



Review

Phytochemical, Nutritional and Medicinal Profile of *Cucumis sativus* L. (Cucumber)

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Abstract: Current studies were performed to review the phytochemistry, nutritional benefits, medicinal/therapeutic value, and cosmetic importance of cucumber (*Cucumis sativus* L.). Cucumber fruits are an important part of the human diet, often used in salads, pickles, and sauces, due to their nutritious qualities and health benefits. They are a good source of vitamins, minerals, soluble carbohydrates, proteins, etc. The leaves, flowers, seeds, fruits, and bark of cucumber are rich in various phytoconstituents, including phenols, glycosides, alkaloids, flavonoids, carotenoids, tannins, steroids, terpenoids, phytosterols, phytoestrogens, saponins, minerals, proteins, carbohydrates, resins, and vitamins. Cucumbers are traditionally used to treat a variety of diseases, including high blood pressure, blood sugar issues, cancer, high cholesterol, kidney stones, constipation, Alzheimer's disease, eczema, hypertension, atherosclerosis, and diabetes-related problems. The therapeutic/pharmaceutical value of cucumbers may be attributed to their laxative, antioxidant, anti-diabetic, analgesic, anti-hepatotoxic, anti-diarrheal, anti-fungal, anti-bacterial, thrombolytic, anti-ulcer, anti-inflammatory, cytotoxic, free radical scavenging, and wound-healing properties. Cucumbers also improve skin quality, promote skin whitening and smoothness, enhance natural beauty, regulate hydration, aid in weight loss, and reduce fat. They are used in cucumber creams, perfumes, face packs, and facials. Cucumber extract is incorporated into several formulations for topical skin treatments. This review article aims to explore the traditional uses, phytochemical contents, nutritional value, cosmetic applications, and pharmacological and therapeutic potential of cucumbers. It will be highly beneficial for a wide range of readers, including the general public, researchers, physicians, farmers, and agricultural stakeholders.

Keywords: cucumber, phytochemistry, nutritional, medicinal, skin, health

1. Introduction

Plants are commonly investigated throughout the world due to their useful phytochemical components [1],

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nutritional [2], and medicinal [3] value. *Cucumis sativus* L. (where “L” refers to Carl Linnaeus, the botanist who first described and classified the species so the full name may be read as *Cucumis sativus Linnaeus*) is commonly known as cucumber and is native to India [4]. Greeks or Romans are likely responsible for its introduction to other regions of Europe [5]. It belongs to one of the most well-known members of the *Cucurbitaceae* family. Cucumber fruits are almost cylindrical in shape, elongated, have tapered ends, and can grow up to 62 centimeters (24 in) in length and 10 centimeters (4 in) in diameter [6] (Figure 1). They have different sizes; however, most of them have the same thickness along the larger parts of the shaft and are thin at both ends. The exterior surface is smooth and shiny and the body can feature small white or green protuberances or lumps or ridges [7]. Cucumber is cultivated in almost all countries of the temperate zone and is known as one of the oldest cultivated vegetable crops. It is frost susceptible and thermophilic in nature and grows best at a temperature above 20 °C [8].



Figure 1. Cucumber fruits (pictures captured from a vegetable market in Rahim Yar Khan, Pakistan)

Cucumber is ranked as the fourth-most important vegetable crop, behind cabbage, tomatoes, and onions [9]. One of the key elements of successful cucumber production is fertilizer (inorganic or organic) [10]. China accounts for 70% of global cucumber production and is also known for its highest consumption [11]. Cucumber has a large number of varieties but the edible types are classified into two categories i.e., slicing and pickling cucumbers. As compared to pickling cucumbers, the slicing cucumbers are longer and thinner [12]. Traditional genetic breeding methods (crossbreeding and mutation breeding) have been used for many years to create new, high-yielding, and high-quality cucumber cultivars [13]. However, cucumber plants have limited genetic varieties so it is challenging to produce stable genetic traits or genotypes [14]. A number of novel molecular techniques and bio-engineering technologies have been applied to the cultivation of cucumbers [11]. In order to produce high yields for better economic benefits and to enhance water efficiency, greenhouses in North China have adopted a widespread growing method that involves planting off-season crops (such as cucumber) with drip irrigation. According to the findings, drip irrigation increased cucumber’s yield and income by 4.3% and 3.1%, respectively as compared to furrow irrigation [15]. In cucumber, the rate of nitrogen fertilization and subsurface drip irrigation scheduling was correlated with the yield of fruit. Three nitrogen fertilization levels i.e., 300 kg·ha⁻¹ (N1), 450 kg·ha⁻¹ (N2), and 600 kg·ha⁻¹ (N3) were applied to the cucumber plants in combination with irrigation water levels of 0.6 Ep, 0.8 Ep, and 1.0 Ep. Using the 20-cm-diameter pan (Ep) positioned above the crop canopy, the volume of irrigation water was calculated. The findings demonstrated that when irrigation water quality was improved, the cucumber fruit output was also increased [16].

Domesticated cucumbers show a notable variety of fruit appearance, size, and flavor when compared to the wild parent yielding small, bitter, and seedy fruit (Figure 2). Recent developments have been made in understanding the genetic basis of organoleptic characteristics (bitterness) and fruit morphological attributes (carpel development, femaleness, fruit spine, color, wart, and size) [17].

Unlike other typical fruits like apples, tomatoes, strawberries, etc., cucumber fruits are all long and narrow and have the same color as their leaves. As a result of their unique color and shape, cucumber fruits are harder to identify by a machine’s vision in greenhouses. To identify cucumber fruits, a pixel-by-pixel instance segmentation technique called mask region-based convolutional neural network (Mask RCNN) of an upgraded adaptation is suggested [18]. It is difficult to increase the yield of cucumber plants that are under heat and saltiness stress, especially in dry areas [19]. In this review, we explore the current phytochemical, nutritional, cosmetic, pharmacological, and therapeutic knowledge about this well-known plant species (*C. sativus*) as well as several other promising aspects. The study will be highly

beneficial for all kinds of readers including the public, researchers, physicians, farmers, and agricultural stakeholders.



Current opinion in plant biology

Figure 2. Molecular basis of cucumber fruit domestication [17]

2. Phytochemical composition

Phytochemicals are non-nutritive chemical components that exist naturally in plants or they are the chemicals that are produced in plants [20]. Leaves, flowers, seeds, fruits, and bark of cucumber are rich in many phytoconstituents, which are biologically active and produce specific pharmacological effects [21]. Glycosides, alkaloids, phenols, terpenoids, steroids, tannins, saponins, carotenoids, resins, and flavonoids are some of the chemical components found in the cucumber fruit [22]. Phytochemicals including phenols, glycosides, carbohydrates, flavonoids, tannins, and terpenoids were found in the ethanolic extract of cucumber seeds [23]. The presence of alkaloids (cucurbitacins A, B, C, D, and E) [24], flavonoids (quercetin, kaempferol, apigenin, orientin, isoorientin, vitexin, isovitexin, and luteolin) [25], tannins, glycosides (2''-O-(6'''-(E)-p-coumaroyl) glucoside, isovitexin 2''-O-(6'''-(E)-p-coumaroyl) glucoside-4'-O-glucoside, isovitexin 2''-O-(6'''-(E)-feruloyl) glucoside-4'-O-glucoside, isoscoparin 2''-O-(6'''-(E)-p-coumaroyl) glucoside, and isoscoparin 2''-O-(6'''-(E)-feruloyl) glucoside-4'-O-glucoside), saponins, and steroids was verified in the acetone extract of cucumber leaves [25]. In addition, cucumbers are also composed of proteins (0.4%), water (96.4%), carbs (2.8%), fat (0.1%), and minerals (0.3%) [26].

2.1 Tannins

Ethanolic extracts of *C. sativus* are rich in tannins [23] which have the ability to speed up the recovery of cuts and inflamed mucous membranes. Tannins have the potential to act as biological antioxidants, proton precipitating agents, and metal ion chelators [27].

2.2 Phytosterols

Phytosterols (β -Sitosterol, campesterol, stigmasterol, brassicasterol) were identified from the seeds extract of *C. sativa* during phytochemical screening. They were verified by a color change from violet to blue or green with acetic anhydride and sulfuric acid [28]. Phytosterols are known for their hypocholesterolemic effects, suggesting potential benefits for cardiovascular health. These findings highlight the therapeutic potential of cucumber seed extract, along with its other phytochemicals like saponins and terpenoids, recommending further research for drug development [29].

2.3 Saponins

Saponins are secondary metabolites having a large molecular weight. They are found in a variety of plant species, where they are dispersed throughout the stems, barks, roots, leaves, and even flowers [30]. The flavor of saponins is sour and in recent years, they have garnered substantial interest due to their diverse biological activities including anti-ulcer, hepatoprotective, anti-inflammatory, antibacterial, etc [31]. Saponins are comprised of either a triterpenoid or more frequently, a sterol. Triterpenoids and steroidal saponins both exhibit surfactant characteristics [32].

Table 1. Important phytochemicals of cucumber and their health effects

Type	Phytochemical	Health effects	References
Triterpenoid	Cucurbitacin D	Anticancer, anti-inflammatory, and antimicrobial properties.	[33]
Triterpenoids	Cucurbitacins	Anti-inflammatory, anti-cancer, and anti-diabetic properties; aids in detoxification.	[34]
Flavonoid	Isoorientin	Antioxidant and anti-inflammatory properties; potential anti-cancer effects.	[35]
Flavonoid (Apigenin glucoside)	Vitexin	Antioxidant, anti-inflammatory, and neuroprotective properties.	[36]
Triterpenoid	Cucurbitacin B	Strong anticancer and anti-inflammatory effects.	[37]
Flavonoid (Apigenin glucoside)	Isovitexin	Antioxidant, anti-inflammatory, and neuroprotective properties.	[38]
Triterpenoid	Cucurbitacin C	Anticancer and cytotoxic properties.	[39]
Flavonoid (Apigenin glucoside)	Vitexin	Antioxidant, anti-inflammatory, and neuroprotective properties.	[36]
Triterpenoid	Cucurbitacin A	Anti-inflammatory, anticancer, and hepatoprotective properties.	[34]
Flavonoid	Isoorientin	Antioxidant and anti-inflammatory properties, potential anti-cancer effects.	[35]
Phytoestrogens	Lignans	Anti-cancer properties, particularly in reducing breast, prostate, and ovarian cancer risks.	[40]
Water-soluble vitamin	Vitamin C	Enhances immune function, promotes healthy skin, and has antioxidant properties.	[41]
Flavonoid	Orientin	Antioxidant, anti-inflammatory, and antiviral properties.	[42]
Antioxidants	Flavonoids	Reduces oxidative stress, lower inflammation, and may reduce the risk of chronic diseases.	[43]
Flavonoid	Isorientin	Antioxidant, anti-inflammatory, and neuroprotective properties.	[42]
Fat-soluble vitamin	Vitamin K	Essential for blood clotting, bone health, and heart health.	[44]
Mineral	Potassium	Regulates blood pressure, reduces the risk of cardiovascular diseases, and maintains electrolyte balance.	[45]
Flavonoid	Apigenin	Anti-inflammatory, antioxidant, and anti-cancer properties.	[46]
Trace mineral	Silica	Promotes joint health, improves skin elasticity, and strengthens hair and nails.	[47]
Phenolic compound	Caffeic acid	Anti-inflammatory and antioxidant properties, may help to reduce the risk of cancer and heart disease.	[48]
Antioxidant	Ascorbic acid	Protects against oxidative damage, supports collagen synthesis, and enhances immune function.	[49]
Flavonoid	Quercetin	Anti-inflammatory, antiviral, and anticancer properties; supports heart health.	[50]
Flavonoid	Kaempferol	Antioxidant, anti-inflammatory, and anticancer properties; supports cardiovascular health.	[51]
Flavonoid	Luteolin	Anti-inflammatory and antioxidant properties; potential anti-cancer effects.	[52]
Flavonoid	Apigenin	Anti-inflammatory, antioxidant, and anti-cancer properties.	[46]
Phenolic compound	Ferulic acid	Antioxidant properties, protects against UV damage, and may reduce the risk of chronic diseases.	[53]

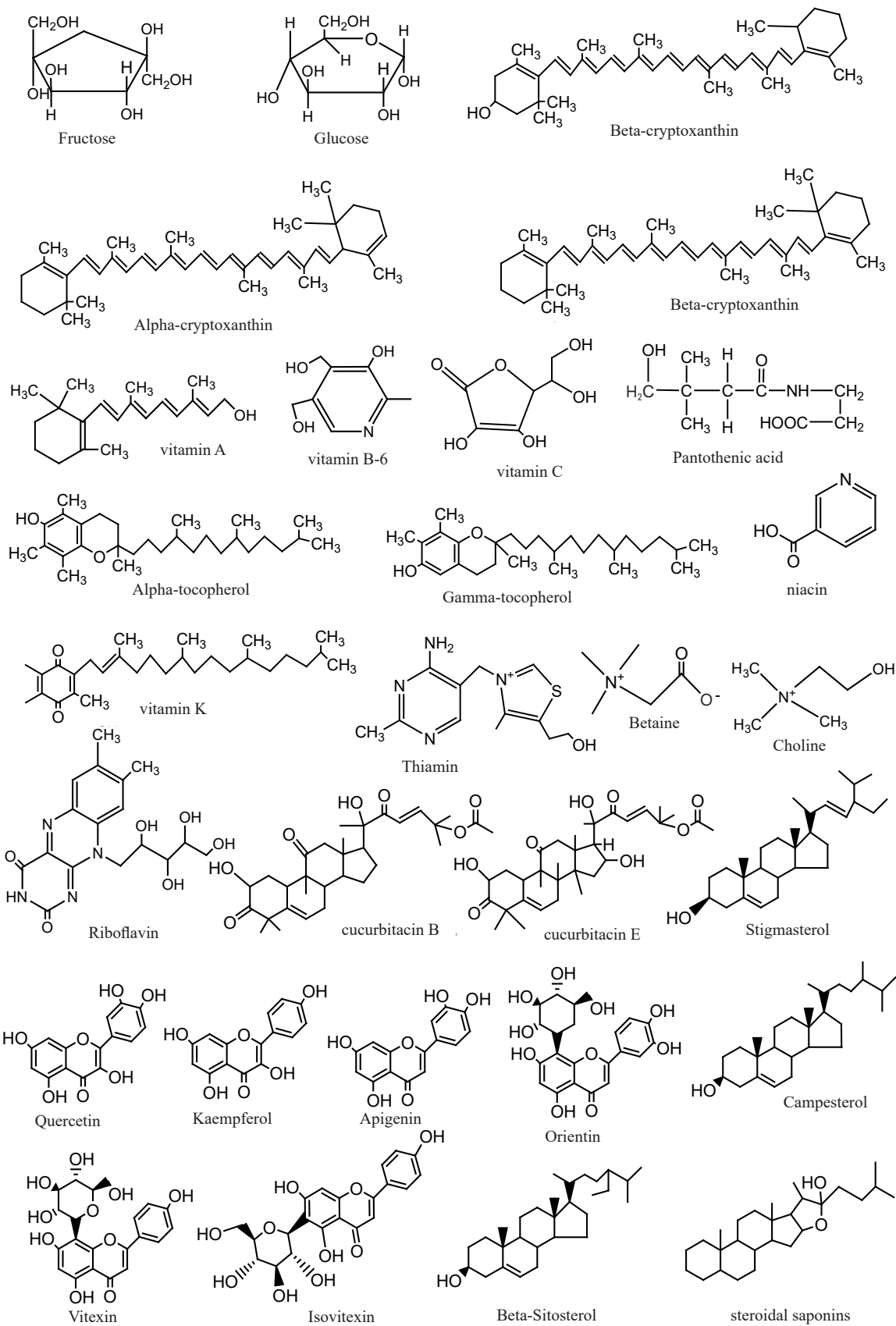


Figure 3. Structures of phytochemicals in cucumber

Table 1 displays the important phytochemicals of cucumber and their health effects whereas Figure 3 shows the structures of important phytochemicals of cucumber.

3. Nutritional value

Plants are beneficial for human health as they are commonly rich in nutritional contents e.g., vitamins, minerals, and antioxidants etc [54, 55]. In the human diet, cucumber is a significant source of vitamins and minerals [56]. Cucumber is one of the most demanded cucurbits due to its health advantages and nutritious qualities [57]. Table 2 shows the primary metabolites, mineral components, vitamin supplements, and bioactive substances in methanolic extracts of cucumber leaves; the proximate analysis of cucumber seeds has also been summarized. The nutritional profile of cucumber along with health effects is given in Table 3.

Table 2. Nutritional and bioactive composition of cucumber (*Cucumis sativus* L.) in methanolic extract of leaves

Component	Quantity	Component	Quantity
Primary metabolites (in methanol extract of leaves) [58]			
Fiber	0.99 ± 0.01%	Carbs	2.01 ± 0.01%
Saturated fat	0.03 ± 0.02%	Protein	0.82 ± 0.02%
Mineral components (in methanol extract of leaves) [58]			
Magnesium	13.00 ± 0.02 mg/kg	Sodium	3.00 ± 0.02 mg/kg
Zinc	0.30 ± 0.02 mg/kg	Phosphorus	23.00 ± 0.01 mg/kg
Iron	0.32 ± 0.01 mg/kg	Calcium	15.00 ± 0.01 mg/kg
Vitamin supplements (in methanol extract of leaves) [58]			
Vitamin A	23.00 ± 0.01 mg/kg	Vitamin B1	0.03 ± 0.01 mg/kg
Vitamin E	0.09 ± 0.01 mg/kg	Vitamin B2	0.03 ± 0.02 mg/kg
Niacin (Vitamin B3)	0.41 mg/kg	Vitamin C	6.11 ± 0.02 mg/kg
Folate (Vitamin B9)	15.00 mg/kg	Vitamin B6	0.44 ± 0.01 mg/kg
Bioactive substances (in methanol extract of leaves) [58]			
Reducing sugars	574 ± 3.88 mg/g	Alkaloids	2.22 ± 0.96 mg/g
Flavonoids	2.14 ± 0.56 mg/g	Cyanogenic glycosides	0.21 ± 0.13 mg/g
Moisture concentration (in fruit homogenate) [22]. 94.6 ± 0.08%			
Proximate analysis of cucumber seeds [59]			
Dry matter	90.53%	Phosphorus	0.807%
Crude protein	26.68%	Gross energy	4,817.72 Kcal
Crude fat	14.14%	β-Carotene molecule	2.82% (by TLC Scanning)
Crude fiber	32.27%	Antioxidant IC 50%	6,555.55 ppm (by DPPH Spectrophotometry)
Calcium	3.024%		

Table 3. Nutritional composition of cucumber and its effects on human health (Per 100 g Edible Portion)

Nutrients [60]	Amount per 100 g Edible Portion [60]	Health benefits	References
Calories	15 kcal	Aids in controlling weight.	[61]
Protein	0.6 g	Vital for the growth and repair of body tissues.	[62]
Fat	0.1 g	Supplies vital fatty acids and maintains the health of cells.	[63]
Carbohydrates	3.6 g	Primary source of energy for the body. Main source of energy supply for the organism.	[64]
Dietary fiber	0.5 g	Facilitates digestion and maintains regular bowel motions.	[65]
Total sugars	1.38 g	Provide rapid energy, although moderation is advised when consuming it.	[66]
Glucose	0.63 g	Rapid source of energy for cells.	[67]
Fructose	0.75 g	Organic sugar, a source of energy.	[68]
Starch	0.08 g	Energy source, digests more slowly than simple sugars.	[69]
Vitamins			
Vitamin C	3.2 mg (5% DV)	Antioxidants support healthy skin and strengthen the immune system.	[70]
Vitamin K	16.4 mcg (21% DV)	Crucial for maintaining bone health and blood coagulation.	[71]
Thiamin (Vitamin B1)	0.031 mg	Supports the metabolism of energy, which is crucial for neuronal activity.	[72]
Riboflavin (Vitamin B2)	0.025 mg	Promotes the synthesis of energy and cellular activity.	[73]
Niacin (Vitamin B3)	0.037 mg	Supports healthy digestion and facilitates the burning of energy.	[74]
Pantothenic acid (Vitamin B5)	0.240 mg	Supports adrenal function and is necessary for the production of fatty acids.	[75]
Vitamin B6	0.051 mg	Vital to the health of the brain and helps to produce neurotransmitters.	[76]
Folate (Vitamin B9)	14 µg	Supports DNA synthesis and cell division, both of which are crucial during pregnancy.	[77]
Vitamin A	4 µg RAE	Immune system support; essential for vision.	[78]
Vitamin E	0.03 mg	Antioxidant, which shields cells from injury.	[78]
Betaine	0.1 mg	Maintains cellular hydration and liver function.	[79]
Beta-carotene	31 µg	Precursor of vitamin A; promotes immune system and visual health.	[80]
Alpha-carotene	8 µg	Antioxidant, which promotes healthy skin.	[81]
Beta cryptoxanthin	18 µg	Antioxidant that boosts the immune system.	[82]
Lutein + Zeaxanthin	16 µg	Enhances ocular health and may lower the chance of long-term eye disorders.	[83]

Table 3. (cont.)

Nutrients [60]	Amount per 100 g Edible Portion [60]	Health benefits	References
Minerals			
Calcium	Varies	Promotes muscle function and is vital for the health of teeth and bones.	[84]
Potassium	147 mg	Maintains fluid equilibrium and supports the health of the heart and muscles.	[85]
Sodium	Varies	Consumed in moderation, essential for nerve function and fluid homeostasis.	[86]
Magnesium	13 mg	Helps maintain the health of bones by supporting muscle and nerve function.	[87]
Phosphorus	Varies	Vital to the health of teeth and bones and involved in the synthesis of energy.	[88]
Iron	Varies	Essential for blood synthesis; keeps blood oxygenated.	[89]
Zinc	Varies	Supports the immune system, which is necessary for DNA synthesis and wound healing.	[90]
Copper	Varies	Vital for the production of red blood cells and immune system support.	[91]
Manganese	0.1 mg	Promotes the growth of bones, antioxidant processes, and the metabolism of carbohydrates, cholesterol, and amino acids.	[92]
Others			
Water	95%	Supports all body functions and is necessary for proper hydration.	[93]
Fluorine	1.3 mg	Vital for maintaining oral health and preventing tooth decay.	[94]
Selenium	0.1 mg	Antioxidant, promotes thyroid function and shields cells from harm.	[95]
Choline	5.7 mg	Promotes the growth of the brain, the movement of muscles, and the liver.	[96]

Cucumbers have been considered as fruits (not vegetables) and can be utilized as food due to the presence of high nutritional content [97]. Cucumber fruit generally contains carbohydrates (2.2%), lipids (0.1%), proteins (0.6%) and water (95%). The edible component of raw cucumber contains 2.16 gram of carbohydrates per 100 gram, including starch (0.08 g), fructose (0.75 gram), glucose (0.63 gram), total sugars (1.38 gram), and total dietary fiber (0.7 gram) [98]. Each 100 g of the edible portion of raw cucumber contains saturated fatty acids (0.013 g), zeaxanthin, lutein (16 µg), beta-cryptoxanthin (18 µg), alpha-carotene (8 µg), beta-carotene (31 µg), betaine (0.1 mg), choline (5.7 mg), vitamin A (72 IU), vitamin A (4 µg RAE), alpha-tocopherol (0.03 mg), vitamin K (72 mg), γ-tocopherol (0.02 mg), folate (14 µg), vitamin B-6 (0.051 mg), pantothenic acid (0.240 mg), niacin (0.037 mg), riboflavin (0.025 mg), thiamin (0.031 mg), vitamin C (3.2 mg), selenium (0.1 mg) and fluorine (1.3 mg) [60]. The chemical structures of these components are shown in Figure 3. Slight changes in the nutritional makeup may occur depending on the cultivar, the producing area, and harvest time [99].

Cucumbers (*C. sativus*) are eaten in a variety of ways, including fresh and processed (pickled) forms [100]. According to another classification, they may be categorized into slicing cucumber and pickling cucumber. Pickling cucumber is used in pickles. They are small in size and have thin skin while slicing cucumber have thick skin and are large in size [101]. Due to their nutritional and therapeutic qualities, since ancient times, cucumbers have played a prominent role in the conventional Mediterranean diet [100]. The nutritional and medicinal benefits of cucumber are

notable due to the presence of valuable ingredients some of which are summarized in Figure 4 [102].

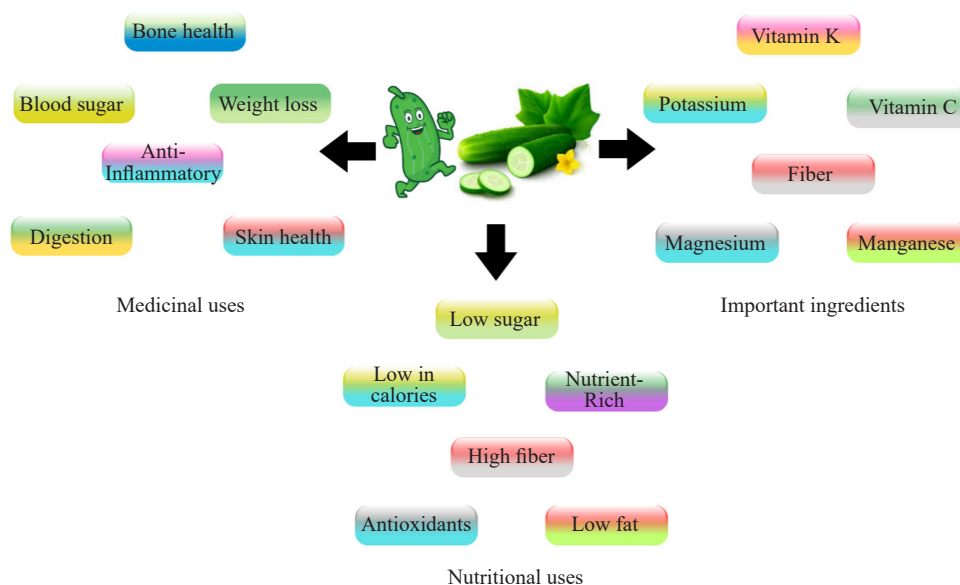


Figure 4. Important ingredients of cucumber and their nutritional and medicinal benefits

Cucumber has 95% water which makes its taste delicious and refreshing. It helps to prevent from kidney stones and constipation and aids in maintaining a healthy intestine (by staying hydrated) [103]. Cucumbers might help us to stay hydrated as they contain a lot of water. The vitamin (K) aids in blood clotting and keeps our bones strong. Additionally, it builds bone mass and prevents people from Alzheimer’s disease by reducing brain damage to their neurons. Many advantages of vitamin A include reproductive health, eye sight and improvement of the immune system; it ensures the proper functioning of our heart, lungs, and kidneys [104]. Potassium and magnesium are also present in cucumbers. The cardiovascular system needs these two nutrients to function properly. Potassium and magnesium both help to reduce the blood pressure [105]. When consumed regularly, the cucumber has been shown to lower harmful cholesterol level and blood sugar. Varieties of vitamin A, vitamin B, and antioxidants, including lignans, are also present in cucumber [103]. Free radicals are removed from the body with the aid of antioxidants. Free radicals typically result from biological functioning in body and external influences like pollution. If the body accumulates a lot of free radicals, they can harm cells and cause a variety of diseases. Cucumbers and other foods contain lignans, which reduce the risk of heart disease and several cancers [103]. Cucumbers regulate hydration, aid in weight loss, reduce fat, and help in digestion [58].

Cucumbers are used in making large number of dishes such as cucumber in sour cream, Greek salad, Scandinavian salad, Russian salad, Dilled cucumber salad, cucumber dip and herbed cucumbers. In processing pickles and sauces, *C. sativus* is also used [106].

4. Use of cucumber in cosmetics

There are several advantages of using cucumbers for skin care and natural beauty; some important skin effects of cucumbers are shown in Figure 5. Cucumber is a great cosmetic for the skin to maintain its smoothness and whitening [107]. Cucumber juice clarifies complexions from the skin and naturally lightens it, leaving a soft, refreshed, and glowing look [58]. Cucumbers are used by women to provide cooling relief to their eyes throughout the summer months due to their high nutritional content and remarkable cooling property [108]. High amounts of vitamin K in cucumber helps to minimize cutaneous manifestations such as puffiness (eye bags) and dark shadows [107]. Cucumber slices put up many benefits to the eyes and their surrounding tissues through their hydrating effects [109]. Lignans, which

are found in cucumbers, have the ability to reduce irritation and inflammation brought on by bug bites and sunburns [109]. In addition to this, *C. sativus* has long been used to cure wrinkles, it also helps in maintaining skin brightness and moisturization by suppressing tyrosinase [110]. Extracts from cucumber fruits and their formulations are frequently used as skin toner, moisturizers, and several topical skin treatments [111]. These formulations have also been used to clean the skin and cure wrinkles. Cucumbers have naturally occurring organic acids, such as salicylic, lactic, and glycolic acids, which contribute to their thorough cleaning properties [107]. Alpha hydroxyl acids such as glycolic and lactic acids are utilized as chemical exfoliants to dissolve the glue-like material in the epidermal layer and encourage the body's natural elimination of dead cells while maintaining the integrity of the outermost layers of protection. Dehydrated, rough, and dull skin is the result of the glue-like substance causing an accumulation of dead skin cells. Through histological analysis, alpha hydroxy acids have been demonstrated to thicken the epidermis, boost collagen density, enhance the quality of elastic fibers, thicken the dermal layer between the papilla and the dermis, and increase dermal acid mucopolysaccharide. It results in thicker and healthier skin [112]. A number of skin disorders, including pain, psoriasis, pimples, eczema, dry skin, age spots, seborrheic keratosis, precancerous growths, hyperkeratosis, actinic keratosis, and blackheads and whiteheads, have been successfully treated with alpha hydroxyl acids. Since glycolic acid may pass through cell walls due to its tiny molecular size, it is considered as one of the most effective alpha-hydroxyl acids for skin care [113]. Within the cell, it starts the production of new collagen, activates the creation of dermal glycosaminoglycans to plump up the cell, and reduces surface wrinkles by lowering the amount of ground substance in the skin [114]. The appearance of surface pigmentation and photodamage is improved by lactic acid. Salicylic acid is a beta hydroxyl acid with keratolytic, antimicrobial, and fungicidal qualities, in contrast to glycolic and lactic acids [113]. It is effective in treating scaling and hyperkeratotic disorders such as psoriasis, ichthyosis, and dandruff [115]. Cucumber is also applied to treat fungal skin infections like tinea [116]. Many ladies use cucumber soap, and it is quite healthy to wash the skin with cucumbers after being in strong winds. It is also utilized in making cucumber cream and perfume [107]. Cucumbers and their preparations have generally found their way into everyday beauty products such as face packs, facials, juice, and many other skin-related items [117]. Besides it, cucumbers are also used as sex toys (stimulators) in place of plastic penises, clitoral stimulators, G-spot stimulators, sex robots, vibrators, dildos, masturbators, and butt plugs [118].

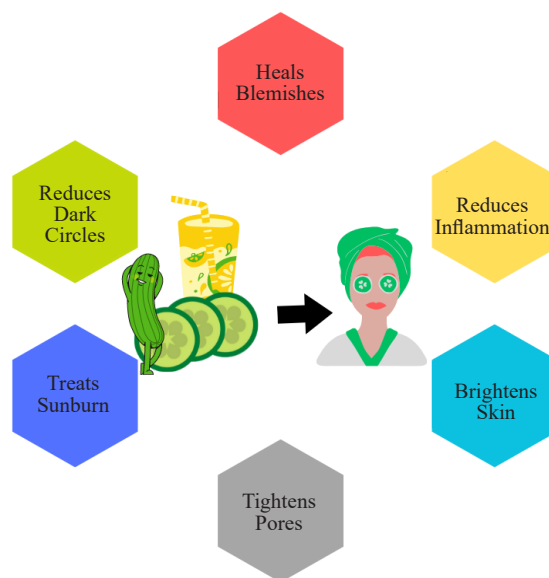


Figure 5. Skin effects of cucumber

5. Pharmaceutical/medicinal and therapeutic value

Plants are common and traditional sources of a lot of medicines [119, 120]. At least 25% of all current medications are thought to be derived from medicinal plants, either directly or indirectly. This is primarily accomplished by combining modern technology with conventional knowledge [121]. In addition to being used as food, *C. sativus* is also employed in traditional medicine, healthcare, and cosmetology [100]. Cucumber displays antioxidant, anti-diabetic, and lipid-lowering effects. It decreases swelling and has a calming effect on skin irritations. Moreover, cucumber can induce relaxation and decrease suntan pain. The fruit is cooling, hemostatic, and beneficial in conditions like myopia and heat stroke. Moreover, the body is cooled by the effect of the seeds [25]. Traditional medical practices utilize cucumber for the management of numerous body illnesses [97]. Cucumber is employed in a number of therapies and shows a number of therapeutic qualities, including antioxidant capacity, antibacterial activity, and glycemic lowering capacity, etc [122]. Its phytochemicals provide good hydration and are effective in treating eczema, hypertension, atherosclerosis, cancer, and other ailments [123]. Numerous pharmacological and natural substances in cucumber have been suggested for reducing diabetes-related problems [124]. It is a trustworthy meal for reducing carbonyl stress and oxidative stress, especially in diabetes conditions, and shows a protective effect against the development of such conditions [125]. Diabetes mellitus is a rapidly growing illness that represents an important social problem and significantly affects lifestyle and physical fitness. It may cause heart failure, kidney failure, and nerve damage and has become a major causes of morbidity and mortality risk [126]. Additionally, cucumber juice is fantastic for the hair, and nails. Due to prolonged sun exposure, the skin produces free radicals, which cause oxidative stress, accelerating the aging process and harming biological molecules and cell membranes [127]. The elasticity of connective tissue is due to hyaluronic acid and elastin, and it decreases noticeably with aging [128]. For healthy cartilages, ligaments, connective tissues and other things, sulfur is a good nutrient and is abundant in cucumbers [129].

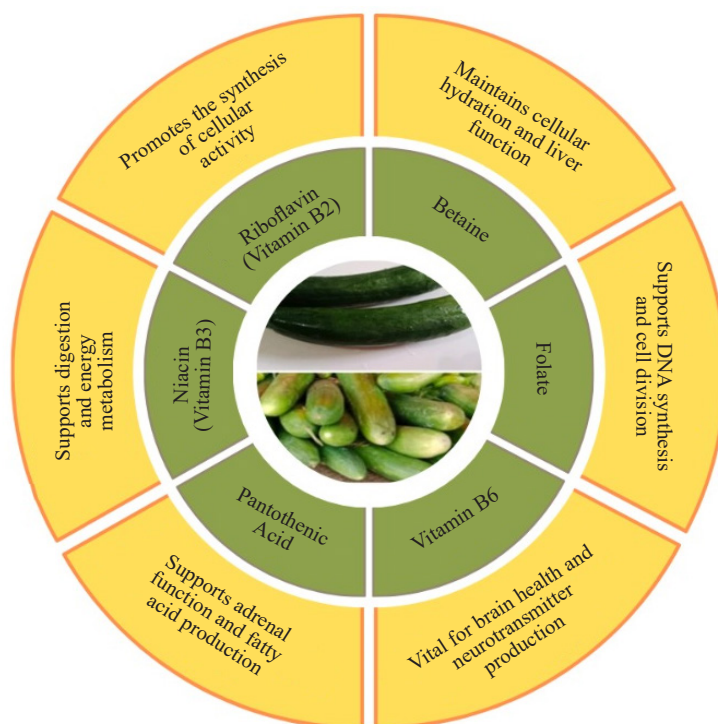


Figure 6. Important medicinal properties of cucumber, depending upon its phytoconstituents

Cucumbers prevent the growth of pathogenic organisms in the intestine that have been lacto-fermented [130].

Furthermore, it is reasonable to credit cucumbers' modest diuretic capability to lower sodium contents and free water. Cucumber also helps to prevent blood pressure and weight gain [57]. Additionally, it is effective for Alzheimer's disease by reducing brain damage to their neurons [131].

C. sativus has long been used in the spa world and for topical skin problem/disease treatments [132]. The fruit's polysaccharides and flavonoids have significant antioxidant effects, cancer prevention properties, and anti-inflammatory properties [133]. For those with high and low blood pressure, cucumber is a good option due to its high potassium level (50-80 mg/100 g) [134].

According to pharmacological studies, cucumbers show thrombolytic, anti-inflammatory, analgesic, antifungal, antibacterial, antidiarrheal, antihepatotoxic, antioxidant, anticancer, and antidiabetic properties [97]. Figure 6 displays some important therapeutic/medicinal properties of cucumber.

5.1 Hepatoprotective activity

Any chemical that causes some toxic effects on liver cells is called hepatotoxic [135]. The long time use or excess dose of such a kind of compound may cause chronic or acute liver damage [136]. The use of sea cucumber suspension (35% concentration) can improve the liver tissue and shows a hepatoprotective effect [137]. The hepatic damage induced by paracetamol in mice was improved by sea cucumber at doses of 500 mg/kg BW. The sand cucumbers can prevent damage to hepatocytes induced by carbon tetrachloride; the best results are achieved at a dose of 50 mg/200 g body weight (BW) of the test animal [137].

Cucumber fruit extract also demonstrates hepatoprotective and antioxidant effects against cumene hydroperoxide (CHP)-induced hepatotoxicity, as its antioxidant and radical-scavenging components can easily cross the cell membranes and combat the formation of intracellular reactive oxygen species (ROS) [138]. Ethanolic extracts of cucumber fruit have shown hepatoprotective action against paracetamol induced toxicity in albino rats. The extract also contains prominent amounts of hepatoprotective enzymes such as superoxide dismutase, catalase, alpha-glutamate trans peptidase serum alkaline phosphatase, serum glutamic pyruvate transaminase, glutamic oxaloacetic transaminase [139].

5.2 Laxative activity

Cucumber's aqueous extract shows a prominent laxative potential. Phytochemical's study of its aqueous pulp demonstrated the presence of sterols, polyphenols, polyterpenes, and tannis. A study on Wistar albino rodents reported that an aqueous extract of cucumber (oral doses) displays a prominent laxative action and reduces loperamide induced constipation [140].

5.3 Anticancer activity

Cucumbers are rich in various antioxidant substances, which could potentially assist in fighting against different types of cancers. It has been suggested that cucurbitacin shows some anti-cancer effects on breast [141], colon [142], lung [143], and pancreatic cancer cells [144]. Lutein with its antioxidant properties is believed to be associated with a decreased risk of breast and colorectal malignancies. Beta-carotene is linked to reduced risks of lung and prostate cancers [145]. Phytosterols may help to protect against breast and prostate cancers while lignans' antioxidant activity may lower the risk of both cancers [146]. Such antioxidants can bind free radicals, thus hindering the occurrence of cancer and maintaining health generally. The ethyl acetate fraction of cucumber flowers produced a compound which was applied by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay for curing liver cancer HePG2 cell line; the CTC50 value of sample was found to be 103.7 µg/L [147].

5.4 Antioxidant activity

The peel of *C. sativus* has shown the presence of good amounts of total flavonoid (quercetin, kaempferol, and isorhamnetin and phenolic contents (caffeic acid, *p*-coumaric acid, and ferulic acid) which are antioxidants. So, its peel is considered to be a good source of antioxidant activity [148]. Flavonoids are effective antioxidants and have the ability to scavenge free radicals and chelate metal ions [119]. The phenolic compounds are useful against many diseases

including inflammatory, cardiovascular, cancer, etc [149].

5.5 Antiulcer property

The methodic extract of *C. sativus* seeds possesses antiulcer potential, which may be owed to its antioxidant activity [150]. A study reported that liquid fruit pulp extract of cucumber (due to the presence of polyphenols and flavonoids) shows gastroprotective property. The liquid extract of cucumber (*C. sativus*) fruit pulp has ulcer curing property [151]. In cucumber, the existence of 9-beta-methyl-19-norlanosta-5-ene type glycosides was reported, which is an antiulcer compound [152].

5.6 Antifungal activity

The presence of a flavonol aglycone namely rhamnetin (3,5,3',4'-tetrahydroxy-7-O-methoxyflavone) was reported in cucumber. It exhibited antifungal activity which was further improved after acid hydrolysis of leaves [153]. Antifungal action against the fungal strains of *Botrytis cinerea* and *Pythium aphanidermatum* is exhibited by sphingolipids which are present in methanol extracts of cucumber stem. Glycosides like quercetin-3-O-rutinoside are prominent, known for their potent biological activities. Steroids such as stigmasterol and beta-sitosterol are also present, which play a crucial role in various pharmacological actions. The presence of saponins, including cucurbitacin B and cucurbitacin E, further enhances the cucumber's medicinal value due to their well-documented antifungal and anti-inflammatory properties. Tannins like ellagitannins and gallotannins contribute to the antioxidant and antimicrobial potential of cucumber extracts. Additionally, alkaloids such as cucurbitacin I and piperine have been identified, which add to the broad-spectrum bioactivity and health benefits of cucumbers. Ethanolic extracts of leaves and stems of cucumber are effective against some fungal strains [154].

5.7 Antibacterial activity

The sphingo lipids exist in the methanol extract of cucumber stem (having flavonoids, tannins, and saponins), which exhibit antimicrobial potential against *Pseudomonas lachrymans*, *Bacillus subtilis* and *Xanthomonas vesicatoria* [155]. Moreover, the seed extract of (*C. sativus*) has shown inhibition action against *Serratia marcescens*, *Escherichia coli*, *Streptococcus thermophilus*, *Aspergillus niger* and *Candida albicans* [156].

5.8 Wound healing property

The wound healing property was shown by aqueous extract of cucumber fruit cream formulation on experimentally induced wounds in rats. It was demonstrated that antioxidant and flavonoid contents of cucumber are responsible for wound healing. The flavonoids and antioxidant properties of cucumber caused wound contraction in Wistar rats, and a faster rate of epithelialization during the healing process [157]. Cucumber juice extract is considered as a first aid in the treatment of acid burnt eyes [107].

5.9 Cytotoxicity property

The aqueous and chloroform extracts of stems and leaves of cucumber display antifungal potential; the ethanolic extract of cucumber is more potent in this regard, especially against *Aspergillus niger*. The antifungal activity of cucumber is attributed to the presence of different phytoconstituents e.g., corticoid, tannin and flavonoid in *C. sativus* [154].

5.10 Free radical scavenging analgesic activity

Cucumber's aqueous extract is comprised of tannins and flavonoids (quercetin, kaempferol, apigenin, luteolin, and rhamnetin). It was tested for the analgesic and radical scavenging activities. The results showed that cucumber fruit extract exhibits significant antioxidant and analgesic effects compared to ascorbic acid, and diclofenac sodium [158].

5.11 Anti-diabetic activity

Cucumber ethanolic extract was used for its hypoglycemic effects on alloxan induced diabetic rats (AIDRs). It was found that *C. sativus* (cucumber) has hypoglycemic, hypolipidemic, and glycogenesis potency. There was a 67% lowering of blood glucose level by cucumber extract after 12 hours of one intra peritoneal injection, while it also lowered the low-density lipoprotein (LDL) level to 13. A total of 29% cholesterol level was decreased by cucumber extract [159]. It was observed that *C. sativus* seeds extract (hydroalcoholic and buthanolic) plays a significant role in controlling diabetes by a process like a euglycemic agent [102]. A glucosidase inhibitory process is observed in cucumber. Two contents *p*-coumaric and syringic acid were reported by high performance liquid chromatography analysis of cucumber. The syringic acids and *p*-coumaric are phenolic acids that are known for anti-diabetic treatment. There are reports that cucumber has the potential to lower the dependence on man-made drugs in the coming future with alpha-glucosidase inhibitory action [160].

6. Conclusions

Cucumber belongs to Cucurbitaceae family and is widely cultivated. Cucumber fruits form an important part of human diet as they are rich in vitamins, minerals, soluble carbohydrates, and proteins, etc. The mineral contents in *Cucumis sativus* include P, Ca, Mg, Fe, Na, Zn, and K in varying amounts. Typically, cucumbers are also used for slicing and pickling. Leaves, flowers, seeds, fruits, and bark of cucumber are rich in many phytoconstituents including phenols, glycosides, alkaloids, flavonoids, carotenoids, tannins, steroids, terpenoids, phytosterols, phytoestrogens, saponins, minerals, protein, carbs, resins, and vitamins. Cucumbers are traditionally used to cure a variety of diseases including blood pressure, blood sugar, cancer, cholesterol, kidney stones, constipation, Alzheimer's disease, eczema, hypertension, atherosclerosis, and diabetes-related problems. The therapeutic/pharmaceutical value of cucumbers may be owed to their laxative, antioxidant, anti-diabetic, analgesic, anti-hepatotoxic, anti-diarrheal, anti-fungal, anti-bacterial, thrombolytic, anti-ulcer, anti-inflammatory, cytotoxic, free radical scavenging, wound-healing properties. Cucumber improves skin quality and skin whitening/smoothness, promotes natural beauty, regulates hydration, aids in weight loss, reduces fat, and is used in cucumber creams, perfumes, face packs, and facials. Its extract is used in several formulations for topical skin treatments. Due to its 90% water content, cucumber is used in cosmetics because it instantly hydrates the skin.

Conflict of interest

We hereby declare that there is no conflict between all the authors regarding this manuscript.

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