Journal of Functional Foods 17 (2015) 83–92

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/jff

Effects of durum wheat debranning on total antioxidant capacity and on content and profile of phenolic acids

Daniela Martini [a,b], *Maria Grazia D'Egidio* [a], *Isabella Nicoletti* [c], *Danilo Corradini* [c], *Federica Taddei* [a,*]

[a] *Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CRA-Unità di Ricerca per la Valorizzazione Qualitativa dei Cereali), Via Cassia 176, 00191 Roma, Italy*

[b] *Università Campus Bio-Medico, Via Alvaro del Portillo 21, 00128 Roma, Italy*

[c] *CNR–Istituto di Metodologie Chimiche (IMC), Area della Ricerca di Roma 1, Via Salaria km 29.300, 00015 Monterotondo, Roma, Italy*

ARTICLE INFO

Article history:
Received 16 December 2014
Received in revised form 23 April 2015
Accepted 28 April 2015
Available online

Keywords:
Durum wheat
Debranning process
Bran fractions
Debranned kernels
Phenolic acids
Total antioxidant capacity

ABSTRACT

Durum wheat was debranned by a twelve-step sequential process, which was evaluated by monitoring the total antioxidant capacity (TAC) and the content of free, conjugated and bound phenolic acids (PAs), in both bran fractions (BF) and resulting kernels (DK). The debranning process was shown to affect the content of PAs, to a different extent depending on the PA form, but not the percentage distribution of individual PAs whereas TAC was mostly affected in the BF and less in the DK. Interestingly, PA content and TAC were significantly higher than those of semolina, wholemeal and even coarse bran produced by the same durum wheat used in the study. These results suggest that the debranning process is a valuable way for reaching the optimal debranning level useful to obtain selected fractions, to be used as functional ingredients, and debranned kernels to be whole milled for the production of less refined foods.

1. Introduction

Whole grain (WG) cereals are well known to be rich in bioactive compounds which are mainly concentrated in the outer layers of kernels, such as aleurone, testa and pericarp (Fardet, 2010). Bioactives include fibre but also molecules with antioxidant activity like carotenoids, tocopherols, and phenolic compounds (Hall & Zhao, 2011; Luthria, Lu, & John, 2015; Yu, 2007) among which most of all phenolic acids (PAs) (Chandrasekara & Shahidi, 2011; Das & Singh, 2015). These compounds are plausibly responsible for the inverse association between

* *Corresponding author*. Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CRA-Unità di Ricerca per la Valorizzazione Qualitativa dei Cereali), Via Cassia 176, 00191 Roma, Italy. Tel.: +39 06 3295705; fax: +39 06 36306022.
E-mail address: federica.taddei@entecra.it (F. Taddei).

Chemical compounds: Ferulic acid (PubChem CID: 445858); Vanillic acid (PubChem CID: 8468); Sinapic acid (PubChem CID: 637775); *p*-Coumaric acid (PubChem CID: 637542); Syringic acid (PubChem CID: 10742); *p*-Hydroxybenzoic acid (PubChem CID:135).

http://dx.doi.org/10.1016/j.jff.2015.04.054
1756-4646/

consumption of WGs and risk of chronic diseases such as cardiovascular diseases, diabetes and some types of cancer (Fardet, 2010; Jacobs, Marquart, Slavin, & Kushi, 1998; Patel, 2015; Shahidi & Chandrasekara, 2013; Slavin, 2004). However, the outer layers of grains also represent the portion where contaminants (e.g. pesticides, heavy metals, moulds and mycotoxins) are mainly accumulated, threatening the safety of cereals (Laca, Mousia, Diaz, Webb, & Pandiella, 2006; Sovrani et al., 2012; Visconti, Haidukowski, Pascale, & Silvestri, 2004). For this reason, whole grains and WG foods could potentially have higher levels of contaminants with respect to the refined products, in which these outer layers are traditionally removed (Cubadda, Raggi, Zanasi, & Carcea, 2003; Pascale et al., 2011). Moreover, WGs often appear less palatable than refined ones, so that sensory preferences of consumers are a barrier to a high consumption of WG foods (Bakke & Vickers, 2007; Kantor, Variyam, Allshouse, Putnam, & Lin, 2001). This low acceptance by consumers is likely due to the higher bran content in WGs than in refined foods, which affects their technological and sensory properties.

This consideration may partially justify why the real consumption is still lower than dietary recommendations, which generally suggest eating at least half of cereals as WGs, or more generally to substitute refined foods with the respective WG ones (INRAN, 2003; Nordic Council of Ministers, 2012; USDA, 2010).

Considering all the above listed benefits and risks concerning the WGs consumption, one of the main challenges for modern food technologies in the cereal field is trying to find innovative solutions for the production of cereal-based foods in which the positive effects of whole grains are preserved and, at the same time, the negative ones are limited as much as possible (Wang, He, & Chen, 2014).

In this context, among the modern cereal technologies, debranning process seems valuable to reach the objectives described above. This process is based on the removal of kernel layers through an abrasive scouring and has been initially used for processing hulled grains such as rice and barley. Recently it has also been applied to improve the safety and quality of wheat and wheat based foods (Cheli, Pinotti, Rosi, & Dell'Orto, 2013; Laca et al., 2006; Rìos, Pintos-Gadais, Abecassis, Zachia-Rozis, & Lullein-Perellin, 2009). Specifically for durum wheat, it has been found that the debranning process increases semolina yield, improves semolina quality, reduces the ash content and the contamination by mycotoxins, pesticides, and heavy metals (Bottega, Cecchini, D'Egidio, Marti, & Pagani, 2009; Ranieri, 2012).

The interest for this technology is evidenced by several studies dealing with the effects of debranning process on the technological and hygienic-sanitary quality of cereal-based foods, while limited investigations have been focused on nutritional and healthy aspects, such as the occurrence of antioxidant compounds. Furthermore, most of these studies have been performed on common wheat (Beta, Nam, Dexter, & Sapirstein, 2005; Fares, Platani, Baiano, & Menga, 2010; Liyana-Pathirana, Dexter, & Shahidi, 2006) which is worldwide one of the most cultivated cereals. On the other hand, only few studies have focused on durum wheat, which is mainly used in the Mediterranean area (Esposito et al., 2005; Žilić, Serpen, Akıllıoğl, Janković, & Gökmen, 2012).

Emerging orientation on the consumption of WG foods for their beneficial effects on human health opens the possibility of applying the debranning process to enhance the content of bioactive compounds which are mostly localized in the outer layers of kernels, while improving the hygienic-sanitary quality. Additional advantages of the debranning process include the possibility of collecting by-products (fractions) with selected content of bioactive compounds and limited or absent content of contaminants, which expands their use in the production of food supplements (Blandino et al., 2013; Luthria & Liu, 2013).

To the best of our knowledge, no studies have so far evaluated the possibility of applying this process to durum wheat in producing debranned kernels with higher content of bioactive compounds preserving the technological properties. Accordingly, the aim of the present study was to evaluate the debranning process, applied to durum wheat, by monitoring the content of phenolic acids (occurring as free, conjugated and bound compounds) and total antioxidant capacity in both the bran fractions and the debranned kernels. Phenolic acids were considered because they are the predominant phenolic compounds in cereals, representing one of the most common class of antioxidants (Luthria et al., 2015) and are mainly concentrated in the outermost layers of the wheat grains, which are progressively removed by the debranning process. Therefore, their abundance in the bran fractions, in combination with the total antioxidant capacity and content of total starch, was investigated in order to evaluate the optimal debranning level producing kernels and fractions rich in antioxidant compounds with potential use as ingredients for the production of dietary supplements and functional foods. The experimental work was conducted by subjecting an Italian durum wheat genotype to a debranning process consisting of twelve sequential debranning steps, which produced separated bran fractions and debranned kernels that were analyzed for the abundance of individual free, conjugated and bound phenolic acids, the level of antioxidant activity and the content of total starch.

2. Materials and methods

2.1. *Samples and debranning process*

To evaluate the effects of debranning process, an Italian durum wheat (*Triticum turgidum* L. var. *durum*) cultivar (Duilio), grown in an experimental field located in Montelibretti (Rome, Italy) during 2010/11 crop year, was used. Plants were grown in randomized blocks with three replications and standard cropping practices were applied to provide adequate nutrition; the elementary plot of 10 m^2 consisted of eight rows, 17 cm apart, sown with 350 germinating kernels/m^2 (Quaranta et al., 2010). The harvested grains were characterized by 12.1% protein content and 60.98 g thousand kernel weight.

The grains, after cleaning, were firstly hydrated with 3% (v/w) water for 15 min, to make the tegumental layers less crumbly, so allowing a more regular and homogeneous removal and reducing kernel breakage (Bottega, Caramanico et al., 2009). Grains were then debranned by a laboratory debranning machine equipped with an abrasive stone element SB-SA (Costruzioni Meccaniche Colombini Sergio and C., Abbiategrasso, Milan, Italy).