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Variability in the chemical composition of triticale grain, flour and bread

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ABSTRACT

During the last few decades triticale has become a commercial crop grown in a variety of environmental conditions worldwide. Triticale, a hybrid cereal developed by crossing wheat and rye combines the valuable properties of both parental forms. In the present study the differences in chemical composition between grain, flour and bread of eight triticale varieties were determined. The results were compared against the standard wheat variety. Independently of the degree of material processing, all samples were characterised for nutrients (protein, starch, ash, lipids) and bioactive components (dietary fibre (DF), total polyphenols (TPC)) and viscosity of water extracts (WEV). Following grain milling, the average content of some components decreased significantly in comparison to grain (protein (2%), ash (58%), lipids (38%), DF (64%), TPC (40%)). After baking the differences in the content of some bread components were compared to flour. The most significant differences between flour and bread samples were noted in the average content of ash (0.8% vs. 2.3%), starch (74.1% vs. 64.7%), DF (4.6% vs. 5.4%), TPC (0.9mgGAE/g vs. 0.5mgGAE/g). Our results show that the grain of some modern triticale varieties, with a favourable chemical composition from a technological and nutritional perspective, is good material for flour and bread production.

1. Introduction

Triticale (X *Triticosecale* Wittmack) is a man made hybrid developed by combining the A and B genomes of wheat (*Triticum turgidum* L., *Triticum aestivum* L.) and the R genome of rye (*Secale cereale* L.). This cereal was created to combine the high yield potential and good grain quality of wheat with the disease resistance and environmental tolerance of rye. During the last few decades, triticale has become a commercial crop grown in a variety of environmental conditions worldwide. Triticale was traditionally used as component of animal feed, but also in the production of renewable energy and very little in food sector (Pena, 2004; Mergoum et al., 2009). Considering its valuable grain composition, this cereal should receive more attention as an alternative source of nutrients and health-protective components in the human diet. Triticale grain is a comparable to wheat protein (11.4–14%) source, with a slightly higher amount of lysine (0.33–0.71%), which is the first limiting amino acid in cereals (Heger and Eggum, 1991). Its dietary fibre content is similar to wheat, but with a higher amount of soluble fraction, especially water-extractable arabinoxylans (WE-AX), which display viscous properties in an aqueous solution (Rakha et al., 2011). Triticale also has many phenolics with antioxidant activity, alkylresorcinols, phytoestrogens, vitamins and microelements (Jonnala et al., 2010). The utilization of triticale in the baking industry is hindered by the high alpha-amylase activity and weak rheological properties of dough due to low gluten content and its poorer quality in comparison to wheat. Triticale gluten is hard to wash, less flexible and harder than wheat gluten (Pena, 2004; Martinek et al., 2008). In spite of its unfavourable bread making but high functional properties, many attempts have been made to promote triticale for baking bread. It was shown that blending triticale flour (up to 50–70%) with wheat flour produced bread with a quality similar to that made from wheat flour only (Pena, 2004; Tohver et al., 2005).

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Some triticale varieties offer acceptable flour quality, giving bread good aroma and taste. The aim of this study was to determine the differences in the chemical composition of triticale varieties, currently approved for cultivation in the European Union, and indicate the variability of nutrients and bioactive components between grain, flour and bread.

2. Materials and methods

2.1. Materials

Eight Polish winter hexaploid triticale varieties (Alekto, Atletico, Elpaso, Fredro, Pizarro, Preludio, Subito, Trapero) were grown in Choryń and obtained from Danko Plant Breeders Ltd, Co., and one variety (Panteon) was grown in Borowo and was kindly donated by the Plant Breeding Strzelce Ltd, Co. (both from Poland). One reference winter wheat variety (Tonacja) was grown and kindly obtained from the Plant Breeding Smolice Ltd., Co. (Poland). All samples were harvested in 2013.

2.2. Sample preparation

All triticale and wheat grain samples were ground prior to chemical analysis in the Perten Laboratory Mill 3100 (Hagersten, Sweden) to yield whole meal passing through a 0.5 mm sieve. To produce flour the triticale and wheat grain was conditioned to 14% moisture content and ground on the Brabender Quadrumat Senior Laboratory Mill (Duisburg, Germany). Breads for analysis were baked in duplicate, according to ICC Standard procedure no 131 (ICC Standards Method, 2005) and were made of 100 g of flour with 1.5% of salt and 3% of yeast. Next, all breads were freeze-dried in the Alpha 1–4 LD plus Martin Christ lyophilizer (Osterore am Harz, Germany) and ground in the Perten Laboratory Mill 3100 (Hagersten, Sweden) with a sieve diameter of 0.5 mm. All grain, flour and bread samples were stored in the fridge, in sealed plastic cups until analysis.

2.3. Analytical methods

Moisture content was determined gravimetrically according to AACC method 44-15A (AACC, 2003).

Crude protein content was analysed using the Dumas method in the Rapid N Cube apparatus (Elementar, Germany) according to AOAC method 990.03 (AOAC, 1995), using N x 6.25 as a conversion factor.

Ash quantification was performed gravimetrically, by sample incineration in a muffle furnace for 5 h at 550 °C according to AOAC method 923.03 (AOAC, 1995).

Total lipids content was assessed gravimetrically by extraction with acid solvent consisting of 60:40:1 (v/v/v) chloroform, methanol and concentrated hydrochloric acid, as described by Marchello et al., 1971.

Available starch was measured with the Megazyme procedure (Bray, Ireland), consistent with AACC approved method 76-13 (AACC, 2003).

Dietary fibre (DF) content was determined using the enzymatic-chemical method in accordance with AACC 32-25 and AOAC 994.13 procedures as a sum of non-starch polysaccharides (NSP), lignin and associated polyphenols (AACC, 2003; AOAC, 1995).

NSP content with its fractionation to soluble (S-NSP) and insoluble (I-NSP) fraction was determined using gas chromatography (GC) as previously described by Englyst and Cummings (1984). In this procedure, the NSP of each fraction is a sum of individual monomers: arabinose, xylose, mannose, galactose and glucose. After enzymatic hydrolysis of starch, the samples were centrifuged and split into soluble (ethanol precipitates from supernatant) and insoluble (remaining pellet) fractions. Each of these fractions were hydrolysed with 1 M sulphuric acid (100 °C, 2 h) to monosaccharides and converted to volatile alditol acetates. The alditol acetates were separated on a capillary quartz column Rtx-225 (0.53 mm × 30 m) using the Clarus 500 gas chromatograph (Perkin Elmer) equipped with an autosampler, splitter injection port and flame ionization detector. The carrier gas was He. Separation was performed at 225 °C, injection and detection at 275 °C.

Lignin and other insoluble residues were determined gravimetrically as described by Theander and Westerlund (1986). The percentage content of lignin and associated polyphenols was calculated on the basis of the loss in weight by incinerating the dried insoluble material.

Viscosity of aqueous extracts (WEV) was analysed using a Brookefield model LVDV-II + Cone/Plate Digital Viscometer (Brookefield, Stoughton, MA) equipped with a 0.8° cone spindle according to Boros et al. (1993). Samples were 1:3 (w/w) extracted with deionized water for 60 min at 30 °C and the suspensions obtained were centrifuged (10000 rpm, 10min). The viscosity of supernatants was immediately determined at a shear rate of 225s and 30 °C. Results of the WEV were expressed in mPa.s.

Total phenolic content (TPC) was determined using the previously described Folin-Ciocalteu Reagent colorimetric method (Naczk et al., 1998). In the first step phenolics from the samples were extracted with 80% methanol, and after centrifugation with 70% acetone. Next, the extracts were reacted with Folin-Ciocalteu Reagent and neutralized with sodium carbonate. After 100 min, the absorbance of the resulting solution was measured at 750 nm. Gallic acid was used as the standard and TPC was expressed as mg GAE/100 g of the sample.

All chemical analyses were performed in duplicate and the results reported on dry weight basis [% of d.w.]. Mean values were accepted if the difference between duplicates was below 10%.

2.4. Statistical analysis

To study variability in the content of chemical components within grains, flours and breads of all tested varieties, a one-way fixed model of analysis of variance (ANOVA) and Tukey's contrast analyse were performed. To study differences in chemical composition between grain, flour and bread, a two-way fixed model of analysis of variance (two-way ANOVA), where varieties were treated as blocks, with Tukey's contrast analyse according to the Spjotvoll-Stoline method, were performed. The significance level was set to $p < 0.05$ to evaluate significant differences. Principal component analysis (PCA) was carried out to obtain an overview of correlations between triticale varieties and its particular components of grain, flour and bread. All statistical analyses were performed using Statistica 12 software (StatSoft, Inc., 2014).

3. Results and discussion

3.1. Grain

The results of chemical composition and variance analysis of triticale varieties are presented in Table 1. For comparison purposes, the results of a standard winter wheat variety (Tonacja) are included. The major constituents of grain are starch and protein. The content of these components differed significantly between triticale varieties, ranging from 60.8% to 67.6% for starch and 11.8%–15.2% for protein, though low variability (coefficient of variation; CV = 3% and 8%, respectively) was observed in each component (Table 2). The highest amount of starch was found in Preludio, and the highest protein content in the Trapero variety. Similar content