

Wheat

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Wheat is a valuable source of essential nutrients, providing carbohydrate-based energy and fiber, protein, B vitamins, calcium, magnesium, phosphorus, potassium, zinc, and iron. In low and medium-income countries, grain-based foods still make up the central part of the diet. The wheat seed can be ground into flour or semolina, for example, which form the essential ingredients of bread, pasta, noodles, and other food products, essentially the primary source of nutrients for most of the world population.

[wheat](#)[nutrients](#)[celiac disease](#)[wheat allergy](#)[non-celiac wheat/gluten sensitivity](#)

1. Introduction

The domestication of wheat revolutionized the human diet as this cereal provided a significant source of energy. Globally, wheat accounts for the largest harvested area of any crop ^[1] and provides more protein and calories than any other cereal crop ^[2]. Wheat is nutritious, simple to transport and store, and can be transformed into several types of food. The most valuable modern wheat species are hexaploid bread wheat (*Triticum aestivum* L.) and tetraploid durum wheat (*T. turgidum* L. var. *durum*), which have distinct genomes, grain composition, and end-use quality attributes. Wheat adapts to all climatic conditions common in agricultural fields (except for the hot tropics), so globally, it is harvested all year round ^[3].

Wheat is a valuable source of essential nutrients, providing carbohydrate-based energy and fiber, protein, B vitamins, calcium, magnesium, phosphorus, potassium, zinc, and iron ^[4]. In low and medium-income countries, grain-based foods still make up the central part of the diet. The wheat seed can be ground into flour or semolina, for example, which form the essential ingredients of bread, pasta, noodles, and other food products, essentially the primary source of nutrients for most of the world population ^[5]. Conversely, the lack of grains too often signifies hunger and malnutrition. The characteristic that has given wheat an advantage over other temperate crops is the unique viscoelastic properties of dough formed from wheat flours, which allow it to be processed into such an array of forms ^[6]. Dough viscoelasticity depends on the structures and interactions that occur between grain storage proteins that form the gluten protein complex ^[7].

Gluten, which is now an almost ubiquitous ingredient in the food industry, is implicated in several immune-mediated disorders, such as celiac disease (CD). Both CD and other intolerances are of increasing concern ^{[8][9]}, and the prevalence of CD is predicted to rise ^[10]. These disorders demand a gluten-free diet (GFD), but a GFD can itself be associated with digestive problems due to insufficient intake of dietary fiber and other nutrients ^[11].

2. The Health Benefits of Wheat

Wheat grain is composed of the germ (2–3%), the bran (13–17%), and the endosperm (80–85%) [5] (Figure 1). Wheat germ is the embryo of the wheat kernel and is relatively rich in protein, lipids, and several of the B-vitamins [5][12]. Whole-wheat flour includes the bran, which contains a limited amount of protein, larger quantities of the B-complex vitamins, trace minerals, and indigestible cellulose material called dietary fiber [5][12]. White flour originates from the endosperm. The endosperm contains most of the protein in the whole kernel, iron, carbohydrates, and many B-complex vitamins, such as riboflavin, thiamine, and niacin [5][12].

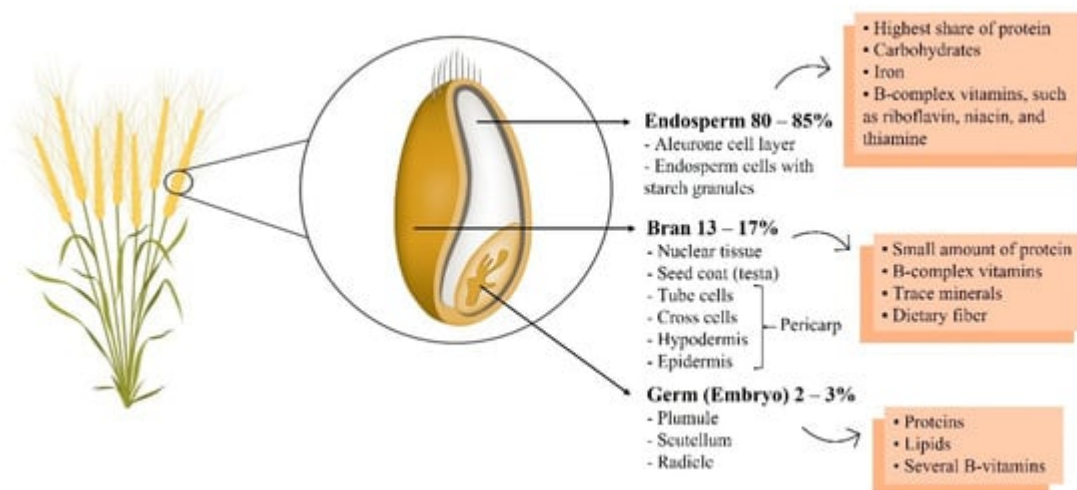


Figure 1. Wheat grain constitution.

Protein is an essential nutrient for humans and animals [5]. Protein content is used to classify wheat. Breeders target this feature by regularly selecting for protein content traits in breeding programs; wheat with a low protein content is suitable for animal feed other uses, while wheat with a high protein content is necessary for breadmaking [4][7]. Protein content differs depending on the growing conditions, type or class of wheat, and fertilizer inputs, especially nitrogen [4][13]. Thus, there is no such thing as typical protein content, but on average, it can vary between 9–18% of the grain weight [4][5][14][15][16][17]. Protein is unequally distributed in the grain. A percentage of 5.1% of protein was reported in the pericarp, 5.7% in the testa, 22.8% in the aleurone, and 34.1% in the germ [16]. T.B. Osborne demonstrated that wheat proteins could be classified according to their extractability and solubility in distinct solvents [18]. Globulins are insoluble in pure water, and high NaCl concentrations but soluble in dilute NaCl solutions; albumins are soluble in water; glutenins are soluble in dilute acid or sodium hydroxide solutions, and gliadins are soluble in 70% ethyl alcohol [5].

Carbohydrates are recognized by WHO/FAO [19] as the macronutrient humans need to consume the most. Many countries have nutritional guidelines that emphasize the importance of cereals and cereal carbohydrates as the foundation of a healthy diet [20], mainly because the primary benefit of carbohydrates is as a source fuel, glucose. All body tissues, including brain tissue, require glucose. While the brain consists of only 2% of body mass, it uses 20% of the fuel [21]. Dietary carbohydrate is also vital in ensuring gastrointestinal integrity and function and glycemic homeostasis. Unlike protein and fat, high levels of complex carbohydrate are not associated with adverse

health consequences to the extent that diets high in complex carbohydrates are less likely to lead to obesity and its morbid consequences than diets high in fat [22]. In an ideal diet, at least 55% of total energy should come from carbohydrates obtained from various food sources [23].

Lipids are a minor constituent of wheat, mostly in the germ, making up 3–4% of the whole grain weight and 1–2.5% of directly milled flour [24]. Lipids have a critical role in baking processes, dough mixing, and the acceptance of the finished products by consumers. Their ability to associate with gluten proteins and form complexes contributes to stabilizing the gas-cell structure, significantly influencing the final texture of baked products and loaf volume [25]. Iron is concentrated in the aleurone and zinc in the embryo [26]. Deficiencies in iron and zinc micronutrients are common in populations that consume wheat as a staple because wheat products are usually low in bioavailable forms of these micronutrients. In wheat, two features contribute largely to the low content in bioavailable iron and zinc: the most consumed form is white flour, which contains low concentrations of these minerals, and the existence of phytates in mineral-rich bran fractions that retain minerals in a form that is not bioavailable.

The B vitamin complex, which at first was thought to be a single compound, comprises eight water-soluble components, which often co-occur in the same foods. They are unequally spread in the wheat kernel and are primarily found in wheat bran and the germ; hence they are present in reduced quantities in refined flours [24]. Cereals are dietary sources of several B vitamins, particularly riboflavin (B2), folates (B9), thiamine (B1), pyridoxine (B6), and niacin (B3) [16]. These molecules play an essential role in metabolism, particularly thiamine in the metabolism of carbohydrates, and riboflavin and pyridoxine in the metabolism of proteins and fats [27]. Consumption of wholemeal products provides 40% of the recommended daily allowance of thiamine, 10% of riboflavin, 22% of niacin, 33% of vitamin B6, and 13% of folate recommended [28]. Niacin is of particular concern as only a proportion of the total present in cereals is bioavailable in a chemically bound form, nicotinic acid [29]. Multiple studies have focused on this issue [30], with some reports of increasing niacin bioavailability by treatment with alkali [31].

3. Wheat/Gluten-Related Disorders

Wheat/gluten-related diseases can be classified into three different disorders: autoimmune, allergic, and neither autoimmune nor allergic. Celiac disease is the most prominent autoimmune gluten-related disorder (CD). It is a condition of the small intestine caused by gluten and gluten-related proteins and influenced by environmental and genetic factors [32][33]. An IgE and non-IgE mediated immune response characterize wheat allergy (WA), resulting in an allergic reaction in some individuals upon contact, inhalation, or uptake of foods containing wheat but not necessarily other grains as barley or rye. However, IgE-cross reactivity to other cereals is possible in some people [34][35][36]. Patients with non-celiac wheat/gluten sensitivity (NCWGS) experience identical symptoms to CD, but they do not test positive for CD [37].

The binding of gluten peptides to T cells triggers Celiac Disease (CD) in some individuals expressing human leukocyte antigen (HLA) DQ2 or DQ8 in cells specialized in presenting antigens. Specific CD4+ T cells then recognize the presented peptides releasing inflammatory cytokines, leading to changes in the architecture of

intestinal mucosa with atrophy and flattening of villi that can lead to total villous degeneration and enteropathy. Moreover, gliadin peptides are responsible for the activation of innate immunity of the intestinal epithelial cells [38][39].

Gluten ataxia (GA) is a form of cerebellar ataxia, affecting mainly Purkinje cells, and is caused by antibodies released when digesting gluten that mistakenly attacks part of the brain in individuals that are sensitive and genetically susceptible [40]. The clinical symptoms of GA are identical to those of other ataxias. They include gait ataxia (100%), lower limb ataxia (90%), gaze-evoked nystagmus (84%), upper limb ataxia (75%), ocular signs like dysarthria (66%), and other movement disorders including chorea, myoclonus, opsoclonus myoclonus, and palatal tremor [41].

Dermatitis herpetiformis (DH), repeatedly associated with CD, is an autoimmune, chronic, and recurrent cutaneous-intestinal disorder detected in genetically susceptible individuals [11][42][43]. Anti-tTG antibodies that also recognize epidermal transglutaminase (ETG) can be produced after exposure to gluten. ETG is homologous to tTG in terms of structure and is the primary antigen in DH [42]. IgA antibody deposition in dermal papillae causes pruritic, vesiculobullous, and localized lesions in DH patients. DH affects the extensor surfaces such as knees, buttocks, elbows, and scapular areas [42][44][45].

Allergens cause allergic reactions, and wheat is one of the five most frequent foods causing them in children. After milk and eggs, wheat is the most common allergen in Japan, Germany, and Finland [46]. In children and adults, wheat allergy (WA) prevalence is approximately 1% depending on age and region [47][48]. In contrast to CD, distinct wheat components such as water-insoluble proteins (gliadin and glutenin) and water/saline-soluble proteins (albumin and globulin) contribute to the development of WA [11][49][50].

4. Gluten-Related Misconceptions

There are three significant misconceptions by the general population leading them to follow a GFD. (1) A gluten-free diet is a healthier option. (2) Eating gluten-free will help them lose weight. (3) The wheat we consume today contains more gluten than older varieties.

Considering the first misconception, claims of the potential benefits of following a GFD include increased energy, better sleep, clearer skin, faster weight loss, and improved medical conditions such as autism and rheumatoid arthritis [51]. Evidence of the health benefits of a GFD for GRD patients is incontrovertible. However, no published experimental evidence supports similar claims for the overall population [52]. On the contrary, an issue associated with unnecessary gluten avoidance is the reduced consumption of whole grains, foregoing the likely benefit of lowering cardiovascular risk. The GFD promotion between people without CD must not be encouraged [53].

Regarding the second misconception, some studies of CD patients report a change in weight as an effect of following a GFD. In a survey of 369 adult patients with CD who followed a GFD for an average of 2.8 years, 22 of the 81 (27%) who were at first overweight increased weight [54]. In another study of 371 adults with CD who adhere

to a GFD for two years, 55 of the 67 (82%) initially overweight patients earned weight [55]. Indeed, a study carried out in 2018 analyzed the most recent surveys on the nutritional quality of gluten-free products and concluded that the key inadequacies of currently available GF products are a low protein content and a high fat and salt content compared with their gluten-containing counterparts. However, they also verified more acceptable levels of fiber and sugar than in the past [56]. In this way, we can affirm that gluten-free products are not adequated to people wishing to lose weight.

The third misconception that wheat breeding has led to the production of wheat varieties containing higher levels of gluten originated from successful books like “Wheat Belly” by William Davis and “Grain Brain” by David Perlmutter [57]. However, the level of gluten in wheat has actually remained unchanged over the years. A 2013 study reported that gluten levels in numerous varieties, on average, have slightly changed since the 1920s, and although there was actually an increase in CD in the second half of the century, the breeding of wheat for higher gluten content does not suggest to be the reason for that [58].

The take-home message is that wheat is an excellent food for people without any associated medical conditions because it is a very nutritious cereal, rich in macro and micronutrients that only beneficiate our health. The problem is that people are removing wheat from the diet without any medical indication or health/nutritional condition with a proven relationship and consequently are not consuming the necessary nutrients. This is a mistake that results from a growing number of misconceptions related to this cereal that should be avoided and clarified as they end up harming these people’s health.

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