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Influence of flour particle size on quality of gluten-free rice bread

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ABSTRACT

In recent years there has been growing interest in gluten-free bakery products. However, few studies have analyzed the influence of flour properties on the quality of these products. This study analyzes the influence of the type of rice, flour particle size and the water content of the dough used in gluten-free bread-making, and the microstructure of the doughs. Behaviour during proofing and the characteristics of the final bread are also described. The finest flours lead to poorest retention of the gas produced during fermentation and produce breads with a lower specific volume in both formulations, although this effect was more pronounced in the bread with 80 g of water per 100 g of flour. Flours obtained from short-grain rice produced breads with higher specific volumes and lower firmness in breads with 80 g of water per 100 g of flour. In breads with 110 g of water per 100 g of flour, the type of rice used had a greater effect on the texture than on the specific volume of the breads. Analysis of dough microstructure showed a film formed of water, hydrocolloid and starch granules fragmented during milling and kneading that covered the larger particles not broken during processing.

1. Introduction

Coeliac disease (CD) is a digestive tract disease that damages the small intestine and interferes with the absorption of nutrients from food. The ingestion of proteins present in some cereals such as wheat, barley and rye causes a loss of the intestinal villi, leading to reduced nutrient absorption. CD has now become one of the most common lifelong disorders, affecting 1% of the population worldwide (Catassi & Yachha, 2009). The only effective treatment for coeliac disease is to maintain a strict gluten-free diet, which leads to recovery of the intestinal mucosa (Farrell & Kelly, 2002; Green & Jabri, 2003). Some of the problems that persons with CD have to face are a lack of gluten-free bakery products, the poor quality (poor crust characteristics, rapid staling and poor mouth feeling and flavour) of the ones that do exist (Gallagher, Gormley, & Arendt, 2004) and the high price of gluten-free products (Arendt, Morrisey, Moore & Dal Bello, 2008). Furthermore, commercial gluten-free breads are mainly starch-based, leading to a nutritionally unbalanced diet due to a lack of fibre, vitamins and nutrients in coeliac diets (Kinsey, Burden, & Bannerman, 2008). Improvement in the quality of gluten-free products is therefore a challenge for modern society.

Wheat-gluten plays an essential role in bread-making, as it is responsible for the formation of a cohesive, extensible and elastic dough that is able to retain the gas produced during fermentation (Gan, Ellis, & Schofield, 1995; Singh & MacRitchie, 2001). This fact makes it difficult to achieve high-quality bread without the presence of gluten, and different approaches have therefore been investigated in attempts to improve the quality of gluten-free bread. First, it is essential to incorporate hydrocolloids as they act as gluten-substitutes, leading some authors to try to improve bread characteristics by comparing the effect of different hydrocolloids in gluten-free bread formulations (Lazaridou, Duta, Papageorgiou, Belc, & Biliaderis, 2007; Mezaize, Chevallier, Le Bail, & de Lamballerie, 2009). Other studies have looked at the use of additives such as emulsifiers (Nunes, Moore, Ryan, & Arendt, 2009), acidic food additives (Blanco, Ronda, Pérez, & Pando, 2011) and prebiotics (Korus, Grzelak, Achremowicz, & Sabat, 2006), as well as enzymes (Gujral, Guardiola, Carbonell, & Rosell, 2003; Gujral, Haros, & Rosell, 2004; Moore, Schober, Dockery, & Arendt, 2004; Renzetti & Arendt, 2009) and sourdough (Schober, Bean, & Boyle, 2007; Wolska, Ceglinska, & Dubicka, 2010). Overall, the objective of those studies was to improve batter consistency in order to achieve greater gas retention during proofing and baking.

A number of authors have looked at the influence of flour processing on gluten-free bread-making. Brites, Trigo, Santos, Collar, and Rosell (2010) studied the differences in bread quality according to the variety of maize used and the milling process employed. Kadan, Bryant, and Miller (2008) compared different milling

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processes, concluding that the excess of fine particles in rice flours led to greater collapse of the breads, producing a lower volume. Some authors developed formulae by mixing different proportions of gluten-free flours and starches in order to improve bread volume or texture properties. For example, Sanchez, Osella, and de la Torre (2002) determined the optimum percentages for composite bread based on cornstarch, rice flour and cassava starch. Others, such as Minarro, Normahomed, Guamis, and Capellas (2010), compared the characteristics of flour-based and starch-based gluten-free formulae after the addition of unicellular proteins, reporting better results with the starch-based formulae.

However, there has been little research into the influence of other flour parameters, particularly particle size and grain type, on bread characteristics. Only Araki et al. (2009) studied the effect of particle size on rice-bread, but their formula was supplemented with wheat-gluten and their main objective was to study differences in the milling process.

The aim of the present study was to investigate the effect of different rice-grain types and flour-particle size on dough microstructure, dough behaviour during fermentation and the final quality of gluten-free bread (specific volume and texture).

Table 1
Flour characterization parameters.

Grain type	Particle size interval (μm)	Median particle size (μm)	Protein (g/100 g)	Starch (g/100 g)	Amylose (g/100 g)	Water hydration capacity (mL/g)
Short	>180	126.43 d	8.56 c	72.3 a	21.41 a	134.7 a
Short	106–180	121.32 cd	7.46 b	76.4 bc	22.84 b	136.3 a
Short	80–106	92.38 b	6.41 a	77.9 c	22.75 b	138.8 b
Short	<80	50.74 a	6.70 a	75.4 b	21.56 a	140.1 b
Long	>106	110.97 c	7.59 b	75.5 b	23.71 c	133.9 a
Long	80–106	92.66 b	6.89 a	75.7 b	25.51 d	134.7 a
Long	<80	48.24 a	7.45 b	72.6 a	23.67 c	145.9 c

Values with different letters in the same parameter are significantly different ($p < 0.05$).
Values are the mean of two measures.

2. Materials and methods

2.1. Materials

Two different types of rice flour were used, one from short-grain and one from long-grain rice. The flours were supplied by Harinera Castellana S.A., (Medina del Campo, Valladolid, Spain). Sifting the two flours for 15 min in a Bühler MLI 300B mill (Uzwil, Switzerland) with screens of 80, 106 and 180 microns, we achieved four different particle-size fractions for short-grain rice flour (<80, 80–106, 106–180, >180 μm), and three fractions for long-grain rice flour (<80, 80–106, >106 μm); an insufficient volume of the largest particle size long-grain rice flour was available for use in the study. Salt, sugar and sunflower oil were purchased from the local market. Dry yeast (Saf-instant, Lesaffre, Lille, France) and hydroxypropyl methylcellulose (HPMC) (Methocel K4M, Dow Chemical, Midlesex, UK) were used.

2.2. Methods

2.2.1. Flour measurements

Flours were analysed following AACC methods (AACC, 2010) for water hydration capacity (WHC) (AACC method 88-04) and protein

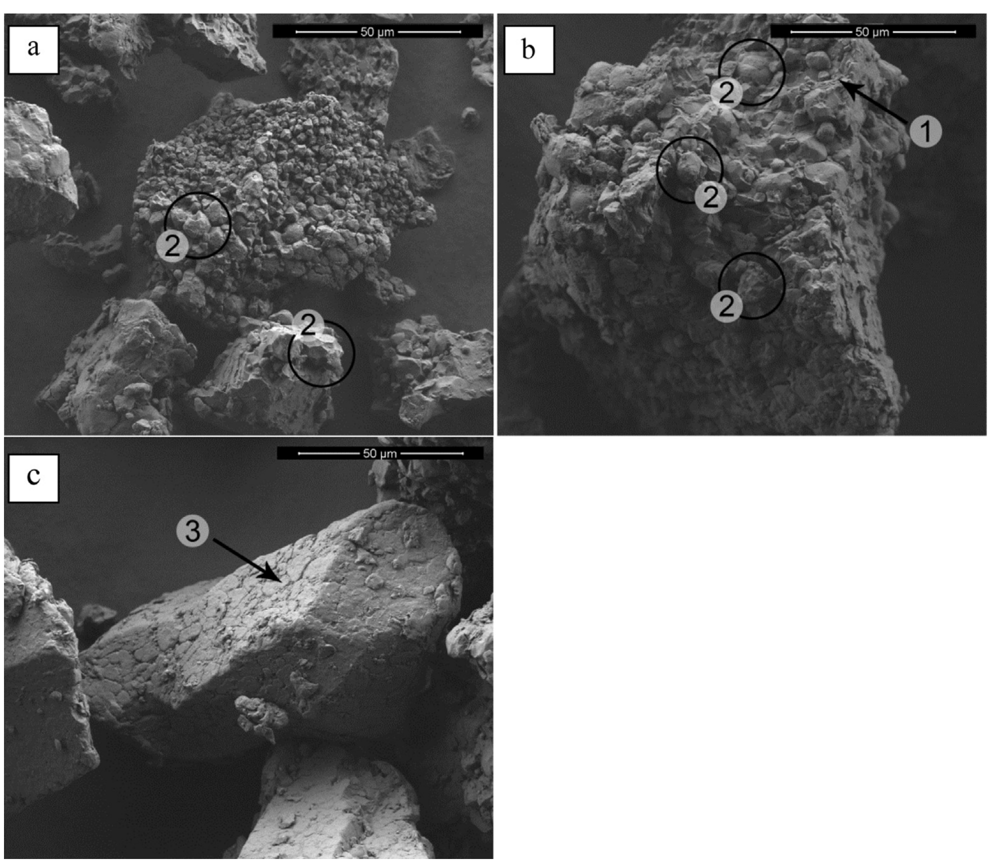

Fig. 1. Environmental scanning electron microscope photomicrographs of the flours: (a) short grain, 106–180 μm; (b) short grain, <80 μm; (c) long grain, 106–180 μm. Footnote: Arrow 1: Disintegrated starch granules within the protein matrix. Circles 2: Whole compound starch granules. Arrow 3: Smooth and compact surface.