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Physicochemical properties of long rice grain varieties in relation to gluten free bread quality

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A B S T R A C T

The aim of this study was conducted to determine the breadmaking potential of six long-grain rice varieties (INIAP 14, INIAP 15, INIAP 16, INIAP 17, F09 and F50) and to identify any flour characteristic governing their breadmaking behavior. Pasting parameters, thermal parameters assessed by differential scanning calorimetry and bread quality parameters (specific volume, color, and crumb texture profile analysis) were assessed. Results confirmed the suitability of long-grain rice varieties for breadmaking. Nevertheless, significant differences were observed in flour properties among varieties. A significant correlation was observed between specific volume of the gluten-free bread (GFB) with swelling power ($r = 0.71$, $P < 0.01$), breakdown viscosity ($r = -0.97$, $P < 0.01$) and conclusion temperature (Tc) of gelatinization ($r = 0.81$, $P < 0.05$). Moreover, a strong correlation was found between cohesiveness and properties of rice flour such as peak temperature (Tp) ($r = -0.96$, $P < 0.001$), DH ($r = 0.71$ $P < 0.05$) and swelling volume ($r = 0.82$, $P < 0.05$). The quality characteristics of the gluten-free breads made of long-grain rice flour were comparable to those reported in commercial GFB. INIAP 14 and F09 were the most promising varieties for bakery applications. Results suggested that the most important parameters of rice flour when defining breadmaking performance of GFB would be WBC, SP, SV, Tp, Tc and enthalpy.

1. Introduction

Rice is mainly consumed as cooked rice, but during the last decade the consumption of rice flour has increased due to its application in breadmaking. Rice has unique sensorial and nutritional advantages for developing gluten-free foods. Specifically, rice flour has a neutral flavor, low levels of sodium, easy digestibility, hypoallergenic proteins, and does not contain gluten. These characteristics make rice flour a suitable ingredient for gluten-free bakery products (Marco & Rosell, 2008). However, features of rice based breads are greatly dependent on rice flour functionality. Physicochemical properties of rice flour, main determinants of its technological functionality, are greatly variable. In fact, these properties are significantly influenced by rice variety (Han, Cho, Kang, & Koh, 2012; Sompong, Siebenhandl-Ehn, Linsberger-Martin, & Berghofer, 2011; Yu, Ma, Menager, & Sun, 2012), storage conditions (Park, Kim, Park, & Kim, 2012; Tananuwong & Malila, 2011), particle size of the flour and length of rice grain (de la Hera, Gomez, & Rosell, 2013), processing method (Guha & Ali, 2011), chemical structure and composition (Kim, Song, & Shin, 2010; Zhu, Liu, Sang, Gu, & Shi, 2010), among others.

Regarding variety, there is a general agreement that rice grain length is a factor that influences the bread quality in gluten-free breads (GFB), although discrepancies about the most convenient type of rice grain have been reported (Kadan, Robinson, Thibodeaux, & Pepperman, 2001; Rosell & Gómez, 2006; de la Hera, Martinez, & Gómez, 2013). In general, the size of the grain is related to its amylose content. Long-grain rice contain higher amylose content and gelatinization temperature, as well as more tendency of retrogradation than short-grain rice. Noomhorm, Bandola, and Kongseree (1994) demonstrated that rice varieties with low amylose content exhibited low gelatinization temperature and soft gels, which was beneficial for baking. Kadan et al. (2001) reported that combining part of the long-grain variety with 10% of short-grain variety produces a smoother texture in bread. Furthermore, Han et al. (2012) stated that intermediate amylose content and low water absorption capacity of rice gave better rice bread physicochemical properties. Studies had shown that short

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and medium-grain rice varieties presented better bread textures (Rosell & Gómez, 2006). de la Hera, Martinez, et al., (2013) showed that short-grain rice produced breads with higher specific volume and lower hardness than long-grain rice. Conversely, few studies demonstrated that long-grain rice could have good breadmaking performance (Han et al., 2012; Kadan et al., 2001; Sivaramakrishnan, Senge, & Chattopadhyay, 2004). In fact, Sivaramakrishnan et al. (2004) reveal that flour of long-grain rice with 3 g of hydroxypropylmethylcellulose per 100 g of flour presents better texture than flour of short-grain rice. Generally, studies related to rice gluten-free bread have been carried out with commercial rice flour, without controlling the rice type or variety (de la Hera, Martinez, et al., 2013b; Kadan et al., 2001; Rosell & Gómez, 2006). Since there is not knowledge about the main properties of rice flour governing breadmaking potential, it is necessary to get additional insight on the properties of rice flour from long-grain varieties.

Therefore, the aim of this study was to determine the breadmaking potential of six long-grain rice varieties and to assess any possible flour characteristic (physicochemical and rheological) of their breadmaking behavior.

2. Materials and method

Six varieties of long-grain rice were selected as representative of the main production in the region. Four of them were from the National Institute of Agricultural Research from Ecuador (INIAP, Boliche, Ecuador): INIAP 14, INIAP 15, INIAP 16 and INIAP 17 and two varieties were from the company PRONACA (Guayaquil, Ecuador): F09 and F50. The average size of the rice grains was 7.2 mm ± 0.1 mm. All varieties were harvested between May and December of 2011. All the samples were provided by INIAP.

2.1. Flour production and chemical characterization

The seeds were polish and milled (Cyclotec Sample Mill, Tecator, Hoganas, Sweden) with a 500 μm screen. Considering the already stated relationship between physicochemical properties of starches and their apparent amylose content (AAC), protein and lipid (Gani, Wani, Masoodi, & Salim, 2013; Kim et al. 2010; Tester & Morrison, 1990a), these parameters have been analyzed. The flour protein, lipid content and moisture content were analyzed following AOAC methods (AOAC 18th 92087 for protein and AOAC 18th 922.06 for fats). Moisture content was determined following the ISO method (ISO 712:1998). The AAC of the rice flour was measured following the iodine calorimetric method (Juliano et al., 1981). Spectrophotometer (PerkinElmer, Waltham, USA) measurements were made at 620 nm after the above starch-iodine solution was incubated for 20 min at ambient temperature. Standard curve was generated using starch reference with 66 g of amylose per 100 g of flour from the Megazyme kit K-AMYL 04/06t (Megazyme International Ltd, Wicklow, Ireland). All the analyses were made by triplicate.

2.2. Flour hydration properties

The water holding capacity (WHC) defined as the amount of water retained by the sample without being subjected to any stress was determined by mixing (1.000 g ± 0.005 g) of flour with distilled water (10 ml) and kept at room temperature for 24 h. The supernatant was carefully removed with a pipette. WHC was expressed as grams of water retained per gram of solid. The swelling volume (SV) was determined following the method reported by Gularte and Rosell (2011) with slight modification. The swelling volume was calculated by dividing the total volume of the swollen sample after 24 h at room temperature by the powder weight of the sample. The water binding capacity (WBC) defined as the amount of water retained by the sample under low-speed centrifugation was determined as described the standard method (AACCI, 2012). Samples (1.000 g ± 0.005 g) were mixed with distilled water (10 ml) and centrifuged at 2,000 × *g* for 10 min. WBC was expressed as grams of water retained per gram of solid. All the analyses were made by triplicate. WHC, SV and WBC were calculated by the Equations (1–3):

$$\text{WHC (g/g)} = \frac{\text{Weight of sediment after draining supernatant} - \text{Sample dry weight}}{\text{Sample weight}} \quad (1)$$

$$\text{SV (ml/g)} = \frac{\text{Total volume of swollen sample}}{\text{Sample weight}} \quad (2)$$

$$\text{WBC (g/g)} = \frac{\text{Weight of sediment after centrifugation} - \text{Sample dry weight}}{\text{Sample weight}} \quad (3)$$

2.3. Flour gelling behavior

Water absorption index (WAI), water solubility index (WSI) and the swelling power (SP) of different rice flour gels were determined following the method of Anderson, Conway, Pheiser, and Griffin (1969), with slight modification. Briefly, flour (50.0 mg ± 0.1 mg) sample was dispersed in 1 ml of distilled water and cooked at 90 °C for 15 min in a water bath. The cooked paste was cooled to room temperature, and centrifuged at 3,000 × *g* at 4 °C for 10 min (Thermo Scientific, Walthan, USA). The supernatant was decanted for determination of its solid content into an evaporating dish and