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Unveiling the Potential of Leaf Proteins

[1] Sagar Kuldeep, [2] Modi R. B., [3] Sardar N. R., [4] Govind P. T., [5] Patel K. N.
[1] M. Tech Scholar, Department of Food Processing Technology, College of Food Processing Technology & Bio-Energy, AAU, Anand.
[2] Assistant Professor, Department of Food Processing Technology, College of Food Processing Technology & Bio-Energy, AAU, Anand.
[3] Senior Research Assistant, Department of Food Processing Technology, College of Food Processing Technology & Bio-Energy, AAU, Anand.
[4] Assistant Professor, Department of Food Processing Technology, College of Food Processing Technology & Bio-Energy, AAU, Anand.
[5] Assistant Professor, Department of Dairy Technology, S.M.C. College of Dairy Science, Kamdhenu University, Anand.
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Introduction

Protein deficiency is one of the major nutritional problems in the developing world. Increasing population in both emerging and developed markets want inexpensive, sustainable, and nutritional protein. Health attributes with a particular focus on increased consumption of plant-based proteins are estimated at USD 14.3 billion in 2024 and projected to grow at a CAGR of 7.5% by 2029. Therefore, aims to identify “new” and reasonably priced sources of plant protein from green leaf biomass. The main protein in green leaves is Rubisco (Ribulose-1,5-bisphosphate carboxylase/oxygenase), which is the most abundant protein in nature. It has good amino acid profile, ranking better than other plant proteins (Anon, 2024; Balfany *et al*., 2023; Ghaly and Alkoaik, 2010; Andersson and Backlund, 2008).

Plant leaf protein sources and its protein content

Green leaves have good number of proteins. High protein yield is obtained by harvesting just before the end of the vegetative growth and beginning of the floral period.

Table 1. Plant leaf and its protein content

Plant leaf	Protein content (%) (w.b.)	Plant leaf	Protein content (%) (w.b.)
Wheat grass	12.5	Amaranth	2.46

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Drum stick	9.40	Sugar beet	2.20
Alfalfa	3.99	Cabbage	1.28
Pumpkin	3.15	Olive	1.03
Spinach	2.86		

(USDA, 2019)

Nutritional aspects of leaf protein

Various nutritional benefits of consumption of leaf protein are reported by (Balfany *et al*., 2023).

- Green leafy proteins almost meet the FAO definition of a complete protein.
- High source of antioxidants, can offer anti-inflammatory, anti-aging, anti-cancer and blood sugar benefits.
- Low allergenicity makes it suitable for individuals with sensitivities.
- Good potential for weight management.

2. Process for extraction of protein from green leaves

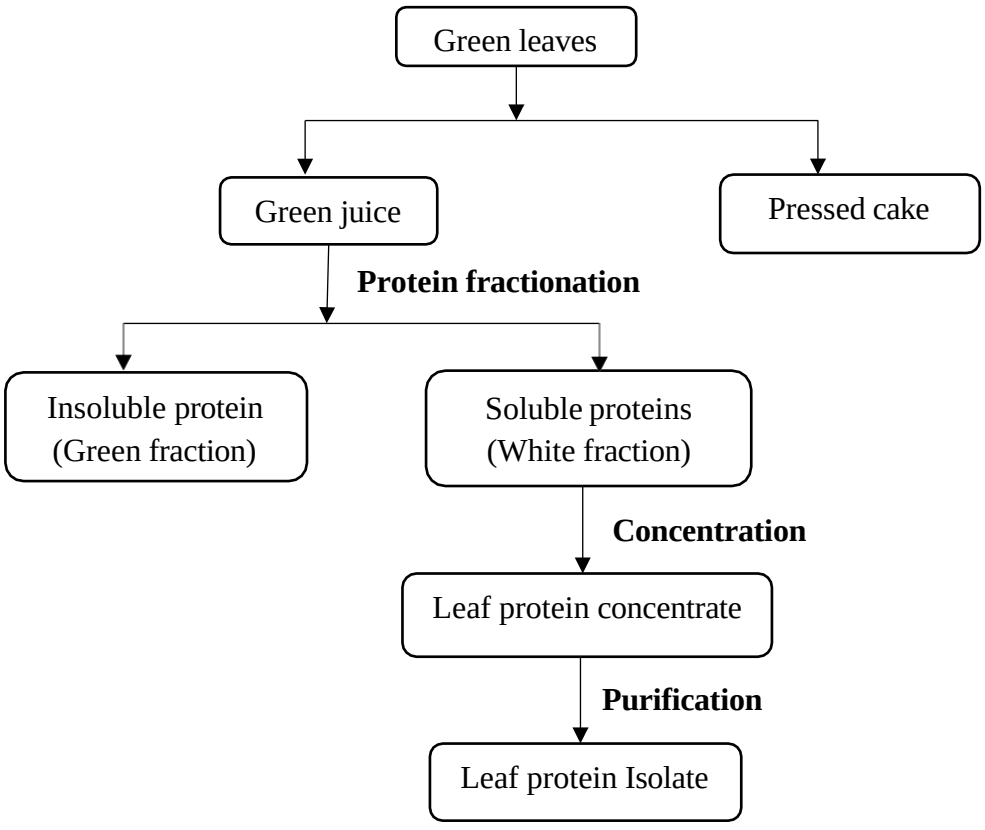

Fig. 1. Flow chart for leaf protein extraction

(Pérez-Vila *et al*., 2022)

3. Factors affecting leaf protein content and quality

The factors affecting the quantity and quality of leaf protein are as follows (Ghaly and

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Alkoaik, 2010).

- Significant variations in the protein production due to the diverse metabolic systems of various species.
- Fast growth ensures a succulent plant, allowing proteins to be released and cells to break easily.
- Large yields are obtained from species that regrow very well over a long growth period.
- lowering of protein yields were shown to be due to sulfur, phosphorus, potassium and magnesium deficiencies.
- Nitrogen which promotes abundant succulent growth and improves the extraction rate by promoting luxurious plant growth.
- High protein yield is obtained by harvesting just before the end of the vegetative growth and beginning of the floral period.

4. Novel technologies used for leaf protein extraction

To overcome the limitations in protein extractions from plant leaves, various novel technologies have been studied as mentioned below: (Balfany *et al*., 2023; Kumar *et al*., 2021; Sari *et al.*, 2013; Boye *et al.*, 2010; Tang *et al.*, 2010; Gachovska *et al.*, 2006).

1. Alkaline Extraction
2. Enzyme-assisted extraction
3. Ultrasound-assisted extraction (Sonication)
4. Pulse electric field-assisted extraction
5. Heat Precipitation
6. Acid precipitation (Isoelectric)
7. Ultrafiltration

5. Functional properties of leaf protein

Leaf proteins possess various functional properties useful for food processing as explained underneath (Balfany *et al*., 2023; Martin *et al.*, 2019; Lamsal *et al.*, 2005).

1. Solubility

Solubility of leaf protein was minimum in the pH range close to the isoelectric point of Rubisco (pH of 3.5–5.0) and reaches maximum solubility at pH 9–11.

2. Gelation

Leaf proteins form strong gel networks at 70-90 °C with lower concentrations (2–10%).

3. Foaming and Stability

Green leaf proteins form better foams at lower pH 2–3 than neutral pH 7.

4. Emulsifying properties

Leaf proteins have good emulsifying properties than other plant proteins.

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6. Applications of leaf protein

- Protein fortification
- Meat analogues and plant-based products
- Functional food ingredients
- Nutritional supplements
- Biopolymer development

7. Case studies

1. Agbede *et al.* (2008) reported that *Telfairia occidentalis* leaf protein concentrate supplemented infant foods increase the weight and have a similar protein efficiency ratio as in commercial foods.
2. Shah *et al.* (1980) studied on comparison of leaf protein concentrate fortified dishes and milk as supplements for children with nutritionally inadequate diets.
3. Okoth *et al.* (2017) worked on the characterization of the nutritional quality of amaranth leaf protein concentrates and suitability of fish meal replacement in Nile tilapia feeds.

8. Challenges against extraction of protein from plant leaf

1. Oxidation and proteolytic reactions
2. Presence of antinutritional and other undesired compounds
3. Maximizing extraction yield
4. Extraction process effect on functional properties

(Pérez-Vila *et al*., 2022)

9. Conclusion

Protein deficiency is one of the major nutritional problems in the developing world. World's population will grow from the current 6.7-9.2 billion by the year 2050 that demands more protein which is affordable, sustainable and nutritious to reduce malnutrition. The rising popularity of vegan and vegetarian diet have increased the demand for plant-based protein. Leaf protein can be an alternative protein source that can fulfill the requirement of daily protein intake that too with better digestibility, biological value and functionality. Fortification of LPC in current food formulations and development of new LPC based food can pave road for new era of research & development and commercialization.

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