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Benincasa hispida (ash gourd) a mighty future crop, it's saga from folk tales and traditional implications to modern applications: A review

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The ash gourd or *Benincasa hispida* (Thunb.) Cogn has played a significant role in traditional medicine, culinary practices, and folklore across various cultures. This underutilized crop has been widely documented in ancient medical texts, including Ayurvedic literature, where it has been ascribed to its cooling, diuretic, and neuroprotective therapeutic properties and nutritional value. This review seeks to connect traditional knowledge and modern scientific insights, highlighting the need for innovation to establish *Benincasa hispida* as an important crop with substantial industrial and economic prospects. The information for this review has been pooled by wide range of sources including research and review papers from data bases *viz.*, PubMed, NCBI, Science Direct, WHO, Web of Science, as well as local newspapers, magazines and YouTube for the traditional cuisines covering from the year 2001-2025. Recent scientific investigations have substantiated the versatile pharmacological attributes of the ash gourd. Its adaptability to tropical and subtropical climates, along with its rich phytochemical content, makes it a promising crop for nutraceutical use. Despite its considerable genetic variability, cultural prominence, nutritional merit, and spiritual relevance, technological innovations to improve its cultivation, waste repurposing, and integration into the food industry have been limited. Amid the rising focus on functional foods and therapies, this versatile crop holds immense potential for addressing contemporary challenges in health and nutrition. Expanding on its traditional uses and the latest research, this study explores diverse applications of *Benincasa hispida* from tradition to food and medicinal products, highlighting its potential to contribute to a more sustainable and healthier future.

Keywords: Ancient vegetable, Ash gourd, *Benincasa hispida*, Cultural significance, Traditional practices

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Benincasa hispida (*Thunb.*) *Cogn*, also known as ash gourd, is an esteemed vegetable from the cucurbit family that is cultivated for its fruits at both immature and mature stages. This crop has been ascribed to a variety of synonymous names, including wax gourds, tallow gourds, winter melons, white gourds, white pumpkins, Chinese preserving melons, ash pumpkins, pith gourds, and hairy melons. The term 'wax gourd' derives from the waxy coating on fully developed fruits, which deters microbes and prolongs the post-harvest lifespan[1]. In India, Ash gourd is known by a variety of regional names depending on its place of origin[2]. Vernacular names practiced in India and other parts of the world are presented in (Table 1). Ash gourd is widely cultivated in tropical regions and is documented among the earliest domesticated plants in both the Eastern and Western hemispheres[3]. Prehistoric agricultural practices as suggested by archaeological evidence from the Kana site in Papua New Guinea convey that *Benincasa hispida* is one of the oldest cultivated vegetables as indicated by the discovery of its rind and seeds[4]. Historically, ash gourds have been associated with folklore, traditional medicine, and religious rituals in many Asian countries, such as India, China, and Japan[5]. Ash gourd is a popular vegetable crop owing to its nutritional and medicinal properties. It is likely native to Japan and Java[6].

Benincasa hispida is a valuable vegetable crop prized for its extended shelf life and versatility in culinary applications through various cooking methods, including baking, frying, boiling, pickling,

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Table 1 — Vernacular names of Ash gourd based on place of origin

Sl. No.	Dialect (Origin)	Vernacular Names	Sl. No.	Dialect (Origin)	Vernacular Names
1.	Assamese (India)	*Komora, Kumora*	14.	Indonesian (Indonesia)	*Kundur*
2.	Hindi (India)	*Petha, Gol-kaddu, Raksa.*	15.	Japanese (Japan)	*Tougan, Togan, Togwa.*
3.	Malay (India)	*Kundur.*	16.	Sri lankan (Sri Lanka)	*Puhul, Alu puhul*
4.	Tamil (India)	*Allatuppucini, Ven poosani.*	17.	Turkish (Turkey)	*Mom kagai.*
5.	Sanskrit (India)	*Brhatphala, Kushmanda, Pushpaphala.*	18.	Chinese (China)	*Bai donggua, Yin donggua, Tung-kua P'i, Dong gua pi, Pai gua.*
6.	Bengali (India, Bangladesh)	*Kumra, chalkumra.*	19.	Dutch (Netherlands and Belgium)	*Waskalebas*
7.	Kannada (India)	*Buda Kumbala*or *Kumbaalakayi*	20.	German (Germany)	*Wachskürbis, Prügelkürbis, Wintermelone.*
8.	Malayalam (India, Sri Lanka)	*Cumbulam, Kumpalam.*	21.	Italian (Italy)	*Zucca della cera*
9.	Marathi (India)	*Kohala.*	22.	Nepalese (Nepal)	*Kubiindo, Petha.*
10.	Urdu (India, Pakistan)	*Petha.*	23.	Singaporean (Singapore)	*Tang kua.*
11.	Cambodian (Combodia)	*Tralach.*	24.	Thai (Thailand)	*Faeng, Fak, Mafakkhom, Mafakmon, Mafakmonkhom*
12.	Danish (Denmark)	*Voksagurk*	25.	Vietnamese (Vietnam)	*Bi dao, bi bee*
13.	French (France)	*Courge à la cire, Courgecireuse, Pastèque de Chine.*			

and confectionery preservation[7]. Additionally, the shoots, tendrils, and leaves can be consumed as edible greens. Apart from fresh consumption, ash gourd is used to make various value-added products, ranging from traditional sweets like 'petha', juices, and to the Ayurvedic medicines, which rise its market demand[8,9]. It an economically viable crop for small and marginal farmers because of its low cultivation input requirements and high yield[10]. It is significantly contributing to local livelihood and rural employment. Furthermore, the increasing demand for natural and health-promoting foods makes significant opportunity for export, particularly to Southeast Asian and Middle Eastern countries, thereby increasing its economic significance in India's agricultural sector[11,12].

Traditional preparations of ash gourd in India

Indian cuisine is considered one of the best because of its preparation methods, dietary values, and medicinal applications. The Indian cuisine system is influenced by regional climate, soil type, religion, occupation, and locally available food ingredients. Indian cuisine includes spices, green leafy vegetables, wild and locally available vegetables, and fruits. In India, there are many plants with medicinal values including ash gourd, which are used as a primary ingredient in variety of foods. Here, we discuss a few dishes that include ash gourds as the prime ingredients. Peeled, immature fruits free from seeds and fibers can be prepared using various culinary methods, such as stir-frying, braising, or steaming, and are commonly incorporated into the preparation of highly seasoned dishes[13]. In northern India, particularly in the middle Himalayan region, ash gourds are commonly paired with crushed pulses, such as *moong* (green gram), to prepare nuggets, which is a local dish known as *bori.* The nuggets are dried in sunlight, hardened, and then utilized in curry dishes, often consumed alongside rice or chapati (flatbread). Juice derived from raw ash gourd (*Maipawl or Khar*) is utilized by the Mizo community and indigenous Assamese ethnic groups of Northeast India as a natural therapeutic agent for the management of mild to severe dysenteric conditions. Candied ash gourd, *Agra Petha* is especially popular in Agra-Uttar Pradesh, which originated from *Mughal* kitchens under Emperor *Shah Jahan* and was used to feed the workers constructing the historical monument *Taj Mahal*. *Petha* has a Geographical Indication (GI) tag. In the state of Assam, fermented vegetable popularly known as *Posakumura* literally means ‘rotten’ in Assamese dialect, is used in food preparations; matured ash gourd is aged over a year and incorporated in several preparations *Borha* (flitters), *Bori* (nuggets), *Gutiraanja* (seed curry), *Khar* (an alkali), *satni* (Indian spread)[14]. In Bengali preparations, there are several dishes prepared with ash gourds: *Chal Kumro’r Bora, Chalkumrorghonto, dudhdiye Chalkumro* and *Chalkumror Bori. Sakara* is a traditional dish of Odisha, specially prepared on the holy occasion of *Bada Osha* (Festival of Lord *Shiva*), and is also offered to Lord *Jagannatha* as part of the *Mahaprasada*

and cooked in the *Nalapaka* process. In the Indian state of Andhra Pradesh, ash gourd is commonly incorporated into stews, stir-fries, and a local delicacy known as *Vadialu*. The preparation involved combining chopped gourds with ground urad beans and spices. The mixture was then sun-dried and deep-fried in oil, serving as an accompaniment to rice, sambar (a lentil-based stew), or other lentil-based preparations. In Karnataka, ash gourd is cooked very simply with a minimum of supporting spices to become translucent in a curry thickened with curd to make *Boodikumbala mor*. This traditional curry is made from the offerings (Ash Gourd) as thanksgiving at various Coorg shrines from freshly harvested produce. *Kumbalakai Majjige Huli* is a delightful South Indian dish that belongs to the "no onion, no garlic" category of recipes. This curry combines the mild and soothing flavors of ash gourd with buttermilk, resulting in a delectable and refreshing dish. Other popular dishes include *Kodel* (*Sambhar*). *Ale bajji*, *Kashi Halwa* and, *chutney*. *Kashi halwa*, also known as *Dumroot*, is a classic dessert recipe prepared from ash gourd vegetables and sugar. This dish originates from the renowned Udupi culinary tradition and is generally considered a premium dessert that is often served during special feasts and celebrations. *Kohalyachi Vadee*, a kind of *Barfi*, was prepared in the Maharashtra region. In the Konkan region, *Kuvalevadi/odi* or *Budu gumbalkayi sandige* is a popular sundry item among Konkan is; grated ash gourd and black gram paste with spices are dried and deep fried. *Kuvalo Sasam* is a mildly spiced coconut and tamarin-based Indian Konkan style curry flavored with mustard seeds (*sasam*). *Kuvaleachi Doce* is a simple goan sweet of Konkani origin popular in Goa. In Andhra Pradesh *Budu gumbalakai pachadi* South Indian accompaniment was made with shredded ash gourds and yogurt. Kerela *olan* is a classic Kerala dish, which is an essential dish in the *Onam Sadya* menu made with ash gourd, cow peas, and fresh coconut milk; it is a traditional vegetarian feast served on banana leaves on the ocassion of *onam*, and features a *Pulissery or a Moru Curry* (buttermilk curry) with either ash gourd or cucumber. *Thoran* is also a traditional dry flavourful that has no garlic. A presentation of various traditional preparations made with ash gourds across India is shown in (Fig. 1).

Fig. 1 — Traditional preparations of ash gourd (*Benincasa hispida*) from various regions of India

Preparations of ash gourd around the world

Ash gourd is commonly consumed as boiled or prepared with meat and eaten raw, such as cucumbers[15]. In Vietnam, ash gourd soup prepared from short pork ribs is traditionally consumed by breastfeeding mothers[9].

In Nepal, where it is called *Kubhindo*, it is cooked as a vegetable when young, but the ripe gourds are usually made into preserves or crystallized candy known as "*murabba*." Occasionally, it is used to produce a fruiting drink with a distinctive taste. It is usually sweetened with caramelized sugars. *canhbísườn* or Vietnamese winter melon soup is made with pork spare has a clear broth and is a comforting preparation in Vietnamese cuisine. *Canh BíĐaovớiTômKhô* is Vietnamese winter Melon Soup with Dried Shrimp. In China, a popular ash gourd dish is the soup known as *dōngguāpáigǔtang,* which is prepared by cooking pork or pork/beef bones within a scooped-out ash gourd It is nutritious and full of vegetables, herbs and meats. The gourd was carved by removing its waxy coating and the broth was then cooked inside the hollowed rind, resulting in a unique serving vessel akin to a pot. Another dish called *hóngshāodōngguā* is a staple Chinese braised winter melon. People in Ningbo region like to pick their food; they would ferment ash gourd so it would have a flavour similar to that of stinky tofu called *Chou donggua* (Chinese Stinky Winter Melon). *Dōngguātáng* is a Chinese candied ash gourd. The Cantonese pastry known as "wife cake" or "*lao po bing*" is a Chinese dessert featuring a flaky crust and a sweet filling made from winter melon. During the Moon Festival, the Chinese and Taiwanese populations also incorporated ash gourds into traditional moon cakes as a filling base. *Dōngguāchá* is the winter melon Tea of Taiwan, which is a widely enjoyed beverage produced by the maceration process. Winter melon tea bricks are also made by slowly cooking winter melon with sugar until the concentrate crystallizes. Ash gourd is candied by the Philippine populace and incorporated as a pastry filling in a sweet called *bakpia*. In addition, it serves as an ingredient in certain savoury soups and stir-fry dishes. The Srilankan *Alu Puhul Curry* is a local dish made of ash gourd in a coconut paste base with local spices. In South Asian nations, the tendrils, shoots, and foliage of the ash gourd plant are utilized as edible green leafy vegetables[6]. Popular food preparations made from ash gourds worldwide are shown in (Fig. 2).

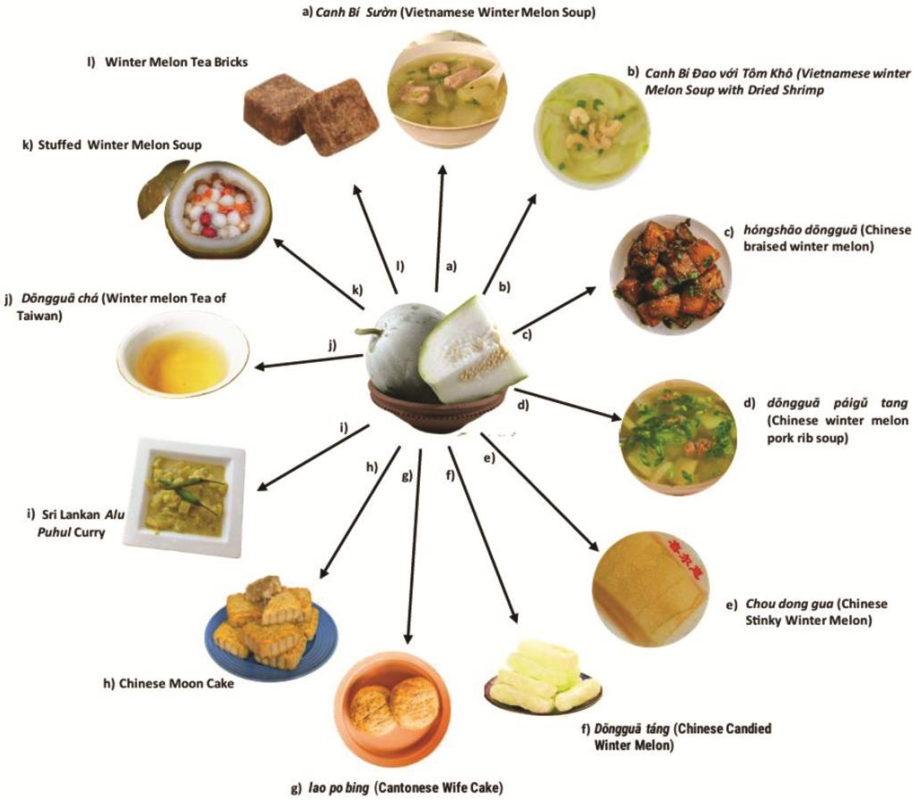

Fig. 2 — Traditional preparations of Ash Gourd (*Benincasa hispida)* from various regions of world

Furthermore, ash gourd is extensively used in traditional Chinese medicine to treat conditions such as fever, cough, and urinary disorders owing to its antipyretic, antitussive, diuretic, and anti-obesity properties[9]. The renowned Ayurvedic formulation '*Kusumanda rasayanam*,' utilized as a nerve tonic and health restorative, was prepared from fully mature ash gourd fruit. *Benincasa hispida* fruits are used in traditional medicinal practices to treat nervous debility and weakness[16].

Cultural and spiritual perspective of ash gourd in Indian culture

The ash gourd occupies a unique place in the Indian culture and rituals. Traditionally, ash gourd was used by Malayali Brahmins in a ritual known as '*Guruthi*,' instead of offering human life on the funeral pyre, which is symbolically cut in half as a substitute for human sacrifice. Hindus also use ash gourd as a sacrificial offering in place of animal sacrifice, believing it to be imbued with a sacred life force called "Prana," representing the essence of life itself. Ash gourds are commonly used in traditional cultural rituals, such as being marked with vermilion and ceremoniously split into two with a sword. This practice is widely observed during festivals such as *Dasara* (ten days of worship to Goddess *Durga*). Ash gourd is explicitly mentioned in the Bengali tradition as sacrificial offerings for the goddess. The cultural significance of ash gourds is deeply rooted in the Vedic tradition, as evidenced by its Sanskrit name, *Kushmanda Rasayana*. It is associated with the *Devi Kushmanda* (Mother Goddess and the creator of the universe and is offered to the deity on the fourth day of *Navratra/Devipaksha* (a nine-day celebration) to ward off the evil eye[17]. In South India, it hangs on the doors of shops, outlets, and homes to ward off evil eyes. Ash gourd is a traditional offering in South Indian temples, particularly for fierce deities such as *Bhairava* and various other goddesses. Ash gourd *deepams* are lighted at temples in southern India by cutting the fruit in two halves and scraping off the pulp enabling it to be used as oil lamps. The vegetables are commonly painted with the visage of an *asura* (Demon) and adorned with red vermillions to symbolize a sacrificial offering. Lighting camphor on the ash gourd and smashing it in front of the main door of a newly built house during *Griha Pravesh* (house warming ceremony), as well as in front of vehicles, is also a popular practice among Hindus.

The genetic diversity of *Benincasa hispida* (*Thunb.*) *Cogn.* in India

The Indo-Chinese region is recognized as the primary centre of genetic diversity for *Benincasa hispida* species[18]. The ash gourd germplasm found in India displays a substantial degree of genetic heterogeneity, Genetic diversity has been assessed through quantitative traits, such as fruit weight, vine length, and flowering time, fruit characteristics such as length, girth, count per plant, average weight and yield per plant, as well as seed parameters such as count per fruit and 1000-seed weight and has shown significant variability among different genotypes[19,20]. However, accessions from different regions of India, particularly the northeastern regions, showed distinct genetic clustering, indicating regional diversity[18]. The high degree of genotypic diversity can be leveraged to improve the cultivars with specific traits through selective breeding and cultivation suited to different agro-ecological zones[21]. In a diversity analysis of 40 *Benincasa hispida;* several high-yielding accessions, including non-scented varieties such as *Coimbatore Local*, *IC 339164*, *KAG 15*, *PAG 72*, *IVAG 10*, *Indu*, *Chalkumar*, *KAU Local*, and *Shadnagar Local*, as well as scented genotypes like *IC 596991*, *IC 596992*, and *IC 596994*, were identified as the best performing for yield[22]. *Kashi Dhawal*, *Kashi Surbhi*, *Kashi Ujwal*, and *Pusa Ujjwal* are popular varieties released by the Indian Institute of Vegetable Research in Varanasi.[23] Similarly, *Pusa Urmi*, *Pusa Sabji Petha*, and *Pusa Shreyali* are popular varieties released by the Indian Agricultural Research Institute (IARI) in New Delhi.[24] Among these, *Pusa Urmi* and *Pusa Shreyali* are relatively new hybrid cultivars that have been identified for commercial-scale production[25] (Fig. 3). The cultivar *BAGS-7* had the highest seed number and weight per fruit[20].

In Karnataka, Indian Institute of Horticultural Research (IIHR), Bengaluru, has developed and recommended improved varieties such as '*Arka Bahar'*, which produces fruits with an average weight of 1 kg. This variety can have a yield potential of 400-450 quintals per hectare in a crop duration of 120 days[26]. While certain hybrids like *'Pusa Urmi'* developed by the Indian Agricultural Research Institute can yield up to 47.5 tonnes per hectare[25].

Further varieties, such as *CO 1*, *CO 2*, *PAG3*, *TNAU Ash Gourd Hybrid CO 1* are popular in the Indian state of Tamilm Nadu. The '*PAG-3*' yields

approximately 120 quintals per acre, with fruits weighing around 10 kg each and a crop duration of about 145 days[27]. Despite the observed genetic diversity, the breeding of ash gourds is challenging owing to its monotypic nature and limited genetic pool. This necessitates the use of diverse germplasms and advanced molecular techniques to enhance breeding efficiency[28]. This diversity provides a valuable resource for breeding programs aimed at improving yield and other agronomic traits[29]. List of the Varieties of *Benincasa hispida* (*Thunb.*) *Cogn* genotypes and their sources in India are listed in (Table 2)[30-32].

Nutritive value of edible fruit of ash gourd vegetable

Gourd fruits are rich in energy, dietary fiber, vitamin C, mineral content, and low levels of anti-nutrients, making them potential health-promoting food sources[33]. Ash gourd has a high moisture content of approximately 96 percent[8]. The fruit contains essential minerals, such as calcium, potassium, sodium, iron, zinc, and phosphorus. It is also a good source of vitamins B1, B3, and C, contributing to its nutritional value[34]. The proximate composition per 100 g of edible fruit of ash gourds is reported as; energy 73 kJ, carbohydrate 2.84 g, protein 0.79 g, ash 0.70 g, fat 0.14 g, total dietary fibre 3.37 g in Indian Food Composition Table[35].

Fig. 3 — Popular varieties of ash gourd; Source: IIVR Varanasi, IARI New Delhi, TNAU Coimbatore

Table 2 — List of land races/released varieties of *Benincasa hispida* (*Thunb*.) *Cogn* genotypes and their sources in India[23,30-32]

Sl. No.	Land races/ Released Varieties	Source	
		Village/Town	District and State
1.	*BAGS-1*	Bhaludunguri	Bolangir, Odisha
2.	*BAGS-2*	Gambhari	Bolangir, Odisha
3.	*BAGS-3*	Rungaon	Sundargarh, Odisha
4.	*BAGS-4*	Kuligaon	Nuapada, Odisha
5.	*BAGS-5*	Banjibahal	Nuapada, Odisha
6.	*BAGS-6*	Biswanathpur	Nuapada, Odisha
7.	*BAGS-7*	Badasasan	Angul, Odisha
8.	*BAGS-8*	Jholpathar	Nuapada, Odisha
9.	*BAGS-9*	Gambhari	Bolangir, Odisha
10.	*BAGS-10*	Kuligaon	Nuapada, Odisha
11.	*BAGS-11*	Dashapalla	Nayagarh, Odisha
12.	*Kashi Dhawal*	IIVR, Varanasi	Varanasi, Uttar Pradesh
13.	*Kashi Ujwal*	IIVR, Varanasi	Varanasi, Uttar Pradesh
14.	*Kashi Surbhi*	IIVR, Varanasi	Varanasi, Uttar Pradesh
15.	*Pusa Ujwal*	IARI, New Delhi	Delhi, Uttar Pradesh
16.	*Pusa Urmi*	IARI, New Delhi	Delhi, Uttar Pradesh
17.	*Pusa Sabji Petha*	IARI, New Delhi	Delhi, Uttar Pradesh
18.	*Pusa Shreyali*	IARI, New Delhi	Delhi, Uttar Pradesh
19.	*Shadnagar Local*	Shadnagar,	Andhra Pradesh
20.	*KAU local*	KAU, Thrissur	Thrissur, Kerala
21.	*Large fruited*	KAU, Thrissur	Thrissur, Kerala
22.	*PAG3*	TNAU, Coimbatore	Coimbatore, Tamilnadu
23.	*PAG72*	TNAU, Coimbatore	Coimbatore, Tamilnadu
24.	*Pusa Ujwal*	NBPGR, New Delhi	Delhi, Uttar Pradesh
25.	*RCAG15*	ICARNEH region, Arunachal Pradesh	Arunachal Pradesh
26.	*Varanasi Local*	IIVR, Varanasi	Varanasi, Uttar Pradesh
27.	*IC596992*	NBPGR, New Delhi	Delhi, Uttar Pradesh
28.	*IC596994*	NBPGR, New Delhi	Delhi, Uttar Pradesh
29.	*BH1*	TNAU, Coimbatore	Coimbatore, Tamilnadu
30.	*BH2*	TNAU, Coimbatore	Coimbatore, Tamilnadu
31.	*BH3*	TNAU, Coimbatore	Coimbatore, Tamilnadu
32.	*Chalkumar*	TNAU, Coimbatore	Coimbatore, Tamilnadu
33.	*Chityal Local*	Chityal	Andhra Pradesh
34.	*CO2*	TNAU, Coimbatore	Coimbatore, Tamilnadu
35.	*Coimbatore Local*	TNAU, Coimbatore	Coimbatore, Tamilnadu
36.	*DAG6*	IARI, New Delhi	Delhi, Uttar Pradesh
37.	*Debpurna*	BCKV, Mohanpur	Nadia, West Bengal
38.	*Haveri Local*	Haveri, Karnataka	Haveri, Karnataka
39.	*HYBH25*	TNAU, Coimbatore	Coimbatore, Tamilnadu
40.	*IC339164*	NBPGR, New Delhi	Delhi, Uttar Pradesh
41.	*IC339178*	NBPGR, New Delhi	Delhi, Uttar Pradesh
42.	*IC339180*	NBPGR, New Delhi	Delhi, Uttar Pradesh
43.	*IC339195*	NBPGR, New Delhi	Delhi, Uttar Pradesh
44.	*Indu*	KAU, Thrissur, Kerala	Thrissur, Kerala
45.	*Indu-K*	KAU, Thrissur, Kerala	Thrissur, Kerala
46.	*IVAG10*	IIVR, Varanasi	Varanasi, Uttar Pradesh
47.	*IVAG3*	IIVR, Varanasi	Varanasi, Uttar Pradesh
48.	*IVAG90*	IIVR, Varanasi	Varanasi, Uttar Pradesh
49.	*KAG1*	KAU, Thrissur	Thrissur, Kerala
50.	*KAG15*	KAU, Thrissur	Thrissur, Kerala
51.	*KAG3*	KAU, Thrissur	Thrissur, Kerala
52.	*RCAG28*	ICARNE Hregion, Arunachal Pradesh	Arunachal Pradesh
53.	*Vaidya kumbalam*	KAU, Thrissur	Thrissur, Kerala
54.	*IC596991*	NBPGR, New Delhi	Delhi, Uttar Pradesh
55.	*IC596993*	NBPGR, New Delhi	Delhi, Uttar Pradesh

The ascorbic acid content of eight selected ash gourd genotypes were examined which ranged from 14.67 to 40 mg per 100 g; among the genotypes, *Kashi Dhawal* exhibited the highest ascorbic acid content at 40 mg per 100 g. Additionally, the fruit of genotype *BAGS-9* had the highest iron concentration (6598.50 mg kg^{-1}), whereas *BAGS-8* was the richest source of potassium, sulphur, and manganese[36]. The

highest zinc concentration was observed in the fruit of the genotype *BAGS-2*[19]. Micronutrient Composition of different varieties of *Benincasa hispida* (*Thunb.*) *Cogn* is are presented in (Table 3)[19,36,37]. Studies have shown that ash gourds are rich in potassium. Furthermore, the *BAGS-2* and *BAGS-9* cultivars are recommended for Ash Gourd growers because they possess a superior nutritional profile, which can assist in maximizing crop production[38].

Nutritive values of ash gourd seed and seed oil

Ash gourd seeds are the most nutritious and antioxidant-rich among cucurbit seeds, with the potential for food applications and thermal stability[39]. *Benincasa hispida seeds* possess significant potassium and iron content and have fair amounts of carbohydrate and fibre content compared to other similar vegetables such as pumpkin. Ash gourd seeds contain 445 mg, 214 mg, 4.2 mg of potassium, calcium & iron per 100 g of ash gourd seeds, respectively[40]. Proximate values of ash gourd seeds reported as moisture 4.91 g, carbohydrate 15.66 g, protein 24.89 g, ash 11.86 g, fat 40.27 g and total dietary fibre 2.41 g[41].

Ash gourd seed oil was predominantly composed of linoleic acid (unsaturated fatty acids) comprising 80.07% of the total fatty acid content. Additionally, palmitic, oleic, and stearic acids were detected as other significant fatty acid constituents, contributing 11.71%, 4.10%, and 3.74%, respectively[42].

Pharmacologicalproperties of ash gourd

Ash gourd is a widely cultivated vegetable crop valued for its nutritional benefits and also for its medicinal properties[43,44]. Consumption of ash gourd juice had a notable impact on anthropometric measures, including body weight, waist circumference, hip circumference, and body mass index[45]. Patients with diabetes and hypertension who require low-sugar diets can use ash gourds because of their low carbohydrate content[33]. The pulp, leaves, and seed have medicinal properties[40]. The various pharmacological effects of the ash-gourd fruit sections reported are outlined in (Table 4)[2,9,34,46-52].

Chemical constituents of ash gourd vegetable

The major constituents of *B. hispida* fruits are volatile oils, flavonoids, glycosides, saccharides, proteins, carotenes, vitamins, minerals, ß-sitostrin,

Table 3 — Micronutrient Composition of different varieties of *Benincasa hispida* (*Thunb.*) *Cogn*[19,36,37]

Varieties	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Ascorbic acid (mg/100 g)
BAGS-1	0.75	0.41	4.90	0.60	7.40	4.30	1612.50	84.11	29.43	20
BAGS-2	0.82	0.42	4.10	0.60	8.70	3.20	1359.80	172.40	62.44	14.67
BAGS-3	1.18	0.39	5.30	0.70	9.30	5.50	1366.70	88.70	43.23	-
BAGS-4	0.97	0.26	5.30	0.70	7.60	4.90	2623.70	158.60	45.15	-
BAGS-5	0.86	0.26	4.10	0.40	6.10	3.80	1129.10	141.60	33.52	-
BAGS-6	0.59	0.42	5.60	0.60	7.30	5.60	2814.60	98.63	45.08	21.33
BAGS-7	1.16	0.29	4.20	0.60	4.60	3.10	664.60	61.90	58.57	13.33
BAGS-8	0.93	0.17	6.75	0.80	5.60	3.90	602.70	229.70	30.30	-
BAGS-9	0.86	0.60	3.70	0.60	8.00	2.00	6598.50	103.20	26.84	-
BAGS-10	0.72	0.62	4.80	0.60	7.40	1.80	1768.00	160.20	60.21	-
BAGS-11	0.84	0.30	4.60	0.40	5.20	2.20	911.10	72.50	16.00	20.00
KASHIDHAWAL	1.03	0.55	5.50	0.30	8.80	5.00	1776.40	68.60	21.12	40
KASHIUJWAL	0.98	0.41	2.80	0.40	4.40	3.10	4178.70	109.60	25.07	-
KASHISURBHI	0.86	0.29	2.90	0.20	4.60	4.00	4852.00	104.00	35.79	16
PUSAUJJWAL	0.67	0.16	3.20	0.40	5.00	5.60	1546.30	89.60	39.47	-
PUSAURMI	0.87	0.15	2.50	0.40	6.80	1.80	1381.80	147.00	23.54	-
PUSASABJIPETHA	0.64	0.16	2.70	0.40	7.50	2.30	2126.00	73.40	38.27	26.67
PUSASHREYALI	0.61	0.27	3.40	0.50	10.00	4.70	5230.40	61.22	30.56	-

Table 4 — Pharmacological properties of ash gourds.

Fruit Part	Pharmacological Property	Reference
Fruit	Anxiolytic, Anti-inflammatory Anticonvulsant, Antidepressant, Antioxidant, Hypolipidemic, Analgesic, Anti-asthmatic.	34,46
Peel	Anthelmintic, Antioxidant	47,48
Seed	Antioxidant, Antiulcer, Ant-inflammatory, Anti-angiogenic, anti-tumor, anti-nociceptive, anti-pyretic activities, treatment of syphilis, soporific effect, Angiotensin converting enzyme (ACE) inhibitor	2,9,49–51
Seed oil	Antimicrobial effect	52

Table 5 — Chemical constituents of *Benincasa hispida* (Thunb.) Cogn

Part	Chemical Constituents	Reference
Fruit	Lupeol, β-sitosterol, cucurbitin, rhamnose, mannitol, triacontenol, alkali, fat, vitamin, glucose, adenine, trigonelline, histidine, pentacyclic triterpene, hexanal, pyrazine compounds flavonoids, sacchrides, proteins, glycosides, carotenes, homogalacturonan, β-(1→4) D-galactan, acidic arabinan, uronicacid and ß-sitosterin.	53,57,58
Peel	galactose, glucose, xylose and sorbose	59,60
Seed	24-z- ethylidene, cholesterol -7 enol, 24- β- ethyl cholesterol, acetoin, octoanol, nonanol, acetoin flavonoids, sterols, glycosides, alkaloids, fixed oils and fats, phenolic compounds, steroids and unsaturated fatty acids	53,61
Seed oil	Myristic acid, palmitoleic acid, oleic acid, linoleic acid, stearic acid, α-linolenic acid, palmitic acid, other saturated and unsaturated fatty acids	61,62
Leaf	Flavonoids, glycosides, alkaloids, steroids, resinshydroxybenzoic acids, flavonoids and hydro cinnamic acids, triterpenes, pectic polysaccharides and hemicellulose poly saccharides.	58,63
Roots	Pentacyclic triterpene, Bryonolic acid and proteins	53,64

and uronic acid[53]. Chemical analysis showed that the main sugars in *Benincasa hispida* peels were galactose, glucose, xylose, and sorbose[54]. Seed oil consists of linoleic, palmitic, oleic, and stearic acids[42,55]. Ash gourd seeds have been reported to contain anosmotin-like proteins that can be isolated[56]. The chemical constituents of the parts of *Benincasa hispida* is are listed in (Table 5)[53,57-64].

Value added products and industrial application of ash gourd (*Benincasa hispida*)

Bari/ Badi (nuggets) and *Petha/ Murraba* (sweet candy) are popular value-added products prepared from ash gourd fruit[36]. Ash gourd-based preparations, such as *badi* (dried nuggets), are commonly prepared by combining vegetables with crushed pulses, such as green gram, and the mixture is sun-dried, then utilized in curried dishes, and consumed with rice or chapati. This preparation is highly favored in various Indian states and throughout Bangladesh, where it is known as the local dish bori[65]. *Petha*, also known as *Murraba*, is a popular Indian confection. They are soft, chewy, and candy-like treat. Ash gourd is cooked in concentrated sugar along with added flavors and coloring to increase aesthetic quality. Furthermore, the combination of ash gourd and basil presents a promising avenue for the development of a nutritious, appealing, and stable vegetable-based beverage[66]. The value-added ash gourd ready-to-serve beverage is a rich source of ascorbic acid with a recorded concentration of 10.8 mg per 100 mL. Despite pasteurization, the juice maintains a pH of 5.14, indicating that it is not overly acidic[67]. Ithas been shown that the stabilization of ash gourd juice and ash gourd mint-blended juice through irradiation treatment resulted in juices exhibiting stability for up to eight months with high acceptability scores and were microbiologically safe. Additionally, researchers have found that ash gourd juice can be processed and preserved using aseptic techniques[68]. When blended with 0.35% pectin, ash gourd-carrot juice maintains acceptable quality and nutritional value for up to 8 weeks at both 4°C and 28°C, with decreasing cloud stability and increasing juice lightness[69]. Additionally, an enzyme isolated from ash gourd juice can be used as a substitute for calf rennet in the production of cheddar cheese[70].

Table 6 — Applications of ash gourd fruit in different value-added products

Sl. No.	Functional food	Form of ash gourd	Sensory Acceptance	References
1.	*Kalakand*	Pulp	High	73
2.	Candy	Pulp	High	74
3.	*Badi*	Pulp	High	36
4.	Juices	Pulp	High	75
5.	Jam	Pulp	High	76
6.	Buffalo meat sausage	Peel	High	77

The fruits can also be processed into pulp-based products such as mash cakes. Additionally, ash gourds can serve as a functional ingredient in various value-added food items, including jams, ketchups, beverages, cakes, and ice creams[71]. Ash gourds are commonly used to produce distinctive-tasting fruit beverages. The drink is typically sweetened with caramelized sugars. In Southeast Asia, this product is commercially available as wax gourd tea or wax gourd punch. Fermented ash gourd fruit enhances health functionality by increasing bioactive compounds, such as 2-furoic acid, which has potential for functional food development[72]. Applications of ash gourd fruit in different value-added products are enlisted in (Table 6)[36,73-77].

Valorization of waste from ash gourd fruit *(Benincasa hispida*)

They produce large amount of waste both during consumption and processing owing to their thick rind and large seeds. These wastes generate potential problems for their treatment and disposal. These wastes

Table 7 — Waste utilization of peel and seed from ash gourd fruit (*Benincasa hispida*)

Sl No.	Form of Ash gourd	Utilization Type	Description	Reference
1.	Peel	Bio-sorbent for heavy metals	Utilization of ash gourd (defatted) peel in biosorption of chromium (Cr)	78
2.	Peel	Dietary fiber enrichment	Vegetable Peel-Enriched Functional Foods	9,79
3.	Peel	Pectin extraction	Peel contains pectic polysaccharides which can be extracted and used as adsorbent, emulsifying agent, gelling agents.	60
4.	Peel	Production of laccase	Peel of ash gourd is rich in sugar, amylose, phenolic components, used to replace the conventional chemical processes of several industries such as the pulp and paper, textile, pharmaceutical, nanobiotechnology, packaging material or used as fodder.	80
5.	Seed	Biodiesel production	Seed oil has suitable fatty acid profile for conversion into biodiesel.	81
6.	Seed	Bio-ethanol yield	Possibility to blend it gasoline for use in engines without any significant change in internal combustion.	82

are also potential raw material for biofuel production. Enzymes from cucurbit peel are utilized in detection and quantification of hazardous metals in industrial effluents and ground water. Ash gourd peel can serve as a substrate for the cultivation of diverse microorganisms, which can then be utilized to produce industrially relevant products through fermentation processes. Much research has been carried out to investigate the conversion of these wastes into useful products or even its use as a raw material for other industries presented in (Table 7)[9,60,78-82].

Conclusion

Despite its genetic diversity, health benefits, and cultural and spiritual significance across India and Asia, ash gourds are not widely consumed. Processed products of this fruit have received little attention. However, ash gourds have been reported to offer significant health benefits. Therefore, it can be reasonably assumed that ash gourd possesses substantial potential as a valuable component for the development of functional foods, and can be exploited for alternative applications in the food industry.

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Author Contributions

PB, HCC, and DG collected the data, planned, designed, interpreted the research data, and drafted the manuscript. KRM and DHA were collected from Indian cuisines from various sources, such as local newspapers, magazines and YouTube. PM and RS conceived and supervised the data, study plan, data execution, interpretation, and manuscript correction. All the authors have read and approved the final manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

Use of Artificial Intelligence (AI)

The authors declare that no artificial intelligence (AI) tools or AI-assisted technologies were used in the conception, preparation, writing, or revision of this manuscript. Grammarly software [Superhuman Platform Inc., licenced version] was used solely for language editing, grammatical correction and text refinement. All work was performed solely by the authors.

Data Availability

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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