International Journal of Agriculture and Plant Science
www.agriculturejournal.in
Online ISSN: 2664-7664, Print ISSN: 2664-7656
Received: 22-11-2025, Accepted: 21-12-2025, Published: 05-01-2026
Volume 8, Issue 1, 2026, Page No. 22-24

Plant-derived proteins: Nutritional value, extraction techniques, and future prospects

Dr. Deepika Dhaware
Department of Botany, Shri Kumarswami Mahavidyalaya, Ausa District. Latur, Maharashtra, India

Abstract
Plant-derived proteins are receiving growing attention as key components of sustainable and health-oriented dietary patterns worldwide. Their increasing adoption is driven by lower environmental impact, cost-effectiveness, and recognized benefits in reducing the risk of chronic diseases. Despite these advantages, the nutritional quality of plant-based proteins varies considerably depending on the source, essential amino acid composition, protein digestibility, and the presence of antinutritional factors such as phytates, tannins, and protease inhibitors. This review presents a detailed overview of major plant protein sources, including legumes, cereals, pseudocereals, nuts, seeds, and emerging alternative sources, with particular emphasis on their nutritional characteristics and limitations affecting bioavailability. Furthermore, the review discusses recent advances in processing technologies such as fermentation, germination, extrusion cooking, and enzymatic treatments, which have been shown to significantly enhance protein digestibility, amino acid availability, and functional properties. The potential role of plant protein blends and complementary dietary strategies in overcoming inherent nutritional deficiencies is also addressed. Overall, the review highlights that plant-derived proteins possess substantial potential to partially or fully replace animal proteins in human diets, provided that appropriate processing methods and balanced dietary formulations are employed to optimize their nutritional quality and functionality.

Keywords: Plant-derived proteins, nutritional quality, digestibility, processing technologies, sustainable nutrition

Introduction

In recent years, consumer interest in plant-based proteins has increased markedly due to rising concerns about climate change, global food security, and the long-term health impacts of high animal-protein consumption. Livestock production is associated with substantial greenhouse gas emissions, extensive land and water use, and biodiversity loss, making it a less sustainable option for meeting future protein demands. In contrast, plant-based protein sources generally require fewer natural resources and generate a lower environmental footprint, positioning them as viable components of sustainable food systems capable of supporting a growing global population [1,2]. From a nutritional and health perspective, plant-derived proteins offer several advantages, including low levels of saturated fat and cholesterol and the presence of beneficial bioactive compounds such as dietary fiber, polyphenols, and antioxidants. Regular consumption of plant-based diets has been linked to reduced risks of cardiovascular diseases, obesity, type 2 diabetes, and certain cancers [3,4]. Major sources of plant proteins include legumes, cereals, pseudocereals, nuts, seeds, and emerging alternatives such as algae and novel pulses, each contributing distinct nutritional and functional properties. Despite these benefits, plant proteins face notable challenges that limit their optimal utilization. Many plant protein sources possess incomplete essential amino acid profiles, with common deficiencies in lysine, methionine, or tryptophan, depending on the source [5]. Furthermore, plant proteins often exhibit lower digestibility compared to animal proteins due to their compact molecular structures and interactions with antinutritional factors such as phytates, tannins, lectins, and protease inhibitors. These compounds can reduce protein digestibility and mineral bioavailability, thereby affecting overall nutritional quality [6]. To overcome these limitations, it is essential to understand the relationship between protein source, composition, and digestibility. Recent advances in processing technologies, including fermentation, germination, extrusion, and enzymatic treatments, have demonstrated significant potential to improve amino acid availability and reduce antinutritional components [7,8]. A comprehensive evaluation of plant-based proteins is therefore crucial for guiding product development, improving dietary recommendations, and promoting their effective use as sustainable alternatives or complements to animal-derived proteins.

Sources of Plant-Based Proteins

1. Legumes

Legumes represent one of the most important categories of plant-derived protein sources worldwide. Soybean is particularly notable, providing about 36–40% protein and serving as a major raw material for protein concentrates and isolates. Other legumes such as peas, chickpeas, lentils, mung beans, and faba beans also play a vital role in meeting global protein requirements. These sources are rich in lysine, an essential amino acid often lacking in cereals; however, they are generally deficient in sulfur-containing amino acids, especially methionine and cysteine. Their nutritional value and versatility make legumes central to plant-based diets and food formulations.

2. Cereals

Cereal grains including wheat, rice, maize, barley, and oats supply moderate amounts of protein, typically ranging from 7 to 14%. Although cereals are limited in lysine content, they are relatively rich in methionine, making them complementary to legume proteins. Wheat protein, particularly gluten, is valued for its unique viscoelastic characteristics, which are essential in bread and bakery products. Rice protein is considered hypoallergenic and is increasingly incorporated into infant foods and sports nutrition products due to its easy digestibility.

3. Pseudocereals
Pseudocereals such as quinoa, amaranth, and buckwheat are gaining attention for their superior protein quality compared to traditional cereals. These crops contain approximately 12–18% protein and provide a well-balanced amino acid composition, including sufficient levels of lysine. In addition to their favorable protein profile, pseudocereals are gluten-free and rich in micronutrients, making them suitable for individuals with gluten intolerance and for the development of nutritionally enhanced food products.

4. Nuts and Oilseeds
Nuts and oilseeds, including peanuts, almonds, walnuts, sesame seeds, sunflower seeds, chia, and flaxseed, contain protein levels ranging from 15 to 30%. Along with protein, they supply beneficial unsaturated fatty acids, dietary fiber, vitamins, minerals, and antioxidant compounds. This combination contributes to improved cardiovascular health and metabolic benefits. Due to their dense nutrient composition, nuts and oilseeds are widely used in functional foods, protein supplements, and plant-based snack products.

5. Novel Sources: Microalgae, Fungi, and Hemp
Emerging protein sources such as microalgae, fungi, and hemp are attracting significant research interest for future food systems. Microalgae like spirulina are exceptionally rich in protein, containing nearly 60–70% highly digestible protein along with bioactive compounds. Mycoprotein derived from fungi and hemp protein offer favorable amino acid profiles and functional properties suitable for meat analogues and nutritional products. Although these sources require advanced cultivation and processing technologies, they hold strong potential for sustainable protein production.

Nutritional Value of Plant-Based Proteins

1. Protein Content and Amino Acid Composition
The protein content and amino acid composition of plant-based proteins differ considerably depending on their botanical origin. Legumes such as soybean, lentils, and peas are excellent sources of lysine but are generally limited in sulfur-containing amino acids, particularly methionine and cysteine. In contrast, cereal proteins are relatively low in lysine yet provide higher levels of methionine. This natural variation allows for strategic dietary combinations of cereals and legumes, resulting in a complementary amino acid pattern that closely resembles the quality of animal proteins. Such combinations improve overall protein utilization and support balanced human nutrition.

2. Bioactive Components
In addition to providing essential amino acids, plant-based proteins are associated with a wide range of bioactive compounds that offer significant health benefits. These include polyphenols, phytosterols, dietary fiber, and natural antioxidants, which collectively contribute to improved cardiometabolic health. Regular intake of plant protein–rich foods has been linked to reduced inflammation, improved lipid profiles, and better glycemic control. The presence of these bioactive constituents enhances the functional value of plant proteins beyond basic nutrition, making them important components of preventive and therapeutic dietary strategies.

3. Antinutritional Factors
Despite their nutritional advantages, plant proteins often contain antinutritional factors that can negatively affect protein digestibility and nutrient absorption. Compounds such as phytates, tannins, lectins, saponins, and protease inhibitors interfere with enzymatic digestion and reduce the bioavailability of proteins and minerals. These antinutritional elements can limit the nutritional efficiency of plant-based diets if not properly addressed. Therefore, appropriate processing methods such as soaking, germination, fermentation, and thermal treatment are essential to reduce these compounds and enhance the overall nutritional quality of plant-derived proteins.

4. Digestibility of Plant-Based Proteins
The digestibility of plant-based proteins is a critical factor determining their nutritional effectiveness and varies widely among different sources. Several factors influence protein digestibility, including the structural complexity of plant proteins, high dietary fiber content, the presence of antinutritional compounds, and resistant starch. Plant proteins are often embedded within rigid cell wall matrices composed of cellulose and hemicellulose, which limit enzyme accessibility during digestion. In addition, compounds such as phytates, tannins, and protease inhibitors interfere with digestive enzymes, resulting in lower digestibility compared to animal-derived proteins.
Various processing techniques have been developed to enhance the digestibility of plant proteins. Thermal treatments such as boiling, roasting, and pressure cooking effectively reduce heat-labile antinutritional factors, including trypsin inhibitors and lectins. Fermentation enhances amino acid availability, decreases antinutrient levels, and improves sensory attributes. Germination activates endogenous enzymes that partially hydrolyze storage proteins, improving digestibility and nutrient bioavailability. Enzymatic hydrolysis further increases solubility and digestibility by breaking peptide bonds, while extrusion processing improves protein functionality and reduces antinutritional compounds, making it particularly useful in producing meat analogues and textured vegetable proteins.

Conclusions

Plant-based proteins represent a promising and sustainable alternative to animal-derived proteins in addressing global nutritional, environmental, and health challenges. They are derived from diverse sources, including legumes, cereals, pseudocereals, nuts, seeds, and novel organisms, each offering unique nutritional and functional properties. Although plant proteins provide important health benefits and bioactive compounds, their nutritional quality is often constrained by imbalanced amino acid profiles, lower digestibility, and the presence of antinutritional factors. However, advances in processing technologies such as fermentation, germination, enzymatic hydrolysis, thermal treatment, and extrusion have demonstrated significant potential in overcoming these limitations. Strategic blending of different plant protein sources can further enhance amino acid balance and overall protein utilization. With continued research, technological innovation, and informed dietary planning, plant-based proteins can effectively complement or partially replace animal proteins, supporting sustainable food systems and improved human health. Their expanded utilization will play a crucial role in meeting future global protein demands while minimizing environmental impact.

References

1. FAO. Dietary protein quality evaluation in human nutrition. FAO Food and Nutrition Paper 92, Rome, 2013.
2. Poore, J. Nemecek, T. Reducing food's environmental impacts through producers and consumers. Science,2018:360:987–992.
3. Willett, W. *et al*. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet,2019:393: 447–492.
4. Satija A. Hu, FB. Plant-based diets and cardiovascular health. Trends Cardiovasc. Med., 2018, 28, 437–441.
5. Young VR. Pellett PL. Plant proteins in relation to human protein and amino acid nutrition. Am. J. Clin. Nutr,1994:59:1203S–1212S.
6. Gilani GS. Xiao CW. Cockell, KA. Impact of antinutritional factors in food proteins on the digestibility of protein and the bioavailability of amino acids and minerals. Br. J. Nutr,2012:108, S315–S332.
7. Sarkar A. *et al*. Emerging trends in processing of plant proteins for food applications. Trends Food Sci. Technol,2021:110:1–15.
8. Day L. Proteins from land plants—potential resources for human nutrition and food security. Trends Food Sci. Technol,2013:32:25–42.