RESEARCH PAPER

Natural Fatty Acids from Seeds of Plants: Sources, Composition, Extraction Techniques, and Biological Importance

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ABSTRACT
Plant seed oils contain a good supply of natural fatty acids and especially saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), including important essential omega-3 fatty acids (Ω-3) and omega- 6 fatty acids (Ω-6). These fatty acids impact the metabolic, cardiovascular, membrane-structure, and inflammatory-modulation. The current review is a synthesis of the recent studies (2021-25) on the variety of plant seed oil sources, comprehensive compositional patterns, recent developments in extraction technologies, and described biological effects. New food, nutraceutical and industrial applications are presented, and research focus in the future. The importance of seed oils in nutrition and sustainable use of bioresources is emphasized by the recent developments.
Keywords: Omega-3, omega-6, extraction technology, nutritional relevance, plant seed oils, fatty acid composition.
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1. INTRODUCTION

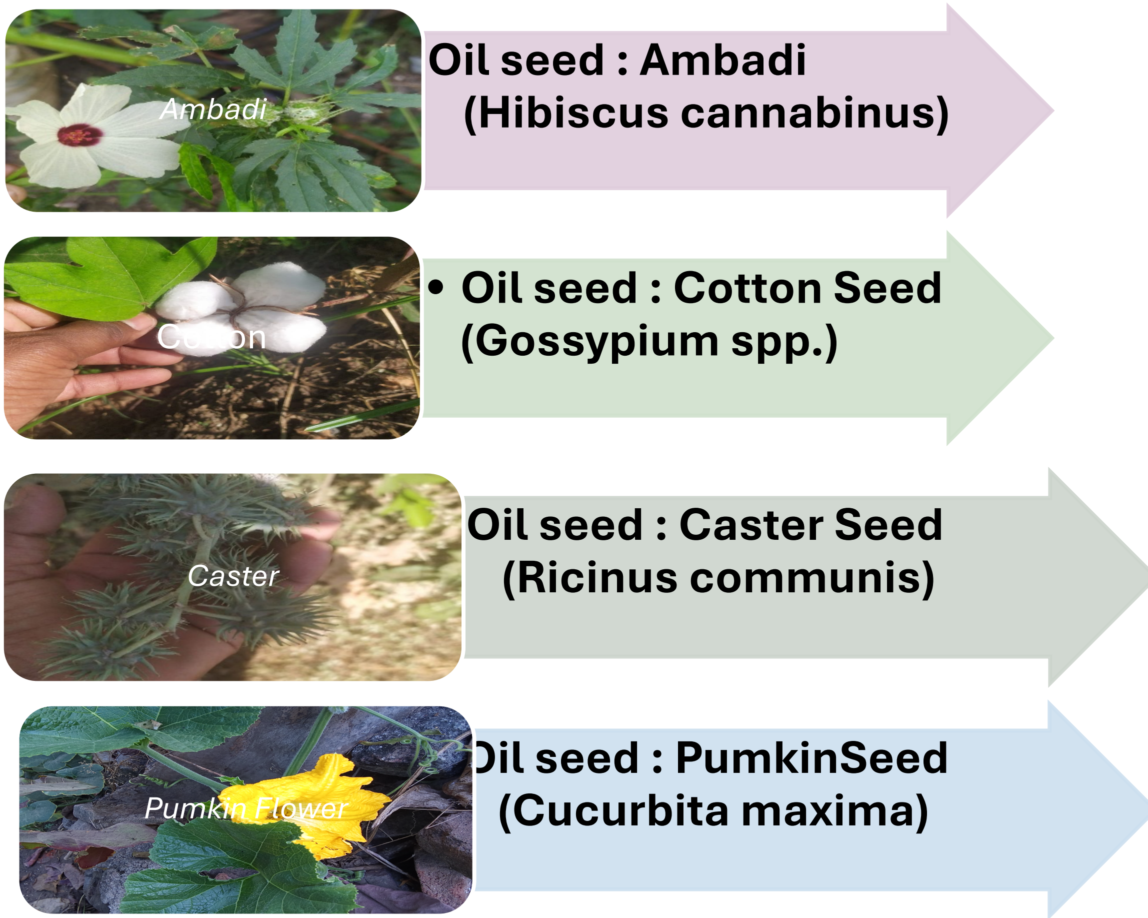
The fatty acids are long hydrocarbon chain carboxylic acids and form the major part of plant seed oils. They are mostly in triacylglycerol form, and are categorized by the saturation: SFAs, MUFAs, and PUFAs. Critical PUFAs like linoleic (LA, ω-6) and elliptic acid (ALA, ω-3) cannot be produced in people and have to be absorbed in the diet (Saini and Keum, 2018). PUFAs are important in membrane fluidity, signal transduction and in biosynthesis of eicosanoids that control inflammation and immunity. In recent decades, there has been an increase in the number of studies focused on the use of plant seed oils in health promotion, functional foods, and sustainability (El-Saadony et al., 2025).

2. PLANT SEEDS: SOURCES OF NATURAL FATTY ACIDS.

The composition of plant oils and fatty acids in plant seeds is highly differentiated depending on the genetics of the species, climate, and practices in the cultivation.

2.1 Conventional Oilseed Crops

The soybean (Glycine max), sunflower (Helianathus annuus),canola (Brassica napus), and sesame are major sources of dietary PUFAs and MUFAs, which are major globally cultivated seeds (Zio et al., 2025). These oils are used in the culinary and industrial fields.



2.2 Functional and Specialty Seeds.

Balanced ratios of omega-6/omega-3 that would assist in maintaining metabolic health are notably found in functional seeds such as flax (Linum usitatissimum) and chia (Salvia hispanica), and balanced ratios of 80.1:1 are found in hemp (Cannabis sativa) and perilla (Perilla frutescens) seeds (PMC12641930, 2025). The seed oil of Camelina (Camelina sativa) has also high ALA levels and is found as a dietary supplement (Wikipedia: Camelina oil).

2.3 Underutilized and New Seed Resources.

The Grape seed oil (Vitis vinifera) shows substantial inter-cultivar differences in the content of PUFA, indicating possible industrial and nutritional importance (Poureshaghi et al., 2025). There are also other by-products and non-used seeds like pomegranate and wild cucurbit seeds that provide new sources of fatty acids and valorization opportunities (Manzari Tavakoli et al., 2025; Reference-Global, 2025).

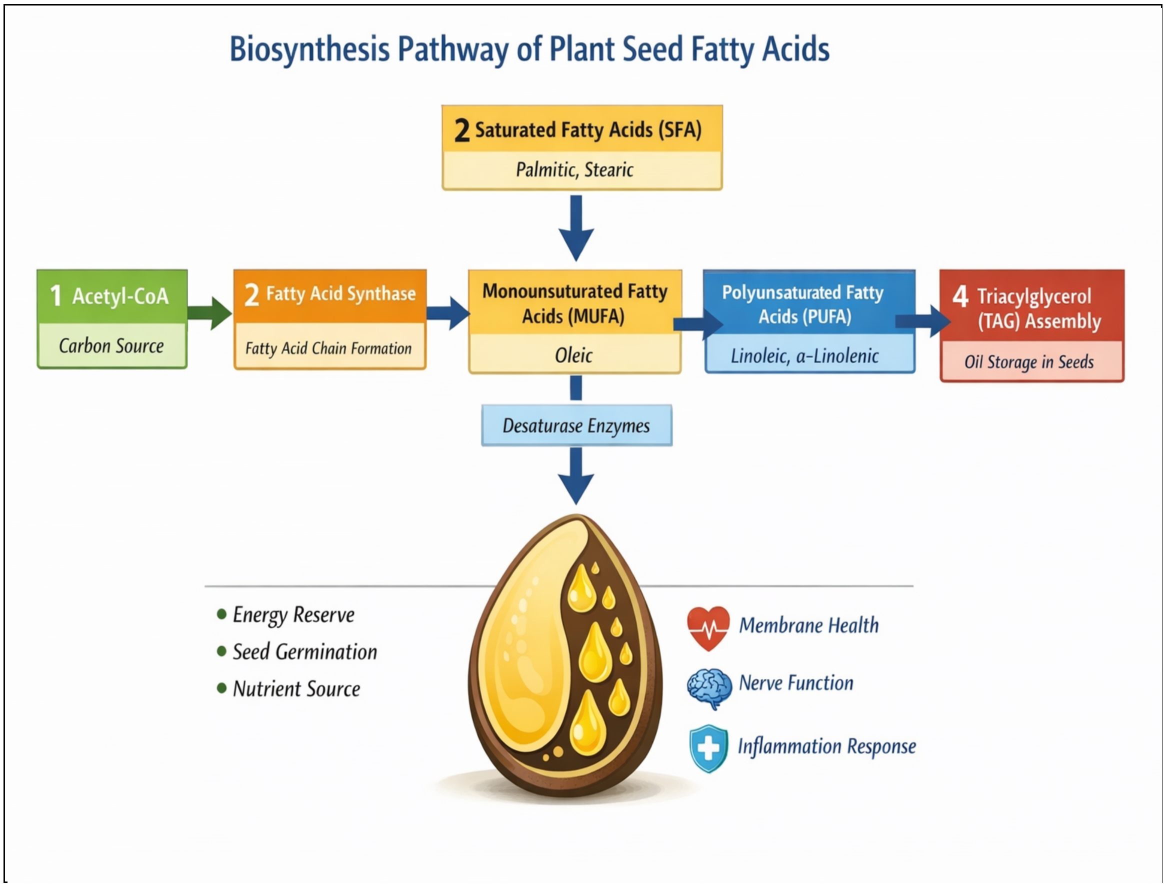


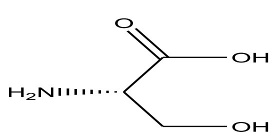
Fig1: synthesis pathway of plant seed fatty Acids.

3. FATTY ACID COMPOSITION OF PLANT SEED OILS

			
Ambadi Seed (Hibiscus cannabinus)	Caster Seed (Ricinus communis)	Pumkin Seed (Cucurbita maxima)	Cotton Seed (Gossypium spp.)

3.1 Saturated Fatty Acids (SFA)

Palmitic acid



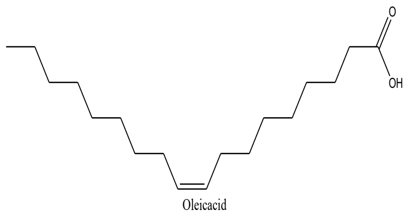
seric acid

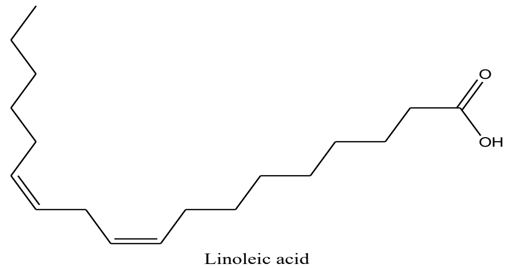
arachidic acid

Palmitic acid (C16:0) Steric acid(C18:O) Arachidic acid (C20:0)

Common SFAs include palmitic (C16:0) and stearic (C18:0) acids, which contribute to oil stability but are less favorable for cardiovascular health at high dietary intakes.

3.2 Monounsaturated Fatty Acids (MUFA)





Oleic acid (C18:1n9c) Linoleic acid (C18:2n6c)

Oleic acid (C18:1) is a predominant MUFA that confers oxidative stability and is associated with beneficial lipid profiles. Higher oleic content is desirable in both health and industrial contexts.

3.3 Polyunsaturated Fatty Acids (PUFA)

PUFAs encompass LA (ω-6) and ALA (ω-3), which are integral to human physiology. Seed oils differ widely in PUFA proportions (e.g., up to ~64% in hemp, ~30% in camelina) and the balance between ω-6 and ω-3 significantly affects biological outcomes (Reference-Global, 2025; Wikipedia: Camelina oil).

Table 1. Typical Fatty Acid Profile (%) in Selected Seed Oils (Literature-Derived)

Seed Oil	SFA (%)	MUFA (%)	PUFA (%)	Major Fatty Acids
Camelina	~20	15–20	60–65	ALA, LA, Oleic: Camelina oil)
Grape Seed	21–78	3.7–16.8	17.9–62.1	LA dominant (Poureshaghi et al., 2025)
Hemp Seed	~10	~10	~80	LA, ALA (-Global, 2025)
Flaxseed	~10	~20	~70	ALA dominant (PMC12641930, 2025)

4. Technologies for Oil Extraction

4.1 Conventional Techniques

4.1.1 Solvent Extraction

The solvent extraction by hexane is still extensively used in industries since it yields high oil, however, the solvent remnants, energy consumption, and deterioration of PUFA are still of concern (El-Saadony et al., 2025).

4.1.2 Cold Pressing

Mechanical cold pressing preserves bioactive compounds and fatty acid integrity, although yields are lower than solvent methods.

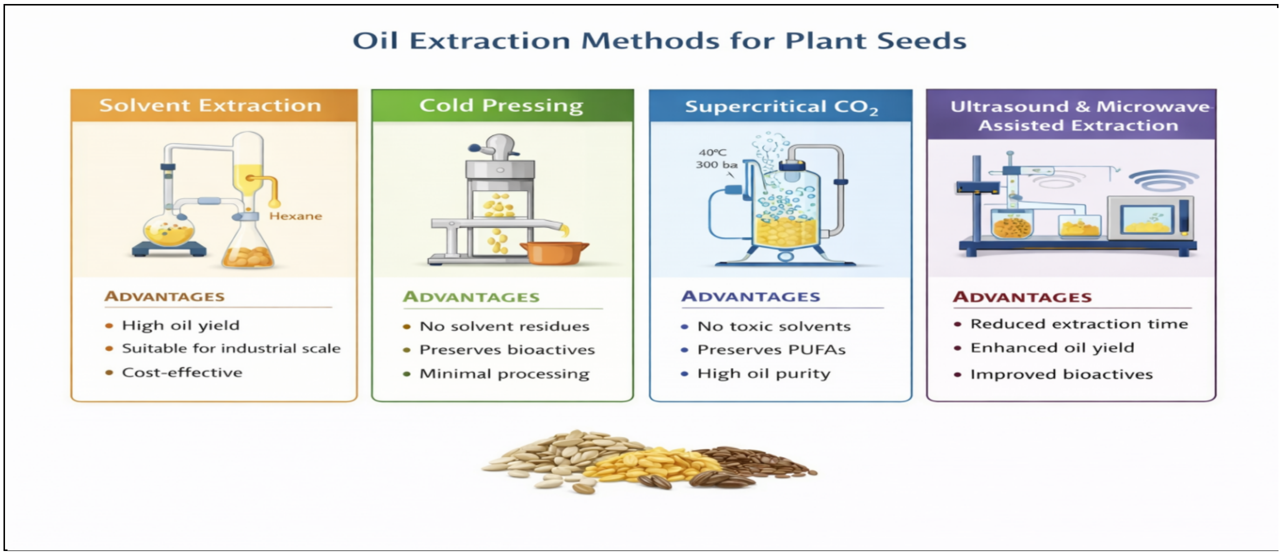


Fig:2 Oil Extraction methods for plant seed

4.2 Emerging and Green Extraction Methods

4.2.1 Supercritical CO_2 Extraction (SFE)

SFE offers high selectivity and avoids toxic solvents, yielding oils that better retain PUFA and antioxidant compounds.

4.2.2 Ultrasound- and Microwave-Assisted Extraction

These assisted methods improve extraction efficiency and reduce processing time. Their adoption is increasing for nutraceutical and functional oil production.

Table 2. Comparison of Key Seed Oil Extraction Techniques

Extraction Method	Yield	PUFA Integrity	Environmental Impact	Suitability
Solvent (Hexane)	High	Moderate	Poor	Industrial
Cold Pressing	Moderate	High	Good	Edible/Functional
SFE	High	Very High	Excellent	Nutraceutical/Bioactive
UAE/MAE	Moderate–High	High	Good	Specialty Oils

5. BIOLOGICAL IMPORTANCE OF SEED FATTY ACIDS

5.1 Nutritional and Clinical Benefits

PUFAs, especially ALA and LA, are linked with reduced cardiometabolic risk factors, improved lipid profiles, and favorable insulin sensitivity (Dean et al., 2025; turn1news20). Findings suggest higher linoleic acid—common in seed oils—may correlate with lower inflammation and diabetes risk in population studies (turn1news20).

5.2 Antioxidant and Anti-Inflammatory Effects

Seed oils often contain tocopherols, phenolics, and sterols that contribute antioxidant and anti-inflammatory activities, mitigating oxidative stress and chronic inflammation. Phenolic content also supports cardioprotective outcomes.

5.3 Functional and Industrial Applications

Beyond food, seed fatty acids are valuable for pharmaceuticals, cosmetics, and biodegradable industrial materials.

6. CONCLUSION

Plant seed oils are a sustainable and biologically useful inexpensive natural source of fatty acids that have broad nutritional, therapeutic, and industrial uses. They have abundant and varied fatty acid profiles, especially the essential polyunsaturated fatty acids (linoleic and α-linolenic acids) that make them essential in the maintenance of metabolic health, cardiovascular activity, immune balance and cellular integrity. There is growing scientific evidence of the health benefits of substituting saturated and trans fats with unsaturated fatty acids of seed origin in the human diet partially in the prevention of chronic diseases such as cardiovascular diseases, metabolic syndrome, and inflammatory diseases.

Recently, the developments of extraction methods, especially green and solvent-free methods like supercritical CO 2 extraction, ultrasound-assisted extraction, and microwave-assisted extraction have been very effective in enhancing the yield of oil, the purity of the oil and the preservation of the thermolabile bioactive compounds. The advantages of these innovations are the fact that besides improving the nutritional value of the seed oils they are also in line with the requirements of environmental sustainability and clean label in the food and nutraceutical sector. In addition, the increasing demand of underutilized and agro-industrial by-products seeds has provided novel possibilities of resource valorization, waste minimization, and economic diversification in the sustainable agricultural systems.

In spite of these developments, there are still problems of maximizing fatty acid stability, maintaining consistent proportions of omega-6 and omega-3 fatty acids, as well as harmonising extraction and quality-control procedures in various sources of seeds with each other. Future studies ought to focus on integrative methods that involve plant breeding, biotechnological interventions and high level tools of analysis in order to improve on the quality and functionality of oil. Moreover, clinical and epidemiological studies should be designed in a way that supports health claims and provides evidence-based dietary recommendations.

To summarize, plant seed oils have a bright future of strategic use in the area of enhanced human health, sustainable food production, and greener applications in the industry. Further interdisciplinary research and technological breakthrough will be necessary to achieve full harnessing of natural fatty acids produced by the seeds of plants in the achievement of global nutritional and sustainability objectives.

REFERENCES

1. Dean, L. L., et al. (2025). Lipid composition and nutritional quality of some seed oils and their health effects. *Frontiers in Nutrition*. https://doi.org/... (turn1search18)
2. El-Saadony, M. T., et al. (2025). Plant bioactive compounds: extraction and biological activities—A comprehensive review. *Frontiers in Nutrition*. (turn1search13)
3. Mukherjee, T. (2025). Metabolic flux analysis related to seed oil biosynthesis. *Plant Physiology*. (turn1search14)
4. Poureshaghi, F., Eghlima, G., Khanmohammadi, D., et al. (2025). Variability in seed oil content and fatty acid profile of Iranian grape cultivars. *Scientific Reports*. https://doi.org/... (turn1search1)
5. PMC12641930. (2025). Fatty acid composition and health benefits of selected seed oils. *PMCID*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC12641930/ (turn1search0)
6. Reference-Global. (2025). Macronutrient and fatty acid content in selected seeds. (turn0search13)
7. Saini, R. K., & Keum, Y. S. (2018). Omega-3 and omega-6 polyunsaturated fatty acids. *Life Sciences, 203*, 255–267.
8. Zio, S. (2025). Nutritional and therapeutic interest of plant oils. *ScienceDirect*. (turn1search11)