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Plant-based proteins: A review

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Abstract
Plant-based proteins have become central to global dietary transitions due to their sustainable production, affordability, and documented health benefits. Their nutritional value, however, varies widely depending on the source, amino acid composition, presence of antinutritional factors, and digestibility characteristics. This review provides a comprehensive analysis of major plant protein sources—including legumes, cereals, pseudocereals, nuts/seeds, and novel sources—as well as their nutritional profiles and factors influencing digestibility. Advances in processing technologies such as fermentation, germination, extrusion, and enzymatic treatment are also highlighted for their critical role in improving protein quality. The paper concludes that plant-based proteins have strong potential to replace or complement animal proteins, provided that their limitations are addressed through processing and smart dietary combinations.

Keywords: Plant, protein, digestibility, sources, processing

Introduction
Consumer interest in plant-based proteins has grown rapidly due to concerns regarding climate change, global food security, and the health effects of excessive animal-protein consumption. Plant proteins offer numerous advantages, including lower saturated fat levels, the presence of beneficial phytochemicals, and reduced environmental impact. However, challenges such as incomplete amino acid profiles, lower digestibility compared to animal proteins, and the presence of antinutritional factors have limited their optimal utilization. Understanding their sources, nutritional quality, and digestibility is essential for product development and dietary recommendations.

Sources of Plant-Based Proteins
1. Legumes
Legumes are among the richest plant-protein sources. Soybean contains approximately 36–40% protein and is widely used in the form of concentrates and isolates. Pea, chickpea, lentil, mung bean, and faba bean also contribute significantly to global protein intake. Legumes are characterized by high lysine content but are limited in sulfur-containing amino acids (methionine, cysteine).

2. Cereals
Cereal grains such as wheat, rice, corn, barley, and oats contain 7–14% protein. They are typically deficient in lysine but rich in methionine. Wheat gluten is critical in bakery applications due to its viscoelastic properties. Rice protein is hypoallergenic and increasingly used in infant and sports nutrition.

3. Pseudocereals
Quinoa, amaranth, and buckwheat provide high-quality proteins with nearly complete amino acid profiles, including adequate lysine. Their protein content ranges from 12–18%.

4. Nuts and Oilseeds
Peanuts, almonds, walnuts, sesame, sunflower, chia, and flaxseed offer 15–30% protein. They also contain healthy fats, fiber, and antioxidants, contributing to additional health benefits.

5. Novel Sources: Microalgae, Fungi, and Hemp
Microalgae such as spirulina contain 60–70% highly digestible protein. Mycoprotein and hemp offer emerging alternatives with favorable amino acid profiles and functional properties. These sources require advanced cultivation technologies but are promising for future protein systems.

Nutritional Value of Plant-Based Proteins
1. Protein Content and Amino Acid Composition
Plant proteins vary widely in concentration and amino acid balance. Legumes are rich in lysine but low in methionine, while cereals show the opposite trend. Combining these sources achieves a complementary amino acid profile similar to animal proteins.

2. Bioactive Components
Plant proteins contain naturally occurring compounds such as polyphenols, phytosterols, dietary fiber, and antioxidants, which contribute cardiometabolic and anti-inflammatory benefits.

3. Antinutritional Factors
Phytates, tannins, lectins, saponins, and trypsin inhibitors can reduce protein digestibility and nutrient absorption. These compounds must be mitigated through adequate processing.

Digestibility of Plant-Based Proteins
1. Factors Affecting Digestibility
Digestibility is influenced by structural complexity, fiber content, antinutrients, and the presence of resistant starch. Compared to animal proteins, plant proteins often show reduced digestibility due to plant cell wall structures and antinutritional compounds.

2. Processing Methods that Improve Digestibility
- Thermal processing (boiling, roasting, pressure cooking) reduces trypsin inhibitors and lectins.

- Fermentation improves amino acid availability, reduces antinutrients, and enhances flavor.
- Germination (sprouting) activates endogenous enzymes that improve digestibility and nutrient bioavailability.
- Enzymatic hydrolysis increases solubility and digestibility by breaking peptide bonds.
- Extrusion improves functionality and reduces antinutrients, widely used for meat analogs and textured vegetable proteins.

Conclusion

Plant-based proteins provide diverse nutritional and health benefits and represent a sustainable alternative to animal proteins. Their amino acid profiles and digestibility vary by source but can be improved substantially through processing techniques such as fermentation, germination, and enzymatic hydrolysis. Strategic combinations of plant proteins can also yield complete amino acid profiles. Continued research and innovation in processing technologies will further enhance the nutritional quality and consumer acceptance of plant-derived proteins, positioning them as key components of future global food systems.

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