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Mixolab™ for rheological evaluation of wheat flour partially replaced by soy protein hydrolysate and fructooligosaccharides for bread production

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ABSTRACT

Replacement of wheat flour (WF) by soy protein hydrolysates (SPH) and fructooligosaccharides (FOS) may have beneficial health effects, but they can modify dough rheology performance, and the technological quality of functional breads with health claim. This study aimed to evaluate the rheological properties of premixes by Mixolab™ parameters, using a Central Composite Design (CCD), with WF partially replaced by SPH ($X_1 = 0–20$ g/100 g) and FOS ($X_2 = 0–10$ g/100 g) for breadmaking. Mixolab™ results were analyzed by Surface Response Methodology (SRM) and the desirability methodology was applied to select two premixes, suitable and unsuitable for breadmaking, comparing with control bread, made only with WF. The results indicated that Mixolab™ parameters and statistical methods including CCD and desirability were appropriate to predict the WF replacement levels by SPH and FOS, for producing functional bread with specific volume and firmness similar to control bread.

1. Introduction

Empirical rheology is used to predict the use of wheat flour (WF) in bakery products. Therefore, several techniques have been used to study dough performance during mixing and proofing, such as farinograph, extensograph, alveograph, rheofermentometer, mixograph, consistograph and maturograph (Ktenioudaki, Butler, & Gallagher, 2010; Rosell, Rojas, & Benedito de Barber, 2001; Rosell, Santos, & Collar, 2006). Although two or more of these techniques are required to make quality prediction (Rosell, Santos, & Collar, 2010) they do not allow the evaluation of dough consistency during heating and cooling stages, and changes in starch paste associated with thermal processes.

Currently, Mixolab™ has been used to replace four determinations in WF, including farinograph and consistograph test, rapid visco-analyser, and falling number (Rosell et al., 2010), thus information on the amount of water necessary for dough development, dough development time, protein strength and weakening, starch gelatinization and retrogradation, enzyme activity and gel strength are provided with a unique test (Dubat, 2010; Švec & Hrušková, 2015).

As reported by several authors, rheological tests of WF containing functional ingredients to define the adequate replacement ratio have been performed by farinograph and alveograph methods, for example, the use of fibers by Wang, Rosell, and Benedito de Barber (2002), Rosell, Collar, and Haros (2007) and Peressini and Sensidoni (2009) and soybeans in bakery products by Maforimbo, Skurray, Uthayakumaran, and Wrigley (2008).In addition, Mixolab™ has been successfully applied to evaluate the effect of different protein sources on wheat dough functionality (Bonet, Blaszczak, & Rosell, 2006); molecular structure of different hydrocolloids on WF dough (Rosell et al., 2007); use of different flours on cookies baking quality (Ozturk, Kahraman, Tiftik, & Koksel, 2008); breads with different wheat genotypes (Koksel, Kahraman, Sanal, Ozay, & Dubat, 2009); effect of dietary fibers on dough (Rosell et al., 2010); and performance of different sources of flours and their relation with quality parameters (Švec & Hrušková, 2015).

For breads made from refined wheat flour, the use of prebiotic fibers and protein isolates can improve their functional claim. In relation to fibers, their use alone or in combination with other

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ingredients have already been studied, but the use of protein hydrolysates is gaining importance due to the presence of bioactive peptides in their composition. Among the prebiotic fibers, despite inulin has been much studied in breads (Rosell et al., 2010), the fructooligosaccharides (FOS) are more commonly used in dairy beverages, candies, sweets, desserts and jellies (Bornet, 1994, 2001). FOS is obtained by synthesis, has low molecular weight, and solubility similar to sucrose, and has been widely used by the food industry as fat and sugar replacers, as well as fiber source (Charalampopoulos, Wang, Pandiella, & Webb, 2002; Foschia, Peressini, Sensidoni, & Brennan, 2013; Karppinen, Myllymäki, Forssell, & Poutanen, 2003; Morris & Morris, 2012). FOS stimulates the growth of bifid bacteria in the digestive tract, has neutral taste, and is stable in a wide range of pH and temperatures. Thus, its addition in bread formulations can bring technological advantages to the processing and health benefits to the consumer.

Similar to fibers, the use of different protein sources in bread is not new, since they are added with the purpose of supplementing the balance of essential amino acids of WF. Soy protein has been used in bread for increasing the protein content and balancing the essential amino acid composition (Ranhotra & Loewe, 1974; Tsen & Hoover, 1973). Legume proteins are rich in lysine and tryptophan, and deficient in methionine and cysteine, and have been used with WF, which is rich in sulfur amino acids, to improve its nutritional quality (Pereira & Oliveira, 2004).

The major problem of the legume proteins is the presence of antinutrients, such as trypsin inhibitor, lectin, α-amylase inhibiting factor, goitrin, and soybean antigen. Despite soybeans is usually subjected to heat treatment, studies have shown that it still contains low-levels of anti-nutritional factors, such as phytoagglutinin (Bajpai, Sharma, & Gupta, 2005; Gu, Pan, Sun, & Qin, 2010), thus the heat treatment of the grains must be strict to inactivate these agents. Therefore, the use of raw legume flours is not indicated, since the baking time of bakery products is not enough for an effective inactivation of these compounds.

Some processes such as germination and fermentation have been used to reduce the levels of these compounds, and currently the use of soy protein hydrolysates including isolates and concentrates has been proposed, which have the advantage of the absence of antinutritional factors and presence of bioactive compounds with beneficial health effects (Paucar-Menacho, Berhow, Mandarino, Mejia, & Chang, 2010; Silva, Celeghini, & Chang, 2011).

Some hydrolysates have been used in breads and assessed for their beneficial effects, as an example, Segura-Campos, Salazar-Vega, Chel-Guerrero, and Betancur-Ancona (2013), who studied white bread and carrot cream containing chia protein hydrolysates, and found an improved ACE-inhibitory (angiotensin I-converting enzyme) activity. In contrast, Fitzgerald et al. (2014) found that breads containing seaweed protein hydrolysate showed better functional quality. However, the effects of the association between FOS and SPH in the dough rheology and technological quality of breads have not been studied.

SPH stimulates the formation of health-promoting bioactive peptides (HTNutri, 2015), and the polypeptides may exhibit antioxidant activity, similar to other antioxidants compounds present in fruits and whole grains and anti-inflammatory effects (Oseguera-Toledo, de Mejia, Dia, & Amaya-Llano, 2011; Paucar-Menacho et al., 2008; Vernaza, Dia, Gonzalez de Mejia, & Chang, 2012).

The aim of this study was to evaluate the use of Mixolab™ to evaluate dough rheology parameters of WF, and premixes of WF partially replaced by SPH and FOS to predict their quality in breadmaking.

2. Material and methods

2.1. Materials

The raw materials were refined WF (Moinho Paulista, Santos, BRA), SPH ("Imunoprotein", HTNUTRI, Camaquã, BRA) and commercial FOS (Short-chain Fructooligosaccharides P-95, Nutraflora) in powder form.

2.2. Characterization of raw materials

Protein (method 46–13.01) and ash (method 08–01.01) contents of the raw materials were analyzed according to AACCI (2010) and expressed on dry basis. The WF was also characterized for farinograph and alveograph properties, according to the AACCI (2010), methods 54–21.02 and 54–30.02, respectively.

2.3. Experimental design

Wheat flour without the addition of SPH and/or FOS was used as standard sample (SS). The premixes, were performed through a Central Composite Design (CCD) with two independent variables: X_1 = SPH (0–20 g/100 g) and X_2 = FOS (0–10 g/100 g), according to Table 1. The premixes were homogenized for four minutes before use in a K45SS planetary mixer (Kitchen Aid Professional, St. Joseph, USA).

2.4. Mixolab™ measurements

Mixing and pasting behavior of the SS and the premixes were determined according to the method 54–60.01 (AACCI, 2010) in a Mixolab™ (Chopin, Tripette et Renaud, Paris, FRA) using the Chopin + protocol. The amount of water added for the initial consistency was enough to reach 1.1 ± 0.05 Nm. The evaluated parameters from the curves (Fig. 1) were: (i) Water absorption (WA): amount of water necessary to reach C1; (ii) Amplitude: width of curve to C1; (iii) Dough development time (DDT): time required to C1; (iv) Stability: mixing resistance of dough; (v) C1: maximum torque during mixing; (vi) C2: protein weakening based on mechanical work and temperature increase; (vii) C3: maximum torque during the heating stage, expressing the rate of starch gelatinization; (viii) C4: minimum torque during the heating period, indicating the stability of the hot gel formed; (ix) C5: torque after cooling at 50 °C, representing starch retrogradation during the

Table 1
Central Composite Design with 2 independent variables: soy protein hydrolysate (SPH) and fructooligosaccharides (FOS) in codified level and real level (g/100 g) for the pre-mixes with wheat flour.[a]

Trial	Codified level[b]		Real level[b]	
	SPH	FOS	SPH	FOS
	x_1	x_2	X_1	X_2
1	−1	−1	2.90	1.45
2	+1	−1	17.10	1.45
3	−1	+1	2.90	8.55
4	+1	+1	17.10	8.55
5	−1.41	0	0.00	5.00
6	+1.41	0	20.00	5.00
7	0	−1.41	10.00	0.00
8	0	+1.41	10.00	10.00
9	0	0	10.00	5.00
10	0	0	10.00	5.00
11	0	0	10.00	5.00
12	0	0	10.00	5.00

[a] Wheat flour in pre-mixes was calculated by: 100 − (X_1 + X_2), in real levels.
[b] x_1 and X_1 are codified and real levels for SPH; x_2 and X_2 are codified and real level for FOS.