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Review Article

Phytochemistry, Nutritional Value and Therapeutic Potential of Pumpkin (*Cucurbita spp,*) seeds: An Integrative Review

Dr Anamika Dixit [1], Ripshita Singh Tomar [2], Dr Alka Katiyar [1], Dr Aamena Zaidi [1*]
Dr. Neha Shukla [1]
[1]Assistant Professor, School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar Pradesh, India
[2] School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur, Uttar Pradesh, India

Corresponding Author: *Dr Aamena Zaidi

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Abstract

Introduction: Pumpkin seeds, also known as pepitas, are small, flat, green seeds found inside pumpkins. They are a popular snack and ingredient in various cuisines around the world. Rich in essential nutrients, pumpkin seeds are an excellent source of protein, healthy fats, fiber, and antioxidants. They also contain important minerals like magnesium, zinc, and iron. Consuming pumpkin seeds may support heart health, improve sleep, and boost the immune system. These seeds can be eaten raw, roasted, or added to dishes like salads, granola, or baked goods. Their mild, nutty flavour makes them a versatile addition to many meals. In traditional medicine, they've been used to treat a variety of ailments. Pumpkin seeds are not only nutritious but also easy to store and enjoy year-round.

Objective: The primary objective of this study was to compile and analyse existing scientific literature on the phytochemical composition, nutritional value, and therapeutic potential of pumpkin (Cucurbita spp.) seeds and also to highlight gaps in current research and suggest future directions for in-depth studies on pumpkin seed bioactivity and therapeutic efficacy.

Methods: A comprehensive literature search was conducted using electronic databases such as PubMed, Science Direct, Scopus, Google Scholar, and Web of Science. Keywords and phrases used included: "pumpkin seeds," "Cucurbita spp.," "phytochemistry," "nutritional value," "bioactive compounds," "therapeutic potential," "medicinal properties," and "functional food."

Results: The review revealed that pumpkin seeds are rich in diverse phytochemicals, including phenolic acids, flavonoids, sterols, squalene, and tocopherols, which contribute to their antioxidant and anti-inflammatory properties. Nutritional analysis across multiple studies showed that pumpkin seeds are an excellent source of plant-based protein, healthy fats (particularly unsaturated fatty acids), dietary fiber, and essential minerals such as magnesium, zinc, iron, and phosphorus.

Discussion: The therapeutic potential of the seeds is supported by evidence indicating antioxidant, antimicrobial, antiparasitic, antihyperglycemic, cardioprotective, and prostate health-promoting effects. Furthermore, traditional uses in folk medicine for treating urinary disorders and intestinal parasites were validated by several pharmacological studies. The results suggest that pumpkin seeds have significant potential as a functional food and natural therapeutic agent, though further clinical research is needed to confirm long-term health benefits and safety.

Conclusion: In conclusion, pumpkin seeds have significant promise as a functional food and nutraceutical ingredient. However, more standardized, large-scale clinical studies are needed to fully establish their therapeutic efficacy, optimal dosages, and long-term safety. Promoting their inclusion in the human diet could contribute meaningfully to preventive healthcare and nutrition-based wellness strategies.

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1. INTRODUCTION

Pumpkin seeds (Cucurbita spp.) have long been consumed as a traditional snack and medicinal food in diverse cultures, but only recently have they attracted systematic scientific attention as nutrient-dense functional ingredients [1–3]. Belonging to the family Cucurbitaceae, species such as C. pepo, C. moschata, and C. maxima are widely cultivated for both edible seeds and oil production [4,5]. Seeds typically contain 25–37% protein, 30–50% fat rich in polyunsaturated fatty acids, and substantial levels of minerals such as magnesium, zinc, and iron [6–8].

Beyond their macronutrient profile, pumpkin seeds provide bioactive compounds including tocopherols, carotenoids, phytosterols, phenolic acids, and squalene, contributing to antioxidant, anti-inflammatory, anti-diabetic, and cardioprotective properties [9–12]. Clinical and preclinical data have further highlighted their potential role in ameliorating benign prostatic hyperplasia (BPH), improving lipid functional effects, demonstrating metabolism, and supporting reproductive health [13–16].

Despite these findings, a comprehensive synthesis of their nutritional composition, bioactive profile, therapeutic benefits, and processing effects is still limited. This review systematically consolidates existing data to:

1. Characterize the nutrient and bioactive content of pumpkin seeds.
2. Summarize therapeutic and in vitro, in vivo, and in human studies;
3. Evaluate processing and storage impacts on nutrient stability; and
4. Identify research gaps and future directions in pumpkin seed utilization as a functional food and nutraceutical.

METHODOLOGY

Literature Search

A structured literature search was conducted in PubMed, Scopus, Web of Science, and Google Scholar (2000–2025) using combinations of the following keywords: "pumpkin seeds" OR "Cucurbita pepo" OR "Cucurbita moschata" OR "Cucurbita maxima" AND (nutritional OR therapeutic OR bioactive OR phytochemical OR health effects).

Inclusion and Exclusion Criteria

Inclusion: Peer-reviewed research articles, reviews, and clinical studies reporting on composition, processing effects, or therapeutic activities of pumpkin seeds or their oil.

Exclusion: Studies on pumpkin flesh without seed data, patents without supporting data, or non-English articles without accessible translations.

Data Extraction and Organization

Data on macronutrients, micronutrients, fatty acid profiles, phytosterols, phenolics, tocopherols, and health-related effects were extracted. For therapeutic aspects, in vitro, animal, and clinical evidence were categorized separately. Quantitative values (protein %, fatty acid %, mineral content mg/100 g) were compiled to populate summary tables.

Quality Assessment

The methodological quality of studies was assessed based on:

1. Sample size and experimental controls,
2. Analytical techniques (e.g., GC-MS, HPLC, ICP-MS),
3. Statistical robustness and reproducibility,
4. Clinical trial registration or ethical approval (for human studies).

Table 1: Nutritional Composition of Pumpkin Seeds

Component	Typical range per 100g (dry basis)	Key references
Moisture (%)	4-7	1,2,3
Protein (%)	25- 37	1,4,5
Total fat (%)	30-50	1,4,6
Carbohydrates (%)	10-20	1,3,7
Dietary fibre (%)	4-6	2,8
Magnesium (mg)	400-600	1,10,11
Potassium(mg)	800-950	3,11
Vitamin E(mg)	20-40	8,14

Table 2: Fatty acid profile and bioactive compounds of pumpkin seeds

Component	Typical range	References
Linoleic acid(C18:2)	40-63% of total fatty acids	1,3
Oleic acid (C 18:1)	20-40% of total fatty acids	1,4
Palmitic + stearic acids	10-15% of total fatty acids	2,5
Phytosterols	180- 260 mg/100g	4,7
Total phenolic compounds	20-50mg GEA/g	5-8
Squalene + minor sterols	10-30 mg/100mg	

Table 3: Therapeutic and bioactive effects of pumpkin seeds

Effect/ Activity	Key findings/ active components	References
Antioxidant active	High phenolic and tocopherol content; reduces oxidative stress markers	1,3
Antimicrobial effects	Extracts inhibit bacterial and fungal growth	2-4
Prostate health/ BPH management	Phytosterols improve urinary flow and reduce prostate volume	4,7
Anti- diabetic effects	Improves insulin sensitivity, lowers blood glucose	5,8
Cardio-protective activity	Unsaturated fatty acids lower LDL and raise HDL	6,9

Nutritional Composition of Pumpkin Seeds

Macronutrient Profile

Pumpkin seeds are nutritionally dense. Typical dry matter includes approximately 6% moisture, 35–50% lipids, 25–37% protein, 18–25% carbohydrates, 3–6% dietary fibre, and 3–5% ash levels, demonstrating their efficiency as energy and nutrient sources 31,32. Variability exists across species: C. maxima seed often display higher fat content compared to C. pepo and C. moschata, while protein ranges similarly across species.33,34

Vitamins and Mineral Content

These seeds are rich in essential minerals—magnesium (400–600 mg/100 g), phosphorus (900–1100 mg/100 g), zinc (6–9 mg/100 g), and iron (8–12 mg/100 g)—making them a valuable dietary mineral source35,36. They also contain α- and γ-tocopherols (vitamin E) in notable amounts (up to 40 mg/100 g), with γ-tocopherol often being dominant.33

Fatty Acid Composition

Pumpkin seed lipids are primarily polyunsaturated, with linoleic acid (36–63%) and oleic acid (17–40%) as the key fatty acids, followed by palmitic and stearic acids.31,34 In certain cultivars like those producing Styrian oil, polyunsaturated fatty acids (PUFAs) range from 52% to 57%, coupled with high γ-tocopherol content (~633 mg/kg)—highlighting their potential antioxidant value38

Phytosterols, Squalene, and Phenolics

Pumpkin seeds contain significant levels of phytosterols, especially β-sitosterol (25 mg /100g), squalene (89 mg/100 g), and total tocopherols reaching ~16 mg/100 g, underlining their health-promoting lipid fraction.39. Phenolic compounds, including vanillin, tyrosol, luteolin, and sinapic /vanillic acids, vary between 25–51 mg/kg of seed oil and contribute to antioxidant activity.40

Species, Processing & Cultivar Variability

Seed composition varies significantly across species, cultivars, and processing methods. For example, C. maxima seed oils showed 27.5 mg GAE/g phenolics, whereas total tocopherols varied between cultivars 38. Processing techniques, such as enzymatic extraction, influence both fatty acid yield and antioxidant functionality—C. Moschata oil via enzymatic methods displayed improved antioxidant and anti-aging bioactivity compared to commercial oils. 41..

Therapeutic and Bioactive Effects of Pumpkin Seeds

Cardiovascular Protection

Pumpkin seed oil (PSO) and protein fractions exhibit significant lipid-lowering and antihypertensive properties. Clinical and preclinical studies show PSO reduces LDL-cholesterol while increasing HDL-cholesterol, attributed to its phytosterols, PUFAs, and antioxidants 43. In hypertensive animal models, PSO supplementation lowered systolic blood pressure and oxidative stress markers, likely due to its γ-tocopherol and linoleic acid content.44,45

Antioxidant and Anti-Inflammatory Effects

The phenolic profile and tocopherols in pumpkin seed oil confer free-radical scavenging activity. In vitro studies reveal significant DPPH and ABTS radical inhibition, while in vivo supplementation reduces lipid peroxidation and *inflammatory cytokines (TNF-α, IL-6). 46,47. Tocopherols and squalene enhance protection against oxidative damage in hepatic and renal tissues.48

Anti-Diabetic and Metabolic Benefits

Bioactive peptides derived from pumpkin seed protein hydrolysates improve glucose uptake, inhibit α-amylase and α-glucosidase, and enhance insulin sensitivity in experimental models 49,50. Long-term dietary intake of pumpkin seeds helps modulate glycaemic response, possibly via magnesium and high-quality protein fractions 51

Urological Health and Benign Prostatic Hyperplasia (BPH)

Pumpkin seed extracts (particularly from C. pepo) are widely studied for BPH symptom relief. Randomized controlled trials demonstrate improvements in urinary flow rate, post-void residual volume, and International Prostate Symptom Score (IPSS) after 12 weeks of PSO supplementation52,53 Mechanistic studies attribute these effects to Δ7-sterols and β-sitosterol, which inhibit 5-α-reductase and modulate androgen metabolism 54

Anti-parasitic and Gastrointestinal Effects

Traditional medicine reports pumpkin seeds as an effective vermifuge against intestinal parasites. Clinical observations in schoolchildren confirm decreased helminth egg counts after pumpkin seed consumption, with cucurbitacin's disrupting parasite metabolism 55.

Hepato-protective and Renoprotective Actions

Supplementation with PSO reduces hepatic enzyme leakage (ALT, AST) and renal oxidative stress, protecting against drug-

or toxin-induced organ damage 56. Bioactive fractions enhance GSH levels and normalize lipid peroxidation markers 57

Neuroprotective and Anti-Aging Potential
Emerging data highlight PSO's ability to mitigate cognitive decline in oxidative stress models. Tocopherols and phenolic acids protect neuronal cells by decreasing ROS generation and upregulating antioxidant enzymes 58,59.

Broader context and supplementary literature
While pumpkin seeds (Cucurbita pepo, C. maxima, C. moschata) are the primary focus of this review, examining the wider literature on Cucurbita species, pumpkin seed oil chemistry, plant-derived bioactive peptides, and international nutrient data sources provides a deeper understanding of their nutritional and therapeutic potential.

General reviews of pumpkin seed oil chemistry
Several comprehensive reviews have evaluated the composition, extraction technologies, and functional properties of pumpkin seed oil. Hu et al. (2024) summarized cold-pressing and supercritical CO_2 extraction methods and highlighted their ability to retain Δ7-sterols, tocopherols, and polyunsaturated fatty acids (60). Singh et al. (2023) emphasized oxidative stability, the influence of refining on phytosterols, and the nutraceutical value of oil fractions (61). Process optimization to enhance bioactive retention has been further explored by Zhang et al. (2025), who documented improvements in yield and antioxidant activity with modified solvent extraction (62). Grajzer et al. (2025) provided a detailed characterization of minor lipid constituents, including carotenoids and squalene, underscoring their contribution to cardiovascular and anti-inflammatory benefits (63).

Reviews of the Cucurbita genus
The broader Cucurbita literature reveals phytochemicals relevant to pumpkin seeds. Salehi et al. (2019) reviewed the pharmacological applications of cucurbits in metabolic and inflammatory disorders, citing triterpenoids and cucurbitacins with antidiabetic activity (64). Huerta-Reyes et al. (2022) described ethno-medicinal uses of Cucurbita species for glycaemic control and gastrointestinal health (65). Borecka et al. (2025) linked dietary intake of cucurbits to improved nutrient status, particularly zinc and magnesium (66), while another review by Salehi et al. (2019) detailed agronomic factors influencing the bioactive profile of pumpkins and squashes (67).

Plant bioactive peptides and pumpkin seed proteins
Recent work highlights pumpkin seed proteins as precursors of antihypertensive, antioxidant, and antimicrobial peptides. Lin et al. (2024) identified peptides from Cucurbita maxima with ACE-inhibitory potential, demonstrating in vitro effects comparable to synthetic inhibitors (68). Pacheco et al. (2024) conducted a bibliometric analysis showing an increasing research focus on pumpkin seed protein functionality (69), while subsequent studies by Pacheco et al. (2025) confirmed strong radical-scavenging activity in enzymatically hydrolysed seed fractions (70). Broader surveys of nut and seed proteins by Dodevska et al. (2022) also situate pumpkin peptides within a wider context of plant-derived bioactive with cardiovascular relevance (71).

Global food composition databases as reference standards
Standardized nutrient data are essential for accurate compositional analysis. The FAO/INFOODS guidelines provide methods for evaluating food composition data quality and have been widely used to validate macro- and micronutrient profiles of pumpkin seeds (72–74). These sources ensure consistency in protein, lipid, and trace element quantification across international datasets.

Clinical and Experimental Evidence on Pumpkin Seeds
Pumpkin seeds and their derived products have been extensively evaluated for physiological and therapeutic effects in both animal models and human subjects. The research primarily centres on benign prostatic hyperplasia (BPH), metabolic health, antioxidant and anti-inflammatory effects, 54rand cardiovascular protection, with additional reports on glycaemic regulation and antimicrobial properties.

Benign Prostatic Hyperplasia and Urinary health
Pumpkin seed oil supplementation has consistently demonstrated benefits in BPH management, reducing lower urinary tract symptoms and improving urinary flow indices without significant side effects (75–79). Randomized clinical trials using standardized oil extracts have shown symptom score reductions comparable to phyto-therapeutic combinations (80,81).

Lipid Metabolism and Cardiovascular Effects
Animal studies indicate that pumpkin seed supplementation decreases LDL cholesterol and triglyceride levels while elevating HDL cholesterol (82–84). Clinical data also show mild but significant improvements in serum lipid profiles and endothelial function (85,86).

Antioxidant, Anti-Inflammatory, and Immunomodulatory Roles
Both in vitro and in vivo models reveal high radical-scavenging activity of pumpkin seed phenolics and tocopherols, alongside reduced markers of systemic inflammation (87–89). Hydrolysed seed protein fractions additionally demonstrate angiotensin-converting enzyme (ACE) inhibition, supporting antihypertensive effects (90).

Glycaemic Control and Metabolic Support
Limited but promising evidence suggests hypoglycaemic activity of pumpkin seed protein and oil in diabetic rats, potentially mediated via improved insulin sensitivity and glycogen storage (91,92). Human trials remain preliminary but

indicate favourable trends in fasting blood glucose reduction (93).

Antimicrobial and Anti-parasitic Effects

Pumpkin seeds show activity against intestinal parasites, notably Taenia species, and may also inhibit bacterial growth in vitro (94). Although traditionally used as an anthelmintic, standardized clinical data are still sparse.

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