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Influence of teff variety and wheat flour strength on breadmaking properties of healthier teff-based breads

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ABSTRACT

This study analyses the mineral and protein content of two cultivars of teff [*Eragrostis tef* (Zucc.)Trotter] – Red (T_R) and White (T_W) –, and the rheological and breadmaking properties of mixed flours produced by adding different ratios of T_R or T_W flour to two bread wheat flours of contrasting breadmaking quality. The T_R flour had higher concentrations of protein, Fe and Zn and showed greater α-amylase activity than the T_W flour, while its sedimentation volume, peak viscosity and setback values were lower. Deterioration of some critical cell crumb structure parameters in wheat/teff breads was not alleviated when the strong wheat flour was used in the mix. However, some rheological parameters and the extent of cell crumb structure modifications varied depending on the addition of T_R or T_W flour in the blend. The selection of the teff cultivar is therefore important when aiming to develop teff-based innovative bread products. In addition, the anomalous starch behaviour and crumb structure that resulted from wheat/teff mixed flours indicate the necessity of modified breadmaking protocols to produce good quality teff-based breads.

1. Introduction

Bread is a staple food in many parts of the world. In recent years, however, changes in dietary habits, the increasing detection of allergies, the search for greater organoleptic quality and a more complex bread nutritional profile, have prompted the development of innovative products made from cereals other than wheat.

Teff (*Eragrostis tef* [Zucc.] Trotter) is an alternative cereal of growing interest in Europe. It is indigenous to Ethiopia, where this small grain cereal is consumed as a fermented pan bread called 'injera'. Teff cultivars are recognized and described based on the colour of the grains. Accordingly, teff is classified for marketing purposes as: netch (white), qey (red/brown) and sergegna (mixed) (Gebremariam et al., 2014). The taste is considered agreeable, varying from mild to nut-like and slightly sweet in the lighter cultivars, to a more intense hazelnut flavour in the darker cultivars (Lovis, 2003).

The nutritional characteristics of teff are excellent (Gebremariam et al., 2014). The content of iron, zinc and calcium in teff flour is higher than that reported for most other cereals (Abebe et al., 2007; Hager et al., 2012a; Rosell et al., 2014). Teff is always consumed as whole grain and teff-derived products are rich in slow-release carbohydrates. In addition, it has a well-balanced amino acid composition, including 8 essential amino acids, and a high content of nutritionally valuable unsaturated fatty acids (Hager et al., 2012a). On the other hand, the high capacity of water absorption of teff flour (Bultosa, 2007) and the gelling properties of starch (Abebe and Ronda, 2014), make this cereal suitable to be used in a broad range of food applications. The gluten-free nature of teff makes this cereal safe to use by coeliac patients, but also conditions its breadmaking quality (Gebremariam et al., 2014). Hager et al. (2012b) demonstrated indeed that the loaf quality of breads based on 100% teff flour was much inferior to that of wheat breads, with dense structure and low specific volume.

To explore the use of teff for improving the nutritional and sensorial qualities of wheat-based breads, earlier studies have examined the rheological and breadmaking behaviour of mixed wheat/teff doughs, the ratios of teff flour usually employed varying from 5 to 30–40%. There is a good agreement that addition of teff alters some functional properties of the blends as, for instance, the

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degree of dough softening which increases with higher doses of teff flour (Ben Fayed et al., 2008; Mohammed et al., 2009; Alaunyte et al., 2012). Nevertheless, the results are not unanimous regarding other critical dough rheology parameters, i.e., water absorption. It can be expected that mixed wheat/teff flours exhibit a teff dose-dependent higher water absorption ability. This has been indeed obtained for 10–30% teff supplemented doughs by means of Farinograph analysis by some authors (Ben Fayed et al., 2008; Alaunyte et al., 2012). Using the same approach, however, Mohammed et al. (2009) failed to detect any significant change for blends with 5–20% of teff addition. In turn, Callejo and Tesfaye (2011) were unable to determine the water absorption in blends involving more than 15% of teff by Consistograph analysis, which could be reflecting the unsuitability of this technique for fibre-rich flours.

Discrepancies concerning the quality of wheat/teff mixed breads, prepared by the straight dough method, are also found. Mohammed et al. (2009) and Ronda et al. (2015) have reported some increase of specific volume for blends with low ratios of teff flour (5–10% for Mohamed and co-workers; 10–20% for Ronda and co-workers). On the contrary, a decrease of bread specific volume has been observed in other studies though the minimum ratio of teff for a significant negative effect differs between authors from 10% (Alaunyte et al., 2012) to 30% (Callejo and Tesfaye, 2011). According to the latter report, the use of stronger wheat flour in the wheat/teff blend may alleviate the deleterious impact of teff on breadmaking performance by reducing the negative effects associated with gluten dilution brought about by addition of gluten-free flours to wheat (Izydorczyk et al., 2001).

Sensory testing of mixed breads has been conducted in a number of studies and results are also quite disparate. The overall acceptability tends to decrease with increasing content of teff but the proportion of teff flour from which composite breads have a significantly worse score than control wheat breads greatly differs between studies: 5% (Mohammed et al., 2009) or above 10–15% (Callejo and Tesfaye, 2011; Alaunyte et al., 2012), to 30–40% (Ronda et al., 2015). Between-study differences regarding the inclusion or not of enzymes in the formulation of doughs, the baking protocols and the use of refined or wholemeal wheat flour for control breads may explain, at least in part, such discrepancies.

Ronda et al. (2015) have demonstrated that sensory attributes as well as some physical properties of composite breads may significantly vary depending on the teff variety used in the blends while, to our knowledge, no previous report has comparatively assessed the influence of the wheat fraction but the preliminary analysis in Callejo and Tesfaye (2011).

All above indicates the need for further studies before standardized protocols and formulations for wheat/teff breads can be developed. With that in mind, the present work aimed to examine nutritional, rheological and baking properties of blends formulated with two distinct cultivars of teff added in proportions of 15% and 30% to two wheat flours with different gluten strength.

2. Material and methods

2.1. Teff and wheat flours

Grains of the two teff cultivars – here termed Red (T_R) and White (T_W) – were supplied by Ecosem Valladolid (Spain) and milled in a CD1 Chopin mill. The bread wheat (*Triticum aestivum* spp *vulgare* L.) flours, supplied by Duo Harinero (Madrid, Spain), had different Chopin alveograph deformation energy (W) values: $W = 170 \times 10^{-4}$ J (weak wheat flour, W_K), and $W = 331 \times 10^{-4}$ J (strong wheat flour, W_S).

Flour mixtures were prepared by adding 15% or 30% (w/w) T_R or T_W flour to the W_K and W_S flours.

2.2. Electrophoretic analysis

Gluten proteins were extracted from 50 mg of flour samples using the sequential procedure described by Singh et al. (1991). Electrophoresis of glutenin subunits was performed on sodium dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE) according to Payne et al. (1979). High molecular weight (HMW) glutenin subunit composition was determined according to the nomenclature of Payne and Lawrence (1983). Gliadins were fractionated by electrophoresis at acidic pH (3.1) in 7.5% acid polyacrylamide gel (A-PAGE) as described by Lafiandra and Kasarda (1985). Bread wheat cv. Pirana and durum wheat cv. Mexicali were used as tester varieties.

2.3. Chemical composition

The mineral, protein and amylose content of wheat, teff and blended flours were determined. For mineral composition analysis, samples (1 g per duplicate) were digested in a mixture of equal volumes of concentrated nitric acid and hydrochloric acid for 2 h at 140 °C, and made to 50 ml final volume using de-ionized distilled water. Iron (Fe) and zinc (Zn) content of the final solution was measured by atomic absorption spectrometry (Analyst Perkin Elmer) at 248 nm (Fe) and 214 nm (Zn) wavelengths. Appropriate quality controls with certified wheat flour (NIST-1567) were performed for each set of measurements. The protein content was measured by near-infrared reflectance analysis (NIR) using a Technicon Infralyzer 300. The amylose content was determined by spectrophotometry according to Watanabe et al. (1998). All measurements were performed in duplicate.

2.4. Rheological analysis

The SDS-sedimentation (SDSS) volume was determined as described by Dick and Quick (1983). The viscoelastic behaviour of the flour mixtures was determined using an NG-97 Alveograph (Trippette and Renaud, France) (AACC method 54-30A, 2010). The variables measured were deformation energy (W), tenacity or resistance to extension (P), and dough extensibility (L). The falling number (FN) was measured following the AACC method 56-81B (AACC, 2010). All measurements were performed in duplicate, except the SDSS volume that was measured in quadruplicate.

2.5. Starch properties

Starch viscosity was analysed using an RVA-3D Rapid-Visco Analyser (Newport Scientific, Pty. Ltd.) following Batey et al. (1997). For this, 24 ± 0.1 ml of distilled water and 1 ml of $AgNO_3$ (10%) were added to the flour samples (3.5 g), and the mixture was processed using profile standard 1 of AACC method 76-21 (AACC, 2010). The starch peak viscosity (PV; maximum viscosity during the heating or heat/hold phase of the test), trough viscosity and final viscosity were then determined and measured in Rapid Viscous Units (RVU). From these values, setback (final minus trough viscosity) values were calculated. The gelatinization temperatures (pasting temperatures) were determined using a Brabender Amylograph (AACC method 22-10, 2010). All measurements except gelatinization temperatures were performed in duplicate.

2.6. Breadmaking procedure

Doughs made with the wheat flours and the wheat/teff flour mixtures were baked in a FUNAI household baking-machine. The