



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 15, Special Issue 1, January 2026

Sustainable Protein Nutrition a Systematic Review of Plant Derived Protein Sources

Manisha Choudhary, Vishakha Bhandari, Viraj Jadhav, Neha Patil

U.G Students, Department of Pharmaceutics, Indala Institute of Pharmacy Kalyan, India

U.G Students, Department of Pharmaceutics, Indala Institute of Pharmacy Kalyan, India

U.G Students, Department of Pharmaceutics, Indala Institute of Pharmacy Kalyan, India

Associate Professor, Department of Pharmaceutics, Indala Institute of Pharmacy Kalyan, India

ABSTRACT: Health-conscious dietary patterns increasingly focus on both nutrient quality and source. Plant-based proteins meet essential nutritional needs while contributing to improved public health outcomes. It plays a central role in tissue building, enzyme and hormone synthesis, immune function, and overall metabolic regulation. Adequate protein intake is essential throughout all stages of life, from infancy to old age, to support normal physiological functions. Dietary proteins are mainly obtained from two major sources: animal-based and plant-based proteins. While animal proteins are considered complete proteins due to their balanced amino acid profile, excessive consumption has been associated with several chronic health conditions, including cardiovascular diseases, obesity, and certain metabolic disorders. Moreover, animal protein production contributes significantly to greenhouse gas emissions, land degradation, and water consumption, thereby increasing the global carbon footprint.

In contrast, plant-derived proteins have gained considerable attention as sustainable, economical, and environmentally friendly alternatives. Plant proteins are primarily obtained from legumes, cereals, pulses, oilseeds, and nuts. These sources not only provide protein but also contribute dietary fiber, vitamins, minerals, and bioactive compounds that promote overall health. Increased intake of plant-based proteins has been linked with reduced risk of chronic diseases, improved gut health, and better metabolic outcomes. As a result, plant proteins are increasingly incorporated into modern dietary patterns, including vegetarian, vegan, and flexitarian diets.

From a functional perspective, plant-based proteins are widely used as important ingredients in food systems. They exhibit diverse functional properties such as water and oil binding capacity, emulsification, foaming, thickening, and gel formation. These characteristics make plant proteins suitable for application in bakery products, meat analogues, dairy alternatives, beverages, and nutritional supplements. In addition to their technological roles, certain plant proteins possess biological activities, including antioxidant, antimicrobial, and anti-inflammatory properties, further enhancing their nutritional significance.

Despite their advantages, plant proteins present several challenges that limit their wider utilization. Compared to animal proteins, many plant proteins exhibit lower digestibility and an imbalanced essential amino acid profile, particularly limiting amino acids such as lysine or methionine. The presence of antinutritional factors like phytates, tannins, and protease inhibitors can further reduce protein bioavailability. Therefore, improving the nutritional quality of plant proteins remains a key area of research. Various protein extraction and processing technologies have been developed to enhance the functionality and digestibility of plant proteins. These include dry fractionation, wet extraction, Enzyme assisted extraction, reverse micelle techniques, and aqueous two-phase systems. Advanced processing methods can help reduce antinutritional factors, improve solubility, and enhance functional properties, making plant proteins more acceptable to consumers.

Overall, plant-based proteins play a crucial role in achieving sustainable nutrition by meeting dietary protein requirements while reducing environmental impact. Continued research and innovation in processing technologies are essential to improve their nutritional quality, functionality, and consumer acceptance, thereby supporting the global shift toward sustainable and health-conscious dietary practices.

KEYWORDS: Sustainability, Plantprotein, Nutrition, Functionality, Extraction.

I. INTRODUCTION

Proteins are high-molecular-weight organic compounds made up of amino acids. They are essential nutrients and cannot be replaced by fats, fibers, or other organic substances. Proteins play an important role in human nutrition as they help in building and repairing body tissues, maintaining muscle mass, supporting immunity, enabling cell signaling, and promoting overall growth and development.

Each protein is made of amino acids, which are the building blocks of the body. Some amino acids can be produced by the human body, while others cannot. These are called essential amino acids and must be obtained from food. A high-quality protein contains sufficient amounts of all nine essential amino acids. Based on amino acid content, proteins are classified into complete proteins, which contain all essential amino acids in proper amounts, and incomplete proteins, which lack one or more essential amino acids.

Proteins are mainly obtained from animal and plant sources. Animal proteins such as milk, eggs, meat, and fish have high biological value. They are easy to digest and are well utilized by the body. However, animal protein production requires more land and water, increases environmental pollution, and has a higher carbon footprint. In addition, food safety issues and diseases have reduced consumer trust in animal-based foods.

Plant proteins are obtained from cereals, pulses, legumes, oilseeds, and nuts. They contain good amounts of essential amino acids, but their digestibility is usually lower due to the presence of fiber and anti nutritional factors such as trypsin inhibitors. These substances reduce protein absorption in the body. However, proper processing methods like heating, fermentation, and enzyme treatment can improve their digestibility and nutritional value.

In recent years, plant proteins have gained more attention because they are renewable, biodegradable, economical, and environmentally friendly. They also have useful functional properties such as emulsifying ability, water-binding capacity, and texture-forming nature. Due to these properties, plant proteins are widely used in food, pharmaceutical, and cosmetic industries. They are also used as wall materials for microencapsulation.

For effective use of plant proteins, suitable extraction techniques are necessary. Traditional methods such as alkaline extraction, solvent extraction, and aqueous extraction are commonly used but often give low yield and may damage proteins. Modern methods like microwave treatment, ultrasound, enzyme-assisted extraction, and high-intensity pulses provide better protein recovery with less damage. These methods are eco-friendly and use fewer harmful chemicals.

With increasing awareness about the disadvantages of animal proteins, research is now focusing on improving plant protein extraction and application. The food industry is also investing in plant-based protein products. Although information is limited, plant proteins have great future potential and can play a major role in meeting global nutritional needs in a sustainable manner.

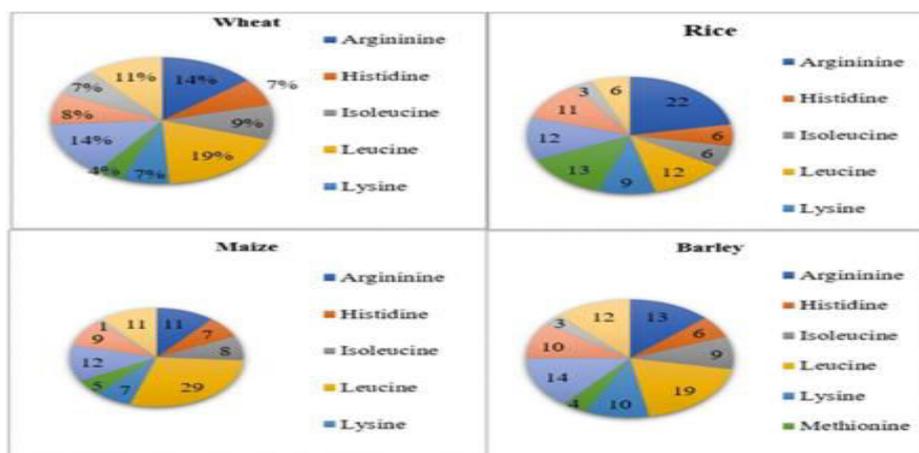


Fig. 1 Amino acid content of plant protein.

II. TYPE OF PLANT DERIVED PROTEIN

Plant-derived proteins are obtained from plant sources and are essential for body growth, repair of tissues, production of enzymes and hormones, and maintenance of good health. They are considered more environmentally friendly and sustainable than animal proteins, making them important for future food security. The main sources of plant proteins include cereals, legumes, oilseeds, nuts, tubers, fruits, and vegetables.

Cereal grains such as wheat, rice, maize, oats, and barley are widely consumed as staple foods and provide moderate amounts of protein. However, cereal proteins are usually low in lysine, an essential amino acid. When cereals are combined with legumes, such as in meals like rice and lentils, they form a balanced source of protein. Legumes like soybean, chickpeas, lentils, and beans are rich in protein and are especially important in vegetarian diets. Soybean contains all essential amino acids, while other legumes are high in lysine but low in methionine.

Oilseeds such as sunflower, sesame, and flax yield protein-rich materials after oil extraction, which are used in food supplements and protein products. Nuts including almonds, cashews, and walnuts provide moderate protein along with healthy fats and antioxidants that support heart and muscle health. Tubers like potatoes contain small amounts of good-quality protein, while fruits and vegetables supply limited protein but contribute essential vitamins, minerals, and protective compounds. Together, these plant sources help meet daily protein needs in a healthy and sustainable way.

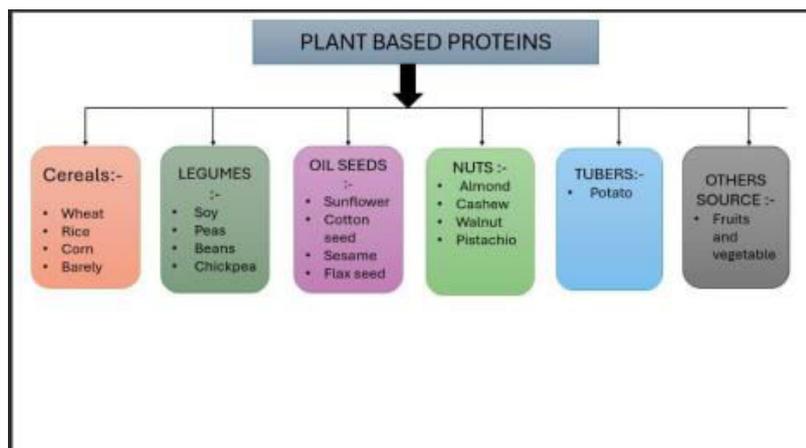


Fig2- Plant based protein derived from different crops

Dietary plant protein quality refers to how effectively plant-based proteins meet the nutritional needs of the human body. It mainly depends on three factors: essential amino acid content, digestibility, and bioavailability. In recent years, plant proteins have gained importance because they are affordable, environmentally friendly, and supportive of sustainable food systems. Animal proteins such as milk, eggs, and meat usually have very high protein quality scores and are considered complete proteins. In comparison, many plant proteins have slightly lower quality scores because they may lack sufficient amounts of one or more essential amino acids. However, this does not mean that plant proteins are nutritionally poor, as their value depends on the overall diet.

Plant proteins usually contain all essential amino acids, but some are present in smaller quantities. For example, cereal grains like rice and wheat are low in lysine, while legumes such as beans and lentils are low in methionine and cysteine. This is known as the limiting amino acid concept. The problem can be solved by combining different plant foods, such as cereals with legumes, which together provide a balanced amino acid profile. Common examples include rice with dal and chapati with chana. Protein digestibility refers to how well the body can break down and absorb proteins. Plant proteins generally have slightly lower digestibility than animal proteins because they contain dietary fiber and anti-nutritional substances such as phytates, tannins, and enzyme inhibitors. These substances interfere with digestion and reduce nutrient absorption. However, traditional processing methods like soaking, sprouting, fermentation, cooking, and extrusion can greatly improve digestibility and increase amino acid availability.

Protein quality is commonly evaluated using methods such as :-

1. Protein Digestibility Corrected Amino Acid Score (PDCAAS)
2. Digestible Indispensable Amino Acid Score (DIAAS).

These methods measure how well a protein meets human amino acid needs after digestion. While individual plant proteins may score lower than animal proteins, this difference becomes less important when a variety of protein sources are included in the diet. A diverse diet helps ensure that all essential amino acids are consumed in adequate amounts.

Glycine is necessary for collagen formation and tissue repair, while glutamine supports muscle and intestinal health. Although these amino acids are not always classified as essential, they are important for normal body function, and plant proteins are valuable sources of them.

Overall, the quality of plant proteins should be judged not only by their amino acid scores but also by their contribution to a balanced and varied diet. With proper food combinations and suitable processing methods, plant proteins can effectively meet human nutritional requirements and serve as healthy, sustainable alternatives to animal proteins.

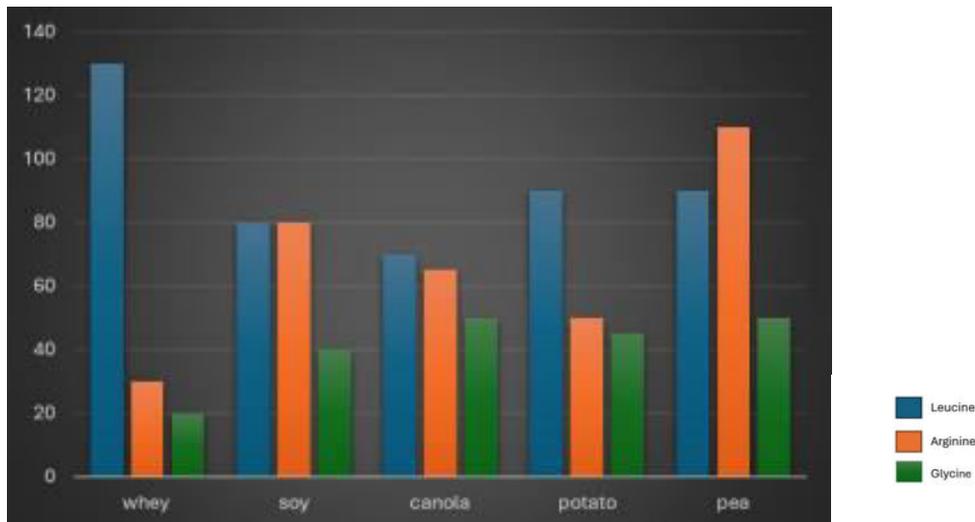


Fig 3:- Comparative Amino Acid Profile of different protein sources

III. DIETARY PATTERNS AND PROTEIN INTAKE

A dietary pattern refers to the regular combination of foods and drinks consumed by an individual, rather than focusing on a single nutrient. Protein intake is strongly influenced by cultural habits, food availability, lifestyle, and health awareness. Adequate protein consumption is especially important for older adults, as it helps prevent muscle loss (sarcopenia). Understanding dietary habits can help in improving daily protein intake and overall health.

Traditional Plant-Based Dietary Patterns

In many countries, particularly India, traditional diets are mainly plant-based. These diets commonly include: Cereals such as rice, wheat, and millets Pulses and legumes Nuts and seeds Fruits and vegetables These foods provide essential nutrients and contribute significantly to daily protein intake when consumed in balanced amounts.

Functions of Dietary Proteins

Proteins play several important roles in the human body. During digestion, proteins are broken down into amino acids, which are necessary for many metabolic processes. These amino acids help in producing energy in the form of ATP, as well as in forming glucose and fatty acids. They are also required for building and repairing body tissues, muscles, organs, and genetic material. In addition, many proteins function as enzymes that speed up chemical reactions essential for normal body functioning. Therefore, proteins are vital for growth, maintenance, and overall health.

Protein Intake Patterns

Research shows that many individuals, including young, middle-aged, and elderly people, consume protein unevenly throughout the day. Most people tend to eat their highest protein meal in the evening. This uneven distribution results in several different intake patterns, with the majority following only a few common ones. Such patterns may affect muscle health and metabolism, especially in older adults.

Recommended Protein Intake

The recommended dietary allowance (RDA) for protein in adults is about 0.8–1.0 g per kilogram of body weight per day. Higher amounts are needed for children, pregnant women, elderly individuals, and athletes. Well-planned plant-based diets can easily fulfill these requirements through: Lentils, beans, and chickpeas Soy products such as tofu and soy milk Nuts, seeds, and whole grains

Modern Dietary Changes

Due to urbanization and changing lifestyles, many people now consume more processed foods and refined carbohydrates. This often leads to poor-quality protein intake or excessive intake from unhealthy sources. However, plant-focused dietary patterns such as vegetarian, vegan, and flexitarian diets are becoming popular because of their health and environmental benefits.

Protein Distribution Across Meals

For better health, protein intake should be evenly spread throughout the day instead of being concentrated in one meal. A balanced meal pattern may include: Breakfast: legumes, nuts, and soy products Lunch: cereals combined with pulses, Dinner: vegetables, legumes, and seeds .This balanced distribution supports better muscle development, improved metabolism, and long-term health.

IV. BIOACTIVE

Plant-based proteins are important functional ingredients in food systems because they can act as thickening and gelling agents, stabilize emulsions and foams, and help bind water and fat in food products. Some of these proteins also possess biological activities such as antioxidant and antimicrobial effects. Their functional behavior depends on their natural structure, which varies among different plant sources and influences their solubility and reactivity during processing. Therefore, suitable dry and wet extraction methods are required to improve protein yield and purity while maintaining their structural integrity and functional properties. Factors such as pH, protein concentration, and ionic strength further affect their performance in food formulations. In addition to technological uses, plant-based proteins provide several health benefits, including antitumor, antioxidant, blood sugar–lowering, blood pressure–regulating, antimicrobial, and cholesterol-reducing effects. These benefits are mainly linked to bioactive peptides released during digestion or enzymatic treatment by enzymes such as pepsin and trypsin. Regular consumption of pulses and legumes has been associated with a reduced risk of chronic diseases, and these bioactive compounds are increasingly used in functional foods, supplements, and nutraceutical products.

BIOACTIVITIES				
Renin inhibitor	Activating ubiquitin-mediated proteolysis	CaMPDE inhibitor	Antiamnestic	Antibacterial
Dipeptidyl peptidase III inhibitor	Antithrombotic	Bacterial permease ligand	ACE inhibitor	Immunostimulating
Immunomodulating	Dipeptidyl peptidase IV inhibitor	Alpha-glucosidase inhibitor	Antioxidative	Anticancer
Regulating	Anti inflammatory	Neuropeptide	Stimulating	Opioid agonist

Fig 4:- Bioactivities of bioactive peptides.

V. PLANT EXTRACTION TECHNOLOGIES

Plant proteins are extracted using both traditional and modern techniques depending on the plant source and the required quality of the final product. Common methods include enzyme-assisted, ultrasound-assisted, alkaline, and high-pressure extraction. Soy protein is often obtained using enzymes and ultrasound to improve yield, while pea protein is mainly extracted through alkaline treatment followed by precipitation. Rice protein is commonly produced using alkaline and enzymatic methods to enhance recovery. Sunflower, pumpkin, and watermelon seed proteins are efficiently extracted using ultrasonic and microwave techniques, which reduce time and energy use while increasing yield. Advanced methods such as pulsed electric fields and green solvents are also used for mushrooms and oilseeds to improve extraction efficiency. Factors like pH, temperature, solvent type, and extraction time

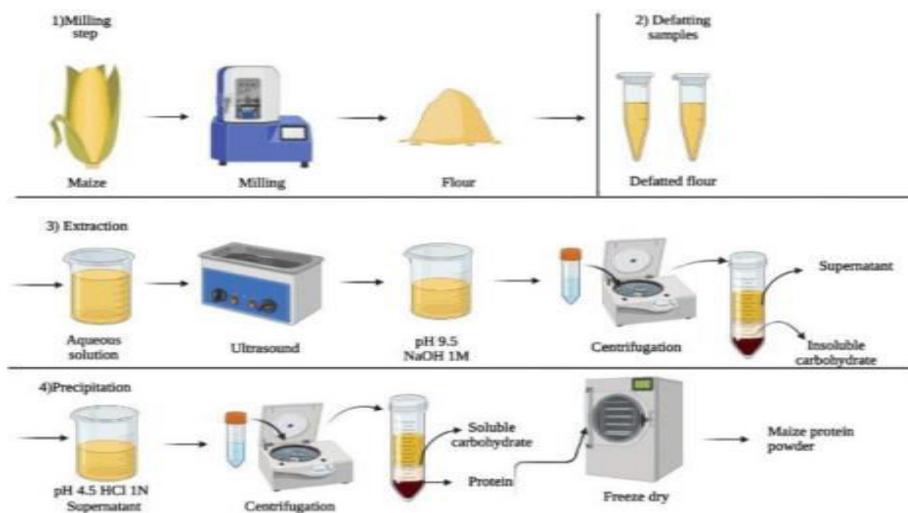


Fig 5:- Methodology for extraction of maize protein

VI. PLANT DERIVED PROTEIN SOURCES

Plant-derived proteins are obtained from a wide range of sources such as legumes, cereals, oilseeds, nuts, pseudocereals, and emerging plant materials. Legumes like soybean, pea, lentil, and chickpea are widely used because of their high protein content and good amino acid balance, while cereals such as wheat, rice, and maize contribute significantly to daily protein intake despite being limited in some essential amino acids. Oilseeds including sunflower, sesame, and peanut provide both protein and healthy fats, whereas pseudocereals like quinoa and amaranth are valued for their nutritional quality and gluten-free nature. In recent years, alternative sources such as algae, mushrooms, and agricultural by-products have gained importance for sustainable nutrition. Technological advancements have led to the development of protein isolates, concentrates, and textured proteins, which improve functionality and expand their use in food products like meat substitutes and supplements. Emerging sources such as leaf proteins and microalgae, along with fermentation techniques, further enhance protein availability and quality. The combined use of traditional and novel plant proteins supports sustainable diets and helps meet future global protein needs.

VII. SIGNIFICATION/NEED

The growing global population, increasing prevalence of lifestyle-related diseases, and rising environmental concerns have intensified the demand for sustainable protein sources. Plant derived proteins play a crucial role in sustainable protein nutrition due to their lower environmental footprint, reduced greenhouse gas emissions, and efficient resource utilization compared to animal-based proteins. As a result, there is an urgent need to evaluate and optimize plant proteins as viable alternatives for meeting human nutritional requirements.

Despite their sustainability advantages, plant proteins often face nutritional challenges such as incomplete indispensable amino acid profiles and lower digestibility. Addressing these limitations is essential to ensure that plant-based diets

provide adequate protein quality for growth, maintenance, and metabolic functions. Strategies such as complementary protein blending, amino acid fortification, and advanced processing technologies are therefore necessary to enhance the nutritional value and bioavailability of plant-derived proteins.

Furthermore, improving plant protein nutrition is significant for global food security, particularly in regions with limited access to animal protein. The development of nutritionally enhanced plant protein products supports affordable, safe, and culturally acceptable dietary solutions.

VIII. CHALLENGE OF NUTRITIONAL VALUE OF PLANT PROTEIN

Plant proteins are widely used as sustainable dietary sources; however, their nutritional quality is often limited by incomplete amino acid profiles and lower digestibility compared to animal proteins. Many plant proteins contain insufficient levels of indispensable amino acids such as lysine, methionine, leucine, tryptophan, or threonine. Cereals are typically deficient in lysine and tryptophan, whereas legumes and vegetable proteins lack adequate sulfur-containing amino acids. These imbalances reduce overall protein quality.

Plant proteins generally show lower digestibility (75–85%) due to the presence of antinutritional factors such as phytates, tannins, enzyme inhibitors, and complex cell wall components. Although protein isolates and concentrates improve digestibility, they are not always consumed in adequate amounts in whole-food-based diets.

Processing and storage conditions also influence plant protein quality. Oxidative changes during processing or storage, especially in rice bran proteins, can negatively affect functional properties. Moreover, short-term studies often report lower muscle protein synthesis following plant protein intake; however, this limitation can be minimized through increased protein intake and targeted amino acid fortification. Overall, improving amino acid balance, digestibility, and processing strategies is essential for enhancing the nutritional value of plant proteins.

IX. CONCLUSION

Plant proteins are an economical and versatile alternative to animal proteins because of their eco-friendly nature. Nowadays, leguminous, cereal and oilseed proteins are utilized as a source of plant-based proteins. Plant protein-based food products rich in plant protein help in body and tissue development for those who follow a vegetarian dietary regime. In addition, due to the growing consumer awareness of the shortcomings of animal proteins, today's research is engrossed in the cost-effective utilization of plant proteins so that they can be better applied. For effective use of plant proteins, energy-efficient protein extraction techniques are required. Scientists today are aiming at non-thermal green technologies (microwave, ultrasound, pulsed electric field, enzyme assisted etc.) to improve extraction efficiency and reduce proteolysis during extraction. These novel techniques have no detrimental impact on the ecological system and the resulting proteins are safe for human use with only small quantities of toxic chemicals and solvents being used. Moreover, not only are food products being developed by using

REFERENCES

1. Akshay s. suri ,Sustainable plant protein : an up-to-data overview sources, extraction techniques and utilization,Journal from sustainable food technology (2023)
2. Y. AbdushevaThe problem of vegetable protein and its solutions ,IOP Conf. Ser.: Earth Environ. Sci., 613 (2020),
3. D. Lin, W. Lu, A. L. Kelly, L. Zhang, B. Zheng ,Interactions of vegetable proteins with other polymers: structure–function relationships and applications in the food industry ,Trends in Food Science & Technology, 68 (2017)
4. A. G. A. Sá, Y. M. F. Moreno, B. A. M. Carciofi ,Plant proteins as high-quality nutritional source for human diet Trends in Food Science & Technology, 97 (2020)
5. F. Mariotti 35 – Plant Protein and Protein Quality Elsevier (2017)
6. Berryman CE, Lieberman HR, Fulgoni VL III, Pasiakos SM. Protein intake trends and conformity with the Dietary Reference Intakes in the United States: analysis of the National Health and Nutrition Examination Survey, 2001–2014. Am J Clin Nutr. (2018)
7. Sá AGA, Moreno YMF, Carciofi BAM. Plant proteins as high-quality nutritional source for human diet. Trends Food Sci Technol. (2020)

8. Sun SS, Liu Q. Transgenic approaches to improve the nutritional quality of plant proteins. *In Vitro Cell Dev Biol Plant.* (2004)
9. Day L. Proteins from land plants—potential resources for human nutrition and food security. *Trends Food Sci Technol.* (2013)
10. Hughes GJ, Kress KS, Armbrrecht ES, Mukherjea R, Mattfeldt-Beman M. Initial investigation of dietitian perception of plant-based protein quality. *Food Sci Nutr.* (2014)
11. A.S. Chandran et al. Sustainable Plant Protein: An up-to-Date Overview of Sources, Extraction Techniques and Utilization Sustain. *Food Technol.*(2023)
12. M. Tan et al. Functional and food application of plant proteins—a review *Food Reviews International*(2023)
13. B. Pam Ismail et al. Protein Demand: Review of Plant protein Used in Alternative Protein Product Development and Production *Anim. Front.*(2020)
14. S.H.M. Gorissen et al. Protein Content and Amino Acid Composition of Commercially Available Plant-Based Protein Isolates *Amino Acids*(2018)
15. L.E. Holt et al. Protein and Amino Acid Requirements in Human Nutrition *Nutr. Abstr. Rev.*(1965)
16. X. Zhao et al. Composition Analysis and Nutritional Value Evaluation of Amino Acids in the Fruit of 161 Jujube Cultivars *Plants*(2023)
17. V. Rao et al. Protein Characteristics, Amino Acid Profile, Health Benefits and Methods of Extraction and Isolation of Proteins from Some Pseudocereals—a Review *Food Prod. Process. Nutr.*(2023)
18. Pojic M, Misan A, Tiwari B. Eco-innovative technologies for extraction of proteins for human consumption from renewable protein sources of plant origin. *Trends in Food Science & Technology.* (2018)
19. Schaafsma G. Advantages and limitations of the protein digestibility-corrected amino acid score (PDCAAS) as a method for evaluating protein quality in human diets. *British Journal of Nutrition.* (2012)
20. Trumbo P, Schlicker S, Yates AA, Poos M. Dietary Reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. *Journal of the American Dietetic Association.* (2002)
21. Watford M, Wu G. Protein. *Advances in Nutrition.* 9: 651-653 (2018)
22. Wen CT, Zhang ZY, Cao LY, Liu GY, Liang L, Liu XF, Zhang JX, Li YD, Yang XQ, Li SG, Ren JY, Xu X. Walnut protein: a rising source of high-quality protein and its updated comprehensive review. *Journal of Agricultural and Food Chemistry* 71: (2023)
23. Wu G. Dietary protein intake and human health. *Food & Function.* 7: (2016)
24. Zaky AA, Simal-Gandara J, Eun JB, Shim JH, Abd El-Aty AM. Bioactivities, applications, safety, and health benefits of bioactive peptides from food and by-products: a review. *Frontiers in Nutrition.* (2022)
25. Pojic M, Misan A, Tiwari B. Eco-innovative technologies for extraction of proteins for human consumption from renewable protein sources of plant origin. *Trends Food Sci Technol.* (2018)
26. Berryman CE, Lieberman HR, Fulgoni VL III, Pasiakos SM. Protein intake trends and conformity with the Dietary Reference Intakes in the United States: analysis of the National Health and Nutrition Examination Survey, 2001–2014. *Am J Clin Nutr.* (2018)
27. Sá AGA, Moreno YMF, Carciofi BAM. Plant proteins as high-quality nutritional source for human diet. *Trends Food Sci Technol.* (2020)
28. Sun SS, Liu Q. Transgenic approaches to improve the nutritional quality of plant proteins. *In Vitro Cell Dev Biol Plant.* (2004)
29. McClements DJ, Grossmann L. A brief review of the science behind the design of healthy and sustainable plant based foods. *NPJ Sci Food.* (2021)
30. Boye J, Wijesinha-Bettoni R, Burlingame B. Protein quality evaluation twenty years after the introduction of the protein digestibility corrected amino acid score method. *Br J Nutr.* (2012)



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details