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PLANT PROTEINS, GLUTEN, AND NITROGEN

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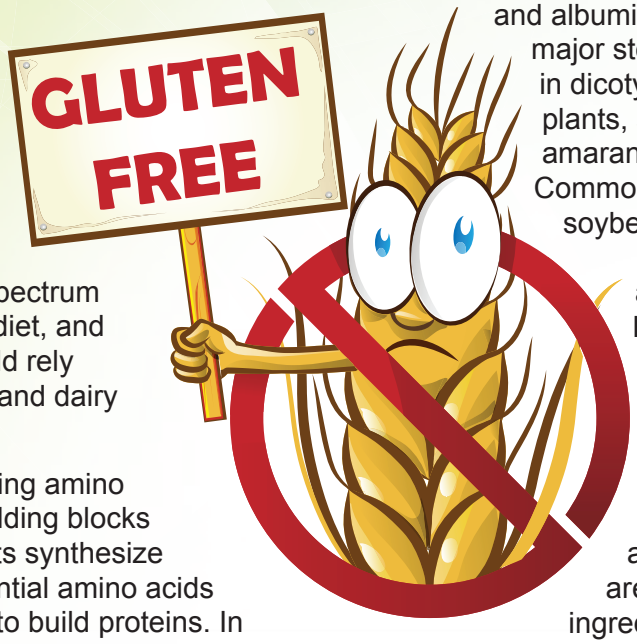
Plants provide people 30% of their protein intake, according to a National Health and Nutrition Examination Survey provided by the USDA (Pasiakos et al., 2015). Breads and nuts were important sources of plant protein for Americans surveyed. Another 46% of protein in human diets was derived from animal sources, and 16% from dairy. Of course, there is a wide spectrum in the American diet, and vegetarians would rely entirely on plant and dairy sources.



Nitrogen-containing amino acids are the building blocks of proteins. Plants synthesize all 20 or so essential amino acids that are needed to build proteins. In contrast, animals cannot synthesize all the essential amino acids. Ruminant animals, for example, depend on plant proteins for such amino acids. Humans too cannot synthesize all essential amino acids, and so we need to eat a variety of animal and plant sources to meet our dietary needs.

When plants reproduce, they store proteins in their seeds. When these seeds are planted, the proteins break down into amino acids that fuel the growth of young seedlings. When harvested, seed protein are an important source of nitrogen (N) for the human diet. There are four basic types of storage proteins in seeds: albumins, globulins, prolamins, and prolamin-like glutelins. Agronomically important crops differ in the types of proteins stored in their seeds (**Table 1**). For example, prolamins are the major forms of storage protein in cereals, with the exception of oats and rice. Glutelin, related to prolamin, is also common in cereals. In contrast, globulins and albumins are the major storage proteins in dicotyledonous plants, such as quinoa, amaranth, and legumes. Common legumes include soybean, field pea, lentils, chickpea, and faba beans. Rice and oats are unique in that they are cereals rich in globulins.

Many of us have heard of gluten, and many foods are labeled if their ingredients include gluten. What does this mean? Gluten is the substance in wheat flour that gives bread its elastic structure and enables the dough to rise. Gluten is also a composite protein, made up of prolamin and glutelin, which is found in wheat and its related species. Other seeds also contain prolamin and glutelin proteins, so what makes gluten *gluten*?

The particular peptides, or the sequence of amino acids that are a component of the composite gluten protein, differ among cereal crops. Some peptides trigger an autoimmune response, and thereby are toxic, for example, to people with celiac disease. These include the gliadin peptides in wheat, hordeins in barley, and secalins in rye. Corn contains both prolamin and glutelin, but the

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> *"Soil fertility plays an important role in building plant protein because the nutritional value of plant seeds depends on having an adequate supply of N."*

Table 1. *Types of storage proteins in various seed crops (Shewry and Casey, 2012; Janssen et al., 2017).*

	Albumin	Globulins	Prolamins	Glutelins
Major component	Legumes Amaranth Brazil nut Cottonseed	Legumes Amaranth Quinoa Oats Rice Brazil nut Cottonseed Palm Cocoa	Wheat Barley Corn	Wheat Barley Corn Rice
Minor component	Wheat Barley Corn Oats Rice	Wheat Barley Corn	Oats Rice Amaranth Quinoa	Amaranth Quinoa

zein peptide in corn is rarely toxic to celiacs (Ortiz-Sánchez et al., 2013). This is also true for oryzenin peptide found in rice. When uncontaminated by wheat, oats (avenin peptide) are also generally considered safe for celiacs (Sanchez et al., 2017), but this may vary among cultivars (Giménez et al., 2017). Contamination can occur in the field or during transport, storage, or processing when harvested oats are in proximity to wheat.

Soil fertility plays an important role in building plant protein because the nutritional value of plant seeds depends on an adequate supply of N. High quality protein crops include legumes and wheat. Legumes can meet their N demand through biological N fixation, but phosphorus (P), potassium (K), and sulfur (S) fertilizers can improve seed yield, protein quality, or the capacity to fix N (Grant and Bruulsema, 2012). For non-N fixing plants like wheat, N fertilization is needed to adequately supply N and maintain soil fertility. Later applications of N fertilizer can help increase protein content in wheat, while S fertilization can improve the protein quality. Other important cereal crops, such as corn and rice, are lower in protein. Nevertheless, both corn and rice are important sources of protein and certain amino acids, and N fertilization is also critical for improving yield and protein quality.

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