nutritional quality, rice-based GF formulations have, in particular, low contents of vitamins, minerals, proteins and dietary fibre (Sciarini et al., 2010; Thompson et al., 2005). Consequently the enrichment of GF rice bread with dietary fibre seems to be necessary. Rice bran is a product obtained from the outer kernel layers and is used as raw material for the production of rice bran oil. However, a large amount of defatted rice bran (DFRB) is accumulated as a by-product, which is mainly used as animal feed. DFRB is a good source of protein, which is rich in lysine, and mineral content (Jiamyangyuen et al., 2005). Its total dietary fibre content ranges from 20 to 51% (Saunders, 1990). Although applications of rice bran in some foods have been reported (Hu et al., 2009; Sharif et al., 2009), addition of rice bran to GF bread has not yet been investigated.

There are two approaches to increase the nutritional value of GF, one is to use raw materials as wholegrain and the second is to add isolated dietary fibre sources to refined flour. The effects on the textural, nutritional and sensory quality of the final product will be different, but both approaches have the potential to enhance the nutritional quality of the final products. The advantage of adding isolated dietary fibre sources (bran fractions) which contain the majority of essential nutrients allows 1) selection of an appropriate milling fraction and 2) control of the amount of its addition and the study and optimisation of its effect on the functional properties of the resulting product. Based on this information, the objectives of this research were (1) to investigate the principal effect of adding rice bran to GF bread (based on refined rice flour and a dough system of protein/emulsifier/hydrocolloid) and to adapt its recipe parameters - amount of egg albumen, emulsifier and hydroxypropyl methylcellulose (HPMC) and (2) to study the effect of four different rice bran fractions of different chemical composition on the physical, sensory and nutritional quality as well as shelf life of GF bread based on rice flour.

2. Materials and methods

2.1. Materials

Four types of rice bran sources or fractions were chosen, which showed pronounced chemical differences in their chemical composition, in particular content of protein and dietary fibre, as well dietary fibre composition. The chemical compositions including protein, fat, total dietary fibre, insoluble dietary fibre and soluble dietary fibre are reported in Table 1. Defatted rice bran (DFRB) was obtained from Thai Edible Oil Co, Ltd. (Bangkok, Thailand) and is a by product from the rice bran oil production process. As a pre-treatment, it was steamed for 45 min and dried for 12 h at 50 °C in order to inactivate enzyme and microorganism activities. Until usage, it was stored at 4 °C. Three types of commercial rice bran sources (Risolubles, Rifiber and Ribran 100) were donated from NutraCea™, Scottsdale, USA. According to the available information from the company, Ribran consists of whole rice bran and rice germ. Risolubles consists of the water-based soluble fibre fraction, while Rifiber is the insoluble fibre fraction from rice bran. Rice flour was obtained from Strobl Caj. Naturmuehle Gesmb.H (Linz-Ebelsberg, Austria), GF wheat starch from Kroener Staerke (Ibbenbueren, Germany; this wheat starch is tested for gliadin residues and certified for being gluten-free, while other commercial wheat starches often exceed the allowed gliadin limits), egg albumen powder from Enthoven-Bouwhuis Eiproducten B.V. (Raalte, Netherlands), vegetable fat powder (REVEL*-BEP) from Loders Croklaan B.V., Wormerveer, Netherlands. Hydroxypropyl methylcellulose (HPMC, Metolose® Shin-Etsu Chemical Co., Ltd., Tokyo, Japan) was donated by HARKE Pharma GmbH, Muelheim an der Ruhr, Germany and compressed baker's yeast (Hagold Hefe GmbH, Vienna, Austria) was bought from the market. The emulsifier was a mixture of 3 parts diacetyl tartaric acid ester of monoglyceride (DATEM, Panodan M2020, Danisco®, Copenhagen, Denmark) and 5 parts distilled monoglyceride (DMG, Dimodan PH 100, NS/B, Danisco®, Copenhagen, Denmark).

Table 1
Chemical composition of the four rice bran types used.

Chemical composition	DFRB[a]	Risolubles[b]	Rifiber[b]	Ribran[b]
Protein (% dm)	16.19	7.5	20.0	14.5
Fat (% dm)	2.5	26.5	13.0	20.5
Total dietary fibre (% dm)	20.3	3.0	42.0	29.0
Insoluble dietary fibre (% dm)	19.2	0.0	41.0	27.0
Soluble dietary fibre (% dm)	1.1	3.0	1.0	2.0

[a] Data determined by authors.
[b] Data provided by company.

2.2. Experimental design

In the first part of the study the effect of rice bran addition to GF rice-based flour was investigated and its recipe optimised by applying a 2^3 factorial screening design, where three factors (0–4% egg albumen, 0.5–1.5% emulsifiers and 1–3% HPMC) were varied. The basic GF bread recipe was chosen according to the state of the art for GF bread baking (system hydrocolloid/emulsifier/protein addition) and was: 100 g flour (mixture of GF wheat starch and rice flour at a ratio of 1:1), 10 g DFRB, 100 g water, 3 g yeast, 2 g salt, 2 g fat, 0–4 g egg albumen, 0.5–1.5 g emulsifier and 1–3 g HPMC. Type of emulsifier and hydrocolloid were selected according to pre-trials (results not shown here). The experiment with three replications of the centre point gave 11 formulas in total. Quality of bread was assessed as crust colour, specific volume, textural properties (crumb firmness and relative elasticity) and porosity (number of pores, average pore diameter, pore size uniformity).

In the second part of the study, the influence of four different types of rice bran (DFRB, Risolubles, Rifiber and Ribran 100) at varying egg albumen content (0, 2 and 4%) on the quality of GF bread was investigated. The formula of GF bread was: 100 g flour (mixture of GF wheat starch and rice flour at a ratio of 1:1), 10 g rice bran, 100 g water, 3 g yeast, 2 g salt, 2 g fat, 0–4 g egg albumen, 1.5 g emulsifier and 3 g HPMC. A GF formula without rice bran addition containing 2% egg albumen and 100% water was used as control. From the best formula of each type of rice bran (0–4 g egg albumen) protein content, dietary fibre content, sensory properties and shelf life were determined. Selecting criteria were higher specific volume and lower crumb firmness.

2.3. Gluten-free bread production

Baking tests were carried out according to ICC Standard Method 131. All dry ingredients (wheat starch, rice flour, rice bran, egg albumen, vegetable fat powder, salt and emulsifier were mixed in a mixer (Model KPM5O, Kitchen Aid, St. Joseph, MI, USA) for 1 min. Compressed yeast was dispersed in the amount of water to be added and poured on to the dry mixture. The mixing process was continued for 6 min at step 2. Subsequently, the obtained GF batter was fermented for 30 min at 30 °C and 85% RH in a fermenter (Model G66W, MANZ Backtechnik GmbH, Creglingen, Germany). After that, the batter was then divided into two portions (450 g each), put into a tin ($L \times W \times H$: 15 × 11 × 7–13 × 9 × 7) and proofed for 50 min at 30 °C and 85% RH. The breads were then baked in a baking oven (Model 60/rW, MANZ Backtechnik GmbH, Creglingen, Germany) for 1 h at 180 °C. After baking, the breads