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Effect of chestnut flour supplementation on physico-chemical properties and volatiles in bread making

Chiara Dall'Asta**, Martina Cirlini, Elisa Morini, Massimiliano Rinaldi, Tommaso Ganino, Emma Chiavaro*

Dipartimento di Scienze degli Alimenti, Università degli Studi di Parma, Parco Area delle Scienze 95/A, 43124 Parma, Italy

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ABSTRACT

In this study, wheat breads supplemented with different contents of chestnut flour (wheat/chestnut flour ratios: 100/0; 80/20; 50/50), were evaluated on the basis of physico-chemical properties (proximate composition, fatty acids, texture, colour, crumb grain, antioxidant capacity, volatile profile). Proximate composition, fatty acids, antioxidant capacity and volatiles for wheat and chestnut flours and their blends in the same proportion were also determined.

Antioxidant capacity increased with chestnut flour content in bread, and in accordance with flour values. A richer volatile profile was shown by bread supplemented with this type of flour as well as for flours. In particular, a marked increase was observed in furans, with their toasty and nutty notes, and phenolic compounds, with their woody and smoky notes.

A more heterogeneous crumb structure characterized 80/20 breads added of chestnut flour with larger and more asymmetrical cavities as compared to a finer and more homogeneous pore distribution of the other formulated breads. A lower volume, harder and darker crumb was also shown by bread formulated with 50/50 ratio of chestnut flour in comparison with the other formulations probably due to its higher fibre and sugar contents.

1. Introduction

Bread is one of the most popular and wide spread baked products in the world and its quality depends on several physical (*i.e.* texture, volume, colour) and organoleptic characteristics (*e.g.* volatiles), which could be influenced by many factors, such as flour type and other ingredients, bread-making procedure, fermentation, cooking time and temperature. In the recent years, bread showed an increasing attention as a potential functional food based on its great diffusion and consumption. Thus, industries and researchers are involved in optimizing bread-making technology to improve the variety, quality, taste and availability of active compounds, adding such components with nutritional and functional properties (Balestra, Cocci, Pinnavaia, & Romani, 2011; Pasqualone et al., 2011) with the final aim to formulate a product with physiological effectiveness encountering consumers' acceptance in terms of appearance, taste and texture (Siró, Kápolna, Kápolna, & Lugasi, 2008). In this context, the utilization of flours derived from minor cereals, pseudocereals, and other non-traditional crops that could be included in bread formulation to obtain a healthier product with excellent sensorial properties was recently explored in the literature (Angioloni & Collar, 2012; de Escalada Pla, Rojas, & Gerschenson, 2013) and also reviewed (Sivam, Sun-Waterhouse, Quek, & Perera, 2010).

Among these flours, the use of chestnut flours was recently evaluated in terms of rheological properties of dough to establish the effect derived by additives and processing procedures (Moreira, Chenlo, & Torres, 2011; Moreira, Chenlo, Torres, & Prieto, 2010). In particular, chestnut flour dough performances were compared with those obtained in gluten and gluten free flour dough, pointing out that chestnut-based products could probably present problems of staling and crumbs firmness (Moreira, Chenlo, Torres, & Prieto, 2012). Chestnut flour utilization was also recently proposed for the production of gluten-free bread. Encouraging results were achieved if moderate levels of chestnut flour were added to rice flours (Demirkesen, Mert, Sumnu, & Sahin, 2010) also optimising content of emulsifier and baking conditions (Demirkesen, Sumnu, Sahin, & Uysal, 2011), while high level led to some deterioration in quality parameters (lower volume, harder texture and darker colour).

Chestnut fruits have a long history of reported health effects related to their composition (excellent energy source due to its high starch content), to the presence of nutritional effective compounds

* Corresponding author. Tel.: +39 0521 905888; fax: +39 0521 906028.
** Corresponding author. Tel.: +39 0521 905431; fax: +39 0521 905472.
E-mail addresses: chiara.dallasta@unipr.it (C. Dall'Asta), emma.chiavaro@unipr.it (E. Chiavaro).

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such as omega-3 fatty acids, vitamins E and C (De Vasconcelos, Bennet, Rosa, & Ferreira-Cardoso, 2010) and to the richness in antioxidant compounds as simple phenolics and more complex tannins (De Vasconcelos et al., 2010). Chestnuts represent a traditional product of European mountain areas from Italy, Spain, Portugal and France, where it has been considered in the past centuries as a staple food thanks to its dietary characteristics and quality. The Italian production of chestnut fruit was the first among European countries in 2010, with a value equal to 53,577 tons (FAO 2010), reaching also very good qualitative standards. Italian chestnut flour generally presents high-quality proteins with essential amino acids (~5.8%), low amount of fat (~3.7%), relatively high amount of dietary fibre (~10.8%) (IEO, 2012) and a rich volatile profile, recently characterised by Cirlini et al. (2012). It is traditionally employed for the production of typical bakery products such as bread and cakes.

Although its use is regaining interest among consumers due to its nutritional qualities and potential health benefits, to the authors' best knowledge, the evaluation of its performance in bread making in association with wheat flour is little or not explored in literature, yet. Thus, starting from flour composition, the scope of this work is to establish the feasibility of manufacturing bread supplemented with different contents of chestnut flour obtained from some Italian traditional cultivars from Parma province (located in Emilia Romagna Region). The influence of chestnut flour supplementation on physico-chemical properties (*i.e.* texture, colour, crumb grain characteristic, antioxidant capacity, and volatile profile) was thus evaluated with the final aim of valorising the traditional production chain.

2. Materials and methods

2.1. Chemical materials

Hexane, methanol, DPPH (2,2-diphenyl-1-pirylhydrazyl free radical) and Trolox ((±)-6-hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid) were purchased from Sigma–Aldrich (St. Louis, USA), while potassium hydroxide was purchased from Carlo Erba Reagents (Milano, Italy).

2.2. Flour and bread formulation and making

Chestnut flour was obtained by mixing, with the same percentage, five cultivars (*Ampollana*, *Leccardina*, *Mondadì*, *Perticaccia* and *Luetta*) from Ceno valley (Parma, Italy). Flours were prepared starting from milled fruits dried at constant temperature (40 °C) for 30 days in a traditional drying kiln called "metato" and peeled (Cirlini et al., 2012). On the other hand, soft wheat flour type "0", as legally defined in the Italian Government Official Bulletin (2001), was purchased in a local market from a single lot.

Three types of bread samples were prepared in this study on the basis of different soft wheat/chestnut flour ratios: soft wheat 100 g/100 g (SW_{100}); chestnut 20 g/100 g of soft wheat flour replacement (SW_{80}/ChN_{20}); chestnut 50 g/100 g of soft wheat flour replacement (SW_{50}/ChN_{50}). The names reported into brackets will be used to refer to the different samples throughout the text.

Bread samples were all produced using the following formulation expressed on a flour basis: flour (100 g), water (67 g/100 g of flour), sugar (7 g/100 g of flour), yeast (3.8 g/100 g of flour), sunflower oil (6.5 g/100 g of flour) and salt (2 g/100 g of flour), by means of a home bread-maker (Severin BM3986, Sundern, Germany). The following programme was employed: pre-heating, 22 min, 30 °C; stirring, 3 min; kneading, 18 min, 35 °C; rising, 45 min, 45 °C; smoothing, 1 min; rising, 25 min, 40 °C; smoothing, 1 min; rising, 50 min, 40 °C; baking, 65 min, 210 °C). Bread loaves were allowed to cool at room temperature for 2 h prior to analysis. Four loaves were produced for each bread-type.

2.3. Chemical analysis on flour and bread

2.3.1. Proximate composition

The moisture content of flours and breads was measured in triplicate according to AACC Approved Methods 44-15A (AACC, 2000). Protein content was determined both on flour and bread samples by Kjeldhal method: 1 g of ground sample was digested by DKL fully automatic digestion unit and distilled with UDK 139 semi-automatic distillation unit (Velp Scientifica, Monza-Brianza, Italy). Nitrogen value derived from titration was multiplied for the correction factor of 5.7, typical of flour mixtures (Mccarthy & Meredith, 1988). The same factor was used for bread samples.

Fat content was determined both on flour and bread samples utilizing a Soxhlet extractor (Velp Scientifica, Monza-Brianza, Italy). In particular, 5 g of ground samples were extracted using diethyl ether as solvent. Fatty acid profile was obtained by GC–MS analysis, after transesterification with a KOH/CH_3OH 5 mL/100 mL solution, as already reported by Dall'Asta, Falavigna, Galaverna, and Battilani (2012). Fatty acids were also reported according to their unsaturation degree, as saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids. One sample from each loaf for each bread type was analysed ($n = 4$) and each analysis was replicated twice.

2.3.2. DPPH free radical scavenging activity test

Flour extracts were prepared starting from 0.1 g of flour, added with 5 mL of a methanol/water (70:30 v/v) mixture, extracted on a stirrer at room temperature for 1 h and then filtered on paper filter. The extract was evaporated and dissolved with 1 mL of a methanol/water (70:30 v/v) mixture. For bread analysis, 5 g of sample were added with 100 mL of a methanol/water (70:30 v/v) mixture, homogenized with a blender, extracted on a stirrer at room temperature for 1 h and then filtered on paper filter. The extract was evaporate, dissolved with 2 mL of a methanol/water (70:30 v/v) mixture and centrifuged at 5040× *g* for 15 min at 4 °C.

Analyses were performed in triplicate on 200 μL of extract, mixed with 2.6 mL of methanol and 2 mL of DPPH. The absorbance of the solution was recorded at 517 nm by a Perkin Elmer UV–Visible spectrophotometer after an incubation time of 30 min at room temperature. Blank was prepared and analysed following the same procedure.

The radical scavenging activity was calculated as follows: $I\% = [(Abs_0 - Abs_1)/Abs_0]^*100$, were Abs_0 was the absorbance of the blank and Abs_1 was the absorbance of the sample. TEAC value (Trolox Equivalent Antioxidant Capacity; μmol Trolox eq./g of d.w) of samples was obtained from the calibration curve calculated measuring the absorbance at 517 nm of Trolox methanolic solutions at different concentrations. One sample from each loaf for each bread type was analysed ($n = 4$) and each analysis was replicated three times.

2.3.3. Volatile compound analysis

The volatile fractions of flour and bread samples were analysed using solid phase microextraction technique (HS-SPME) coupled with GC/MS. For each SPME analysis, 3 g of flour or 2 g of bread were placed in a 30 mL glass vial, adding 200 μL of a toluene aqueous solution (250 ml/L), in according with method utilized by Cirlini et al. (2012). Identification of volatiles was obtained both by comparing mass spectra recorded with library mass spectra (NBS75K, WILEY275) and by Kovats Indices calculation. One sample from each loaf for each bread type was analysed ($n = 4$) and each analysis was replicated three times.