PHYSICAL, TEXTURAL AND STRUCTURAL PROPERTIES OF GLUTEN-FREE BREADS MADE FROM EXTRUDED WHOLE GRAIN FLOURS

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Abstract
The objective of this study was to use pre-cooked whole corn, parboiled brown rice and sorghum flours by thermoplastic extrusion as a pretreatment to improve the quality characteristics of gluten-free (GF) bread. The methodology included the evaluation of the physical, textural and structural properties of the bread crumb. GF bread made from whole grains were characterized by lower hardness and cohesiveness compared to GF bread made from refined grains. In addition, the volume, distribution of air cells, porosity and height bread crumb were improved, so it is possible to use extrusion to create functional whole grain flours for bakery products.

Keywords: gluten-free cereals, cooking extrusion, TPA, image analysis, breadmaking

1. INTRODUCTION

Gluten sensibility is a term integrating three major types of gluten-related disorders: autoimmune celiac disease, allergy to wheat, and non-celiac gluten sensitivity (Balakireva & Zamyatnin, 2016). Gluten prolamins are the gluten fraction, which is directly related to trigger disorders in individuals sensitive to wheat proteins, barley, rye and/or their derivatives. Therefore, gluten-free (GF) products are the only lifelong dietary alternative to which people who endure from sensitivities related to gluten intake should adhere. Whole grains (WG) are rich in carbohydrates, mainly starch, and consumed as the whole form they provide phytochemicals and dietary fibers that have a positive influence on our health (Mir & Bosco, 2019). Corn, rice, and sorghum are currently the most produced gluten-free grains in Brazil (FAOSTAT, 2019) that have hypoallergenic characteristics and provides molecular evidence for the absence of toxic gliadin-like peptides on their storage proteins (Rosell; Barro; Sousa & Mena, 2014). Thermoplastic extrusion is a process that operates under controlled conditions of heating, shearing, moisture, and in a short time (Guy, 2001), can

modify the biopolymers present in materials of plant origin, thus conferring functional properties that mimic wheat gluten (Gómez & Martínez, 2016). The aims of the present study were to investigate the influence of the thermoplastic extrusion on the physical, textural, and structural gluten-free bread properties.

2. MATERIAL AND METHODS

Corn grains were donated by Indústrias de Alimentos Granfino (Nova Iguaçú, Brazil). Sorghum grains of red pericarp, low tannin were donated by Embrapa Maize & Sorghum (Sete Lagoas, Brazil). Parboiled brown rice and commercial whole wheat flour (WWF) were acquired from the local market of Rio de Janeiro. Whole grains were milled for obtaining fine flours (0.8 mm screen opening).

2.1. Extrusion conditions

Whole grain flours adjusted at 25% of moisture, 200 rpm and 10 kg/h of feed rate were processed in a twin-screw Clextral Evolum HT25 co-rotating intermeshing extruder (Clextral Inc., Firminy, France) with ten temperature zone (25, 40, 60, 80, 100, 110, 110, 90, 80, and 70 °C). Extrudates were milled in fine corn (EWCF), parboiled brown rice (EPBRF), and sorghum (EWSF) flours.

2.1. Gluten-free bread preparation

The formulation of gluten-free breads proposed by Encina-Zelada et al. (2018) was followed. The preparation of the dough was done in a 35 g micromixer (National MFG. CO., Lincoln, USA), where the dry ingredients were previously homogenized for 2 min, to later be incorporated the liquid ingredients for a mixing time of 2.0, 3.0, and 1.5 min for corn, rice, and sorghum, respectively. Portions of 20 g were they fermented at 30 °C and 85% RH for 60 min and baked at 200 ° C for 14 min. Bread analyzes were carried out after 24 hours and two controls were used: breads made from commercial whole wheat flour (control 1) and the mixture of raw and extruded rice flours in a proportion of 1:1 (control 2).

2.2. Bread characterization

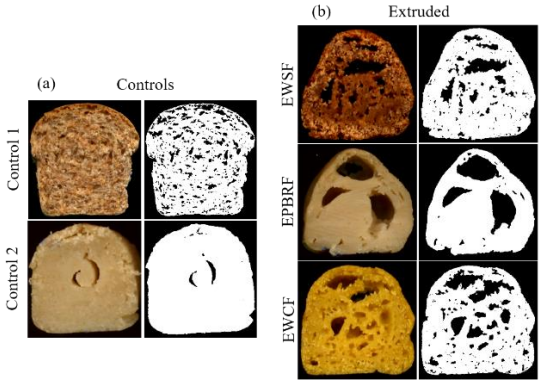
The texture profile analysis (TPA) was performed onto center of the bread crumb slices using a Texture Analyser TA-XT Plus (Stable Micro Systems, Surrey, U K) according to Schober et al. (2005). The sample was taken from its center with a 20 mm thickness. Specific volume was measured according to method 10-05.01 (AACC, 2001). Crumb of each bread slice was scanned at 300 dpi with a scanner (Epson perfection 1240U Nagano-Ken, Japan). Image

analysis was performed using the ImageJ software (v.1.51j8, Wayne Rasband, National Institute of Health, USA) and consisted of an area from the centre of the slice.

3. RESULTS AND DISCUSSION

Gluten-free bread made with the extruded flours presented lower values of crumb hardness and cohesiveness compared to the studies reported by Torbica; Belovic & Tomic (2019) in sorghum bread, Sciarini; Ribotta; León & Pérez (2008) in rice bread, and Kotancılar; Güdük & Seyyedcheraghı (2018) in corn bread. These lower values of hardness and cohesiveness found in our samples were already demonstrated in previous studies carried out by Phimolsiripol; Mukprasirt & Schoenlechner (2012), where the authors demonstrated that the addition of dietary fiber reduces the crumb rigidity. The specific volume of the breads was increased by 67, 34 and 83% (for the corn, rice, and sorghum breads, respectively) compared to control 2. However, it was not possible to obtain similar volumes to control 1 (bread made from whole wheat flour, as observed in Fig. 1a).

Figure 1. Structure of the bread crumb made from whole wheat flour (control 1), the mixture of raw and extruded rice flours in a proportion of 1:1 (control 2) and extruded corn (EWCF), parboiled brown rice (EPBRF), and sorghum (EWSF) flours.



The extrusion process favored the formation and distribution of internal air cells at the same time preventing the collapse and integration of air cells (Fig. 1b). The structure of the breads made from extruded flours showed better CO_2 retention during the fermentation process. Consequently, they were a significant increase ($p < 0.05$) in the total area of the bread slice, total cell area, porosity, and height. EWCF and EWSF showed better development of porosity within the crumb structure, associated with the increase in specific volume and height. Likewise, both samples had the least collapse of air cells compared to the EPBRF sample, possibly due to the development of viscoelastic properties after the extrusion process.

4. CONCLUSIONS

Gluten-free whole grains produced crumbs with lower hardness and cohesiveness compared refine GF flours. The extrusion process favored the increase of the specific volume in all gluten-free breads without using chemical additives. The breads made from extruded corn and sorghum flours were those that presented the highest volume, total bread slice area, total cell area, porosity, and height. Thus, the functional ingredients produced by extrusion process can be used successful, since it contributes favorably to the quality characteristics of gluten-free breads.

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