Review Article

A Review of *Sechium edule* on Traditional Utilization, Phytochemical Existence, Food Technology, and Ethnobiological Benefits.

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ABSTRACT

Sechium edule, known as Chayote, belongs to the Cucurbitaceae family. It is also grown worldwide in tropical and subtropical regions. Because of its medicinal benefits, Chayote is being used as a traditional medicine in different areas of the northeast. Chayote fruit and vegetables show practical components people use in their regular diet. The current review revealed that the plant's edible parts could be used to treat different illnesses due to the presence of other secondary metabolites. The plant has also been shown to possess several pharmacological properties. The toxicological report in the present review also documented that the plant *Sechium edule* does not contain any neurotoxic or genotoxic metabolites, which will contribute to the toxicological information. Different parts of the plant, such as young stems and seeds, are also consumed in various forms due to the presence of proteins and vitamins. The plant has also shown high contents in aspartic, glutamic acid, alanine, proline, serine and valine which recommends that the plant can offer medicinal benefits and be used in hospital diets.

Keywords: Chayote, *Sechium edule*, anti-microbial, medicinal benefits.

INTRODUCTION

With the increased efficacy in pharmacological effects of medicinal plants in the twenty-first century, there is a rising demand for plant-based medicines, pharmaceuticals, food supplements, health products, and cosmetics derived from plants[1]. Herbal medicine has been regarded as a promising future medicine for managing health care. The Indian Ayurvedic system has also detailed many plant or plant product-based remedies. According to the World Health Organisation (WHO), approximately 80% of the world's population still uses these herbs and other traditional medicines for medicinal purposes [2]. Understanding their morphological, pharmacognostic, or pharmacological applications can help to recognise their active principles and mode of action, which can aid in researching different therapeutic plants.

Chayote (*Sechium edule*) belongs to the gourd Cucurbitaceae family and is known as squash. The plant is extensively grown in India and has been cultivated in backyards, including places like Tamil Nadu, Karnataka, West Bengal, Himachal Pradesh and the northeast hill area of India. Mizoram is the leading state, with an estimated size of 845 ha and a yield of 10,985 metric tonnes[3,4,5]. It is also grown worldwide in tropical and subtropical regions [6,7]. It is an herbaceous perennial, monoecious, vigorous creeper or climbing plant. It extends from a single, thick root, producing adventitious tuberous roots[4,8]. It is famous for human consumption in various countries[9]. It is one of the least expensive vegetables available. The plant has several medicinal properties as it contains a high concentration of polyphenol flavonoids, especially in leaves, roots and stems[10]. Chayote fruits and vegetables are good sources of fibre and dietary fibre; many of these have been found to significantly affect lipid metabolism.

Therefore, the current review aims to systematically document and bridge scientific evidence about chayote's nutritional, phytochemical, pharmacological actions and medical benefits found in various Cucurbitaceae family literature, books, and scientific articles. It also discusses the versatile utility of chayote in nutrition as a functional ingredient in the food, cosmetic, and pharmaceutical industries and biotechnological processes.

Local names

Chayote is so common throughout many parts of India and so well known as a valuable plant that it has been known by various names in different languages[8]. In Sikkim it is known as Iskus, in Mizoram it is known as Ishkut, in Meghalaya it is known as Piskut or Sikot, and in West Bengal it is known as Squash.

Plant description and morphology

Sechium edule blooms from April to December and bears fruit from September to January. The most contented average temperature is 13-21°C. Temperatures below 13°C damage minor or unripe fruit, while temperatures above 28°C promote excessive growth and the shedding of flowers and unripe fruit, affecting production[8]. The chayote plant has many calories, especially in the young stems and tuber roots[9]. The branches of the *Sechium edule* are angular-grooved and glabrous, several meters long, slightly compressed, and longitudinally wrinkled, and grow simultaneously from a single root[11]. They are green when young and brownish-grey when mature[6]. The leaves are dark green. They are simple, spirally arranged, thin, broad, and heart-shaped, measuring 10-25cm wide. The petiole

measures 3.25cm in length, and the leaf blade is broadly ovate circular in outline, measuring 7.25cm in diameter. They are angular or lobate (with three or five lobes) and have minutely denticulate margins and three to five divided tendrils[12]. The fruit is pendulous, big, oblong, or pyriform, with a variable number of longitudinal depressions, a white surface, and light or dark bright green that grows individually or in pairs[6]. When ripe, they may have woody ridges or lenticels on the surface; the pulp is pale green or whitish and tastes bitter in wild plants and pleasant, sweet, or watery in cultivated plants[13]. Flowers in long racemes are unisexual and staminate, yellowish to pale green. The ovary is inferior, and the pistillate flowers are solitary, with corollas measuring 12 to 17 mm[11]. The *Sicyos edulis* consists of a single large seed with smooth testa. The seed is cordate, flat, and centrally embedded in the mature fruit. Before germination, the seed coat is obsolete, and it can germinate while still inside the fruit[11]. The *Sechium edule* plant contains heavy metals and produces tuberized roots with more than 65% starch[11].

Figure 1: Fruit of *Sechium edule* plant

Figure 2: Flowers of *Sechium edule* plant

Cultivation

Francisco Hernández, a European naturalist who lived in Mexico between the 15th and 16th centuries, was among the first to report on the existence of chayote[14]. It was cultivated in the valleys of Oaxaca and Tehuacan, Puebla, in southern Mexico (the states of Veracruz, Puebla, and Oaxaca)[3]. The crop was introduced to India by Western Missionaries, and it is now widely distributed along the Himalayas from Mizoram in the east to Himachal Pradesh in the west, as well as adjoining areas of Myanmar, Bhutan, and Nepal. It is also grown in the peninsular region of India, particularly in the Madurai and Nilgiri hills of Tamil Nadu, as well as parts of Kerala and Karnataka[15].

Chayote cultivation varies according to soil type and climatic conditions[11]. It requires high humidity (80 to 85%), temperature ranging from 20 to 25°C, and rainfall of 1500 to 2000mm per year (or irrigation). During hot months (above 31°C), chayote leaves show yellow, their stems will deteriorate, and tubers will not produce[16]. Therefore, the planting site is prepared in advance where the chayote is typically grown. It is necessary to dig a hole that is big enough, usually filled with organic manure, to allow the roots to grow to their full extent without harm. A frame of branch wood or some other material is often made nearby so the plant can climb[5]. For this reason, seeding is usually near a tree. A trellis system made of wooden poles and wires is used in commercial plantations. During the first weeks of plant development, care is somewhat intense (watering, fertilising, etc.), but attention to the root (keeping it from physical injury) is seen as critical throughout the plant's life cycle[8].

Chemical constituents

Four flavonols (rutin, myricetin, quercetin, and galanin), two dihydrochalcones (phloretin and phlorizin), and one flavanone (naringenin) were detected unambiguously in extracts of chayote fruit. Phenolic acids and corresponding esters, together with flavonoids and glycosylated flavonoids, have been seen previously in extracts of seeds from species of the genus *Cucurbita* (Cucurbitaceae)[17].

Using high-performance liquid chromatography photodiode array mass spectrometry, the flavonoids of *Sechium edule* were studied in several edible parts. Eight flavonoids, comprising three C-glycosyl and five O-glycosyl flavones, were discovered and quantified in the plant's roots, leaves, stems, and fruits using LC-photodiode array-MS. These flavonoids were identified by nuclear magnetic resonance spectroscopic data and were confirmed to be present in the plant's roots, leaves, and fruits. In contrast to the sugar units of glucose, apiose, and rhamnose, apigenin and luteolin stand in for the aglycone moieties. The findings showed that the leaves (35.0 mg/10 g of dried portion), roots (30.5 mg/10 g), and stems (19.3 mg/10 g) contained the highest total amount of flavonoids[18].

Seeds of *Sechium edule* are a rich source of Gibberellins, paranoid and other plant hormones. Identification and localisation of Gibberellins in the cucurbit *Sechium edule* maturing seeds were studied. Twenty known Gibberellins (GAs) have been identified[19]. Table 1 highlights the phytoconstituents in different parts of *Sechium edule.*

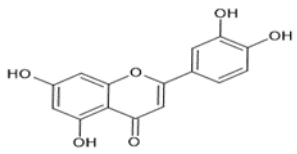
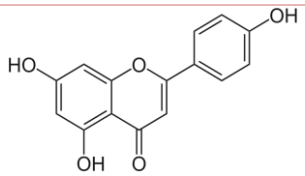
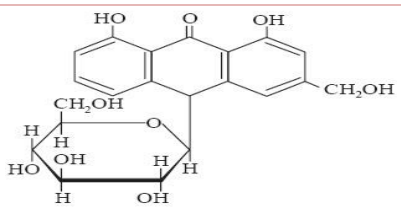
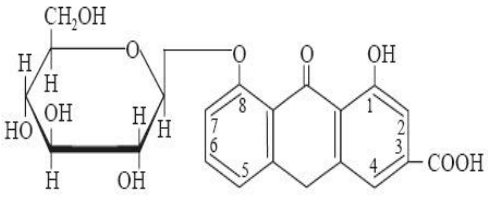
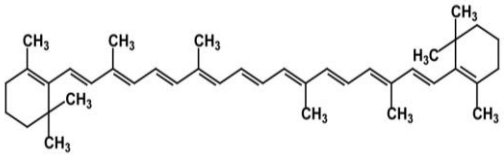
The primary phytochemical components of *Sechium edule* extracts have been identified as polyphenols, phenols,

flavonoids, alkaloids, tannins, saponins, steroids, and triterpenes[9]. Chayote young shoots were found to have a high calorie and carbohydrate content. Through the inhibition of lipid peroxidation and free radical scavenging activity, it has been demonstrated that ethanolic extracts of dried leaves and water extracts of seeds have greater radical scavenging, reducing power, and antioxidant characteristics[20]. The fruit, particularly the seeds, is high in several essential amino acids. They contain several vital amino acids, including aspartic acid, glutamic acid, alanine, proline, serine, tyrosine, threonine and valine[20]. Table 2 represents the chemical structure of *Sechium edule*.

Table 1: Phytoconstituents found in different parts of *Sechium edule*

Method used	Parts studied	Phytoconstituents	Reference
Thin layer chromatography	Fruit	Rutin	17
	Seeds	Myricetin Quercetin Galangin Phloretin Phlorizidin Naringenin	
High-performance liquid chromatography	Roots	Apigenin	18
	Leaves	Luteolin	
	Stems	Glucose	
	Fruit	Apiose Rhamnose	
Gas chromatography	Seeds	Abscisic acid Phaseic acid Dihydrophaseic acid	19

Table 2: Chemical structure of *Sechium edule*

Chemical constituent	Molecular formula	Structure
Luteolin	$C_{15}H_{10}O_6$	
Apigenin	$C_{15}H_{10}O_5$	
C-glycosidic	$C_{45}H_{74}O_{18}$	
O-glycosidic	$C_{29}H_{32}O_{12}$	
β- carotene	$C_{40}H_{46}$	

Chayote in food technology

Chayote is a source of numerous enzymes, such as polyphenol oxidase, alcohol dehydrogenase, catalase, phosphatase, lipoxygenase and peroxidase, which can be used in biotechnological processes. The research revealed that chayote peroxidases were effective at removing pentachlorophenol, a persistent and mutagenic halogenated hydrocarbon pesticide used to protect wood from fungi, germs, and insects. From the action of these oxidoreductases, free radicals are generated, which are polymerised into low-toxicity products[21]. Additionally, by changing the amino acid sequences of the low molecular weight trypsin inhibitors found in chayote seeds, novel protease inhibitors with biological interest can be created[22]. Trials have been conducted to use fruits, shoots and tubers as fodder in erosion control. Chayote seems to be significantly important in the management of poultry, cattle or their health management and promotes growth in pigs. The growth and nutritional utilisation of Zovawk pigs fed on various amounts of chayote meal (fruits and leaves) in the diet were examined by Lalthansanga and Samata (2015). Chayote meal might replace the usual grower ratio of up to 40% in the diet of pigs without having any negative impacts on growth and nutrient uptake, according to the results of a 90-day feeding research[23]. The fruits are also valued as vegetables in many rural communities and are either boiled or used in stews and desserts[35]. Chayote fruit is also recommended in hospital diets due to its high content of aspartic acid, glutamic acid, alanine, proline, serine, tyrosine, threonine, and valine. The tuberous roots are a good source of easily digested starch, especially for babies and invalids, and are sold in indigenous markets for soups, stews, and candies. Shoots and tender young leaves are nutritious pot herbs with vitamins A and C, calcium, iron, and B[16]. In recent years, The Asian continent has emerged in the consumption of chayote shoots and in countries like Malaysia, Taiwan, Thailand, and Vietnam, young leaves and tendrils are frequently stir-fried[36]. In Indonesia, the shoots are consumed raw as a salad or cooked. However, cooking methods may potentially reduce or increase the phytonutrient content of vegetables[36]. Compared to other vegetables, the edible sections of *Sechium edule* are comparatively poor in fibre, protein, and vitamins. Despite this, they contain a high caloric and carbohydrate content, particularly in young stems, roots, and seeds, and the fruit's micro and macronutrient content is adequate[9,14]. Many of these qualities, especially the softness of the fruit flesh, make it ideal for hospital meals and add consistency to infant foods, juices, sauces, and pastes[10]. As a raw fruit, the pulp has a firm and crisp texture that may show a delicate and soft texture after cooking[4].

The stems and fruits of *Sechium edule* are primarily consumed for food, whereas the roots are described as succulent fibrous tuber with a unique flavour[3]. Chayote fruit serves as a substitute for artichoke hearts in France. The matured fruit and seed are sliced, boiled, and consumed. In India, chayote is eaten with other vegetables in a curry meal[9]. Its tender leaves, stems, fruits and the tuberous part of the adventitious roots have been essential components of the diets of people in India, South America and other countries such as Australia, Madagascar, China, Portugal, and South Italy[10].

PHARMACOLOGICAL PROPERTIES AND MEDICINAL BENEFITS

Antioxidant properties

The extract antioxidant activities (AA) of *Sechium edule* were evaluated using three well-established in vitro methods: reducing power, b-carotene linoleate model, and 1,1-diphenyl-2 picrylhydrazyl (DPPH) radical scavenging. Leaf ethanolic and leaf and seed water extracts significantly inhibited b-carotene bleaching (AA values of 90%). Furthermore, these extracts had the hydrogen-donating ability in the presence of DDPH stable radical (IC50 2 lg/ml). The potassium ferricyanide reduction method revealed that these extracts had high reducing power. Leaf and seed extracts can be used as bio preservatives in food, as well as in health supplements and functional foods, to reduce oxidative stress[24].

Anti-microbial effect

Alcoholic extracts of *Sechium edule*'s antibacterial activity against clinically significant nosocomial infections was studied. The antibacterial activity was carried out with several gram-positive bacteria (*Enterococcus faecalis*, *Staphylococcus aureus*, coagulase-negative *staphylococci*, *Streptococcus pyogenes*, *Streptococcus agalactiae, Staphylococcus aureus*, *Enterococcus faecalis*. All ethanolic extracts showed activity against gram-positive bacteria. Minimal inhibitory concentration (MIC) values were determined with a microdilution assay. The highest activity was obtained with the 80% aqueous-ethanolic leaf extract (MIC values of 4.16/8.32 mg/ml against *staphylococci* and *enterococci*) and with the 96% ethanolic seed extract (MIC values of 8.32/16.64 mg/ml and/8.32 mg/ml against *staphylococci* and *enterococci*, respectively). According to the findings, fluid extract and tincture are quite effective at combating multi-resistant *staphylococci* and *enterococci* in all of their various strains[25,26].

Anti-ulcer activity

The anti-ulcer activity was carried out by inducing aspirin orally in female albino rats (150-200gm). The study showed pre-treated rats with ethanolic extract of *Sechium edule* fruits at 500mg/kg body weight p.o. Reduces the formation of gastric ulcers compared to the normal group. The quote also protects the rat's gastric mucosa against haemorrhagic lesions and causes a substantial decrease in ulcer index[27].

Hepatoprotective activity

To study the hepatoprotective activity, the ethanolic extract of *Sechium edule* roots against paracetamol-induced liver damage study was conducted in rats. The Ethanolic extract of *Sechium edule* roots at 300mg/kg and 600mg/kg was administered orally to the animals with hepatotoxicity induced by a single dose of paracetamol at

2gm/kg. Estimation of different serum biomarkers such as aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), and total protein (TP) levels were determined. Treatment with Paracetamol at a single dose by administering 2gm/kg of body weight in albino rats caused a considerable increase in AST, ALT, and ALP levels and decreased TP. In the results, the ethanolic extract at doses 300mg/kg and 600mg/kg body weight reduced the elevated levels of AST, ALT and ALP and increased total protein. A histopathological study of liver sections was also carried out, where the control group showed normal cellular architecture with distinct hepatic cells, sinusoidal spaces, and a central vein. However, in the liver sections of paracetamol-intoxicated rats, there was disarrangement and degeneration of normal hepatic cells with intense centrilobular necrosis, sinusoidal haemorrhages, fatty changes, cytoplasmic vacuolisation, inflammatory changes[28].

Cardioprotective activity

The cardioprotective activity of the ethanolic extract of *Sechium edule* fruits was determined by administering isoproterenol (60 mg/kg, s.c.) for two days. *Sechium edule* pretreatment (200mg/kg p.o. and 100mg/kg p.o.) for 28 days considerably decreased serum transaminases, alkaline phosphates, lactate dehydrogenase, creatinine kinase, total cholesterol, triglycerides, LDL-cholesterol, and VLDL-cholesterol levels, and significantly increased HDL-cholesterol levels. Histopathological examinations of the hearts of isoproterenol-treated rats revealed inflammatory cell infiltration and a lack of muscle fibre continuity, indicating irreversible cell injury. Whereas animals given an ethanolic extract of *Sechium edule* showed less degenerative changes than animals given isoproterenol[29].

Anti-diabetic activity

The anti-diabetic activity of ethanolic extract of *Sechium edule* was evaluated using white male Wistar rats against streptozotocin (50mg/kg b.w.) and nicotinamide (120mg/kg b.w.) body weight. After 21 days, the diameter of pancreatic-β cells was measured. In the results, the ethanolic fruit extract of *Sechium edule* showed improvement in the diameter of pancreatic β cells by increasing insulin sensitivity by inhibiting glycogenolysis and thus accelerating glucose transport to peripheral tissues[30].

Anti-epileptic and CNS activity

The anti-epileptic and CNS depressant activity of the ethanolic extract of *Sechium edule* fruit was studied in rats. To induce convulsions and seizure electroconvulsiometer model was used to provide maximal electroshock (150 mA) for 0.2 sec through ear electrodes and pentylenetetrazol (PTZ) at a dose of 80mg/kg through an intraperitoneal route. For 30 minutes, various phases of epilepsy were observed. An actophotometer and rotarod apparatus were used to evaluate the effect of locomotor activity and motor coordination test. The extract (200 mg/kg body weight orally) significantly reduced the duration of various phases of convulsions in both MES-induced seizures and PTZ-induced convulsions. In the CNS depressant model, the locomotor activity was also decreased in a dose-dependent manner compared to the control group extract. In addition, the Rota rod test revealed a significant loss of muscular coordination activity[31].

Anti-obesity property

The effects and mechanisms of *Sechium edule* shoots (SWE) extract to modulate fat accumulation in a high-fat diet (HFD)-induced animal model was investigated. According to a study, *Sechium edule* shoot water extracts (SWE) can control hepatic lipid contents, such as triglyceride and cholesterol levels, as well as body weight and adipose tissue fat. Additionally, treatment with the primary components of SWE, caffeic acid (CA) and hesperidin (HPT), prevented HepG2 cells from accumulating lipids as a result of oleic acid (OA)-induced lipogenesis. SWE decreased numerous lipogenic-related enzymes, including HMG-CoA reductase (HMG-CoR) proteins and sterol regulator element-binding proteins (SREBPs), which are essential regulators of hepatic lipid metabolism, and increased the activation of AMP-activating protein kinase (AMPK). The outcomes showed that SWE can inhibit lipogenic enzymes and stimulate lipolysis by upregulating AMPK, which could avoid a fatty liver and reduce adipose tissue fat. Additionally, it was established that both CA and HPT function as the primary activators of SWE[32].

MEDICINAL BENEFITS

The use of natural ingredients in traditional medicine has been a common practice around the world. Several medicinal benefits for the chayote plant have been found. Traditionally, the plant has been used to treat dysentery, vaginal problems, inflammations, burning sensation, fatigue, liver disorders, and jaundice [28]. It also treats symptoms such as severe headaches with ringing ears, nervousness, and anxiety. The decoction of the leaves is also prepared for use as drinking water throughout the day. It has also been used to treat urinary diseases such as bladder or urethral inflammation, difficulties and pain when peeing, enlarged veins in legs and feet and venous insufficiency[3]. There is evidence that the tea of *Sechium edule* leaves or fruits has diuretic effects and even destroys renal calculi; besides this, it can also be used to decrease the buildup of fats and cholesterol and decrease blood pressure[5]. It also treats severe hypokalaemia in pregnant women[33]. Species of cucurbitacins show decisive cytotoxic and anti-tumour action[14]. Aside from that, it has a wide range of uses in the cosmetic and toiletry sectors, including moisturisers, cleansers, sun lotions, toothpaste, mouthwashes, shaving creams, deodorants, and shampoos[31]. Because of their flexibility and strength, the stems are used in handicrafts in some regions to construct baskets and hats[8]. Wang, Shih, and Chang (2017) claimed an invention for a chayote fruit extraction method that can be used in skin care products (chayote fruit mask) and pharmaceutical products. The application of this chayote

fruit mask to the skin of female volunteers resulted in a noticeable wrinkle smoothing effect[34].

Dehydration of the fruit has been attempted in Mexico and other countries to extend the shelf life of chayote and make it more readily available. Some countries, such as the Philippines, have used chayote plants successfully in mixed plantations developed especially for soil recovery and conservation[8].

TOXICOLOGICAL REPORT ON *SECHIUM EDULE*

The *Sechium edule* extract is not cytotoxic to mononuclear bone marrow cells *in vitro* and *in vivo* when administered intraperitoneally at 800 mg/kg doses every 48 h for seven days. The extract contains metabolites, such as flavonoids, phenolic acids and cucurbitacins, which can eliminate tumour cells while protecting normal bone marrow cells. Therefore, *Sechium edule* extract is an emerging natural agent that can treat various diseases without harmful side effects[37,38].

CONCLUSION

Chayote is an herbaceous perennial, monoecious, vigorous creeper climbing plant. The plant is grown in various parts of the world. Different parts of plants are rich in alkaloids, vitamins, polyphenols, phenols, flavonoids, tannins, saponins, steroids, and triterpenes, responsible for curative benefits. The proven pharmacological potential of this plant, such as anti-obesity, anti-diabetic, anti-epileptic, anti-microbial, anti-ulcer, hepatoprotective and cardioprotective properties, will make this plant a permissible candidate to treat several diseases. Moreover, isolated compounds such as abscisic acid phaseic acid, dihydrophaseic acid have been reported using thin-layer chromatography, gas chromatography, and high-performance liquid chromatography. This displays the potential benefits, safety, and efficacy of the Chayote plant as a source of novel therapeutic agents in functional foods. This lead bioactive molecule could be further developed as drug molecules by generating pharmaceutical and clinical trial data.

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