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Carotenoids evolution during pasta, bread and water biscuit preparation from wheat flours

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ABSTRACT

The loss of carotenoids content during food processing was investigated during the production of bread, water biscuits and pasta from refined flours of einkorn, bread and, for pasta only, durum wheat semolina.

Total carotenoids content decreased throughout the processing stages. For bread and water biscuits, kneading led to limited degradation (on average, 15% and 12%, respectively), bread leavening had almost negligible effects (3%), while baking had a marked influence on carotenoids loss in bread crust and water biscuits (29% and 19%, respectively) but not in bread crumb (3%). In contrast, in pasta the longer kneading-extrusion phase determined relevant losses (48%), while the drying step did not induce significant changes. During kneading, *Triticum monococcum* consistently showed lesser percentage degradation, probably because of the lower lipoxygenase activity of its flour. Overall, manufacturing led to average carotenoid losses of 21%, 47%, 31% and 49% for bread crumb, bread crust, water biscuits and pasta, respectively. Notwithstanding the significant decrease, einkorn still supplied considerably more carotenoids than durum and bread wheats in the end products, characterised by an attractive deep yellow colour.

1. Introduction

Antioxidants consumption helps in the protection against age-related health risks associated with oxidative stress (Adom, Sorrells, & Liu, 2003). Wheat, a major component of the human diet, is a source of lipophilic antioxidants, such as carotenoids and tocols, that inhibit lipid peroxidation of polyunsaturated fatty acids (PUFA) in cell membranes and thus play a vital role in delaying several degenerative diseases (Krinsky, 1994; Van den Berg et al., 2000). Although carotenoids (mainly lutein) are scarce in bread wheat (*Triticum aestivum* L. subsp. *aestivum*), where they range from 0.1 to 2.5 mg/kg dm, they are more abundant in durum wheat (*Triticum turgidum* L. subsp. *durum*), where they span from 1.5 to 4.8 mg/kg dm (Hidalgo, Brandolini, Pompei, & Piscozzi, 2006; Panfili, Fratianni, & Irano, 2004). The highest carotenoid content among cultivated wheats, nevertheless, is found in einkorn (*T. monococcum* L. subsp. *monococcum*), which has an average content of 8.5 mg/kg dm and a variation between 5.3 and 13.6 mg/kg dm (Abdel-Aal et al., 2002; Brandolini, Hidalgo, & Moscaritolo, 2008; Hidalgo et al., 2006).

By and large, wheat is processed into white flour (bread wheat) or semolina (durum wheat), for the preparation of bread, oven products, and pasta. The broad diffusion of these foods makes wheat, and particularly yellow durum wheat used in pasta-making, a significant carotenoid contributor to the human diet. Even small changes in the relative content of this compound may thus have a relevant impact on population health.

The inherent carotenoid content of the seeds is mainly linked to wheat species and variety (Hidalgo et al., 2006); relevant pigment losses occur during milling (Hidalgo & Brandolini, 2008a; Leenhardt et al., 2006a) and storage (Hidalgo & Brandolini, 2008b), but enzymatic activity and processing conditions still exert a major influence on carotenoids preservation down to the end products. As a result of their antioxidant activity, the carotenoids are easily degraded by oxygen, with a strong influence of heat, light end exposure to hydroperoxides (Leenhardt et al., 2006a). During processing, naturally occurring enzymes (mainly lipoxygenase) catalyse the hydroperoxidation of polyunsaturated fatty acids, such as linoleic acid, producing conjugate hydroperoxides; radicals from the intermediate steps of this reaction are responsible for oxidative degradation of carotenoids (Gardner, 1988).

A better understanding of the critical steps in food processing, and of their effect on different wheat species, will help to limit carotenoid degradation during manufacturing, thus leading to products with improved nutritional properties. Aim of this research was therefore to evaluate the evolution of carotenoids during the production of bread, water biscuits and pasta prepared

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from refined flour of einkorn, bread and, for pasta only, durum wheat semolina.

2. Materials and methods

2.1. Samples

Kernels of einkorns Monlis and ID331, and of bread wheat Blasco to be used for bread and water biscuit preparation were harvested from 10 m^2 plots with three replications and stored at 5 °C until utilization. Kernels of Monlis and Blasco for the pasta trials came from a 200 m^2 unreplicated plot and were stored at room temperature until processing. All the accessions were cropped in 2006–07 at Sant'Angelo Lodigiano (Po plain, Italy), following standard cultural practices (Castagna, Borghi, Di Fonzo, Heun, & Salamini, 1995). Pasta was also produced from commercial durum wheat semolina (Molino Grassi, Parma, Italy).

Before milling, the seeds of Monlis and ID331 were de-hulled with an Otake FC4S thresher (Satake, Japan); dehulling was not necessary for the free-threshing bread wheat Blasco. After overnight tempering at 15% moisture, the samples were milled with a Bona 4RB (Bona, Italy) experimental mill.

2.2. Bread preparation

Four bread loaves per accession, each from 100 g of Monlis, ID331 or Blasco flour, were produced according to AACC method 10-10B (AACC, 1995), but excluding ingredients such as shortening and ascorbic acid, in order to avoid any interferences with the lipophilic oxidation mechanism. Baking was performed at 215 °C for 25 min. For analytical determinations, samples of flour, mix (just made dough), leavened dough (immediately before baking), as well as bread crumb and crust were collected and stored at −20 °C until analysis.

2.3. Water biscuits preparation

Four water biscuits from Monlis, ID331 or Blasco flour, were manufactured according to AACC method 10-52 (AACC, 1995) but without shortening and nonfat dry milk, to avoid interferences with the lipophilic oxidation mechanism; baking was carried out at 205 °C for 25 min. For analytical determinations, samples of flour, mix (just made dough) and baked water biscuits were collected and stored at −20 °C until analysis.

2.4. Pasta preparation

About 2 kg of durum wheat semolina, as well as Monlis and Blasco flours were processed into short-cut pasta (maccheroni), extruded at 8000 kPa, 40 °C, no vacuum with a P630VR lab pasta maker (Parmasel, Parma, Italy) (coded as L). About 15 kg of durum wheat semolina and Monlis were also processed into short-cut pasta (maccheroni), extruded at 10,000 kPa (11,000 for the semolina pasta), 40 °C and vacuum 100 kPa with a Zambra continuous industrial-scale vacuum pasta extruder (Braibanti, Padova, Italy) (coded as Z). Dough mixing lasted, in both cases, seven minutes; pre-extrusion moisture of the doughs was 30% (33% when semolina was used); extrusion lasted ca. 5 min in the lab plant and ca. 10 min in the industrial plant. Pasta drying was carried out at low temperature (pre-heating: 50 °C; peak temperature: 65 °C) over 17 h in a dark drying cabinet (Braibanti, Padova, Italy), at a constant 75% relative humidity.

For analytical determinations, samples of flour, mix (just made dough), extruded and dried pasta were collected and stored at −20 °C until analysis.

2.5. Analytical methods

Deep-frozen doughs and final products were ground with a Commercial Heavy-Duty Blender (Waring, Torrington, USA) just before analysis. Dry matter was determined following method 44-15 (AACC, 1995). Carotenoids quantification was performed by normal phase HPLC, following Panfili et al. (2004): 2 g of flour, bread, biscuits or pasta products were exactly weighted in a screw-capped tube and saponified under nitrogen for 45 min at 70 °C, with the addition of 5 ml of ethanolic pyrogallol (60 g/l) as antioxidant, 2 ml of ethanol (95%), 2 ml of sodium chloride (10 g/l) and 2 ml of potassium hydroxide (600 g/l). During the saponification, the tubes were vortexed every 5–10 min. Afterwards, they were cooled in an ice bath and 15 ml of sodium chloride (10 g/l) were added. The suspension was then extracted twice with 15 ml of hexane:ethyl acetate (9:1 v/v). The organic layer was collected and evaporated under vacuum, followed by nitrogen drying; the residue was dissolved in 2 ml hexane:isopropyl alcohol (90:10 v/

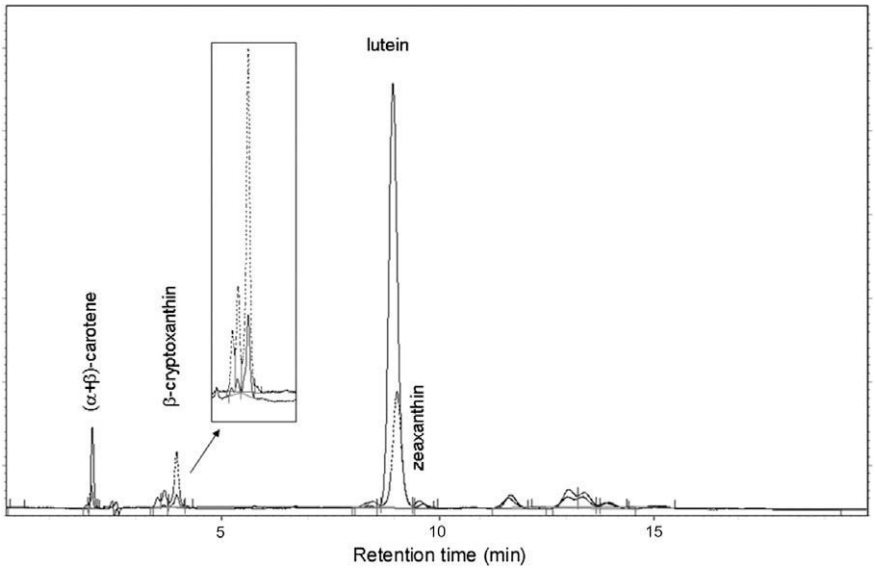

Fig. 1. Chromatogram of einkorn wheat flour (continuous line) and bread crust (dotted line).