Triticum aestivum L.

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Common wheat (*Triticum aestivum*), one of the world's most consumed cereal grains, is known for its uses in baking and cooking in addition to its medicinal uses. As this plant's medical benefits are enormous and scattered, the pharmacological activities were focused, phytochemistry, and the nutritional values of *Triticum aestivum*. It is a good source of dietary fiber, resistant starch, phenolic acids, alkylresorcinols, lignans, and diverse antioxidant compounds such as carotenoids, tocopherols and tocotrienols. These constituents provide *Triticum aestivum* with a wide range of pharmacological properties, including anticancer, antimicrobial, antidiabetic, hypolipemic, antioxidant, laxative, and moisturizing effects.

wheat Triticum aestivum phytochemicals

1. Introduction

Wheat is one of the world's most consumed cereal grains, along with rice and maize. The wide range of varieties of wheat contributed to its popularity. The top wheat producer was China, as it produced around 30% (112 to 120 million tons) [1] of the overall world wheat production between 2012 and 2016. Other countries that accounted for 63.46% of the world wheat production are India, the Russian Federation, the United States of America, and Canada [2]. Wheat is commonly used in cooking and baking. However, it was discovered that different parts of the wheat plant have medicinal uses such as wheat bran with anticancer properties and wheat sprouts for their antimicrobial activities [3].

Wheat is an excellent energy source as it contains carbohydrates and significant amounts of other crucial nutrients such as proteins, dietary fiber, and smaller amounts of lipids, terpenoids, vitamins, minerals, and phytochemicals [4]. According to the Healthy U.S. Style Eating Pattern, 2000 calories per day is six ounce-equivalents daily, half of which should be whole grains [5]. Whole grains are great sources of nutrients, such as dietary fiber, iron, zinc, manganese, folate, magnesium, copper, thiamin, niacin, vitamin B6, phosphorus, selenium, riboflavin, and vitamin A. Studies done by Liu et al. [6], Meyer et al. [7], and Parker et al. [8] supported the statement that consumption of two or more servings of whole grains a day may reduce the risk of cancer, cardiovascular diseases and diabetes mellitus type II. The pharmacological activities, medicinal use, phytochemistry of *Triticum aestivum* (T.A.) will be comprehensively introduced.

2. Botanical Description

This annual grass forms either solitary or tufted leafy culms about 2 to 3 and a half inches tall. The culms are light green, erect, terete, glabrous, and sometimes glaucous. Along the length of each culm, alternate leaves grow. The leaf blades are 6–18 mm across and 5–12 inches long. The leaves appear bluish or grayish-green, glabrous, and sometimes glaucous. These blades are ascending, arching, or rather floppy. The bases of these blades often have rounded auricles with scar-like wavy margins. The open leaf sheaths have the same characteristics as the leaves. The ligules are short-membranous and are about 1–2 mm in length; meanwhile, the nodes are swollen and glabrous. Each culm ends in an erect floral spike about 2–4 inches long. These floral spikes are also grayish or bluish-green with additional darker markings. Furthermore, each floral spike has multiple overlapping spikelets appressed against the rachis, which is the central stalk of the spike that is also nearly erect [9].

Each spikelet is about 10–15 mm in length, consisting of a pair of glumes at the base along with 2–5 florets with lemmas above. The glumes are 9–11 mm long and are ovate in shape, partially keeled, and glabrous. The lemmas are around 9–11 mm in length, ovate in shape, convex along their surfaces, and glabrous. Along the inner sides of the florets are membranous paleas similar to the lemmas. At the apex of both the glumes and lemmas, there are 1–2 small teeth. Each floret consists of an ovary, a pair of feathery stigmata, and stamens. The blooming period usually occurs from the late spring to mid-summer. The wind cross-pollinates the florets. They are replaced by grains that are 7.5–8.5 mm long and 3.5–3.75 mm across and ovoid-ellipsoid in shape. The light-colored grains are convex on one side and incurved on the other. The root system is fibrous [9].

For wheat cultivation, the preferred conditions are places with full sun, mesic to dry-mesic conditions, and soil containing loam or clay-loam. Some varieties of wheat, such as winter wheat, are planted during the fall season, while other varieties such as spring wheat are planted during spring. Wheat originated from the eastern part of the Mediterranean or the Middle East in Eurasia and is considered the major agricultural crop. Typical habitats of such plants include fields, roadsides, railroads, areas near grain elevators, and open waste areas. Sometimes T.A. is deliberately planted as a food source for wildlife and to control erosion along roadside embankments until perennial grasses become established. Wheat thrives in highly disturbed areas with exposed topsoil [9]. Dried wheat is typically milled into flour which is then used to create many different flour-based foods such as bread, pasta, cereal, and many more.

3. Phytochemistry of *Triticum aestivum*

Wheat products are divided into three fractions: bran, germ, and endosperm. Ninety percent of the dry weight of mature wheat grain comprises three major components: starch, proteins, and cell wall polysaccharides. Wheat bran is a major byproduct of wheat grain milling when producing white or refined flour. At the same time, the rest are other minor elements, including lipids, terpenoids, phenolics, minerals, and vitamins. Lipids make up about 8–15% of the germ, around 6% of the bran, and 1–2% of the starchy endosperm in the whole wheat kernel. Many vital minerals and antioxidants are included in the germ, as well as natural oil (wheat germ oil). When a germ is crushed and exposed to air, the oil begins to oxidize, eventually becoming rancid. The removal of the germ extends the shelf life of flour and eliminates the risk of rancid oils imparting a strong taste to the flour [10]. Germ lipids are primarily nonpolar (up to 85%), with polar lipids accounting for just a small part (up to 17%), but the profile of endosperm lipids differs significantly from that of germ and bran lipids. Among the various wholegrain components, endosperm lipids are the only significant source of galactolipids (primarily monogalactosyl diglyceride and digalactosyl diglyceride) and phospholipids (primarily phosphatidylcholine, lysophosphatidylcholine, phosphatidylethanolamine, and lysophosphatidylethanolamine) [11].

Different solvent systems were employed using the Soxhlet apparatus to extract T.A. grass and it was found that they contain rutin, chlorogenic acid, tocopherol, and gallic acid in the organic solvents; hexane, chloroform, and methanol [12]. Those organic extracts showed antimicrobial activity against *Salmonella typhi*, *Staphylococcus aureus*, and *Vibrio cholerae*. The evaluation of carotenoids (lutein and zeaxanthin) and phenolic acid concentrations of the whole wheat in Titlis and Runal cultivars over several years was tested under conventional and organic production methods [13]. Up to 98% of the phenolic acids were bound to cell components such as ferulic acid. Ferulic acid comprises 85% of the total phenolic acids followed by coumaric, sinapic, and caffeic acids. Generally, both the conventional- and organic-produced T.A. yielded similar concentrations of phytochemicals. Marrelli et al. [14] studied two wheat varieties from Italy: Carosella and Majorca. High concentrations of polyphenols and antioxidant activities were found in both varieties and considered as potential sources of antioxidants with IC_{50} values of 0.008 mg/mL and 0.011 mg/mL, respectively. Zhou et al.'s [15] investigation for seven varieties of wheat bran phytochemicals from different countries found a wide range of phenolic acids, tocols, and carotenoids. The ferulic acid concentration was 99−231 μg/g, while α-, δ-, and γ- tocopherols yields were up to 21.29, 7.0, and 6.90 μg/g, respectively, and lutein, zeaxanthin, and cryptoxanthin were up to 1.80, 2.19, and 0.64 μg/g, respectively. In a different study investigating the effects of pearling on wheat [16], the authors illustrated that the antioxidant capacity of both pearled grains and byproducts of *Triticum turgidum* and *Triticum aestivum* significantly decreased as the degree of pearling increased. The maximum antioxidant capacity was found in the byproducts of 10–20 percent pearling. For increasing degrees of pearling, subsequent removal of exterior layers resulted in a drop in phenolic content as well as poorer antioxidant activity levels. Endosperm diluted the antioxidant elements when the exterior layers were eliminated, including the bran and aleurone layers, the latter being the endosperm's outermost layer.

Phytic acid is an important plant molecule that acts as a primary reservoir of phosphates in crops. Phytic acid is also involved in plant developmental and signaling processes including auxin storage and transport, phosphatidyl inositol signaling, cell wall biosynthesis, and production of stress-related molecules [17]. The storage form of phytic acid is referred to as phytate or phytin, which is mainly located in the aleurone layer of seeds. Phytic acid accumulation negatively impacts human nutrition because of its ability to chelate micronutrients such as iron, zinc, and calcium, which reduces their bioavailability and absorption [18]. An inverse relationship was observed between iron and phytic acid, as suppressing phytic acid genes, overexpression of plant and fungal phytases generate less new phytic acid and degrade phytic acid that was already synthesized, respectively. In contrast, overexpression of plant ferritin enhances storage of iron and zinc [19], while nicotinamide synthase overexpression mobilizes them from roots to seeds [20].

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