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Assessing the effect of traditional hulled wheat processing on bioactive compounds retention

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ABSTRACT

Glume removal is the preliminary operation to make hulled wheats suitable to human consumption. Traditionally glumes are separated from kernels by means of stone mills, simultaneously causing kernel crushing, a loss of kernel parts and associated phytochemicals. The aim of this study was to compare bioactive compound retention of hulled wheat products obtained by traditional processing still used in Turkey and Armenia, with a more update plant located in Italy.

On-plant samplings were carried out in two einkorn wheat bulgur processing plants in Turkey, and one emmer wheat processing plant, in Armenia and Italy. Whole and crushed kernels sampled at different processing stages were analysed for their phytochemical compound content. For the Italian plant, also the pearling process was considered.

Whole kernels showed higher contents of lipid and phytochemical compounds than the correspondent processed fractions, with special respect for tocopherols and phytosterols. Carotenoid content was mainly affected by genotype.

Pearling had a lower effect on the content of phytochemicals; however the correspondent waste fraction showed very high amounts of lipids and other compounds.

All the plants showed similar retention of phytochemicals upon processing, with higher losses occurring in smaller kernel crushed fractions, mainly because of the loss of the germ.

1. Introduction

Einkorn and emmer wheat are hulled wheat species grown as traditional crops in several south European countries, which uses have been recently the subject of cross-country, comparative investigation within the BaSeFood programme (D'Antuono, 2013; Giambanelli et al., 2013b).

Glume removal is the necessary preliminary operation to make hulled wheat grain suitable to human consumption. The historical and traditional ways to carry out this operation have been described for various areas (D'Antuono and Bravi, 1996; Giuliani et al., 2009; Peña-Chocarro, 1996). Basically, the lack of technologies allowing an easy separation of the glumes from kernels, largely determined the kind of edible product obtained. In fact, whole spikelets are traditionally crushed by means of stone mills: this operation removes the glumes, but also simultaneously breaking the kernels in pieces of different size, that are subsequently sorted by sieving.

Teguments and embryo parts may represent an important source of phytochemicals. The nature and content of specific cereal bioactive compounds, and their putative health benefits have been the subject of numerous periodic reviews (Andersson et al., 2014; Liu, 2007; Ward et al., 2008). Bioactive compounds are variously located in the caryopsis and the operations of glume removal and crushing could differently affect the content of bioactive compounds, as a consequence of their distribution in the kernel fractions. The only references giving an indication about bioactive compounds distribution in kernel fractions are the ones dealing with the milling of other cereals, where it clearly appears that the distribution of kernel phytochemicals depends on the parts in which they are mainly contained: embryo residues are rich of sterols and tocols, bran of phenolics and tocols (Ko et al., 2003; Lampi et al., 2004; Steadman et al., 2001).

However specific experiments on hulled grains have been carried out about the effect of glume removal and crushing, with

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different purposes, mainly addressed at the evaluation of milling equipment and mechanical properties (Unal and Sacilik, 2009; Unal, 2009).

Process efficiency and yield factors of hulled wheats traditional processing during glume removal and kernel breaking have been described in a previous work (Giambanelli et al., 2013a). The present study was aimed at investigating the fate of phytochemical compounds associated to the kernel parts generated by the typical hulled wheat processing. Preprocessed einkorn and unprocessed emmer wheats, directly sampled at local plants, were analysed for their content of tocols, carotenoids, phytosterols, and phenolics after husk removal and grain crushing, the main unit operation performed during kernel processing. In particular, husk removal and grain crushing were selected as the main unit operation to be considered for the comparison of local processing outputs from Turkey, Armenia and Italy. In case of the Italian plant, also the pearling process was taken into account.

2. Materials and methods

2.1. Materials

The fractions resulting from glume removal and kernel crushing were directly sampled on-place from traditional plants in Italy, Turkey (two plants) and Armenia. In the Italian plant also the fractions from pearling process were sampled and analysed. The complete list of the samples is reported in Table 1; the processing flow charts and the resulting process fractions have been described in a previous study (Giambanelli et al., 2013a). Briefly TR1BL, TR2BL, ITF1, and ARF5 represented the input material, represented by whole kernels still with glumes: einkorn wheat bulgur, in Turkey, and raw emmer wheat spikelets, in Armenia and Italy. During processing, the following outputs were sampled:

- in plant 1 from Turkey einkorn wheat spikelets (TR1BL) were crushed by means of a stone mill and the following products were obtained: TR1F4: coarse groats and unbroken kernels; TR1F5: medium-size groats; TR1F6: smaller groats; these fractions remained above one of the three sieve series used in processing; TR1F8: semolina-like material, passing through the third mechanical sieve and remaining above the last manual sieve;
- in plant 2 from Turkey einkorn wheat spikelets (TR2BL) were crushed by means of a stone mill and the following products were obtained: TR2F4-F5: larger or medium size groats + unbroken kernels; TR2F6: smaller groats; TR2F8: semolina-like material, respectively, remaining above one of the four manual sieves;
- in the Armenian plant emmer wheat spikelets (ARF5) were crushed by means of stone mills and the following products were obtained: ARF6: whole dehulled kernels; ARF7: coarse groats; ARF8: fine groats;
- in the Italian plant, emmer wheat spikelets (ITF1) were firstly fed into a dehulling equipment to remove glumes, and the resulting material was sorted by sieving, to yield the following fractions: ITF2 and ITF4, respectively, smaller and larger whole kernels, destined to crushing, and ITF3, medium-size whole kernels, destined to pearling. In the Italian plant crushing was carried out in a second phase by means of hammer mills and yielded: ITF7: fine groats (farricello), and ITSP, a waste consisting of finer material. Pearling used abrasive discs to partially remove the pericarp, yielding: ITF6: pearled kernels, ITF5: kernels broken during the pearling process and destined to crushing, and ITPR: a waste, exclusively composed of bran.

2.2. Chemicals

All chemicals and solvents were of analytical grade, purchased from Sigma-Aldrich (St. Louis, MO, USA). Deionised water was obtained by an Elix 10 water purification system from Millipore (Bedford, MA, USA). Solvents employed in high performance liquid

Table 1
List of the samples considered during on-plant collection and analytically characterized. • Input materials (whole kernels).

Tag	Fraction description
Turkey (TR1)	
•TR1BL	Manually dehulled whole kernels from cooked spikelets
TR1F4	Keşkeklık, almost not broken kernels remaining above the 1st sieve
TR1F5	Pilavlık, coarse groats remaining above the 2nd sieve
TR1F6	Çorbalık, fine groats remaining above the 3rd sieve
TR1F8	Kısırlık, semolina-like material recovered by the last manual sieving
Turkey (TR2)	
•TR2BL	Manually dehulled whole kernels from cooked spikelets
TR2F4-F5	Keşkeklık, almost not broken kernels above the 1st sieve + pilavlık, coarse groats remaining above the 2nd sieve
TR2F6	Çorbalık, fine groats remaining above the 3rd sieve
TR2F8	Kısırlık, semolina-like recovered by the last manual sieving
Armenia (AR)	
•ARF5	Manually dehulled whole kernels
•ARF6	Whole de-hulled kernels
ARF7	Coarse groats, for human consumption
ARF8	Fine groats and semolina like fraction, mainly for animal feed
Italy (IT)	
•ITF1	Manually dehulled whole kernels
•ITF2	Small or broken grains, for crushing
•ITF3	Medium-size whole grains, for pearling
•ITF4	Large grains, to be used as such, or for crushing
ITF5	Broken kernels from pearling, for crushing
ITF6	Pearled output, for packaging
ITF7	Medium-size groats (farricello), for packaging
ITSP	Waste, from crushing
ITPR	Waste, from pearling