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RESEARCH ARTICLE

Diversity of Antioxidant Content and Its Relationship to Grain Color and Morphological Characteristics in Winter Wheat Grains

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Abstract

The current interest in the health benefits of whole wheat grain has prompted breeders to further increase the concentration of antioxidants in wheat. The objective of this study was to investigate the variation in antioxidant content among Chinese wheat grains and the relationship between antioxidants and grain color and morphological characteristics. A wide variation was observed in the total phenolic, carotenoid and flavonoid contents, as well as the antioxidant activity (AOA), of Chinese wheat varieties. Black wheat had the highest mean total phenolic, carotenoid and flavonoid contents and the highest AOA, followed by red and white wheats. The grain color parameters were significantly negatively correlated with total phenolic, carotenoid and flavonoid contents and AOA among all of the wheat varieties examined, and grain weight was also significantly negatively correlated with these traits. The same correlation between grain weight and antioxidant traits was also observed within individual groups of wheat, which indicates that grain weight may be used as an index for selecting wheat varieties with high AOA. Landraces had significantly higher flavonoid content than commercial wheat varieties. The results of this study may be useful for breeding nutrient-rich wheat varieties.

Key words: wheat, total phenolic content, antioxidant activity, flavonoid, carotenoid

INTRODUCTION

Wheat (*Triticum aestivum* L.) is among the most extensively cultivated crops worldwide and is a staple food consumed by one-third of the world's population. Wheat not only provides humans with basic nutrients (carbohydrates, proteins, vitamins), but also contains significant levels of biologically active dietary substances, such as carotenoids, flavonoids and phenolic acids (Zielinski and Kozlowska 2000; Adom *et al*. 2005). Epidemiological studies have shown that the regular intake of these phytochemicals is associated with lower risks of cancer (Arts and Hollman 2005), cardiovascular disease (Mellen *et al*. 2008) and type 2 diabetes (Lutsey *et al*. 2007). Phenolics are compounds that possess one or more aromatic rings with one or more hydroxyl groups (Liu 2007). Major phenolics in wheat bran extracts include ferulic, vanillic and *p*-coumaric acid, along with other free phenolics such as caffeic, chlorogenic, gentisic, syringic, and *p*-hydroxybenzoic acid (Onyeneho and Hettiarachchy 1992). The regular consumption of phenolic compounds can reduce the risk of cardiovascular disease and certain cancers (Kris-Etherton *et al*. 2002; Arts and Hollman 2005). Flavonoids are a group of phenolics that consist of two aromatic rings linked by three carbons (Liu 2004). The regular consumption of flavonoids in diets may prevent the development of disease or reduce the impact of oxidative stress when disease occurs (Moskaug

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et al. 2005). Carotenoids, including lutein, zeaxanthin and β-crypoxanthin, can prevent ocular damage, as these compounds can absorb damaging blue light that enters the eye (Johnson 2002).

Recently, much attention has focused on natural food antioxidants. Adom and Liu (2002) compared the total phenolic content and total antioxidant activities of corn, oats and rice. The results showed that corn has the highest total phenolic content and total antioxidant activity, followed by wheat, oats and rice. Hernández *et al*. (2011) identified and quantified three hydroxybenzoic acids, six hydroxycinnamic acids, four ferulic acid derivatives, and a flavonoid (apigenin) in 34 wheat accessions. The antioxidant properties of wheat and wheat products are significantly influenced by genotype and environment (Onyeneho and Hettiarachchy 1992). The total phenolic content, antioxidant activity and vanillic acid, syringic acid and ferulic acid contents are considerably more influenced by environmental effects than by genotype effects (Mpofu *et al*. 2006). Some studies have focused on the relationship between total phenolic content or antioxidant activity and grain color and size. Zong *et al*. (2006) reported that there is a close relationship between grain color and antioxidant activity; blue, black-purple and purple wheat grains are significantly higher in antioxidant capacity than white or red wheat grains. However, Mpofu *et al*. (2006) found that grain color does not appear to be a factor in the expression of antioxidant-related parameters. The total phenolic content and antioxidant activities of wheat subjected to different processing or milling methods has also been investigated (Moore *et al*. 2009; Hung *et al*. 2009).

The current interest in the health benefits of whole wheat grain may drive breeding programs further to increase the antioxidant content in wheat grain. Understanding the relationship between the naturally occurring genetic diversity in phytochemical content and the health benefits of whole wheat grain may help improve the wheat breeding process. The objective of this study was to evaluate the total phenolic, flavonoid and carotenoid contents and the antioxidant activity of a large number of Chinese wheat genotypes and to analyze the relationship between these antioxidant substances and grain characteristics. The results of this study may be useful for breeding nutrient-dense wheat.

RESULTS

Variation in total phenolic, flavonoid and carotenoid contents and antioxidant activity

The wheat variety had a significant effect on total phenolic, flavonoid and carotenoid contents as well as AOA (Table 1). The total phenolic content in all of the wheat varieties ranged from 492 to 1 313 μmol 100 g^{-1}, with a mean value of 744 μmol 100 g^{-1} and intergenotypic variability of 18.5%. Variation was also detected within white, red and black wheats. Black wheat had the highest intergenotypic variability (24.5%), followed by white wheat (17.8%), while red wheat had the lowest intergenotypic variability (10.0%). The highest mean value (909 μmol 100 g^{-1}) was observed in black wheat, followed by red wheat (824 μmol 100 g^{-1}), and the lowest value was found in white wheat (724 μmol 100 g^{-1}). The differences in total phenolic content between black, red and white wheats were statistically significant.

Table 1 Variations in total phenolic, flavonoid and carotenoid content and antioxidant activity among white wheat (n=148), red wheat (n=24) and black wheat (n=6) genotypes

Variety type	Statistics variable	Phenolics (μmol 100 g^{-1})	Flavonoids (mg 100 g^{-1})	Carotenoids (μg g^{-1})	Antioxidant activity (mmol 100 g^{-1})
Total wheat	Mean	744	25.2	3.3	5.3
	CV (%)	18.5	19.2	25.0	17.1
	Range	492-1 313	14.7-39.7	1.4-6.6	3.1-8.3
White wheat	Mean	724 b	24.1 c	3.2 b	5.1 c
	CV (%)	17.8	16.8	20.5	16.0
	Range	492-1 034	14.7-35.1	1.6-4.7	3.1-6.8
Red wheat	Mean	824 a	29.0 b	3.1 b	5.7 b
	CV (%)	10.0	10.6	15.8	9.2
	Range	650-1 088	21.8-38.9	1.4-4.1	4.9-8.3
Black wheat	Mean	909 a	36.1 a	6.0 a	7.2 a
	CV (%)	24.5	10.6	15.1	4.4
	Range	660-1 313	32.1-39.7	4.7-6.6	6.7-7.5

Means in the same column followed by different letters are significantly different (P<0.05). The same as below.

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