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Review on the Pharmacological and Health Aspects of *Apium Graveolens* or Celery: An Update

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ABSTRACT

Apium graveolens or celery belongs to the Apiaceae family. Celery is a branched biennial plant, has thick dense branches and stems, and can grow up to 1 m. The leaves are triangular, diamond, or spear-shaped and are about 5-50 mm long. Celery comes from swamps and wild plants that are widespread in Asia and Europe. The seeds, leaves, and stems of celery can be used to treat a variety of ailments. The results of phytochemical analysis showed that celery contains fatty acids, sesquiterpenes alcohol, and essential oils, other active compounds. The results of the nutritional analysis showed that celery contains vitamin C, beta carotene, fat, protein, and several minerals. Previous pharmacological studies have shown that celery has antimicrobial, antiparasitic, cardioprotective, gastroprotective, neuroprotective, hypolipidemic, cytotoxic, antioxidant, anti-inflammatory, and anti-infertility activities.

Keywords: *Apium graveolens*, phytochemistry, pharmacology

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INTRODUCTION

Medicinal applications using herbal plants have long been used in human civilization until now, various herbal plants used have shown pharmacological activity in treating various diseases [1, 2]. One of the herbal plants that can be used as a treatment is celery [3].

Apium graveolens or celery belongs to the Apiaceae family. Celery plants grow throughout the continent of Asia, Europe, and parts of Africa that have a tropical climate [4], but until now celery has been consumed and cultivated throughout the world [5]. The seeds, leaves, and stems of celery can be used to treat gout, rheumatism, urinary tract inflammation, and arthritis. Celery can also be used as a diuretic, for stimulation of the glands, bile, kidney stones, to regulate the intestines, to increase appetite, and as a prophylaxis for nerve agitation [6]. The methanol extract of the celery seeds contains several chemical compounds of flavonoids, steroids, glycosides, and alkaloids [7, 8]. Celery also contains furocoumarins, phenols, sesquiterpenes alcohol, and essential oils [9]. Previous pharmacological studies have shown that celery has antimicrobial activity [10], antiparasitic [11], cardioprotective [12], gastroprotective [13], neuroprotective [14], hypolipidemic [15], cytotoxic [16], antioxidant [17], anti-inflammatory [18], and anti-infertility [19]. Until now, the public's knowledge in using celery is still limited as a flavor enhancer for food and vegetable commodities [20]. The public in general still rarely knows that celery is an herbal plant that is beneficial to human health in treating various diseases [21].

Therefore, this review will explain the taxonomy of celery, the plant description of celery, the geographical distribution of celery, the phytochemicals of celery, the nutritional value of celery, the traditional use of celery, the medicinal value of celery, and the pharmacological activity of celery.

TAXONOMY

Kingdom: Plantae
Division: Spermatophyta
Class: Dicotyledonae
Ordo: Apiales
Family: Apiaceae
Genus: *Apium*
Spesies: *Apium graveolens* L. [22]

PLANT DESCRIPTION

Celery is a branched biennial plant, has thick dense branches and stems, and can grow up to 1 m. The leaves are triangular, diamond, or spear-shaped and are about 5-50 mm long. Leaf edges are lobed and serrated [23]. The stems of this plant are branched, moist, ribbed, and the root type of this plant is riding and has root fibers that spread sideways with a radius of about 5-9 cm from the base of the stem and the roots can penetrate the soil to a depth of 30 cm. The fruit is brown with black stripes on the outer layer. The fruit is 1-2 mm in diameter, sub-orbicular, aromatic, schizocarps, and has two mericarps [24]. The seeds are oblong with a width of 1.5-2 mm. The seeds are brown and serrated. Small flowers are greenish white. There is one seed in each carpel, or two carpels joined to one fruit. Flowers are oval shaped and have five petals [25]. Celery plant morphology can be seen in Figure 1.

The celery seasoning has a distinctive, but pleasant aroma. Celery plant parts can be used for flavoring foods such as stalks, leaves, oleoresins, and seeds [26]. Celery can be grown every season. Celery grows faster in cloudy, cool, and slightly hot regions. March is a suitable month for planting celery seeds, after which celery can be harvested in November. Celery can grow on all types of soil, except alkaline soils. Clay and waterlogged soils are suitable media for growing celery. Celery is very sensitive to soil reactions, therefore the pH threshold value in the soil should be 5-7 [27].

Fig 1. *Apium graveolens* or celery. A. Whole plant of celery; B. Leaves of celery; and C. Seeds of celery [28]

GEOGRAPHICAL DISTRIBUTION

Celery comes from swamps and wild plants that are widespread in Asia and Europe [29]. Consumption and cultivation of celery is very much practiced in developing countries such as India, Abyssinia, Iran, Algeria, the Caucasus, and Indonesia [30]. As many as 40,000 tons of celery can be produced by India each year and 250 tons of them are exported [31]. Celery needs elevated dampness to grow [32]. Therefore, celery can grow optimally in areas with cold and warm weather [33]. In Iran, regions suitable for celery cultivation are Tehran, Semnan, Baluchistan, Khuzestan, Zabo, Sistan [34], and the Caspian coast [35]. Celery also needs a shady place to grow, because high light intensity can inhibit its growth [36].

PHYTOCHEMISTRY

Initial phytochemical examination showed that the methanol extract of celery seeds contained flavonoids, glycosides, steroids, alkaloids, and carbohydrates [7]. Celery contains phenolic compounds and furocoumarins. Furocoumarins include apigravrin, celereoside, bergapten, osthenol, apiumoside, isoimperatorin, celerin, isopimpinellin, apiumetin, 5-hydroxy methoxypsoralen, and 8-hydroxy methoxypsoralen. Phenols include isoquercitrin, apiin, tannin, apigenin, Graurobioside A, Graurobioside B, and phytic acid [8, 37-42]. The leaves, stems, and oil of celery seeds contain fatty acids, alcohol sesquiterpenes, and essential oils, compounds isolated include camphene, limonene, terpinolene, cymene, selenin, sabinene, α-pinene, α-thuyene, β-phellendrene, β-pinene, γ-terpinene, p-cymene, stearic acid, palmitic, linoleic, petrocellinic, myristic, oleic, myristicic, myristoleic, palmitoleic, α-eudesmol, sant eudesmol, sedanenolide, phthalide, and 3-n-butyl phthalide. Celery tubers contain 5-methoxypsoralen, methoxsalen (8-methoxypsoralen), and prophylactic allergens (Api g1) [9, 43-51]. Some of the compounds found in celery can be seen in Figure 2.

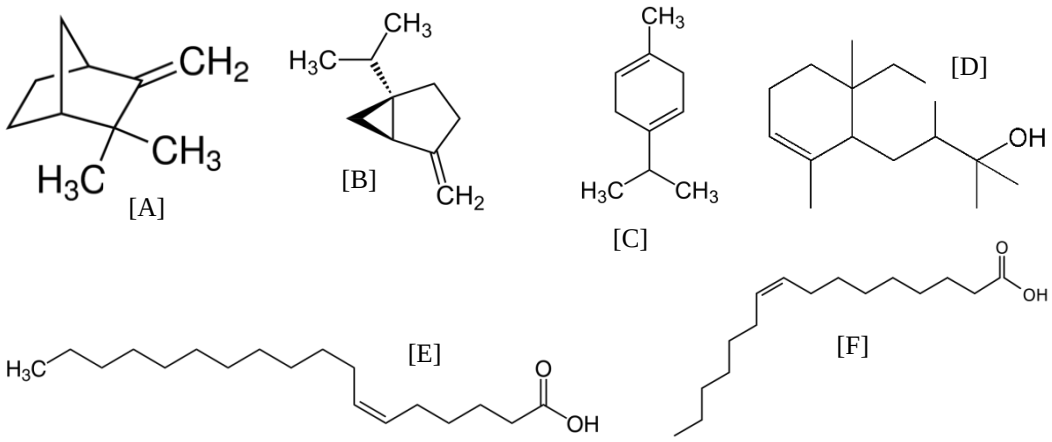

Fig 2. Some phytochemicals of celery. A. Camphene; B. Sabinene; C. γ-terpinene; D. α-eudesmol; E. Petroselinic; and F. Palmitoleic [6]

NUTRITIVE VALUE

The results of the nutritional analysis showed that celery contains protein (5.68-7.53%), fat (2.21-3.14%), vitamin C (15.87-18.28%), ash (1.12- 1.98%), and beta carotene (1.89-2.97 mg/g). Celery also contains several minerals such as Zn (11.96-15.61 mg/100 g), Mg (243-556 mg/100 g), P (3243-4667 mg/100 g), Mn (35.3-39.3 mg/100 g), Se (0.08-1.32 mg/100 g), Ca (403-709 mg/100 g), Cu (39.98-56.90 mg/100 g), Cd (0.31- 1.66 mg/100 g), Ni (2.01-5.5 mg/100 g), Na (4113-5333 mg/100g), Pt (0-2.63 mg/100 g), Fe (101.4-305.2 mg/100 g), Cr (0.11-0.73 mg/100 g). K (1235-2166 mg/100 g), dan Pb (2.37-5.12 mg/100 g) [8].

TRADITIONAL USE

Celery has been used in traditional medication to manage stomach aches and spasms as well as a laxative, diuretic, and sedative. This herb can also be employed as a heart tonic to lower blood pressure in traditional African medicine in Tobago and Trinidad [52]. In addition, a report stated that celery can be used to treat joint problems [27]. In traditional medicine, celery seeds can be used as a libido stimulant because of its role in strengthening sperm cells and as a protector against sodium valproate in the testes [53]. Celery seeds can also be used to increase breast milk secretion [54].

MEDICINAL VALUES

Celery can be used to treat kidney problems, because celery contains active compounds that can reduce uric acid levels [55]. Celery stems and seeds can be used as anti-inflammatory, hypotensive, carminative, urinary antiseptic, sedative, antirheumatic, and spasmolytic antiseptic [56]. Celery can also be used as a laxative, stimulant, diuretic, aphrodisiac, emmenagogue, carminative, antispasmodic, and anthelmintic [27]. In addition, celery can be used to relieve flatulence and abdominal pain [57]. Celery can be employed for the medication of insomnia and post-nasal edema [58]. Celery

can be combined with carrot juice as a treatment for chronic diseases [59]. Celery seeds can be used to treat stomach disorders and chemical imbalances in the body [55].

PHARMACOLOGICAL ACTIVITY

Celery have many pharmacological activities as listed in below:

Antimicrobial activity

The ethanol extract of celery leaves and roots showed antimicrobial activity against several bacteria such as *Enterococcus faecalis*, *Escherichia coli*, *Enterobacter aerogenes*, *Salmonella typhimurium*, *Bacillus cereus*, *Citrobacter freundii*, *Proteus vulgaris*, *Listeria monocytogenes*, *Hafnia alvei*, and *Staphylococcus aureus*. In addition, the ethanol extract of celery leaves was more efficient and effective than the dry root ethanol extract of celery. The higher doses of ethanol extract from celery leaves and roots showed higher antimicrobial activity. Celery extract can also inhibit the growth of the bacteria *Citrobacter freundii* and *Proteus vulgaris* [51].

Antifungal activity

Celery methanol extract at a concentration of 200 µg/mL showed anti-fungal action against several fungi such as *Aspergillus flavus*, *Fusarium solani*, *Trichphyton longifuss*, *Microsporum canis*, *Candida glabrata*, and *Candida albicans* [8].

Antiparasites activity

Celery seed oil has antiparasitic (larvicidal and repellent) activity, which is effective against *Aedes aegypti* larvae, which are vectors of dengue fever [5, 60]. In another study celery oil (with 5% vanillin) was effective in repelling mosquitoes better than commercial mosquito repellents [61].

Anti-inflammatory activity

The anti-inflammatory action of celery has been evaluated in an experimental model mouse ear test induced by celery oil. The results of the study indicated that celery oil-induced mice showed seven times lower anti-inflammatory activity compared to indomethacin as the standard drug. This mechanism may occur due to the inhibitory activity of the apiin compound against the production of nitride oxide (NO) and nitric oxide synthase (iNOS) which can be induced [62]. Polysaccharides found in celery, apiuman, can increase the production of interleukin-10 (IL-10), decrease IL-1β, and reduce neutrophil migration, which causes anti-inflammatory activity [63]. In addition, the water extract of celery stalks contains polar compounds that play a role in anti-inflammatory activity [18].

Anti-cancer activity

Celery oil contains important active compounds called phthalides, these compounds show protection against cancer, cholesterol, and high blood pressure. The most active phthalide compound is sedanolide which can fight tumors in cancer patients. Celery seed oil contains two main active compounds, namely sedanolide and 3-n-butyl phthalide which can stimulate a detoxification enzyme in the target tumor tissue called glutathione S-transferase (GST) [64]. Celery can also reduce mutations in cancer cells by fighting free radicals found in cells that have been damaged, thereby reducing the potential for these cells to mutate into cancer cells. This activity is also shown in other active compounds of celery, namely coumarins. Celery can be used as a juice drink as a strong electrolyte substitute because celery is high in potassium and sodium. Celery can also control cholesterol and cancer levels after increasing detoxification [26].

Antiulcer activity

Celery seed ethanol extract can effectively protect indomethacin and cytodestructive agents (0.2 M NaOH, 80% ethanol, and 25% NaCl) induced by rat gastric ulcers. The results were evaluated using histopathological and biochemical analyzes of the treated sample and control groups. The ethanol extract of celery seeds shows protection against the mucosa of guava and suppresses gastric basal secretion in mice possibly through its antioxidant potential which can be seen from the presence of antioxidant compounds (tannins and flavonoids) in the ethanol extract of celery seeds [13].

Antioxidant activity

Celery contains many phenolic compounds, which can be a great source of antioxidants [65]. The antioxidant activity of celery leaves has been studied by capturing the radical activity of 1,1-diphenyl 2-picrylhydrazyl and is known to be a natural antioxidant by inhibiting the oxidant process [66]. It is associated with other antioxidant compounds including L-tryptophan and derivatives of methoxy-phenyl chromenone [67].

In another study, celery extract has been investigated, the results found good activity of 2,2-diphenyl-1 picrylhydrazyl and hydroxyl radical scavenging. *In vivo* experiments with CCl4-induced toxicity also showed significant antioxidant activity [68].

Antidiabetic activity

In a study using n-butanol extract from celery seeds to investigate the antidiabetic activity against male rats induced by streptozotocin in improving antioxidant status and lipid peroxidation. The results of these studies indicate that the n-butanol extract from celery seeds (60 mg/kg BW) or insulin treatment as a standard drug can regulate the activity of all antioxidant enzymes, promote weight growth, improve stress complications accompanied by diabetes mellitus, and maintain levels normal blood glucose [69, 70].

Anti-infertility activity

An experiment showed that celery extract had protective activity against sodium valproate-induced rat testicular toxicity. The results of this experiment have been strongly supported based on histopathological analysis. Apigenin, which is one of the main active compounds of celery, may play a role in this activity [53]. In addition, other experiments have shown that celery extract has recovery activity in rat testes against chemically induced rat testicular damage [34, 71, 72].

Antiplatelet activity

Celery extract has strong antiplatelet activity because celery extract contains apigenin compounds, which play a role in inhibiting adenosine diphosphate, collagen, and arachidonic acid-induced platelet aggregation. In addition, apigenin can also inhibit collagen-adenosine diphosphate-induced aggregation in the blood [73].

Anti-spasmolytic activity

The ethanol extract of celery has strong anti-spasmolytic activity because the ethanol extract of celery can inhibit the ileum concentration in a dose-dependent manner. The active compounds apigenin and flavonoids from the ethanol extract of celery may play a role in this activity [74].

Hepatoprotective activity

The methanol extract of celery seeds has strong hepatoprotective activity against paracetamol-induced liver damage [75] and carbon tetra chloride [76]. Celery extract can reduce the risk of developing hepatotoxicity including alanine transaminases, albumin, alkaline phosphatase, aspartate transaminase, and total protein

when compared to silymarin as a standard drug. The histopathological analysis also showed that the methanol extract of celery seeds can restore the structural changes of the liver tissue induced by paracetamol. In another experiment, dietary intake of celery plus barley and chicory can reduce levels of triglycerides, total cholesterol, and serum liver enzymes [77].

Cardioprotective activity

In one study, rabbits were given water and ethanol extract of celery, then measured the mean blood pressure and atrial contraction in these rabbits. The results of this study indicate that the ethanol extract of celery has a more significant hypotensive activity than the water extract of celery. The hypotensive activity of aqueous and ethanol extracts of celery can be blocked by induction of atropine (0.3 mg/kg) [78].

Neuroprotective activity

In a study using methanol extract of celery seeds, their anti-depressant activity was evaluated using an *in vivo* experimental model. In the results of this study, the methanol extract of celery seeds (100 mg/kg BW and 200 mg/kg BW) showed significant anti-depressant activity in mice in the tail suspension test, forced swimming test, and the actions of the mice were found to be similar to imipramine as a standard drug. Celery seed methanol extract at a dose of 200 mg/kg BW showed a more prominent anti-depressant activity compared to lower doses [7]. Sedanolide and 3, n-butylphthalide isolated from celery oil showed weak sedative activity, prolonged pentobarbital narcosis, and induced sleep immediately after recovery from previous barbiturate treatment in mice [79].

Cytoprotective activity

Sedanolide is one of the main active compounds of celery oil. Celery has been widely used in the treatment of rheumatism and gout based on hydrogen peroxide and tert-butyl hydroperoxide which are used in vitro for the production of toxicity. Human hepatoma cells and highly differentiated colon adenocarcinoma cells were used to evaluate cytoprotective activity. Cell survival was measured by means of a spectrophotometer. The percentage of viable cells was assessed by the microtetrazolium assay. In the results of these experiments, the viability of intestinal cells was more when compared to liver cells, it can be concluded that high concentrations of sedanolide have some toxic effects on liver cells even though sedans do not show any protection [50].

Hypolipidemic activity

Celery ethanol extract was used to determine hypolipidemic activity in rats. The ethanol extract of celery (213 mg/kg and 425 mg/kg) was given to mice orally for 60 days. The results of this study indicate that the ethanol extract of celery can reduce levels of total serum cholesterol, triglycerides, low-density lipoproteins, and increase levels of high-density lipoproteins. The results of this study confirm that celery has been used for hypolipidemic activity for a long time. Possible mechanisms include inhibition of hunger, decreased intake of energy from food, increased disbursement of energy, and prevention of absorption of nutrients from the digestive tract [80, 81].

Analgesic activity

The ethanol extract of celery seeds has strong analgesic activity in rats induced by acetic acid through the hot plate and writhing test method [82]. The analgesic activity of the ethanol extract of celery seeds is associated with the involvement of celery in cytochrome P450, which was found to be decreased in hepatic homogenate [83].

CONCLUSION

Apium graveolens or celery belongs to the Apiaceae family. Celery plants grow in all continents of Asia, Europe, and parts of Africa that have a tropical climate, but until now celery has been consumed and cultivated throughout the world. Based on the phytochemicals, nutrients, and pharmacological activities found in celery, it can be concluded that celery can be a very potential medicinal plant. However, a number of studies are still needed to validate the effectiveness of celery as a treatment.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this study.

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