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A comprehensive review of pharmacological potential, nutritional profile and industrial applications of ash gourd (*Benincasa hispida*) seeds

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Abstract

Ash Gourd (*Benincasa hispida*) is a significant member of Cucurbitaceae family. *Benincasa* is a monotypic genus and is one of the most well-known cucurbit crop. The fruit is valued for its nutritional and medicinal attributes, particularly in Ayurveda and is widely cultivated across South and Southeast Asia. India is home to cottage-scale industry of 'Petha', a popular sweet prepared by osmotically dehydrating ash gourd flesh. However, the industry generates substantial amount of processing waste in form of rind and seeds. This underutilized fraction, particularly the seeds, offers significant potential for value addition due to their rich nutritional and pharmacological properties, making it an important focus for scientific review and exploration. Globally, food wastes poses social, economic and environmental concerns. Valorizing nutrient-dense by-products is therefore highly relevant, especially when they contain essential nutrients. Ash gourd seeds are as beneficial as fruit flesh and serve as rich source of plant-based protein, essential fatty acids and mineral. The seed oil is of notable therapeutic value due to its content of vitamins (A and E) and terpenoids. The seed extract is reported to have anti-inflammatory, anti-microbial, anti-nociceptive and anti-pyretic properties making ash gourd seeds of considerable value for food, pharmaceutical and nutraceutical industries. This review comprehensively discusses the cultivation, pharmacological studies, nutritional profile and industrial application of ash gourd seed, emphasizing their potential as a promising source of nutritional and functional ingredients.

Keywords: Ash gourd seeds, nutritional profile, valorization

Introduction

Ash gourd (*Benincasa hispida*), a tropical melon of Cucurbitaceae family is the sole species classified under genus, *Benincasa* (Rabbani *et al.*, 2013) [39]. It is commonly known as *Petha* in Hindi, *Kushmanda* in Sanskrit, *Boodida Gummadi* in Telugu, *Neer Pooshnikkai* in Tamil, *Kumbalam* in Malayalam, *Bhuru Kolu* or *Safed Kolu* in Gujarati and winter melon, white gourd, wax gourd, white pumpkin, Chinese preserving melon in English (Bimakar *et al.*, 2012; Robinson & Decker-Walters, 1997) [4, 42]. According to the International Plant Name Index (IPNI), the seeds of *B. hispida* refer to the plant's seeds along with their shells derived from *Benincasa hispida*. Ash gourd cultivation widely spans across India, Sri Lanka, Myanmar, Vietnam, Indonesia, Korea, Japan and Australia (Patil *et al.*, 2012) [37]. It has traditionally been employed to manage a wide range of ailments, including diabetes mellitus, diuretic and urinary disorders, chronic inflammatory conditions (Grover & Rath, 1994; Lee *et al.*, 2005) [16, 25] as well as epilepsy, cough, fever, cardiovascular issues, liver diseases (Dhiman *et al.*, 2012; Zaini *et al.*, 2011) [7, 59], peptic ulcer and hemorrhages from internal organs (Bhalodia *et al.*, 2009) [3]. 'Kooshmanda rasayana', an ayurvedic preparation, is developed from ash gourd (Firke *et al.*, 2020) [11]. 'Petha', the world famous confectionary from Taj Mahal city, Agra is exported globally. A sweet preparation from ash gourd flesh, the pieces are cured in lime solution followed by cooking in concentrated sugar syrup to produce translucent, candied sweet (Yadav *et al.*, 2023) [58]. Petha manufacturing is a cottage industry with almost 1500 units involved in production in Agra only, with daily estimated capacity of 700-800 tonnes of petha sweet. Despite its long-standing popularity and cultural significance, by-products comprising fruit peels and seeds from processing has become a major environmental concern (Singh & Saini, 2014) [50]. While the flesh is extensively utilized, seeds which constitute a significant portion of the fruit by weight are usually

discarded by industries. This practice results in wastage of a nutritionally dense resource that could otherwise serve as a low-cost ingredient in food and pharmaceutical formulations. The valorization of daily waste is one of the food industry's most pressing issues (Viuda *et al.*, 2014) [54]. The literature review reveals ash gourd fruit contains 75 - 77% flesh, 15% peel and 8 -10% seeds (Sreenivas *et al.*, 2011) [51]. Recent studies have also revealed that ash gourd seed extract possess free radical-scavenging and enzyme-inhibitory properties, suggesting their possible applications in the prevention of chronic metabolic and neuro-degenerative disorders (Acharya *et al.*, 2025) [11]. This is similar to the case of pumpkin, watermelon and cucumber seeds, which for many years were neglected before being recognized as valuable sources of protein concentrates, healthy fats and minerals.

Food loss and waste are serious threats to the sustainability of our food systems. According to the Food and Agriculture Organisation of the United Nations (FAO), one-third of the global food production for human consumption ~1.3 billion tonnes per year is lost or wasted (FAO, 2011) [9]. One of the Sustainable Development Goals outlined by United Nations' in 2015 intends to 'halve the per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses' by 2030 [52]. From the perspective of sustainability, valorisation of ash gourd seeds could play a dual role in reducing food processing waste while providing affordable sources of plant-based protein and bioactive compounds to address global nutritional challenges.

Plant proteins and oils are being actively explored for their role in improving food security, reducing dependence on animal sources. Ash gourd seeds fit perfectly into this paradigm, offering an opportunity for the development of dietary supplements and nutraceutical formulations (Gade *et al.*, 2022; Kakker & Bukya, 2024) [12, 19]. Moreover, the seeds could be used in bakery products, protein-rich

chocolate (Pallavi *et al.*, 2018) [36], biscuits, energy bars and as a raw material for pharmaceutical extractions.

Despite this potential, systematic reviews compiling the existing data on ash gourd seeds are lacking. The available literature is scattered while comprehensive studies on ash gourd seeds remain limited. This lack of integration creates a notable gap in understanding and utilizing the potential bioactivities of ash gourd seeds. Therefore, a consolidated review is necessary to fill this gap by synthesizing the available evidence on *B. hispida* seeds. By bringing together the current state of knowledge, this review seeks to emphasize the importance of ash gourd seeds as a sustainable and valuable bioresource rather than an agricultural waste.

Cultivation: Ash gourd, a large trailing vine is cultivated as vegetable throughout India upto 1, 200 m of altitude (Firke *et al.*, 2020) [11]. It can thrive in wide range of climates, especially in the north-western plains of India where it grows well in both spring-summer and monsoon seasons. It's strong adaptability and high heat tolerance make it a dependable crop for cultivation in tropical and subtropical areas (Kumara *et al.*, 2011; Nagaraju *et al.*, 2018) [24, 33]. Ash gourd is a warm season crop which grows well in temperature range of 22-35 °C. It is sensitive to frost and low temperature conditions. It can be grown in all types of soils but sandy loam soil is ideal for its growth, with optimum pH range 6.5-7.5. The best time for raising the crop is February-March. The fruits are ready for harvesting after 120-150 days of sowing (Devi, 2025) [5]. The round or oblong fruit weighs between 0.5-3 kg on average, while length varies between 18-35 cm, width 15-33 cm and circumference 30-37 cm. The average yield is documented ~25-30 tonnes/ha. Ash gourd is listed as one of the vegetables covered under the APEDA HortiNet system for monitoring and export purposes, indicating its relevance as an export-oriented crop (Dewan *et al.*, 2014; APEDA, 2024) [6, 2].



Fig 1: A-Ash gourd plant with fruit, B- Flower of ash gourd plant, C-fruit of Ash gourd and D- Seeds of Ash gourd

Pharmacological potential

Anti -microbial effects

Multiple *in-vitro* studies and reviews report extracts of *B. hispida* (fruit pulp, peel, waxy coating and seeds) shows anti-microbial activity against range of Gram-positive and Gram-negative bacteria. Studies commonly report inhibition of standard test strains such as *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*, reporting measurable zones of inhibition and low-moderate Minimum Inhibitory Concentration (MIC) values depending on extract and concentration. This activity is attributed to phytochemicals such as alkaloids, tannins, flavonoids, saponins, terpenoids and phenolics (Islam *et al.*, 2021;

Sharma *et al.*, 2014) [18, 45]. Another study investigating the antibacterial activity of pulp and seed extract of *B. hispida* against major periodontal pathogens reveals the seed extract to be more effective indicating its potential as a natural adjunct for managing periodontal infections (Wadikar *et al.*, 2015) [56]. Ng & Parkash, 2002 reports, a ribosome-inactivating protein (RIP), 'Hispin' extracted from ash gourd seeds having anti-fungal properties as fungal ribosomes are susceptible to RIPs [35].

Anti-cancer properties

Anti-angiogenic therapy is a cornerstone of cancer treatment as tumor growth beyond a small size critically depends on

neovascularization (Rajabi & Mousa, 2017) [40]. Lee *et al.*, (2005), reports the seed extract of *B. hispida* to demonstrate potent anti-angiogenic activity. The active fraction inhibited basic fibroblast growth factor (bFGF) induced proliferation of human umbilical vein endothelial cells (HUVECs) and suppressed tube formation *in vitro* with consistent results observed in an *in vivo* matrigel plug assay in mice. The authors recommend further work to isolate and characterize the specific bFGF-inhibitory compound. Another study proves inhibition of testosterone induced hyperplasia of prostate by petroleum ether extract and *B. hispida* seed oil in experimental rats model (Nandecha *et al.*, 2010) [32].

Anti-convulsant activity

Anti-convulsant activity refers to the ability of a substance to prevent or reduce the frequency and severity of seizures by stabilizing neuronal excitability and inhibiting abnormal electrical discharges in the brain (Katzung *et al.*, 2021) [21]. The ethanolic extract of *B. hispida* seeds (EEBH) has been assessed for its anti-convulsant properties using Maximal Electroshock Seizure (MES) and Pentylenetetrazol (PTZ)-induced seizure models in albino Wistar rats. Phenytoin served as the reference drug in the MES test while diazepam was used in the PTZ test. Findings revealed that EEBH lowered the duration of tonic hind limb extension in a dose-dependent manner in the MES model and in the PTZ model it increased seizure latency and reduced the incidence of convulsions. Overall, the study suggests that EEBH possesses promising anticonvulsant activity (Gohain & Kaushik, 2014) [15].

Anti-diabetic activity

The anti-diabetic activity of the ethanolic extract of *B. hispida* seeds was evaluated in alloxan-induced diabetic Wistar rats. The extract demonstrated a notable ability to regulate blood glucose levels at 500 mg/kg/day (oral) for 15 days, showing a stronger hypoglycemic effect compared to the diabetic control group (Maity *et al.*, 2021) [27]. Water and other extracts of *B. hispida* seeds show high phenolic/flavonoid content and strong antioxidant activity *in vitro*, a plausible mechanism by which seed extracts could protect β -cells from oxidative stress, is mechanistically linked to diabetes. This supports a mechanistic basis for seed hypoglycaemic effects (Samad *et al.*, 2012) [43].

Anti-inflammatory activity

Inflammation is the body's protective mechanism in response to any injury or infection, involving pain, swelling, heat and redness (Medzhitov, 2008) [29]. Anti-inflammatory activity is beneficial as it helps reduce tissue damage, pain and swelling, promoting faster healing and preventing chronic inflammation-related diseases (Libby, 2007) [26]. The methanolic extract of *B. hispida* seeds exhibited significant anti-inflammatory activity in rats, as demonstrated by the carrageenan-induced paw edema model, where it produced a 59.7% reduction in paw swelling (Gill *et al.*, 2010) [13]. Also, the seed extract is reported to have inhibitory effects

on histamine secretion and anti-tumor effects by enhancing immunoreactions (Yoshizumi *et al.*, 1998) [59].

Anti-nociceptive and anti-pyretic activity

Anti-nociception refers to the suppression of nociceptive (painful) signal transmission within the central or peripheral nervous system. Similarly, anti-pyretic activity refers to the ability of a substance to reduce or suppress fever through inhibition of prostaglandin synthesis in the hypothalamus (Millan, 2002; Rang *et al.*, 2016) [30, 41]. The ethanolic seed extract of *B. hispida* was assessed for its anti-nociceptive and antipyretic activities, with Brewer's yeast (15%) used to induce fever in Wistar albino rats. The extract significantly ($P < 0.05$) enhanced pain-relieving effects in a dose-dependent manner at 250 and 500 mg/kg body weight. Likewise, it markedly ($P < 0.05$) lowered yeast-induced fever at the same dosage levels. These findings indicate that the ethanolic seed extract of *B. hispida* possesses strong anti-nociceptive and anti-pyretic potential (Wadikar *et al.*, 2015) [55].

Anti-ulcer activity

Peptic ulcers are acid-induced lesions that typically occur in the stomach or duodenal wall. It involves loss of the protective mucosal layer, resulting in open sores in stomach lining that penetrates into the submucosa or even the muscularis propria (Narayanan *et al.*, 2018) [34]. The methanolic extracts of *B. hispida* seeds (MEBH) were assessed for its anti-ulcer potential in rats using three experimental models namely, pyloric ligation, water-immersion stress and non-steroidal anti-inflammatory drug (NSAID) i.e. indomethacin induced gastric ulceration with ranitidine serving as the standard drug. At a dose of 300 mg/kg, MEBH demonstrated notable ulcer protection, producing 52.7%, 67.4%, and 61.2% inhibition in the pyloric ligation, water-immersion stress and NSAID-induced ulcer models, respectively (Gill *et al.*, 2011) [14].

Expectorant effect

The ability of a substance to increase bronchial mucus secretion and promote its expulsion, helping clear the airways and ease coughing is attributed to its expectorant effect. *B. hispida* seed extract is reported to promote mucus production, thereby exhibiting expectorant activity (Hopp & Townley, 1995; Kim & Shin, 1999) [17, 23].

Nutritional profile

Proximate Composition

The literature review on proximate composition of ash gourd seeds reveals high proportion of protein such as trigonelline, coffearin and osmotin. X-ray diffraction analysis of selected cucurbit seeds, obtained highest degree of crystallinity for ash gourd seeds among all, suggesting the presence of high amount of fat and protein in the seeds. The lipid content of ash gourd seeds predominantly consists of unsaturated fatty acids (86.54%). Linoleic acid, the main polyunsaturated fat is helpful to prevent coronary heart disease (Gade *et al.*, 2022; Sew *et al.*, 2010; Shih *et al.*, 2001; Farvid *et al.*, 2014) [12, 44, 47, 10].

Table 1: Proximate Composition of Ash Gourd Seed

Seeds	Moisture (%)	Total ash (%)	Fiber (%)	Crude fat (%)	Crude protein (%)	Carbohydrate (%)	Calorific value (KCal/100 g)
Ash gourd seeds	4.9 $\pm$ 0.22	11.86 $\pm$ 0.57	2.41 $\pm$ 0.12	40.27 $\pm$ 0.04	24.89 $\pm$ 0.98	15.66 $\pm$ 0.23	253.38 $\pm$ 3.67

Source-Pallavi *et al.*, 2018 [36]

Table 2: Fatty Acid Composition of Ash Gourd Seed Oil

Fatty Acid	Percentage of Total Fatty Acids
Linoleic acid (C18:2, ω -6)	67.37%
Palmitic acid (C16:0)	17.11%
Oleic acid (C18:1)	10.21%
Stearic acid (C18:0)	4.83%

Source-Sew *et al.*, 2010**Amino Acid Profile**

In the ash gourd seeds, the amino acid reported in highest amount were glutamic acid (9.48 mg/100 g) and aspartic

acid (6.14 mg/100 g), while methionine (1.01 mg/100 g) and cystine (1.06 mg/100 g) were reported in lowest amount (Gade *et al.*, 2022) ^[12].

Table 3: Essential amino acid profiling of Ash Gourd Seed (g/100g)

Seeds	Thr	Val	Met	Ile	Leu	Phe	His	Lys	Trp
Ash Gourd seeds	0.1719	0.20094	0.03088	0.19172	0.34831	0.26776	0.13355	0.26166	-

Abbreviations: His, Histidine; Ile, Isoleucine; Leu, Leucine; Lys, Lysine; Met, Methionine; Phe, Phenylalanine; Thr, Threonine; Trp, Tryptophan; Val, Valine.
Source-Zaini *et al.*, 2011

Vitamin Content**Table 4:** Fat soluble and water soluble vitamins of Ash Gourd Seed

Vitamins	(mg/100 g)
A	86.34 $\pm$ 0.060
E	496.72 $\pm$ 0.080
B1	0.21 $\pm$ 0.040
B2	0.19 $\pm$ 0.020
B3	4.8 $\pm$ 0.020
B5	0.68 $\pm$ 0.030
B6	1.4 $\pm$ 0.040
B9	1.1 $\pm$ 0.040
C	80.62 $\pm$ 0.025

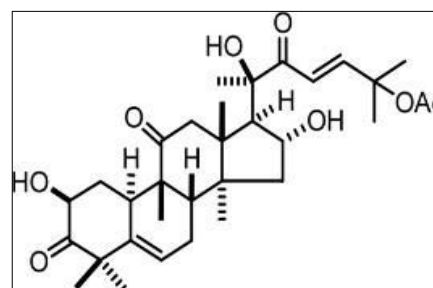
Source -Gade *et al.*, 2022 ^[12]**Minerals**

In a comparative study of ash gourd pulp, leaves and seeds, the mineral content was determined using standard methods. The calcium, iron and potassium content in ash gourd seeds were reported at 214 mg/100 g, 4.2 mg/100 g and 445 mg/100 g respectively with potassium content being highest in seeds against pulp and leaves. In another study, the mineral (Fe, K, Mg, Zn, Na) content of ash gourd seeds is found to be significantly higher at 13.06 mg/100 g, 1286 mg/100 g, 1330.95 mg/100 g, 29.49 mg/100g and 98.2 mg/100g respectively (Gade *et al.*, 2022; Kakker & Bukya, 2024) ^[12, 19].

Anti-nutritional factors

The major antinutritional factors reported in ash gourd seeds include phytates (2.15 mg/100 g), alkaloids (65 mg/100 g), tannins (1.11 mg/100 g) and saponins (7.13 mg/100 g). A minor amount of oxalate (0.13 mg/100 g) is reported in it. Cucurbitacin, a tetracyclic triterpenoid derived from cucurbitaceae species is present in minute amount in ash gourd seeds. It exhibits anticancer effects by suppressing Janus kinase 2 (JAK2) activity and signal transducer and activator of transcription 3 (STAT3) in cancer cell lines from the breast, prostate, and nasopharynx. Due to its insolubility in water and general toxicity, cucurbitacin is

administered in its polymeric form (Gade *et al.*, 2022; Uchikoba, 1998; Polu *et al.*, 2015) ^[12, 53, 38].

**Fig 2:** Chemical structure of Cucurbitacin**Anti-oxidant activity**

When antioxidant activity of water extract of dried ash gourd seeds was tested using 2, 2-diphenylpicrylhydrazyl (DPPH) assay, hydroxyl radical scavenging activity measuring assay and 1, 2, 2'-azino bis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assay, the inhibition was reported at 79.8%, 95.5% and 82.3% respectively after 1 hour of incubation. The total flavonoid content (TFC) was about 486.8 $\pm$ 4.1 μ g catechin/g dry mass (Samad *et al.*, 2012) ^[43]. Another study reveals total phenolic content (TPC) of water extracted from dried ash gourd seeds at 81.3 $\pm$ 1.4 μ g gallic acid/g. Gade *et al.*, 2022 reports total phenolic content (TPC) of ash gourd seeds at 176.07 mg GAE/100 g, highest amongst pumpkin, watermelon, muskmelon.

Bioactive compounds

Ash gourd seeds were reported to found an osmotin-like protein which belongs to the PR-5 (Pathogenesis-Related protein 5) family. These proteins have well-studied biological roles in plants especially anti-microbial and antifungal activity. It was also found to consist of acetoin, 1-octanol, 1-nonanol as key volatile compound as glycosidic conjugate (Shih *et al.*, 2001; Sikorski, 2006; Silva *et al.*, 2018; Wu *et al.*, 1987) ^[47, 48, 49, 57]

Potential application in industries**Food Industry Applications**

With 8-10% seed content in ash gourd, the valorization of seed waste for food purposes can help to overcome nutritional security besides aligning strongly with sustainable production frameworks and circular bioeconomy

goals (Ebert *et al.*, 2021; FAO, 2011; Viuda *et al.*, 2014) [8, 9, 54]. The protein fraction of ash gourd seeds presents a low-cost, plant-based alternative to animal proteins. The seeds may be incorporated into functional food formulations e. g. protein-rich snacks, bakery products, protein isolates to enhance protein density in plant-based foods or defatted seed meal as a fibre- and protein-rich composite flour. The seed's thermal-stability and functional attributes were also documented supporting processing suitability. In a recent work, prebiotics identified from ash gourd seed extract were used to prepare prebiotic chocolate (Gade *et al.*, 2022; Pallavi *et al.*, 2018) [12, 36].

Bioactive Peptides with Antimicrobial Activity

A novel cationic peptide ('Hispidalin') of molecular mass 5.7 kDa and 49 amino acid residues, purified from the seed extract of *B. hispida* showed broad-spectrum antibacterial and anti-fungal activity against human pathogens, with growth inhibition significantly comparable with commercially available antibacterial and antifungal drugs. At 40 µg/mL concentration, Hispidalin exhibited 70.8% DPPH free radical-scavenging activity and 69.5% lipid peroxide inhibition, indicating that seed-derived peptides can be developed into antimicrobial agents (Sharma *et al.*, 2014) [46].

Chemotherapy

An experimental study of anti-proliferative activity of *B. hispida* against the Triple Negative Breast cancer cell line (MDA-MB-231) is particularly noteworthy. In this study, the aqueous seed extract of *B. hispida* was tested at concentrations of 20, 40, 80, 160, 320 and 640 micrograms per millilitre (µg/mL). For comparison, the standard chemotherapeutic drug doxorubicin (DOXO) was applied at concentrations of 5, 10, 20, 40, 50 and 60 µg/mL to the same cell line. The results demonstrated that the cytotoxic effect of the *B. hispida* aqueous extract on MDA-MB-231 cells increased steadily with rising concentration, indicating a clear dose-dependent response. The extract produced a half-maximal inhibitory concentration (IC₅₀) of 142±7.54 µg/mL. In comparison, doxorubicin, used as the positive control, showed a much lower IC₅₀ value of 52±3.41 µg/mL, confirming its stronger potency (Kanase *et al.*, 2025) [20].

Nanomedicine / Nanoparticle-based Applications

In a recent study by Khan *et al.*, 2023, selenium nanoparticles (SeNPs) were synthesized utilizing *B. hispida* aqueous peel extract. The nanoparticles showed strong antibacterial activity (low Minimum Inhibitory Concentration) and anticancer activity (IC₅₀=0.19 µg/mL against HeLa cells) while being non-toxic to human osteoblasts. Although not strictly seed but the study on peel extracts paves way for environmentally sustainable synthesis of *B. hispida*'s phytochemicals which be used in biomedical nanotechnology (drug delivery, antimicrobial coatings, cancer therapeutics etc.)

Source of bioactive lipids

Analysis of different solvent extracts from *B. hispida* seeds identified presence of several medically important bioactive fatty acids such as 9, 12-octadecadienoic acid, hexanoic acid, Nonanoic acid, 13-octadecenal (Z), hexadecanoic acid, 2-hydroxy-1-(hydroxyme) that have known therapeutic

effect. The wide range of bioactive molecules detected in different crude extracts underscores the potential of these plants for medicinal applications (Muzahid *et al.*, 2020) [31].

Applications in the Nutraceutical Industry

The relatively high phenolic content and reported antioxidant activity of ash gourd seeds position them well for nutraceutical development. Seed extracts standardized for total phenolics or specific flavonoids can be formulated into capsules, powders or functional beverage ingredients aimed at reducing oxidative stress and supporting metabolic health (Gade *et al.*, 2022; Islam *et al.*, 2021) [12, 18]. Ultrasound-assisted and other green extraction methods have been optimized for seed oil and bioactive recovery, demonstrating scalable pathways to obtain concentrated seed extracts with measurable antioxidant capacity. As nutri-cosmetic and anti-ageing markets value natural antioxidants, seed-derived concentrates could be developed for both oral and topical nutraceuticals after toxicology and efficacy validation (Islam *et al.*, 2021; Bimakar *et al.*, 2012) [18, 4].

Conclusion

Ash gourd seeds though commonly discarded are a promising, low-cost biomass with tangible potential across food, nutraceutical and pharmaceutical sectors. While going through existing research studies of ash gourd seeds, it can be said without doubt that it can be utilized for its nutritive values and therapeutically for managing chronic disorders. Focused efforts in compositional profiling, standardized extraction, safety evaluation, formulation development and clinical validation are required to convert laboratory findings into safe, effective, and marketable products [2, 18, 26].

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