CHAPTER 1

OVERVIEW AND PROSPECTIVE

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1.1 INTRODUCTION

The pathology of a number of chronic diseases including cancer involves oxidative damage to cellular components. For instance, reactive oxygen species (ROS) capable of causing damage to DNA have been associated with carcinogenesis, coronary heart disease, and many other health problems related to advancing age. Minimizing oxidative damage may well be one of the most important approaches to the primary prevention of these aging associated diseases and health problems. Antioxidants terminate ROS attacks and appear to be of primary importance in the prevention of these diseases and health problems. It has been widely accepted that diet can significantly alter the overall health and quality of life. Development of functional foods rich in bioavailable antioxidants may play an important role in this regard. The key for developing functional foods is to provide a sufficient amount of the bioavailable safe active components, the functional additives/nutraceuticals, in the finished functional food products. Multidisciplinary approaches are required to select suitable agricultural materials containing adequate concentrations of beneficial components, to enhance and preserve the bioactives through postharvest treatments and optimized storage conditions, to understand their bioavailability and efficacy, to evaluate the potential side effects of elevated intakes of these bioactive components, to preserve the bioactive components during food formulation and processing, to evaluate the potential impact of the functional food intake on biomarkers of targeted health problems, and to promote the production and the consumption of these foods.

Recent research demonstrates that wheat grain contains significant level of natural antioxidants. Wheat is an important agricultural commodity and a primary food ingredient worldwide and contains considerable beneficial nutritional components. Wheat and wheat-based food ingredients rich in natural antioxidants can ideally serve as the basis for development of functional foods designed to improve the health of millions of consumers. Development of functional foods using wheat-based ingredients may also find value-added alternative utilization of wheat grain and fractions, thus enhancing agricultural economy.

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1.2 ANTIOXIDANT PROPERTIES OF WHEAT GRAIN

Growing evidence indicates that intake of whole wheat foods may be associated with potential health benefits including the reduced risk of coronary heart diseases and certain types of cancer (1–3). These beneficial effects are attributed to the bioactive factors in wheat grain such as nondigestible carbohydrates and phytochemicals (1–4). Antioxidants are a group of small molecular weight phytochemicals present in wheat grain. These include but are not limited to carotenoids, tocopherols, lignans, and phenolic acids. These antioxidative components may prevent life important molecules such as DNA and enzymes from oxidative damages through different mechanisms. For instance, wheat antioxidants may directly react with reactive oxygen species (ROS) such as hydroxyl radicals or singlet oxygen molecules to terminate their attacks to biological molecules. Wheat antioxidants may also form chelating complexes with transition metals to reduce their availability as catalysts for free radical generation. Antioxidant properties of wheat grain and fractions and their phytochemical composition have been investigated and are summarized in Chapters 2–4. In addition to showing the significant level of natural antioxidants in wheat grain, the results from these studies suggest that antioxidants are not evenly distributed in wheat grain but are concentrated in wheat bran and aleurone fraction of bran. This finding may lead to the production and consumption of "super bran" and other wheat-based food ingredients rich in natural wheat antioxidants. The effects of genotype, growing conditions, and interaction between genotype and environmental conditions on antioxidant properties of wheat grain and fractions have also been reported by several research groups and discussed in Chapter 3. The results from these studies indicate the potential for producing wheat grain rich in natural antioxidants and other bioactive factors. These results also warranty further investigations for enhancing levels of natural antioxidants and other beneficial factors in wheat grain through wheat breeding effort, improved agricultural practices, and genetic modification.

Several research groups reported that wheat phenolic acids, a group of phenolic antioxidants in wheat grain, are predominantly present in the insoluble bound forms in wheat grain, along with a small portion in the soluble free or conjugated forms (Chapter 3), suggesting the possibility to enhance the availability of wheat antioxidant availability through improved postharvest treatments. A few studies investigated the postharvest treatments, milling practice, and storage conditions for their potential influences on the antioxidant availability in wheat bran. The results from these studies showed that postharvest enzymatic and yeast treatments, bran particle size, and storage conditions may significantly alter the antioxidant availability in wheat-based food ingredients (Chapter 6). Additional research is needed to advance our understanding of these postharvest and ingredient storage approaches and optimizing these conditions to enhance the antioxidant availability in wheat-based food ingredients.

Interestingly, recent studies showed the potential effects of food processing conditions on antioxidant availability in wheat-based food products and the antioxidant properties of selected food products (Chapters 6 and 7). It is well accepted that bioavailability is required for any bioactive food factors to have any health beneficial effects. Bioavailability depends on a number of factors including their availability in

food products, and their absorption and *in vivo* delivery to target organs and tissues. The availability of bioactives in food products is determined by their concentration in food ingredients and their preservation through food formulation and processing conditions. Interaction of wheat antioxidants with other food ingredients and the effects of food processing conditions such as thermal treatment on overall antioxidant properties of wheat-based food products are not fully understood.

Wheat phenolics including the phenolic acids and lignans are known antioxidants. Phenolic acid composition and lignan contents in different varieties of wheat have been studied (Chapters 3, 4, and 16). The interaction between the selected wheat phenolic acids and free radicals and transition metals was also investigated (Chapter 5). The bioavailability of phenolic acids from a few previous studies has also been discussed in Chapter 15. It is noted that food matrix may alter the availability and bioavailability of bioactives. Thoroughly designed animal and pilot human studies are needed to investigate the bioavailability of wheat antioxidants including phenolic acids and lignans from different wheat-based food ingredients and food products. This information is very important to optimize human benefits of wheat-based functional foods rich in natural antioxidants.

A number of analytical methods have been adapted and developed for investigating the antioxidant properties of wheat grain and fractions and their phytochemical compositions. These methods are summarized in details (Chapters 8–12). The limitations of these methods are also discussed along with their advantages and disadvantages. In addition to the spectrophotometric and fluorometric methods, electron spin resonance (ESR) spectroscopy has been discussed because it directly measures the presence of free radicals and has been utilized to evaluate radical scavenging activities of wheat antioxidants and to validate the analytical methods for wheat antioxidant research (Chapter 10). These analytical methods may be applied to other cereal grains and botanicals. It needs to be pointed out that there is still a need to develop new analytical methods that may evaluate antioxidant properties of a selected sample under physiologically relevant conditions and may compare hydrophilic and lipophilic antioxidants under same experimental conditions.

1.3 OTHER BIOLOGICAL ACTIVITIES OF WHEAT ANTIOXIDANTS

It is noted that wheat antioxidants may differ greatly in their chemical structures. Lutein, α-tocopherol, secoisolariciresinol, and vanillic and ferulic acids are known antioxidative compounds present in wheat grain (Fig. 1.1). They share a conjugation system with or without phenolic substitution(s). This common structural component allows them to have strong interaction with free radicals and convert the radicals to less reactive components, showing radical scavenging capacities. Besides their capacity to interact with ROS, wheat antioxidants may have other biological activities. It is well known that α-tocopherol has vitamin E activity, whereas lutein is a carotenoid compound that may affect macular pigment optical density (5). On the contrary, secoisolariciresinol is known as a phytoestrogen that may have potential in

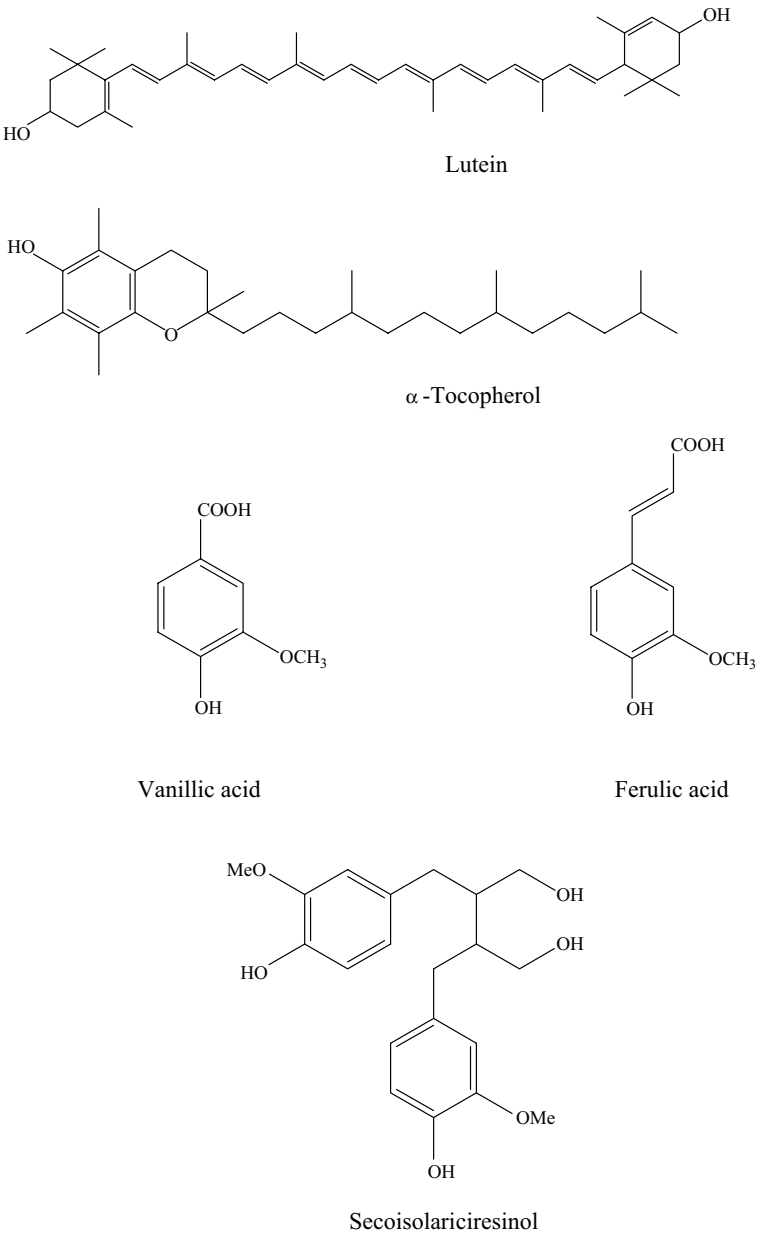

Figure 1.1 Chemical structures of the phenolic acids.

chemoprevention of breast and prostate cancers, osteoporosis, and cardiovascular diseases (6,7). In addition, ferulic acid, the predominant phenolic acid in wheat grain or bran, has been shown to restore endothelial function in aortas of spontaneously hypertensive rats and to prevent trimethyltin-induced cognitive dysfunction in mice (8,9). In summary, individual antioxidant components may contribute to different

health beneficial effects of whole wheat foods or wheat antioxidants because of their different chemical structures.

A recent study showed that wheat antioxidants may alter mRNA levels of 3-hydroxy-3-methylglutaryl-CoA reductase (HMG-CoA-R) and cholesterol 7α-hydroxylase (CYP7A1). These activities are also not related or mediated through their antioxidative actions. Wheat antioxidants may alter total plasma and low density lipoprotein (LDL) cholesterol levels through altering the levels of these two enzymes. Effects of wheat antioxidants on genes involved in cholesterol metabolism are discussed in Chapter 14. Chapter 15 in this book discusses the potential effect of wheat antioxidants on normal intestinal cells and nutrient absorption. These biological activities may also contribute to their overall health beneficial effects. Additional research is needed to investigate the other biological activities of individual wheat antioxidant compounds *in vitro* and *in vivo*, potential synergistic effects between wheat antioxidative components, the molecular mechanisms involved in their bioactivities, and their possible toxic effects.

1.4 WHEAT ANTIOXIDANTS: OPPORTUNITIES AND CHALLENGES

Wheat is an important agricultural commodity and a popular food ingredient worldwide. Wheat antioxidants and other beneficial phytochemicals are concentrated in the bran fraction of wheat grain. Bran is mostly used for low-value animal feed instead of human food ingredient. Research promoting the production and consumption of wheat-based food ingredients and food products rich in natural antioxidants may provide new value-adding opportunities for wheat bran, whole wheat flour, and other wheat-based food ingredients, which may benefit wheat growers, grain processing industry, food ingredient industry, and food manufacturers. The consumer desire of health beneficial functional foods also promotes research in the fields of wheat breeding, plant physiology, general plant science, food chemistry, food processing, general food science, nutrition, human health, and other biological and health sciences.

Wheat antioxidants also offer challenges for researchers in the related fields. Multidisciplinary approaches are required to advance our knowledge on wheat antioxidants. For instance, chemists and crop scientists have to work together to investigate how agricultural practices may alter antioxidant property and composition of wheat grains. It is also hard to ensure the consistency of wheat antioxidant properties in wheat grain and wheat-based food ingredients because many factors may be involved. To date, the chemical composition of wheat antioxidants is not fully understood. This makes it hard to quantify individual antioxidant compounds in the wheat-based food ingredients, which may be important for quality assurance of wheat-based food ingredients rich in antioxidants.

Food is a very complicated chemical system. Many interactions between food components may occur during food formulation, processing, and storage. These interactions may alter the status of individual antioxidants in the system, which may

alter the effectiveness of analytical approaches such as antioxidant extraction. This makes it very challenging to research chemical components in food.

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