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A comprehensive review on unlocking the nutritional and phytochemical power of Ash gourd, *Benincasa hispida* (Thunb.) Cogn.

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Abstract

This review explores the nutritional and phytochemical properties of Ash gourd, *Benincasa hispida* (Thunb.) Cogn. and their potential health benefits. Ash gourd, known for its diverse bioactive compounds such as flavonoids, triterpenoids, and vitamins, exhibits significant antidiabetic, hypoglycemic, hypolipidemic, antioxidant, anti-inflammatory, and neuroprotective properties. By synthesizing findings from extensive literature and experimental studies, this review highlights the mechanisms through which Ash gourd exerts its therapeutic effects and identifies the key compounds responsible for these benefits. The review also addresses optimal dosages and consumption forms, the synergistic potential with other medicinal plants, and sustainable cultivation practices. This comprehensive review aims to provide a scientific basis for the inclusion of Ash gourd in dietary guidelines and its potential as a natural alternative to synthetic drugs, contributing to improved public health outcomes.

1. Introduction

A minimum of 300 g of vegetables should be consumed daily by each person, as suggested by the Indian Council of Medical Research (ICMR). This includes 50 g of green leafy vegetables, 200 g of various other vegetables, and 50 g of roots and tubers. These guidelines are intended to guarantee that a balanced intake of vital nutrients is consumed in order to sustain optimal health (Amarapalli Geetha *et al*., 2024). Ash gourd, known as *Benincasa hispida* (Thunb.) Cogn. stands out as a distinctive melon relished by many, offering not only a unique taste but also possessing medicinal and functional qualities. Its diverse applications include serving as counteragent for ethanol toxicity, an antimercurial agent, a laxative, a diuretic, a remedy for internal heamorrhages as well as constipation. It is referred to as Kundur in Malay, Petha in Hindi, Bhuru Kolu or Safed Kolu in Gujarati, Kushmanda in Sanskrit, Beligo in Indonesia and Donggua in Chinese. It is also recognized as winter melon or wax gourd in English (Bima *et al*., 2012), reflecting its varied nomenclature based on its place of origin. *B. hispida* (2n = 24) is an annual, monoecious vines cultivated for their edible fruits. These fruits hold particular significance for smallholder farmers, notably in Southeast Asia (Dhillon *et al*., 2017) serving as a crucial source of vitamins A and C, iron and calcium. Ash gourd finds extensive use in confectionery and in ayurvedic medicinal formulations. *B. hispida* commonly cultivated across India, thrives in various terrains and altitudes, reaching up to 1200 m. This robust, climbing herb boasts a stout, angular stem covered in bristly hairs. Primarily grown as a vegetable, it exhibits notable gastroprotective, antioxidant, and antipyretic properties. The fruit of this herb contains carotenes, flavonoids, saccharides, glycosides, vitamins, minerals, proteins, β-sitosterin, volatile oils, and uronic acid. It is rich in terpenes, flavonoid C, glycosides, and sterols and contributes significantly to its potent antioxidant nature. Notably, its fruit contains higher levels of potassium and lower sodium, earning recognition as a valuable vegetable in terms of nutritional quality. Roughly 90% of prescriptions in conventional medical systems come from plant based medications, and about 80% of the world's population depends on plant extracts for primary healthcare (Zeenath Banu *et al*., 2024; Bhuvaneswari *et al*., 2021).Traditionally, the fruit has been utilized as an cardiovascular tonic, aphrodisiac treatment for laxative, urinary calculi, diuretic, tonic, and treatment for various conditions including blood diseases, psychosis, schizophrenia, epilepsy, psychological disorders jaundice, dyspepsia, fever, menstrual disorders like dysmenorrhea, amenorrhea, premenstrual syndrome and menorrhagia (Jayasree *et al*., 2011). The objective of this comprehensive review was to elucidate the chemical constituents and pharmacological implications associated with Ash gourd.

2. General description

2.1 Origin and geographic distribution

The Ash gourd has a widespread presence across tropical and subtropical regions of Asia. Despite mentions suggesting Java as its original home, the belief leans towards its Indian origins (Swamy, 2022). The Indo-China area stands as a hub of diversity, displaying notable variability in fruit characteristics, *viz*., shape, size, flesh thickness, and maturity within the species. Discoveries of gourd

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remnants at Papua New Guinea's Kana site, identified as *B. hispida* suggest a possible domestication at that location. Determining the origins of *B. hispida* remains largely unexplored, lacking molecular studies. Presently, cultivation primarily occurs in Southeast Asia and Australasia (Chomicki *et al*., 2020), yet the specific domestication site remains uncertain, although its wild varieties have been identified in Australia, Japan, and parts of Melanesia (Marr *et al*., 2007). Pinpointing Ash gourd's exact origin poses challenges due to its antiquity and extensive genetic diversity across various regions. Botanists propose potential locations like Japan, Indonesia, China, and Indo-Malaysia, all of which have a historical presence of Ash gourds. Chinese texts dating back to the 5th to 6th century praise its medicinal properties. Despite scientific inclinations towards Japan, China, Indonesia, or Indo-Malaysia as native habitats, determining the precise origin remains elusive due to the Ash gourd's ancient heritage. Nevertheless, these countries have a longstanding history of Ash gourd utilization (Swamy, 2022). The potential origin of cultivated variations likely traces back to Southeastern Asia. References in Chinese texts from the 5th and 6th centuries A.D. mention *B. hispida* indicating an earlier cultivation in China, possibly dating to pre-Han times (before 206 BC-220 AD) through a folk story (Walters and Decker-Walters, 1989). With the absence of confirmed wild populations, pinpointing the exact birthplace of *B. hispida* remains uncertain. There's speculation that it could be indigenous to Indo-Malaysia. The Indo-China region is frequently considered the epicenter of origin, with the *Benincasa* genus being monotypic. *Benincasa* lacks known closely related wild species. Ash gourds, native to Asia and Southeast Asia, have a longstanding history of cultivation since ancient times. Experts suggest that these climbing plants were utilized in culinary and medicinal practices in China as early as 500 CE (Common Era). References to its medicinal properties can be traced back to Chinese texts from the 5th-6th century AD (Swamy, 2022).

2.2 Botanical description

The Ash gourd is characteristically a monoecious, annual herbaceous plant that exhibits a climbing growth habit, utilizing tendrils that are segmented into two to three distinct parts, achieving an extension of up to 35 cm. Figure 1 illustrates the different plant part of Ash gourd. The stem can grow up to 5 m in length, displaying thickness, a round cross-section, longitudinal furrows, and a whitish-green hue adorned with scattered coarse hairs. The vines have the capability to either crawl or climb, extending to several meters, even in trees. The leaves are arranged alternately in a distichous manner, simple in structure, lacking stipules; the petiole measures 5 to 20 cm, while the blade, broadly ovate in shape, the size ranges from 10-25 cm in length and from 10-20 cm in width. The base exhibits a pronounced cordate shape, the apex is characterized by an acuminate form, and the margin displays a variable degree of irregularity, presenting with 5 to 11 angles or lobes with an unevenly undulated crenate or toothed edge. The leaves, covered in hair, have a heart-shaped base and palmately lobed. In Ash gourd, male flowers precede female flowers. The calyx is silky and bell-shaped, while the petals are yellow. The corolla is large and yellow. Male flowers possess a solitary structure with a long pedicel and three stamens, whereas female flowers have a shorter pedicel, a hairy ovary, and a short style with 3 stigmas. The male to female flowers ratio is 34:1. Usually, anthesis occurs from 4:30 a.m. to 7:30 a.m., while in the case of anther dehiscence occurs from 3:00-5:00 a.m. Receptivity of the stigma remains receptive from 8 h before to 10 h after the occurrence of anthesis (Swamy, 2022). Ash gourd plants have individual male and female flower part present in the similar plant, and insects help with cross-pollination.

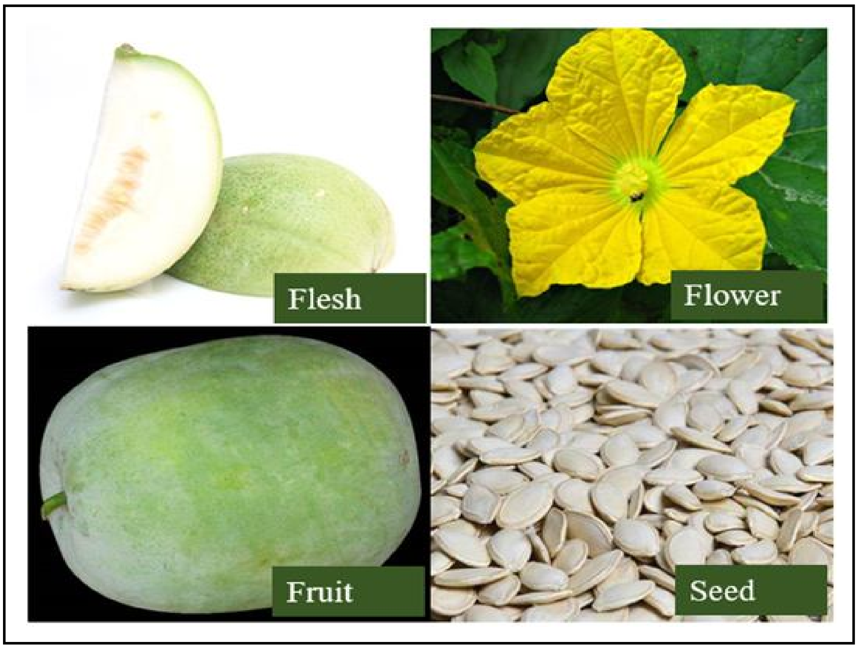

Figure 1: Various plant parts of Ash gourd.

The fruit is a globose berry or ovoid-oblong, ellipsoid that measures 20-60 cm × 10-25 cm. Its colour varies from speckled pale green to dark green or glaucous, and when it is immature, its surface is hispid; when it is ripe; however, it changes to thin hispid or almost smooth. The fruit is covered in a layer of easily removable, chalk-white wax. The flesh is greenish white, slightly fragrant, juicy, and spongy containing numerous seeds. A ripened green fruit that contains flat white-coloured seeds of 1 cm in length. Seeds are ovate-elliptical, flattened, measuring 1-1.5 cm in length, and are yellow-brown, sometimes featuring prominent ridges (Grubben, 2004). In certain cultivars, the edges of the seeds exhibit ridges, while in others, they appear smooth. Propagation of Ash gourd is achieved through seeds. Typically, harvesting starts around 90-100 days after sowing, completing within approximately 140 to 160 days. The ripened fruits are harvested upon the disappearance of the Ash or waxy coating on the outer surface. It possesses a mild taste. The average yield amounts to around 25-30 tonnes per hectare (Islam *et al.*, 2014). Upon maturity, the edible portion of the gourd contains roughly moisture (96.3%), with TSS at 3.5 °B, acidity (0.12%), and minerals (0.5%) (Sahu *et al.*, 2015; Shinde *et al.*, 2016).

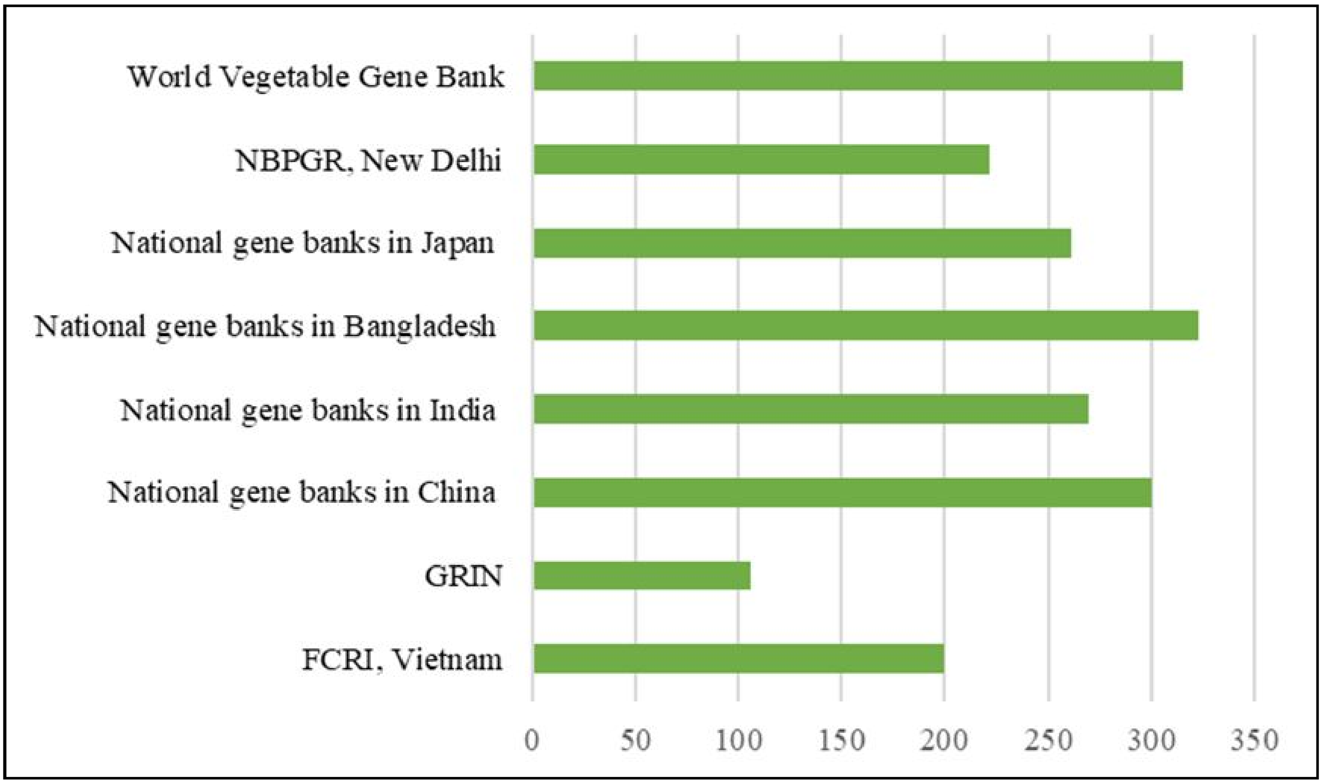

Figure 2: Genetic resources of Ash gourd maintained at different institutes.

3. Genetic resources

Dhillon *et al.* (2017) documented the presence of 285 Ash gourd varieties in the World's Vegetable gene bank. Of these, 13% (36) were accessible while 87% remained inactive. Additionally, FCRI Vietnam held over 200 wax gourd accessions and in India, NBPGR in New Delhi maintained more than 222 accessions. Germplasm Resources Information Network (GRIN) in 2016, enlisted 106 Ash gourd accessions from 6 Nations, including 57 accessions from China along with 21 from India. Among these, only 12% were suitable for distribution, while 71% were inactive. Ebert *et al.* (2021) later reported a global conservation of 1,650 Ash gourd accessions. The International World Vegetable Gene Bank held the most germplasm (315 accessions), followed by national gene banks in China (300), India (270), Japan (261), and Bangladesh (323) (Figure 2).

4. Nutritional and medicinal value

4.1 Nutritional value

According to the USDA nutrient database, Ash gourd offers a nutritional profile per 100 g, including 13 kcal of energy, no fat, 2.9 g of fibre, 4 g of protein, 3 g of carbohydrates, along with various vitamins and minerals such as folate (5 µg), niacin (0.4 mg), riboflavin (0.1 mg), calcium (19 mg), magnesium (10 mg), sodium (111 mg), phosphorous (19 mg), zinc (0.6 mg), iron (4 mg), manganese (0.1 mg), potassium (6 mg), and pantothenic acid (0.1 mg) (Swamy, 2022). Ash gourd is mostly water, making up approximately 96% of its composition. However, it contains a range of essential B-Complex vitamins like vitamin B_1 (0.04 mg), vitamin B_2 (0.145 mg), vitamin B_3 (0.528 mg), vitamin B_5 (0.176 mg), vitamin B_6 (0.046 mg) and vitamin C (17.2 mg) per 100 g edible portion (Morton, 1971). Additionally, it is rich in vital minerals like calcium and potassium which help maintain the blood pressure at an optimum level (Bello *et al.*, 2014), iron which transports oxygen to brain; its deficiency can impair memory and lead to mental issues (Kim and Resnick, 2014). Magnesium, essential for intracellular activities (Chen *et al.*, 2018) and zinc are also important components of Ash gourd. According Swamy (2022), this vegetable also offers a decent amount of carbohydrates, protein and dietary fibre.

4.2 Medicinal and industrial uses

Ash gourd contains a variety of essential nutrients necessary for maintaining optimal health. Its pulp, leaves, seeds, and flowers possess medicinal properties, as illustrated in Figure 3. Ash gourd seeds contain trace levels of alkaloids (such as 5-methylcytosine), proteins (including trigonelline), steroids (β-sitosterol and stigmast-5-ene-3-beta-ol), and triterpenoids (isomultiflorenol and cucurbitacin).

Cucurbitacin, a tetracyclic triterpenoid derived from cucurbitaceae species, exhibits anticancer effects by suppressing 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 (Polu *et al*., 2015).

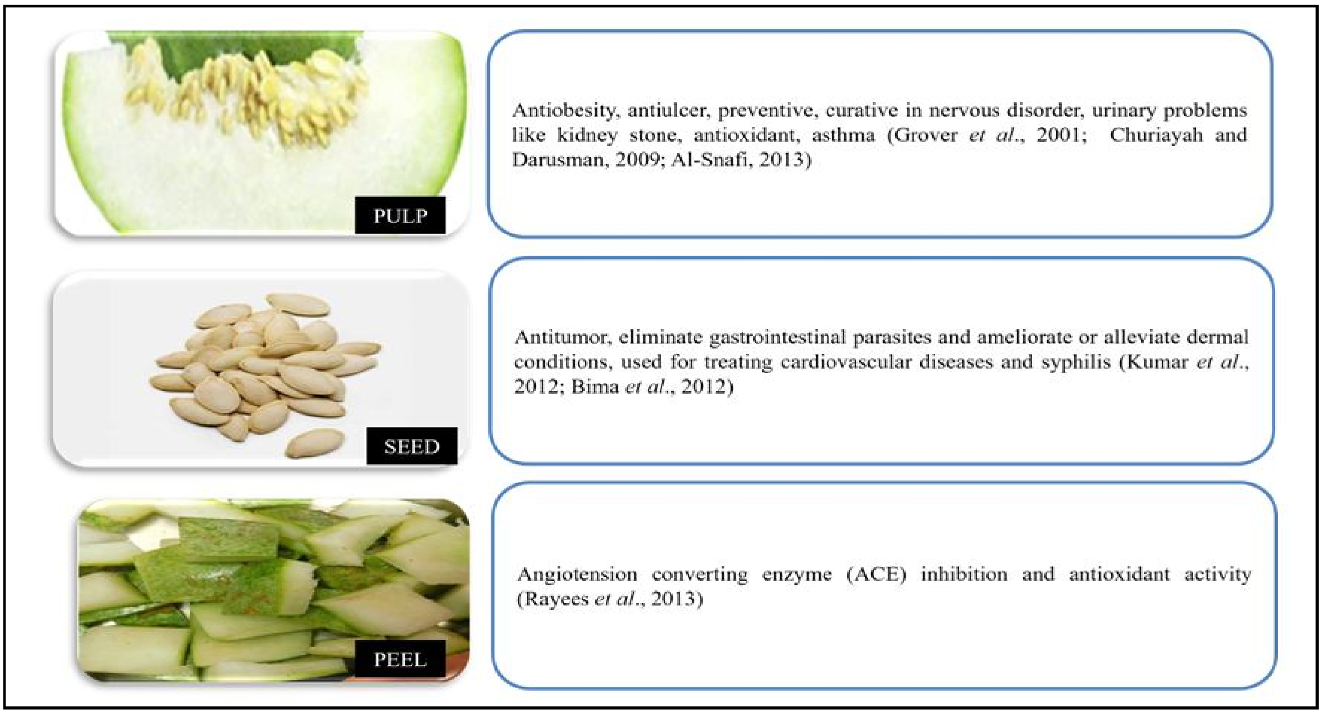

Figure 3: Different Ash gourd fruit sections' functional and medicinal qualities.

The high total dietary fibre content in Ash gourd has been linked to a reduction in blood cholesterol levels, thereby lowering the risk of bowel disorders and coronary heart diseases (Palamthodi *et al*., 2019). Additionally, Ash gourd's low sugar content makes it a suitable option for individuals with diabetes and hypertension (Bello *et al*., 2014). Moreover, the peel of Ash gourd can serve as a substrate for the growth of various microorganisms, enabling the fermentation-based production of industrially significant products (Mitra *et al*., 2017). When the peel is extracted and separated from its wax, it can also be used as a substitute for packaging materials (Fatariah *et al*., 2014). In traditional medicine, the leaves of Ash gourd are used to treat wounds, manage peptic ulcers, and heal internal organ hemorrhages, epilepsy, and other nervous system disorders. Figure 4 illustrates the chemical structures of the alkaloids, proteins, steroids, triterpenoids, and cucurbitacin found in Ash gourd (NCBI, 2024).

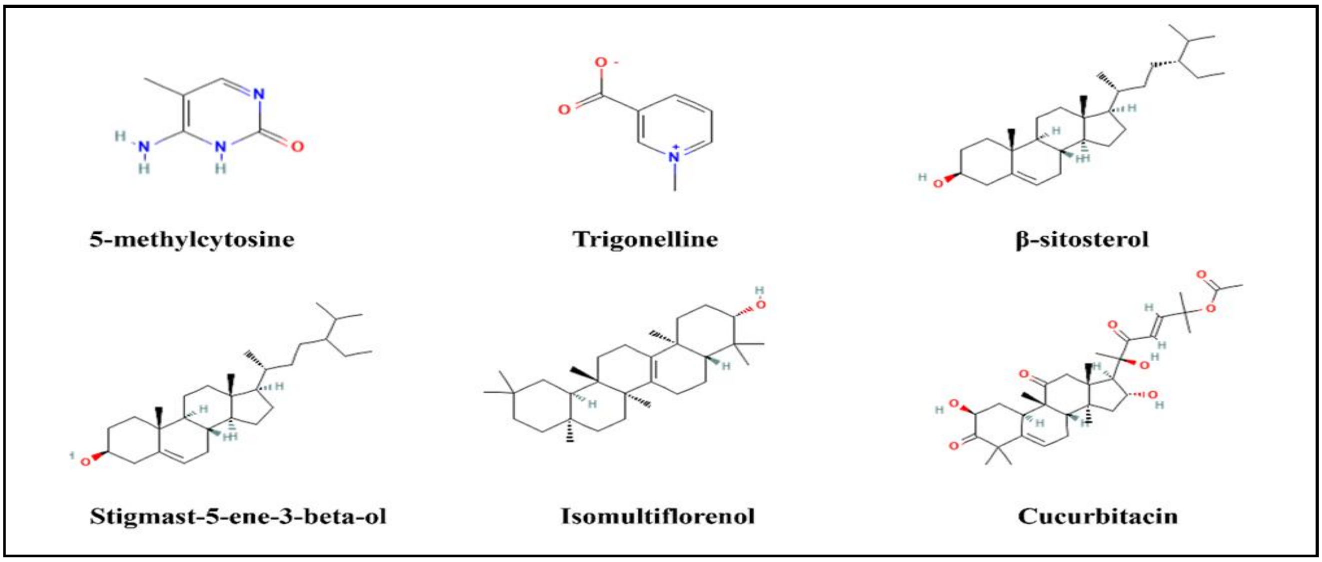

Figure 4: Chemical structure of alkaloids, proteins, steroids, triterpenoid and cucurbitacin presented in Ash gourd.

In terms of mineral content, the fruit follows this order: Na (268.00 ± 0.02 mg) > Ca (99.40 ± 0.1 mg) > Fe (3.20 ± 0.02 mg) > Zn (1.30 ± 0.01 mg) > K (1.10 ± 0.05 mg) > Mn (1.10 ± 0.01 mg) per kg of fruit. These minerals play essential roles in vital bodily functions and maintaining water balance (Rumeza *et al*., 2006). Iron supports oxygen transport to the brain (Kim and Wessling-Resnick, 2014), sodium aids in fluid balance, potassium and calcium assist in regulating blood pressure (Bello *et al*., 2014), and zinc is vital for various bodily functions (Roohani *et al*., 2013). Ash gourd seeds contain triterpenoids, proteins, steroids and alkaloids. Rich energy, minerals, fruit's high dietary fibre, vitamin C and low anti-nutrient levels signify its value as a healthful food source (Bello *et al*., 2014). Dietary fibre, which is indigestible complex carbohydrates, is crucial for intestinal health. It functions as a laxative by absorbing water and making undigested complex carbohydrates bulky. It also helps to regulate bowel motions and shields the mucous membrane of colon from substances that can cause cancer (Somraj *et al*., 2024). Comparatively, the local Ash gourd pulp, peel, and seeds exhibit higher proximate composition values than reported for other melons (Table 1).

Table 1: Nutritive value of different parts of Ash gourd fruit (g/100 g)

Fruit part	Protein (g)	Moisture (%)	Carbohydrate (g)	Zinc (mg)	Fat (g)	Calcium (mg)	Iron (mg)	Fibre (g)	Reference
Pulp	0.50	92.5	2.3	0.14	0.1	19	0.4	0.6	Grover *et al*., 2001 Rahman *et al*., 2008
Peel	-	3.70	-	0.16	-	-	1.01	1.1	Sirsat *et al*., 2013 Bellur Nagarajaiah and Prakash, 2015
Seed	30	-	14.7	-	49	-	-	6.6	Gade *et al*., 2022
Total fruit	12	96.20	3.96	0.6	-	30	11.8	2.9	Bima *et al*., 2012

5. Phytochemistry of Ash gourd

Phytochemicals are biological compounds with diverse biological activities, such as mitigating oxidative stress and combating degenerative diseases (Manju and Pushpa, 2020). The bioaccessibility and bioavailability of Ash gourd's phytochemicals are influenced by its phenolic and flavonoid components. The fruit of Ash gourd contains 28.36% total phenols, 12.60% antioxidant activity, 0.210% acidity, 0.002% total volatiles, 4.60% alcohol, and 1.67% total flavonoids (Devaki and Premavalli, 2012; Nadhiya and Vijayalakshmi, 2014). The high dietary fibre and lipid content of Ash gourd enhance the interaction of sugars and polyphenols linked to dietary fibre, which increases their bioaccessibility (Palamthodi *et al*., 2019). Additionally, Ash gourd dietary fibres exhibit excellent probiotic properties (Sreenivas and Lele, 2013). Ash gourd contains cucurbitin B, known for its anti-inflammatory and cytotoxic properties. Gruben and Denton (2004) reported that Ash gourd's triterpenes, including multiflorenol and alnusenol, are effective inhibitors of histamine release.

However, the presence of antinutrient compounds such as phytates, tannins, and oxalates is concerning as they can negatively affect mineral availability. A diet high in oxalates has been linked to the formation of kidney stones and may impair calcium absorption (Gul and Monga, 2014). Table 2 displays the most typical phytochemicals found in Ash gourd (Islam *et al*., 2021).

Table 2: Typical phytochemicals present in Ash gourd

Plant part	Compounds
Fruit	E-2-hexenal, n-hexyl formate and n-hexanal, 2-ethyl-5-methylpyrazine, 2,6-dimethylpyrazine, 2-methylpyrazine, 2,5-dimethylpyrazine, 2,3,5-trimethylprazine, sterols, alnusenol, flavonoid C-glycoside, benzyl glycoside, triterpenes, multiflorenol, astilbin, catechin, naringenin, Di-2-ethylhexyl phthalate, β-Carotene, tryptophan, oleic, palmitic, stearic acids and linoleic, gallic acid, ascorbic acid, polysaccharides, catechin, quercetin, ursolic acid, rutin, quercetin-3-D-galactoside, trans-ferrulic acid, epicatechin, oleanolic acid.
Sarcocarp	Cucumisin-like protease.
Seeds	Osmotin-like protein, chitinase, linoleic acid, linolenic acid, palmitic acid, oleic acid, stearic acid, lupeol, gallic acid, β-Sitosterol.
Stem	W-sitosterol, V-amyrin, quercetin.
Seed oil	Palmitoleic acid, linoleic acid, stearic acid, myristic acid, α-linolenic acid, oleic acid, palmitic acid, other unsaturated and saturated fatty acids.
Exudate	Phloem lectin-like protein.
Peel	Galactose, glucose, xylose, sorbose, β-Carotein, ascorbic acid.
Leaf	Phytol, oleic acid.

6. Biochemical properties of Ash gourd

Proteins, volatile oils, saccharides, flavonoids, glycosides, vitamins, carotenes, uronic acid, minerals and β-sitosterin were the main components of Ash gourd fruits (Figure 5).

According to the chemical analysis report, the primary sugars in Ash gourd peels include galactose, glucose, xylose, and sorbose (Chidan *et al*., 2012). The extract of Ash gourd seeds was tested using DPPH and ABTS scavenging activity studies, conventional Soxhlet extraction (CSE), the antioxidants activity and total phenolic content (TPC). According to Mandana *et al*. (2012), the ethanolic extract had the highest TPC at 11.34 ± 1.3 mg GAE g^{-1}. It also showed the highest level of antioxidant activity, followed by ethyl acetate and n-hexane extracts. According to a chemical study, the percentages of total dietary fibre (58.43%), crude fat (20.70%) and crude protein (11.63%) were found in seeds. Linoleic acid predominates (67.37%), followed by oleic (10.21%), palmitic (17.11%) and stearic acids (4.83%) in seed oil constituents (Sew *et al*., 2010). The root aqueous extract's phytochemical study showed that while glycosides, alkaloids and tannins were present, carbohydrates, sugars, and lipids were lacking. For these tests, the analytical responses have been the intensity of colour or precipitate formation (Pal *et al*., 2018).

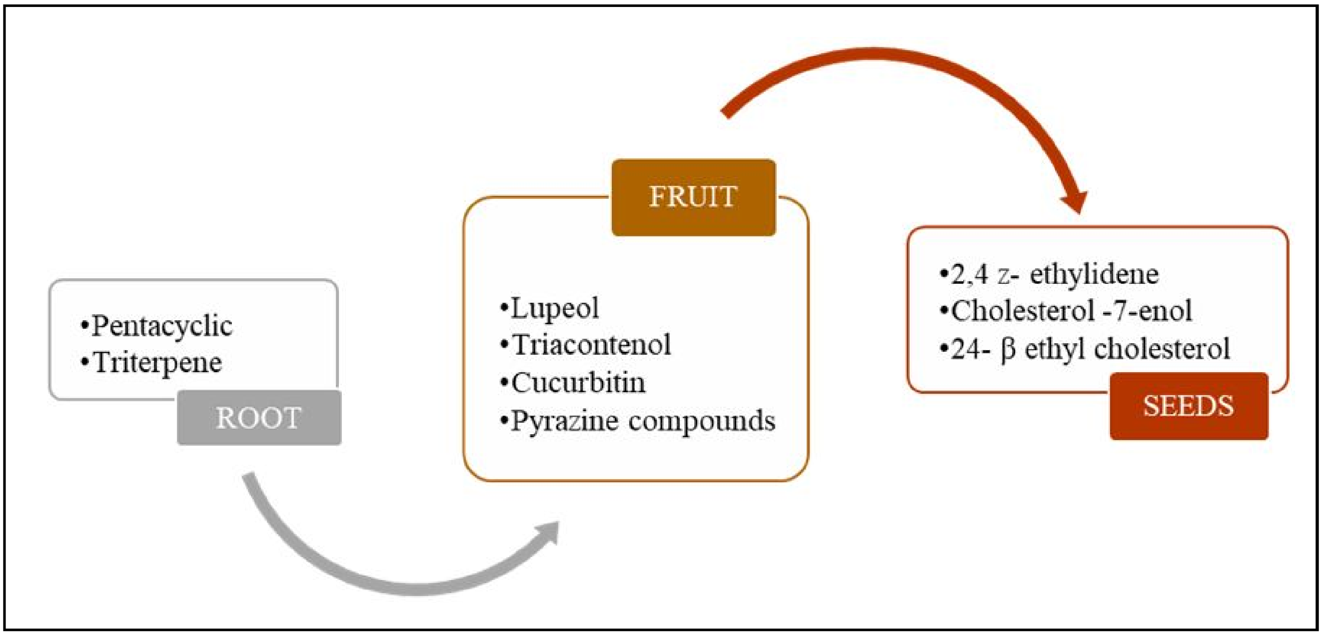

Figure 5: Chemical components identified in the entire *B. hispida* plant.

7. Pharmacological activity

Scientific research in pharmaceuticals is advancing at a rapid pace, with particular interest being shown in natural compounds with anticancer properties (Suprabha Nishad *et al*., 2024). Typically, the entire plant, fruit peel, flowers, seeds, and leaves of Ash gourd are subjected to deep pharmacological actions (Vinod Doharey *et al*., 2021) (Figure 6).

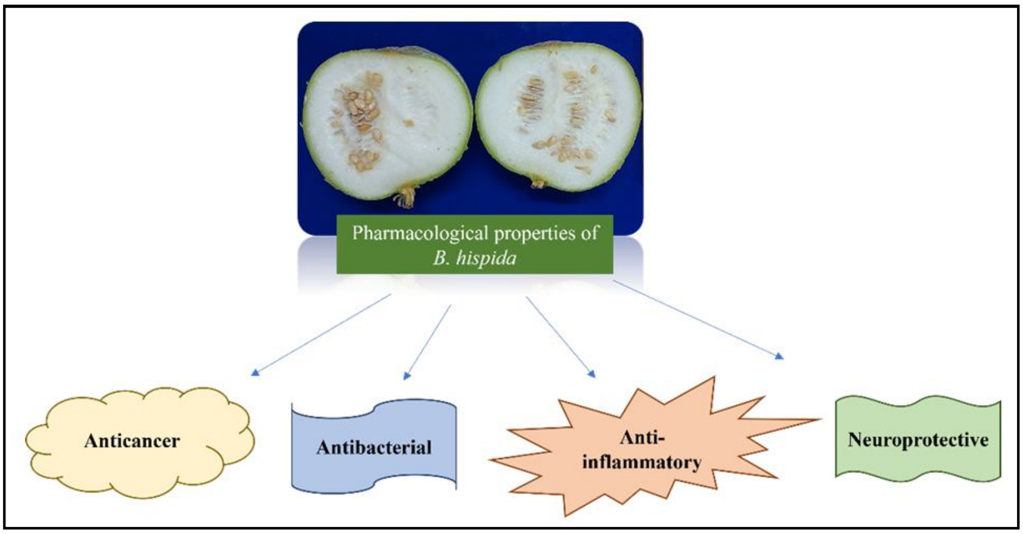

Figure 6: Pharmacological properties of Ash gourd.

7.1 Central nervous effects

Anxiolytic effects were observed using an alcoholic extract of the fruit, tested via the light-dark transition test and elevated plus maze. Antidepressant effects were demonstrated with a methanolic extract of the fruit, assessed through the swimming test (Dhingra and Joshi, 2012). Convulsion is a recurrent and severe neurological condition that affects around 2% of the global population, are characterized by excessively brief neuronal discharges (Kumar *et al*., 2022). Anticonvulsant effects were identified with the fruit's alcoholic extract, using the maximal electroshock test (MEST) (Nimbal *et al*., 2011).

7.2 Gastrointestinal effects

Acid-induced lesions, commonly known as peptic ulcers, frequently occur in the duodenum and stomach. These ulcers are characterized by mucosal damage that extends into the muscularis propria or submucosa. Ash gourd has potential medicinal and therapeutic qualities, including the ability to raise the stomach's base volume and lower the pH by increasing free acidity and chloride excretion in stomach juice (Souza, 2022). The methanolic extract of Ash gourd seeds have demonstrated antioxidant effects, as tested using the DPPH method (Gill *et al*., 2011). Additionally, this methanolic extract has shown antiulcer effects in an indomethacin-induced gastric ulcer model (Gill *et al*., 2011). Furthermore, the ethanol extract of Ash gourd fruit peel exhibited antihelmintic activity, as assessed in vitro using adult earthworms (Muley *et al*., 2012).

7.3 Antioxidant effects and total phenolic content

A number of epidemiological studies have demonstrated the potential benefits of dietary rich antioxidants for health, lowering the risk of serious illnesses and early ageing. Natural antioxidants are acknowledged as essential nutrients or components of a healthy diet, alongside proteins, fats, carbohydrates, vitamins, and trace elements. A methanolic extract of the fruit was tested for antioxidant effects and total phenolic content using DPPH and ABTS scavenging methods (Mandana, 2012). It is also high in ascorbic acid (vit C) and contains an enough quantity of carotenoids and flavonoids that exhibits antioxidant properties in the body and offer immunity benefits.

7.4 Anti-inflammatory and analgesic activity

A healthy immune system aids in the activation of acute inflammatory responses, to counteract against acute infections and injuries. Leucocytes and other immune mediators are drawn to the sites of infections and injuries by these acute reactions, which are important processes. An individual enters a state of chronic inflammation when the inflammatory stimulation is long-lasting. Chronic inflammation raises the risk of a number of chronic illnesses, including cancer, diabetes, hypertension, and cardiovascular diseases (CVDs). One of the foods that most strongly influences persistent systemic inflammation is Ash gourd. It extracts were known to reduce the adhesion of monocytes and CAM expression, along with the adhesion of high glucose-induced intracellular reactive oxygen species (ROS) formation, also the adhesion activation of redox sensitive transcription factor (NF-kB) through suppressing IkB degradation and phosphorylation activities. These findings demonstrated that by reducing oxidative stress, Ash gourd can reduce inflammations in the vascular system of the diabetic patients preventing athero-sclerosis. As a result, by raising pro-inflammatory cytokines, Ash gourd has a significant potential to reduce inflammation (Souza, 2022). The petroleum ether and methanolic extracts of fruit showed anti-inflammatory and analgesic activity through various methods including the carrageenan-induced paw edema method, histamine-induced paw edema method, and the cotton pellet-induced granuloma method (Rachchh, 2011). Grover and Rathi (1994) claimed that Ash gourd seed's ability to scavenge free radicals could lower inflammation in the carrageenan - induced paw edema in rats.

7.5 Hypoglycemic effect and hypolipidemic effect

The chloroform extract of the stem expressed hypoglycemic effects in Wistar rats (Jayasree *et al*., 2011). Consuming 100g of freshly prepared salad of Ash gourd daily was shown to have a hypolipidemic effect in 200 hyperlipidemic diabetic patients over 90 days (Amerthaveni and Priya, 2011). A lipid metabolic condition called hyperlipidemia raises the risk of CVDs and diabetes mellitus. Ash gourd is utilized in China and other East Asian nations to cure ailments including hyperlipidemia. The peel of Ash gourds modulates PPARs, which prevent intracellular lipid build-up and lipogenesis. This enhances insulin resistance and reduces the expression of genes that are involved in insulin resistance. Ash gourd has been shown to contain 4 triterpenes, 2 sterols, 1 flavonoid called 1 benzyl glycoside and c-glycoside. In hyperlipidemic mice, triterpenes lower the serum triglycerides, β-lipoproteins and cholesterol.

7.6 Antibacterial and antimicrobial effect

The Ash gourd has antimicrobial properties against some bacteria and fungus. Ash gourd seeds and pulp have demonstrated antibacterial activity against a variety of Gram-negative and Gram-positive bacteria. *A. actinomycetemcomitans*, *Porphyromonas gingivalis*, *Prevotella intermedia*, and *Fusobacterium nucleatum* were among the microorganisms against which the aqueous extracts of pulp and seeds exhibited superior antibacterial properties. Carotenes, glycosides, flavonoids, triterpenoids, saccharides, vitamins, and sitosterin uronic acid are fruit constituents that possess antibacterial properties (Souza, 2022). The seed oil demonstrated antimicrobial activity, evidenced by the zone of inhibition against *Candida albicans* (Natarajan *et al*., 2003). Antimicrobial substances and other bioactive peptides of hispidalin in *B. hispida* are of great medical significance. These peptides effectively combat harmful bacteria and fungus that affect both humans and plants.

7.7 Diuretic effects

When it comes to treating hypertension and maximizing the benefits of antihypertensive medications, diuretics are invaluable. They can also be used to treat peripheral edema and pulmonary congestion. They avoid the formation of renal calculi and force diuresis in cases of barbiturate intoxication. The whole fruit has diuretic properties, and it is known that the juice of the fruit is utilized traditionally as a medicine to lower the BP (blood pressure) and kidney calculi. Ash gourd rind extract has been found to dramatically increase urine volume, as well as the excretion of salt and chloride, while lowering potassium excretion.

7.8 Cytotoxic and anticancer effects

There has been significant progress in the fight against cancer globally in terms of cures and preventative treatments (Desai *et al*., 2021). Over 10 million cancer related fatalities have been reported, according to the WHO global cancer report 2020 (Devidi and Manickam, 2023).

The word "cancer" refers to diseases where aberrant cells grow uncontrollably and continuously and have the potential to invade the healthy tissues in the vicinity (Drocas *et al*., 2016; Docea *et al*., 2012). Typical cells originate from any human tissue and can appear anywhere in the body (Zlatian *et al*., 2015; Buga *et al*., 2019; Sharifi-Rad *et al*., 2021). Natural substitutes for anticancer drugs can directly impact cancerous cells and boost the body's defences against disease-causing agents by aggressiveness of internal or external carcinogenic causes (Sharifi-Rad *et al*., 2020; Salehi *et al*., 2020). The main biochemical components responsible for beneficial effects of some medicinal plants were: β-carotene, a potent antioxidant with cancer therapeutic properties, inhibits malignant cells; flavonoids inhibits the carcinogens activity and prevents the metastasis of malignant cells; carotenoids protecting the colon cancer; whereas terpenes of essential oils blocks the action of carcinogens, possessing a well antioxidant action; antioxidant vitamins, *viz*., C, E, and A, destroys the free radicals, destroy cancer cells, blocks metastasis process (Salehi *et al*., 2020; Salehi *et al*., 2019; Akev *et al*., 2020).

8. Volatile composition of Ash gourd

Ash gourd has three main volatiles: n-hexanal, (E)-2-hexenal, and n-hexyl formate. (E) hex-2-enal smells strongly on unripened fruit and vegetables. Ash gourds contain the following compounds: 2-methylpyrazine, 2-ethyl-S-methylpyrazine, 2, 3 Strimethyl-pyrazine, 2, 6-dimethylpyrazine, and 2 S-dimethylpyrazine. Pyrazine is a volatile substance that gives drinks their flavour. When juice is extracted for value-added products, the Millard reaction causes the flavours to be liberated (Maarse, 1991). According to Wu *et al.* (1987), pyrazine compounds contribute to the distinct smells and scents connected to food preparation. Food systems that lack thermal processing aimed at preserving flavour integrity have been shown to exhibit degradation to harbor naturally occurring pyrazines (Maga and Sizer, 1975). The volatile chemicals oct-1-en-3-ol, (Z) hex-3-enal, and (E) hept-2-enal, which preserve flavour in beverages, are also found in Ash gourd at low amounts (Sikorski, 2006). Figure 7 shows the chemical structure of volatile substances of Ash gourd (NCBI, 2024).

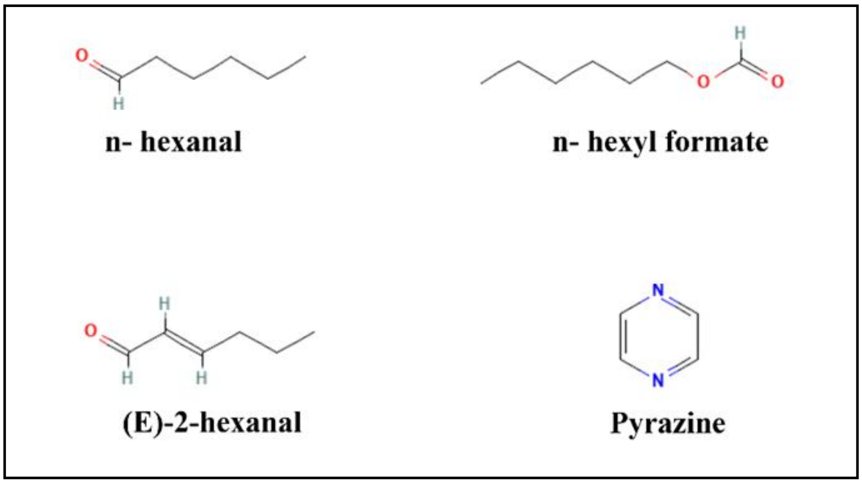

Figure 7: Chemical structure of volatile substances of Ash gourd.

9. Discover the health-boosting wonders of Ash gourd fruit

9.1 Antidiabetic

Majumdar *et al.* (2010) observed a 42% decrease in blood glucose levels in type 2 diabetic subjects after applying Ash gourd juice for 21 days. In rats with alloxan-induced diabetes, the blood glucose level was dose-dependently reduced by the methanolic extract of stems (50, 100 and 200 mg/kg, p.o.). In the alloxan-induced diabetic albino rats, lipid metabolism derangement takes place after 14 days of treatment which were dose-dependently improved by the chloroform extract (250, 500 mg/kg, p.o.). The results of the study indicate that there was a considerable α-amylase inhibitory activity in the methanol, ethanol, and aqueous peel extracts. The diabetic mice's blood glucose level was decreased in a dose-dependent manner by the leaf extracts of ethanol and ethyl ethanoate (Islam *et al*., 2021).

9.2 Hypoglycemic and hypolipidemic

Lim (2007) documented a significant decrease in blood glucose levels, plasma triglycerides (TGs), and free fatty acids by as much as 60% in rodent models subsequent to the administration of Ash gourd extract. Battu *et al.* (2007) reported that an alcoholic extract of Ash gourd, administered at a dosage of approximately 200 mg/kg body weight over a period of 45 days, results in the decrease in blood glucose levels from a range of 195 to 118 mg/dl for alloxan-induced diabetic rats. Majumdar *et al.* (2010) observed a marginal elevation in HDL levels, a reduction in VLDL levels, an increased serum cholesterol/HDL proportion, and diminishing TG/HDL ratio when the dyslipidemic subjects were supplemented with the juice for 45 days.

9.3 Antioxidant property

Huang *et al.* (2004) and Rao *et al.* (2007) indicated that the juice derived from the Ash gourd fruit exhibits antioxidant properties within the human liver and brain, as evidenced by both *in vitro* as well as *in vivo* investigations.

9.4 Contribute to obesity management

The World Health Organization (WHO) lists obesity as one of the world's most serious health concerns. Obesity is defined as an excessive build-up of fat in the body that negatively impacts overall health. Regardless of genetic predispositions, modifications to lifestyle, dietary patterns, and energy balances all have a significant role in the development of obesity. The primary treatment for obesity is dietary management. Ash gourd is a water-dense meal that dramatically reduces body weight and is low in calories. Consuming low-calorie foods contributes to long-term enjoyment by reducing hunger and preserving sensations of fullness and satiety. Consuming these low-energy foods may assist people in controlling their energy balances in order to maintain their weight. Dietary fibre is abundant in Ash gourd. In contrast to other carbohydrates (such as sugars and starches), dietary fibres are plant-based carbohydrates that pass through the small intestine undigested and enter the colon or large intestine. Dietary fibre consumption lowers the risk of obesity and the non-communicable diseases that are linked to it, according to several epidemiological studies. Fibre can reduce overall energy intake and delay the onset of obesity by increasing feelings of fullness and reducing calories consumed.

9.5 Anticompulsive effect

Girdhar *et al*. (2010) documented that the methanol extract derived from Ash gourd demonstrates the effect of anticompulsive in the marble burying behaviour observed in rats, potentially due to tryptophan enhancing serotonin biosynthesis.

9.6 Alzheimer's disease

Among the most important public health issues affecting the elderly is Alzheimer's disease. In 1906, Alois Alzheimer initially defined the disease by citing gradual disorientation, memory loss, and pathological indicators including neurofibrillary tangles and senile plaques. Inflammation, oxidative stress and protein aggregation are the hallmarks of this neurodegenerative illness. Roy *et al.* (2008) demonstrated that an administration of 400 mg/kg body weight of Ash gourd exhibited a neuroprotective effect in a colchicine-induced experimental rat model of Alzheimer's disease, potentially mediated by the antioxidant properties of vitamin E and β-carotene in safeguarding neuronal cells from oxidative stress.

9.7 General health

Bhalodia *et al*. (2009) observed reductions in gastritis (50% to 29.7%), urinary tract infections (34.7% to 16%), over breathing (25% to 5%), and thirstiness (97% to 81%) with Ash gourd juice supplementation. The hydroalcoholic extract of the fruit rind was evaluated for its effects on the renal system in adult male guinea pigs (Jayasree *et al*., 2011).

9.8 Allergic inflammation

Park *et al*. (2009) found that Ash gourd extract was effective against allergic inflammation in mice. Rachchh and Jain (2009) reported that Ash gourd had an antiulcerogenic effect by lowering peptic ulcers. Peptic ulcers are acid-induced lesions that are frequently observed in the duodenum and stomach. Their characteristic is a denuded mucosa with a defect that extends into the muscularis propria or submucosa. The Ash gourd has several medicinal and therapeutic properties, including the ability to raise the basal volume of the stomach liquid and lower its pH by raising the free acidity and chloride excretion of gastric juices. Amounts of pepsin, vit C, and chlorides in the stomach juice with antioxidant activity were shown to have significantly increased.

9.9 Antiageing effects on skin

On human stratum corneum and dansyl chloride fluorescence models, a cream made from dried fruit pulp extract (petroleum ether, chloroform, ethyl acetate and methanol) shown a notable antiageing effect (Islam *et al*., 2021).

9.10 Prebiotic effects

Prebiotics are non-digestible carbohydrates that serve as fermentable carbon sources in the intestine, promoting the growth and activity of beneficial probiotic microorganisms. These probiotics play a crucial role in maintaining gut health by inhibiting the growth of harmful microorganisms, strengthening the mucosal gut barrier, and enhancing the production of specific immune-regulating compounds and antibodies.

Ash gourd, when utilized as a prebiotic, has been shown to significantly contribute to the production of short-chain fatty acids (SCFAs) in the large intestine, such as acetate, butyrate, and propionate. According to research by Sreenivas and Lele, (2013) Ash gourd aids in the absorption of bile acids and supports the growth of beneficial gut bacteria, which in turn boosts SCFA levels. These SCFAs are known for their various health benefits, including enhancing gut barrier function, reducing inflammation, and potentially exerting anticancer effects.

The ability of Ash gourd to influence SCFA production highlights its potential as a functional food with prebiotic properties. By promoting a healthy balance of gut microbiota and supporting the production of bioactive compounds, Ash gourd may contribute to overall health and disease prevention. Its role in prebiotic function underscores its value in dietary strategies aimed at improving gut health and potentially reducing the risk of certain diseases.

10. Future thrust

Ash gourd is highly regarded for its impressive nutritional profile, which includes essential vitamins, minerals, and antioxidants. Its high-water content and low-calorie nature make it an ideal choice for maintaining overall health and managing weight. Additionally, Ash gourd is known for its various health benefits, including its potential to support blood sugar regulation, reduce inflammation, and provide antioxidant protection. These properties contribute to its increasing popularity in both the food and medicinal sectors.

The multifunctional nature of Ash gourd extends its utility beyond mere dietary consumption. Its diverse applications in the manufacture of food products, medicinal formulations, and industrial goods underscore its versatility. In the food industry, Ash gourd can be used in a range of culinary preparations, from soups and salads to desserts and beverages. Its medicinal value is harnessed in traditional and modern practices, where it is utilized for its potential therapeutic properties, including its role in digestive health and detoxification.

The growing interest in Ash gourd highlights the need for innovative applications to fully leverage its benefits. This includes developing new industrial uses, such as incorporating Ash gourd extracts into functional foods and dietary supplements. In the medical field, further research and product development could lead to novel treatments or preventive measures for various health conditions. Additionally, exploring culinary innovations can enhance the incorporation of Ash gourd into everyday diets, making it more accessible and appealing to consumers.

Overall, the expanding range of Ash gourd applications presents significant opportunities for advancing both its industrial and medicinal uses. By fostering ongoing research and innovation, we can optimize the potential of this valuable plant and enhance its contribution to health and well-being.

11. Conclusion

Future research on the nutritional and phytochemical properties of Ash gourd should prioritize comprehensive clinical trials to validate its health benefits across diverse populations, particularly its antidiabetic, hypoglycemic, hypolipidemic, antioxidant, and anti-inflammatory effects. Investigating the molecular mechanisms of these benefits will uncover the pathways influenced by Ash gourd's bioactive compounds. Efforts to isolate and characterize these compounds will pave the way for their potential use as natural alternatives to synthetic drugs. Additionally, determining optimal dosages and forms of Ash gourd for maximum efficacy, along with studying its synergistic effects with other medicinal plants, will enhance its application in integrative medicine. Innovative product development, sustainable cultivation practices, and increased public awareness will further promote the use of Ash gourd in everyday diets. Finally, advocating for its inclusion in national health guidelines and establishing regulatory standards will ensure its safe and effective use in healthcare.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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