22 Celery

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22.1. Introduction

Celery (*Apium graveolens* L.) is a salad crop grown for its long fleshy leaf stalk. It resembles leafy onion. The seed is both a spice and a condiment. It ranks second in importance among salad crops. In the USA, France and in other European countries, it is grown commercially and is available in the market throughout the year, but it is not a commercially popular vegetable in India. There are three commonly used types of celery. The leafy types are referred to as var. *seculinum*, blanched celery as var. *dulce* and celeriac (with swollen edible roots) as var. *rapaceum* (Smith, 1976). The celeriac is also known as the turnip-rooted celery (Pruthi, 1976). Intergeneric hybridization of celery and parsley (*Petroselinum crispum*) has been reported (Smith, 1976).

22.2. Botany and Uses

Botany

Celery belongs to the family Umbelliferae. It is a biennial plant, although grown as an annual crop. The leafstalks are 15–38 cm long; bear three pairs and a terminal leaflet, coarsely serrated and alternately lobed or divided. The flower stalks are 60–100 cm in length, branched and leafy (Bailey, 1950). The flowers are small, white and borne in compound umbels. The fruit is rigid, 1.0–1.5 mm long, 1.0 mm in diameter and contains a small brown-coloured seed (Knott, 1960). The seeds are somewhat bitter in taste and 10 g contains about 26,450 seeds (Choudhury, 1970).

Celery grows wild in Europe, the Mediterranean region and in Asia, west of the Himalayas. The ancient Greeks and Egyptians cultivated celery. It was probably first grown as a medicinal plant, later for the leaves as flavouring. Celery has a long history in China, dating back to at least the 6th century AD. It is reported as being cultivated in several African countries, in Eritrea, Ethiopia, Mozambique and Réunion, and more commonly in South Africa (http://en.wikipedia.org/wiki/Celery). According to Thompson and Kelly (1957), the site of origin of celery extends from Sweden to Algeria, Egypt, Abyssinia, Asia and even to Caucacus, Baluchistan and the mountain regions of India. It has been found growing wild in California and in New Zealand. The first mention of its cultivation as a food plant was in 1623 in France. Janes (1954) reported that it was a native British plant, cultivated there for centuries.

Uses

The succulent leafstalk, often with a part of leafblade, is used for the preparation of sauces, vegetable juices, stews, soups, salads, etc. The type known as Chinese celery has thinner stalks and a stronger flavour and is rarely consumed raw, but is often added to soups and stir-fries. Celeriac, or turnip-rooted celery, is used mainly as a cooked vegetable in stews and soups, but is becoming increasingly popular as a grated raw salad. Leaf celery, also called smallage, is chopped and used as garnish and flavouring, either fresh or in dried powdered form (http://en.wikipedia.org). Sometimes, celery is also used in fried form.

Celery seed is used as a condiment in European countries and a spice in India. The seeds can be used as a flavouring or spice, either as whole seeds or ground and mixed with salt, as celery salt. Celery salt can also be made from an extract of the roots. Volatile oil obtained from the seeds is used in the perfume and pharmaceutical industries (http://en.wikipedia.org). The growing plant is an insect repellent; it repels the cabbage white butterfly so is a good companion for brassicas (Riotte, 1978). Essential oil of celery is most active against *Campylobacter jejuni*, with BA50 values ranging from 0.003 to 0.009 (Friedman *et al.*, 2002). The oil is toxic to cercariae of *Schistosoma mansoni* (96% killed at 40 ppm) and also exerts a chemotactic effect (Saleh *et al.*, 1985). All parts of the plant have medicinal uses.

22.3. General Composition

The leaves of celery are more nutritive than stalks, especially in vitamin A, protein and calcium. Traces of copper and arsenic have been reported in the tuberous root. The herb contains the glucoside apiin (Anon., 1952). A nutritive analysis of celery leaves is given in Table 22.1. Celery seeds are also nutritive. The major composition of the seeds is carbohydrate, followed by fat, protein and ash. They also contain micronutrients and vitamin A. Table 22.2 gives the composition of celery seeds as per ASTA and the *USDA Agricultural Handbook.*

Table 22.1. Nutritive composition of celery leaves (per 100 g of edible portion).

Moisture (g)	88.0	Thiamine (mg)	0.00
Fat (g)	0.6	Riboflavin (mg)	0.11
Protein (g)	6.3	Vitamin C (mg)	62
Carbohydrate (g)	1.6	Calcium (mg)	230
β-carotene (mg)	3990	Iron (mg)	6.3

Table 22.2. Nutritional composition of celery seed (per 100 g).

Composition	Content[1]	Content[2]
Water (g)	6.04	5.00
Food energy (Kcal)	392	450
Protein (g)	18.07	18.00
Fat (g)	25.27	22.80
Carbohydrates (g)	41.35	43.80
Ash (g)	9.27	10.20
Calcium (g)	1.767	1.800
Phosphorus (mg)	547	550
Sodium (mg)	160	170
Potassium (mg)	1400	1400
Iron (mg)	44.9	44.9
Thiamine (mg)	–	0.41
Riboflavin (mg)	–	0.49
Niacin (mg)	–	4.4
Ascorbic acid (mg)	17.14	17.00
Vitamin A activity (RE)	5	5

[1] *USDA Handbook*; [2] ASTA.
Source: Anon. (1977); ASTA (1977).

22.4. Chemistry

Volatiles

The volatiles showed variation in different environments. The composition of the oil from the fresh aerial parts of *A. graveolens* var. *secalinum* (at the flowering stage) obtained from three locations in Egypt revealed that the main components were α- and *β*-pinene, myrcene, limonene, *cis*-*β*-ocimene, γ-terpinene, *cis*-allo-ocimene, *trans*-farnesene, humulene, apiol, *β*-selinene, senkyunolide and neocnidilide (Saleh *et al.*, 1985). The chief component in the essential oils from fruits, and to a lesser extent in the leaves and stems, was limonene, whereas the roots and tubers had more *trans*-ocimene, 3-methyl-

4-ethylhexane and *β*-pinene (Fehr, 1981). Sipailiene *et al.* (2005) reported that the main constituents in the oil from roots were limonene, carvone and 3-*n*-butylphthalide. The structures of some of the volatiles are given in Fig. 22.1.

The volatiles also showed variation between genotypes. The concentration of terpenes and phthalides, the key volatile components, found in various cultivars of both celery and celeriac varied over a wide range (Van *et al.*, 1990). Eleven flavour compounds were identified in cv. Black Celery of Trevi, 17 compounds in cv. D'Elne and 21 compounds in cv. Verde Pascal. The main constituent of these cultivars was limonene. Twenty-one compounds were identified in cv. Dorato d'Asti. The main constituent was *γ*-terpinene. The cv. Black Celery of Trevi had a very low amount of *γ*-terpinene compared with other varieties (Tirillini *et al.*, 2004).

Studies on the qualitative and quantitative changes in the flavour of juices from Monarch and Bergers weiBe Kugel varieties showed the presence of 3-butylphthalide enantiomers. The enantiomeric distribution of 3-butylphthalide lowers the flavour quality of the Bergers weiBe Kugel celery juice (Greule *et al.*, 2005). Among the 12 compounds identified as potent odorants, 3-*n*-butylphthalide 1, sedanenolide 2, and *trans*- and *cis*-sedanolides 3, four were assessed to be most contributive to the overall odour of celery. These three phthalides, (3*E*,5*Z*)-1,3,5-undecatriene, myrcene and (*E*)-2 nonenal, were common to both raw and boiled materials. Two compounds ((*Z*)-3-hexenal and (*Z*)-3-hexenol) were dominant in raw celery and four compounds (2-methylbutanoic acid, sotolon, *β*-damascenone and *β*-ionone) were dominant in boiled celery (Kurobayashi *et al.*, 2006).

GC-MS analysis to study the content and composition of extracts of celery revealed the presence of terpenoids, sesquiterpenoids and phthalides in the essential oils and extracts obtained with organic solvents from two celery cultivars (Wolski *et al.*, 2004). The composition of the essential oil obtained from the fruits of three *A. graveolens* var. *dulce* cultivars, i.e. Helios, Orient and Zefir, showed that the main components of the essential oil were isoprenoids, including monoterpenes and sesquiterpenes. Essential oil content ranged from 2.5 to 3.0%. The percentage

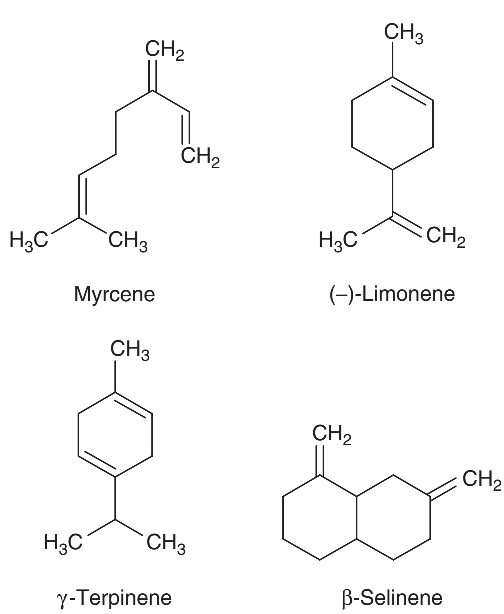

Fig. 22.1. Structures of some of the volatiles of celery.

of monoterpenes in the essential oil ranged from 79.1 to 82.8, while that of sesquiterpenes ranged from 15.7 to 18.8 (Wolski *et al*., 2001).

Volatile constituents of celery × parsley hybrid

The celery × parsley hybrid inherited all the terpenoids from celery and heptanol from parsley, while synthesizing new compounds of its own. The content of these new compounds was higher than that of the main celery components, limonene and myrcene (Madjarova *et al*., 1979). The volatile components of celery consisted of monoterpene hydrocarbons (46.0%) and phthalides (42.3%). The major components were limonene and 3-butyl-4,5-dihydrophthalide (or sedanenolide). Celery volatiles contained higher concentrations of γ-terpinene and α-pinene. A celery-like odour was associated during GC elution with each of the 16 phthalides reported (MacLeod and Ames, 1989).

Influence of nitrogen on volatile constituents

Increasing the rate of nitrogen fertilizer application affected the relative proportions of some of the essential oil components (Martin *et al*., 1985). At higher N rates, limonene and other monoterpene concentrations decreased to very low values, while those of sedanolide and phthalides increased to above 75% (D'Antuono *et al*., 2002).

Leaf oil

The chief components of the celery leaf oil were limonene, myrcene and *cis*-ocimene (Bubarova, 1973; Fehr, 1974). The sesquiterpene content of the leaf oil (< 5%) was relatively low compared with that of the fruit oil. The essential oil of leaves contained a higher amount of limonene compared with the roots and a very small amount of carvone (Sipailiene *et al*., 2005). Studies conducted on the leaf essential oil showed that the matured dry leaf contained essential oil having a composition similar to that of seed oil (Thappa *et al*., 2003). High limonene content in celery oil renders it unfit for direct consumption. The increase in phthalide content is linked with the corresponding decrease in limonene content. The reduced limonene content offers significant advancement towards the development of celery oil with improved quality (Thappa *et al*., 2003).

Leaf oil in relation to location

The three main constituents of volatiles from leaf stems of a local cv. from Libya were apiole (about 23%), 3-butylphthalide (about 22%) and sedanolide (about 24%). The last two possess a strong characteristic celery aroma (MacLeod *et al*., 1988). Limonene (40.5%), β-selinene (16.3%), *cis*-ocimene (12.5%) and β-caryophyllene (10.5%) were the major volatile oil constituents of celery leaves collected from Nigeria (Ehiabhi *et al*., 2003). Analysis of celery leaf oil from Cuba revealed 28 compounds, representing about 94% of the oil. Limonene (18.3%), β-caryophyllene (13.5%) and 3-butyl-4,5-dihydrophthalide (32.1%) were the major constituents (Pino *et al*., 1997).

Seed oil

Limonene (50.1–65.5%) and β-selinene (11.2–22.2%) were the major components in the seed oil of celery. A sesquiterpene ether, kessane (2.2–7.6%), was also detected (Philippe *et al*., 2002).

Sterols in seed oil

Sitosterol and stigmasterol were the major components of celery seed oil. The other components were cholesterol, brassicasterol, campesterol, ∂7-campesterol, ∂5-avenasterol, ∂7-stigmasterol and ∂7-avenasterol (Zlatanov and Ivanov, 1995). Oil bodies isolated from celery cell suspension cultures contained at least 60% of the total steryl ester present in the cells. Free sterols comprised < 0.5% of the total lipid in the oil body. Sterylesters constituted 4.5% of the total lipid of celery oil bodies. The proportion of precursor 4-methylsterols in the free sterol fraction of celery was greater in the oil body (Dyas and Goad, 1994). Stigmasterol was either undetected or contributed very little to the steryl ester fraction. The precursor sterols (cycloartenol, obtusifoliol) were esterified in greater proportion to palmitic acid than to the C_{18} fatty acids in suspension cultures (Dyas *et al.*, 1994).

Phospholipids in seed oil

The phospholipid composition of glyceride oils from celery seeds indicated that the phospholipid content was 1.7–3.7% in glyceride oils and 0.2–0.5% in seeds. Phosphatidylcholine (38.5–51.1% in the phospholipids fraction), phosphatidylinositol (18.6–32.0%) and phosphatidylethanolamine (9.3–18.6%) were identified as major components in all the glyceride oils (Zlatanov, 1994).

Volatile production in cell suspension cultures

Two phthalides, 3-isobutylidene-3a,4,5,6-tetrahydrophthalide and 3-isobutylidene-3a,4-dihydrophthalide, were identified in the intact plant and the differentiated callus, but were absent in the undifferentiated callus. The phthalide composition of this culture was comparable to that of the intact plant (Abta *et al.*, 1979). In the green slow growth cultures, flavour compounds, the phthalides (3-butylphthalide and sedanenolide) and other terpenoid compounds were present, both in the media and the cells. Maximum secondary product synthesis and greening occurred in media containing 3,5-dichlorophenoxyacetic acid [3,5-D]. There was no stimulation of phthalide and terpenoid synthesis in cultures grown in a medium containing 2,4-D in darkness and at high (30°C) and intermediate (20°C) temperatures. However, when the cultures were maintained at 4°C for the first 5 days of the growth cycle and then transferred to 25°C, phthalides and other terpenoids, particularly limonene, were released into the medium (Watts *et al.*, 1984).

In young plants, the concentrations of limonene and other terpenoids increased in the petiole and leaf extract as the level of chlorophyll increased. In the cell cultures, greening was induced by transferring to a medium where 2,4-D was replaced by 3,5-dichlorophenoxyacetic acid (3,5-D). During the first subculture, phthalides (the major flavour compounds) were produced in the growth phase, but were present in trace amounts only in the second and third subcultures. Limonene levels, however, increased after the first subculture. Phthalide production was stimulated by the transfer from a 2,4-D- to a 3,5-D-containing medium but, as the level of aggregation and greening increased in the culture, phthalide production was reduced and limonene production increased (Watts *et al.*, 1985).

Non-volatiles

The quantification of the potentially health-defensive and disease-preventive flavonoids, quercetin, kaempferol, myricetin, apigenin and luteolin, in celery revealed that the quercetin level was generally below 10 mg/kg and kaempferol was below 30 mg/kg. Detectable amounts of apigenin, luteolin and myricetin were also present (Lugasi and Hovari, 2000). The leaf stalks of three celery cultivars (Helios, Orient and Tango F1), analysed for the composition of tannins and free phenolic acids, indicated that tannin levels ranged from 5.78 to 7.68%. Phenolic acids, protocatechuic, *p*-hydroxybenzoic, caffeic, *p*-coumaric and ferulic acids were also detected (Najda and Dyduch, 2004). Four linear furocoumarins (psoralen, bergapten, xanthotoxin and isopimpinellin) were isolated from three varieties of healthy, commercially grown celery. Previously, psoralen had not been reported to occur in celery (Beier *et al.*, 1983). The phenolic compounds, particularly the flavonoids, may be responsible, in part, for the antioxidant activity of traditional plant extracts including celery (Pendry *et al.*, 2005).

Five sesquiterpenoid glucosides (celerioside A–E) and three phthalide glycosides (celephtalide A–C), together with six aromatic compound glucosides, two norcarotenoid glucosides and a lignan glucoside, were isolated from the water-soluble portion of the methanol extract of the seed (Kitajima *et al.*, 2003). Cyclooxygenase inhibitory and antioxidant bioassay-directed extraction and purification of celery seeds yielded sedanolide, senkyunolide-N, senkyunolide-J, 3-hydroxymethyl-6-methoxy-2,3-dihydro-1*H*-indol-2-ol, L-tryptophan and 7-[3-(3,4-dihydroxy-4-hydroxymethyl-tetrahydrofuran-2-yloxy)-4,5-dihydroxy-6hydroxymethyl-tetrahydro-pyran-2-yloxy]-5-hydroxy-2-(4-hydroxy-3-methoxy-phenyl)-chromen-4-one (Momin and Nair, 2002).

Extraction of flavour compounds

The best results were obtained with C_{18} Nova-Pak, C_{18} Symmetry and C_{18} Genesis columns for the analysis of free and conjugated flavonoids and the same were used for the quantitative analysis of endogenous flavones and flavonols in acid-hydrolysed extracts from celery (Crozier *et al.*, 1997). A newly developed simultaneous purging and solvent-extraction apparatus was used to isolate and identify 14 terpenes and two aromatic compounds in the headspace sample from celery (Macku and Shibamoto, 1991). The supercritical fluid extraction of oil from milled celery seeds, using CO_2 as a solvent, indicated a significant increase in extraction rate with increase of pressure or decrease of the particle size of the celery seed. A similar effect was observed with the increase of the solvent flow rate and decrease of temperature (Papamichail *et al.*, 2000). High-speed counter-current chromatography (HSCCC) with an Ito multilayer coil separator–extractor was applied to perform efficient separations of natural products such as phthalides (aroma compound) from celery and parsley roots (Fischer *et al.*, 1991).

22.5. Medicinal and Pharmacological Uses

Celery has been used traditionally to treat many disorders. All parts of the plant are known to be a remedy for one or more maladies. Wild celery also is no exception to this. The medicinal value of celery in treating various ailments and its various other medicinal and pharmacological properties is outlined below:

- Treatment for rheumatism
- Treatment for urinary disorders
- Digestive remedy
- Cure for nervous disorders
- Antimicrobial activity
- Other medicinal uses.

Treatment for rheumatism

The herb is used in treating rheumatism (Launert, 1981). Infusions from the seeds are used for rheumatoid arthritis and gout. The essential oil is used in warm water to soak painful, gouty areas of the feet. Root tinctures and also fresh juice from the whole plant are also used in arthritic remedies (http://www.innvista.com/health/herbs/celery.htm).

Treatment for urinary disorders

The diuretic property of celery has been used to prepare herbal medicine (Houghton, 1995). The ripe seeds, herb and root are diuretic (Lust, 1983; Chiej, 1984; Grieve, 1984). The seeds are used mainly as a diuretic and can help clear toxins from the system, especially in cases of gout where uric acid crystals collect in the joints. Root tinctures have been used to cure urinary disorders, such as urinary stones, and used as a kidney stimulant and cleanser. Fresh juice from the whole plant is also used as a cure for urinary tract inflammations and urethritis (http://www.innvista.com/health/herbs/celery.htm). The herb is used against kidney complaints (Launert, 1981).

Digestive remedy

Wild celery relieves indigestion (Bown, 1995). The celery roots act as a bitter digestive remedy and liver stimulant. The seeds also act as a digestive stimulant (http://www.innvista.com/health/herbs/celery.htm).

Cure for nervous disorders

Celery is also used to cure a few nervous disorders (http://www.innvista.com/health/herbs/celery.htm). An essential oil obtained from the plant has a calming effect on the central nervous system. Some of its constituents have antispasmodic, sedative and anticonvulsant actions. It has been shown to be of value in treating high blood pressure (Chavallier, 1996). Wild celery promotes restfulness and sleep in hysteria patients (Grieve, 1984) and is also used to lower blood pressure (Bown, 1995).

Antimicrobial activity

Sesquiterpene lactones from *A. graveolens* showed activity against *Bacillus subtilis* and *Proteus vulgaris* and also tested fungi (Jawad *et al.*, 1985). Essential oil of celery inhibited the growth of *Listeria monocytogenes*, *Staphylococcus aureus*, *Escherichia coli* O:157:H7, *Yersinia enterocolitica*, *Pseudomonas aeruginosa*, *Lactobacillus plantarum*, *Aspergillus niger*, *Geotrichum* and *Rhodotorula* (Elgayyar *et al.*, 2001). The root extracts possessed high activity against *B. cereus* and *Enterococcus faecalis* only (Sipailiene *et al.*, 2005).

Other medicinal uses

The ripe seeds, herb and root are aperient, carminative, emmenagogue, galactogogue, nervine, stimulant and tonic (Lust, 1983; Chiej, 1984; Grieve, 1984). Eating fresh stalks is good for lactating mothers, although wild celery is more effective (http://www.innvista.com/health/herbs/celery.htm). Wild celery also stimulates the uterus and is anti-inflammatory (Bown, 1995). A few compounds, such as L-tryptophan and others isolated from celery seeds, exhibited good antioxidant activity at concentrations of 125 and 250 μg/ml (Momin and Nair, 2002).

The polyacetylenes present in celery have shown to be highly toxic towards fungi, bacteria and mammalian cells, to display neurotoxic, anti-inflammatory and antiplatelet aggregatory effects and to be responsible for allergic skin reactions. The effect of these polyacetylenes towards human cancer cells, their human bioavailability and their ability to reduce tumour formation in a mammalian *in vivo* model indicates that they may also provide benefits for health (Christensen and Brandt, 2006). Celery oil induced significant anti-inflammatory activities 2, 3 and 5 h after administration to rats (Afifi *et al.*, 1994). *A. graveolens* is a potent plant against experimentally induced hepatocarcinogenesis in Wistar rats (Sultana *et al.*, 2005).

22.6. Quality Specifications

Chemical and physical specifications

Celery contains 1.5–3.0% volatile oil, primarily containing about 60–70% *d*-limonene and 10–20% *β*-selinene. The characteristic celery odour is thought to be due to oxygenated compounds present in the oil (sedanolide and sedanonic acid anhydride). Essential oil of celery seed is available; however, the most common extractive form is the oleoresin, due to its fuller flavour. This product contains 12–16% volatile oil.

ASTA suggest maximum moisture levels of 10%. Ash and acid-insoluble ash should be less than 10 and 2%, respectively. Tables 22.3 and 22.4 summarize the typical chemical and physical specifications, including the FDA's DAL, for whole celery and ground celery, respectively.

ISO specifications

The following are the ISO specifications available for celery:

ISO 927, Spices and condiments – determination of extraneous matter content.
ISO 928, Spices and condiments – determination of total ash.
ISO 930, Spices and condiments – determination of acid-insoluble ash.
ISO 939, Spices and condiments – determination of moisture content – entertainment method.
ISO 948, Spices and condiments – sampling.
ISO 2825, Spices and condiments – preparation of a ground sample for analysis.
ISO 6571, Spices, condiments and herbs – determination of volatile oil content.

Celery seeds specification (IS 3797:1993)

The following Indian Standards are necessary adjuncts to this standard:
IS No. Title
1070; 1992 Reagent grade water (third revision).

Table 22.3. Whole celery: chemical and physical specifications.

Specification	Suggested limits
ASTA cleanliness specifications	
Whole dead insects, by count	4
Mammalian excreta (mg/lb)	3
Other excreta (mg/lb)	3.0
Mould, % by weight	1.00
Insect-defiled/infested, % by weight	1.00
Extraneous, % by weight	0.50
FDA DAL (condimental seed)	
Adulteration with mammalian excreta (mg/lb)	Average of 3
Volatile oil[1] (% min.)	1.5
Moisture[2] (% max.)	10.0
Ash[1] (% max.)	10.0
Acid-insoluble ash[1] (% max.)	2.0
Average bulk index (mg/100 g)	195

Note: [1]These are suggested limits that the authors put together from the data collected over the previous 5 years. These numbers are equivalent to the level in to which most quality spices fall.
[2]ASTA suggested maximum moisture level.
Source: Tainter and Grenis (2001).

Table 22.4. Ground celery: chemical and physical specifications.

Specification	Suggested limits
FDA DAL	None
Volatile oil[1] (% min.)	1.0
Moisture[1] (% max.)	10.0
Total ash[1] (% max.)	10.0
Acid-insoluble ash[1]	2.0
Military specifications (EE-S-631J, 1981)	
Volatile oil (ml/100 g, min.)	2.0
Moisture (% max.)	10.0
Total ash (% max.)	14.0
Acid-insoluble ash (% max.)	2.0
Granulation (% min. through a USS No. 55)	95
Non-volatile ether extract (% min.)	12.0
Bulk index (ml/100 g)	190

Note: [1]These are suggested limits that the authors put together from the data collected over the previous 5 years. These numbers are equivalent to the level in to which most quality spices fall.
Source: Tainter and Grenis (2001).

1797; 1985 Methods of test for spices and condiments (second revision).
13145; 1993 Spices and condiments – methods for sampling (first revision).
For the purpose of this standard, the following definitions shall apply.
Extraneous matter: includes dust, dirt, stones, clay particles, chaff and stem or straw.
Damaged seeds: discoloured, shrivelled and immature seeds.
Foreign seeds: seeds other than those of *A. graveolens* L.
Celery seeds shall be of three grades, namely, Special, Good or Fair.

Requirements

DESCRIPTION The celery seeds shall be the dried, ripe fruits of *A. graveolens* L. The seeds shall be light brown to greyish-brown in colour. The shape of the seeds shall be ovoid to hemispherical, their length about 1.0–1.5 mm and width 0.5–1.0 mm. The seeds shall have several raised streaks running along their longitudinal axis, these streaks being lighter than the rest of the seeds.

TASTE AND AROMA OR FLAVOUR The taste and aroma or flavour of celery seeds shall be fresh and characteristic of the type and variety. The material shall be free from foreign taste and aroma or flavour, as well as from any musty odour.

FREEDOM FROM MOULDS AND INSECT ATTACK The celery seeds shall be free from visible insects and moulds and shall be practically free from dead insects and contamination by rodents, visible to the naked eye, corrected, if necessary, in any particular case. In case the magnification exceeds × 10, this fact should be stated in the test report. Table 22.5 lists the grade designations of celery seeds and their requirements as per IS 3797:1993.

Packing

Celery seeds shall be packed in sound, clean and dry containers made of a material which shall protect celery seeds from insect infestation, as well as from any offensive odour.

Marking

The following particulars shall be marked or labelled on each container:

1. Name of the material and grade designation.
2. Variety or trade name.
3. Batch or code number.
4. Net mass.
5. Date of packing.
6. Country of origin.

Sampling

Representative samples of celery seeds shall be drawn according to IS 13145:1991.

Tests

Tests shall be carried out in accordance with Table 22.5.

Quality of reagents

Unless specified otherwise, pure chemicals (chemicals that do not contain impurities which affect the results of analysis) and distilled water (see IS 1070:1992) shall be employed in tests.

22.7. Conclusion

Celery is used both as a vegetable and a spice. It has several medicinal uses. It is believed to cure most urinary disorders. It has diuretic properties. It is also commonly used to relieve pain. Limonene is the major volatile compound in both leaf and seed oil. Phthalides, myrcene, pinene, etc., are also present. Higher nitrogen inhibited limonene

Table 22.5. Grade designations of celery seeds and their requirements (as per IS 3797:1993).

Sl. No.	Characteristic	Requirement			Method of test, ref. to Cl No. IS 1797:1985
		Special	Good	Fair	
i	Moisture (% by mass, max.)	10.0	11.0	11.0	9
ii	Total ash (on dry basis) (% by mass, max.)	10.0	11.0	12.0	6
iii `	Acid-insoluble ash (on dry basis) (% by mass, max.)	2.0	2.5	3.0	8
iv	Volatile oil content (on dry basis) (% by mass, min.)	2.0	1.5	1.5	15
v	Extraneous matter (% by mass, max.)	0.5	1.5	3.0	4
vi	Damaged and foreign seeds (% by mass, max.)	1.5	2.5	3.0	4

production but favoured phthalide production. The volatile oil is reported to be inhibitory to some pests. In cell suspension cultures, 3,5-dichlorophenoxyacetic acid stimulated flavour production. There is great scope for *in vitro* production of celery flavour. Also, there is scope for directed studies on some of the medicinal properties, such as its diuretic properties and its use in controlling pain, as well as the treatment of urinary disorders.

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