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Review

Is the *in vitro* antioxidant potential of whole-grain cereals and cereal products well reflected *in vivo*?

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Abstract

There is strong epidemiological evidence that whole-grain cereals protect the body against age-related diseases such as diabetes, cardiovascular diseases and some cancers. This may be due to the fibre and micronutrients in the outer layer and germ fractions of the grain acting together to combat oxidative stress, inflammation, hyperglycaemia and carcinogenesis. Oxidative stress is associated with these metabolic diseases. Whole-grain cereals are a good source of vitamin E, folates, phenolic acids, zinc, iron, selenium, copper, manganese, carotenoids, phytic acid, lignins, lignans, and alkylresorcinols, all of which have significant antioxidant potential *in vitro*. Phenolic acids such as ferulic acid are characteristic of cereals. They may scavenge free-radical oxygen species both *in vitro* and *in vivo*. Phenolics may also act *in vivo* by triggering gene induction/repression via cell signalling through transcription factors. Whole-grain cereals are also a good source of betaine, choline and sulphur amino acids that can improve antioxidant status. Betaine, which accounts for about 1% (w/w) of the bran fraction in wheat, acts as a methyl donor that may decrease hyperhomocysteinaemia, a cardiovascular risk factor, but it has been neglected. Cereals and cereal products are antioxidative *in vitro*, as are most fruits and vegetables. The *in vitro* antioxidant capacity of cereals and their constituent fractions is significantly correlated with their polyphenol content, except for maize. However, the *in vitro* antioxidant capacity of cereals is only an approximate reflection of their *in vivo* antioxidant effect due to differences in antioxidant solubility/bioavailability within the digestive tract and the metabolism/conjugation of compounds such as polyphenols. During digestion, the antioxidant capacity of cereals is increased and is likely to provide a favourable antioxidative environment for the epithelium tract, notably in the large intestine. Most of the studies performed on animals have been concerned with the antioxidant property of coloured rice, especially black rice and its anthocyanin fraction, showing a positive effect on some antioxidant biomarkers. Those very few studies that have been done on humans have shown that wheat bran and rye product supplements have no effect on antioxidant status, while a black rice pigment fraction and an avenanthramide-enriched mixture extracted from hulled oats have a positive effect. *In vivo* studies are therefore needed to further explore the real antioxidant potential of cereals.

Keywords: Whole-grain cereals; Micronutrients; *In vitro* Antioxidant potential; *In vivo* studies

Contents

Abbreviations: AAPH, 2,2′-azobis 2-amidinopropane dihydrochloride; ABTS, 2,2′-azinobis 3-ethyl-benzothiazoline-6-sulfonic acid; CAT, catalase; DPPH, 2,2-diphenyl-1-picrylhydrazyl; FRAP, Ferric Reducing Antioxidant Power; GSH, reduced glutathione; GSH-Px, glutathione-peroxidase; GSH-Red, glutathione-reductase; GSSG, oxidized glutathione; LDL, low-density lipoprotein; MDA, malondialdehydes; ORAC, Oxygen Radical Absorbance Capacity; SOD, superoxide dismutase; TBARS, thiobarbituric acid reacting substances; TE, trolox equivalent.

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