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Review Article

TECHNOLOGY, CHEMISTRY AND BIOACTIVE PROPERTIES OF LARGE CARDAMOM (*AMOMUM SUBULATUM* ROXB.): AN OVERVIEW

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Abstract

Large cardamom (*Amomum subulatum* Roxb.) is an aromatic and medicinal spice native to Eastern Himalayas belonging to the family Zingiberaceae. It is used as flavoring and preservative to different types of coffee, liquors, confections, beverages and tobacco. Volatile oil (2-4%) is the principal aroma-giving compound in large cardamom and 1,8- cineole is the major active compound after compound, in an extent 60 to 80% of the total volatile oil. Alcohol and aqueous extract of large cardamom have been reported to contain allopathic, analgesic, anti-inflammatory, antimicrobial, antioxidant, antiulcer, cardio-adaptogenic and hypolipidaemic activities. Large cardamom and its powder, oleoresin and essential oils have many culinary and therapeutic uses. Objectives of this review is to give short overview on the processing technology, chemistry, bioactivity and uses of large cardamom and its components.

Keywords: Large cardamom; production; capsules; 1,8- cineole; bioactivity; uses

Introduction

Large cardamom (*Amomum subulatom* Roxburgh) is one of the popular spices that comes under the family Zingiberaceae. Origin of this spice is vivid but some author reported Eastern Himalayas region (Sharma *et al.*, 2000) as its origin where wild species are still located. Large cardamom is also called black cardamom (Chempakam and Sindhu, 2008). The major producers of this spice are Nepal (52%), India (37%) and Bhutan (11%) (Pothula and Singh, 2013) of total world production per annum. Large cardamom is a tall, perennial, evergreen, herbaceous monocot plant (Gopal *et al.*, 2012). Height of this plant ranges from 1.5-3.0 m (Bisht *et al.*, 2011) and leaves are found at the upper portion of the stem. The rhizomes are off dull red color and flower buds protrude from the base of the rhizome. Spring is the flowering season for large cardamom flowers. The peduncle is short and the buds encased in tight red bracts. Individual flowers remain open for three days and more. At the same time, new ones open successively. The inflorescence remains intact with flower for over a month (Sharma *et al.*, 2000). The plants are usually grown on moist and shady parts of mountain streams and hilly slopes at an altitude of 765 to 1675 m above the sea level (Gopal *et al.*, 2012). It is climate dependent crop; best production is between temperature of 4-20ºC, annual rainfall of 2000-2500 mm and more than 90 % humidity (NSCDP, 2009). The fruit is anterio-posteriorly flattened, having 15-20 irregular, dentate-undulate wings which extend from the apex to downward for two-thirds of its length (Gopal *et al.*, 2012). The ripened fruit is trilocular, reddish brown, and contains dark pink seeded capsules (Hussain *et al.*, 2009).

Capsules of large cardamom are held together inside the spike with viscous sugary pulp and are 20–25 mm long and oval to globular in shape (Thomas *et al.*, 2009). The plant matures during the third year of its growth (Gopal *et al.*, 2012) and harvesting is usually carried out during September to November, depending on the variety of plant and altitude of the plantation place (Spices Board, 2001). Small (true) cardamom, known as the 'Queen of Spices' is expensive and considered as one of the best spices in terms of quality (Chomchalow, 1996). Large cardamom is often used as a substitute of small cardamom, *Elettaria cardamomum*, in industrial products for flavoring of food (Joshi *et al.*, 2013). The method of harvesting and curing (heaping) the cobs before stripping in the traditional method employ locally made wood fired curing house for drying. However, there are some improved methods suggested to retain the quality of produce (Rao *et al.,* 2001). The major fragrance compound of the large cardamom is essential oil which mostly contains 1,8-cineole and it contributes pungent aroma. On the other hand, terpenyl acetate (component of fragrance) contributes the pleasant and cardamom like aroma (Chempakam and Sindhu, 2008). Color of large cardamom is mainly due to the presence of two pinkish-red pigments namely the cyanidin 3-glucoside and cyaniding-3,5-diglucoside (Naik *et al.*, 2004).

In general, large cardamom is valued for its acceptable taste, flavor and aroma (Chempakam and Sindhu, 2008). It has been used as a spice and condiment since antiquity (Bhandari *et al.*, 2013). The seeds of large cardamom have been used to flavor food, confections, beverages and liquids (Singh *et al.,* 2008). Furthermore, it has been used as an insecticide as well (Satyal *et al.,* 2012). Its usage in Ayurvedic is well known from prehistoric time. Cardamom have reported to posses valuable properties like allopathic, analgesic, anti-inflammatory, antimicrobial, antioxidant, antiulcer, cardio-adaptogen and hypolipidaemic activities. Therefore, large cardamom is highly valued spice and needs research on production, composition, uses and many more. Objectives of this review is to provide overview on the processing technology, chemistry, bioactivity and uses of large cardamom and its components and discuss on some lagging aspects.

Production

Total world production of large cardamom is about 12,278.20 MT (Pothula and Singh, 2013). Nepal is a world's top producer of large cardamom (Avasthe *et al.,* 2011; Pothula and Singh, 2013; Kafle, 2013). Currently, its commercial cultivation spreads over 37 districts of Nepal (NSCDP, 2009; MOAC, 2010; Chaudhary *et al.,* 2015). The Eastern development region of Nepal specifically accounts for around 97 % of the total national production. The four major districts (Taplejung, Ilam, Sankhuwasabha and Panchthar) accounts for 81 % of the national production (MOAC, 2010) but most of them are producing in small scales (Khatiwada and Piya, 2009). The annual production in Nepal has been exceeding 6,600 Metric Ton (MT) and many local farmers persuade to increase its production every year (Adhikari and Sigdel, 2015).

Like in Nepal, large cardamom is one of the main cash crops in Sikkim and Darjeeling district of West Bengal, India (Pathak, 2008). Major numbers of cardamom holdings in Sikkim are smaller than 1-Hectare (ha) area and around 30% of total cultivators have 1-3 ha of cardamom holdings (Sharma *et al.,* 2009). According to Pothula and Singh (2013), Sikkim is the major production area in India. The plantation area of this crop in other than Sikkim on Indian Himalayan region comprises of 550 ha covering a total of 34,252 ha in India (Sharma *et al.,* 2009) with an annual production of over 4,500 MT (Pathak, 2008).

Apart from Nepal, India and Bhutan; large cardamom is also cultivated, to some extent in some of the Southeast Asian countries such as Thailand, Indonesia, Laos (Naik *et al.,* 2004) and China. Of them, Indonesia has recently emerged as the additional key producers (ACCESO, 2011).

Varieties

The local varieties of large cardamom found in Himalayan regions are *Ramsey, Golsey, Chibesey, Dambersey, Sawney* and *Kantidar.* Among them, *Ramsey, Golsey* and *Chibesey* are widely distributed in Nepal (Thapa, 1998). The most important varieties found in Sikkim (India) include *Ramsey*, *Golsey*, *Sawney, Kopringery, Madhusay and Rhangbhang.* Among these, only *Ramsey, Golsey* and *Sawney* are considered for commercial production as these cultivars are well suited to high altitudes and can be cultivated even in steep slopes (Harktkamp, 1993).

The varietal differences of cardamom described by Chempakam and Sindhu, (2008), are presented in Table 1. Other varieties includes *Ramla, Chivey Ramsey, Garday Seto Ramsey, Ramnag, Seto Golsey, Slant Golsey, Red Sawney, Green Sawney, Mingley* (Chempakam and Sindhu, 2008), *Barlanga* (Rao *et al.,* 1993) *Bebo, Boklok Tali, Jaker* and *Belak* (Pathak, 2008). Sajina et al. (1997) indicated that large cardamom can be used to enhance micro-propagation from rhizome buds. The protocols standardized for micro-propagation through direct regeneration, can be used for large-scale production of planting material. Scientists have identified some varieties of large cardamom, which seem to be significantly more tolerant to diseases than the other varieties (Rai, 2011) and research work is currently on progress.

Diseases

Large cardamom plant are affected by a number of diseases, most of which are of viral and fungal origin. Among fungal diseases, flower rot caused by *Fusarium* and *Rhizoctonia* sp., leaf streak caused by *Pestalotiopsis royenae* and wilt caused by *Fusarium oxysporum* are some well-known causes to damage crop yield (Sanghamitra, 2008). Two viral diseases, *Chirkey* and *Foorkey* in recent years (Pathak, 2008), have brought a great numbers of destruction. These diseases spread due to radical change in climate, inadequate rain in dry months and absence of good agricultural practices by the farmers. Some researcher (Sharma *et al.,* 2009) and the local farmers reported that these two viral diseases are the major cause of declining in cardamom plantation and agronomic yield in cardamom producing countries.

Table 1: Characteristics of different varieties of large cardamom

Character/variety	*Ramsey*	*Golsey*	*Sawney*
Altitude	High	Low to middle	Middle
Cultivation extent (%)	60	30	7
Features	Tall, vigorous wide clump growth	Less vigorous with erect leafy stem bearing stout upright leaves, clumps medium	Tall, vigorous, bent downwards
Stem color	Maroonish with dense foliage	Greenish to marronish	Pinkish with dark green foliage
Flowers	Yellowish and small, corolla tip with pink tinge at base	Yellowish-orange	Yellowish with pink tinge as base of corolla
Capsules	Smaller (16-30 seeds)	Bold to round (40-50 seeds)	Medium bold (30-40 seeds)
Essential oil (%)	1.0-8.0	2.3-5.0	1.8-2.5
Shade requirement	Deep shade	Less shade	Moderate to deep shade
Disease susceptibility	Susceptibility to Chirkey and Foorkey at lower altitudes	Tolerant to Chirkey and Foorkey but susceptible to leaf spots	Suspectible to viral diseases

Source: Chempakam and Sindhu, (2008)

Chirkey

Major cause for the declining large cardamom productions in Nepal and India is associated with disease named *Chirkey*. This disease is characterized by mosaic appearance and pale streak on leaves (Sanghamitra, 2008). Those streaks turn the plant to pale brown and then plant will dry and wither. This will lead to extensive reduction in flowering of plant. Transmission of this disease is caused by mechanical sap inoculation and by aphid, *Rhopalosiphum maidis* Fitch (Varadarasan and Biswas, 2002). Growth and yield of the infected plants gradually decline and ultimately leads to death of the plant (Pathak, 2008).

Foorkey

Foorkey is another major disease of large cardamom characterized by excessive sprouting and formation of bushy dwarf clumps at the base of mother plants, which gradually leads to death (Pathak, 2008). Numerous small tillers also appear at the base of affected plants, which becomes stunted and failure to give any production. The spikes/inflorescence is transformed into leafy vegetative parts and fruit formation is suppressed. The primary spread of disease from one area to another is through infected rhizomes and further spread within a plantation by aphids (Raychaudhuri and Chatterjee, 1958). Nano virus is associated with *foorkey* (Mandal *et al.*, 2004) and the aphid, *Micromyzus kalimpongensis* is a transmitting vector for virus from the diseased to a healthy plant thereby leading to spread of the disease (Adhikari and Sigdel, 2015). The budget for the improvement on treatment and control over diseases is very high and hence not significantly noticeable to overcome the amount of loss because of *foorkey* (Mandal *et al.*, 2004).

Post-harvest technology

Harvesting

The yield starts from third year onward after planting (Kafle, 2013). Harvesting usually depends on the altitudes and cultivars and the fruits are harvested when the capsules are fully matured, usually during September to November (Spices Board, 2001). Harvesting at the correct stage of maturity produces high quality cardamom capsules (Ali, 2007). Brown color in the seeds of topmost capsule indicates full maturity of the capsule. When the topmost capsule is fully matured, the spike-bearing shoots are cut at 45 cm height and left for another 10–15 days to ensure maturity of all the capsules (Pathak, 2008). Spikes are harvested using mechanical utensils e.g. knife (Kafle, 2013). The harvested spikes are stored for 2–3 days after harvesting in order to separate capsules easily (Spices Board, 2001). Separation of capsules from spikes is perform manually, and no device has been used for this operation so far. The separated capsules are cleaned manually before curing (Pothula and Singh, 2013) to remove other plant materials. There are no modern sophisticated or automated machineries developed or implemented yet in large cardamom producing region of Himalayas.

Curing

Curing is one of the important steps to determine the quality of large cardamom (Mande *et al.,* 1999; Rao *et al.,* 2001). Curing is normally associated with equilibration of color, moisture and ripeness. Fresh large-cardamom capsules contain about 70 to 80% moisture (on wet basis) (Mande *et al.,* 1999), depending upon the maturity levels of capsules at the time of harvest. To achieve optimum moisture level and other quality-defining factor, the spikes with ripened capsules are harvested and heaped (cured) for 2-3 days (Oli, 2011). After heaping, capsules are stripped off from the spikes, cleaned and subjected to drying (Oli, 2011).

Drying

Cardamom is dried below 10 % (wet basis) moisture content for the safe storage level and marketing of cardamom, (Mande *et al.,* 1999). Drying is mostly achieved by traditional wood-fired dryers, which are built in the orchard. However, this traditional process causes blackening of the capsules and gives smoky flavor (Oli, 2011). In current scenario, some improved dryers have been also introduced but their use is limited. Very rare use of improved dryers is mostly associated with economy and availability of dryers to the local level. One reason to prefer traditional method over recently developed method is lack of adequate farmers' awareness on the quality degradations and processing loss of produce by traditional dryers. Furthermore, lack of farmers' knowledge on the operation of improved dryers is also another determining factor.

Traditional method

In traditional method of drying, the fresh cardamom capsules are dried in *bhatti*, a locally made curing house (Rao *et al.,* 2001). Capsules are spread uniformly in a thick layer of 25-30cm on bamboo mat placed over the frames of wood firing pit. Capsules are then dried by the combined effect of heat and smoke generated by the burning wood. This process takes about 24 to 28 hours and frequent racking is made to get uniform drying. After uniform drying, the capsules are rubbed against the rough surface in order to remove the tail (Tamang, 2000; Oli, 2011). The quality of large cardamom capsules cured in traditional *bhattis* is poor and they have a dark brown color with smoky flavor. There is a production of large quantity of charred, cracked capsules having less volatile oil in traditionally cured capsules. However, no scientific knowledge is required to build these kind of traditional *bhattis.* In the villages of producing areas, building, operation and management cost of *bhattis* is low and they are mostly constructed from locally available materials (Singh *et al.,* 1989).

Improved method of drying

In the improved method, cured capsules are dried into two stages, at 60ºC and 55ºC respectively to get the desired moisture content (approx. 10-12%) (Naik *et al.,* 2000). The content is then cooled, cleaned, tails are removed and capsules are graded according to their size. Those capsules are packed in jute bags (waterproof lined with polythene) and stored in dry places (Oli, 2011).

Traditional *bhattis* are improved for more efficient and effective drying, where heating is performed indirectly through hot air and smoke is released outwards. Due to use of heat in the absence of smoke in improved dryers, they give more natural color and better quality product than traditional method (Oli, 2011). Department of food technology and quality control (DFTQC), Nepal has developed six drum dryer containing two sections- firing and drying sections (Oli, 2011) for more effective drying of cardamom capsules. These sections are enclosed in a wall made from stone and mud and the whole assembly is kept under enclosed roofed structure. Capacity of this dryer varies from 360 kg to 400 kg of fresh cardamom and the drying time is reported to have 24 h (Oli, 2011).

Another modified dryer is made by Tata Energy Research Institute, modification is based on gasifier system. It consist an updraft-type biomass gasifier connected to a traditional *bhatti* (Pothula and Singh, 2013). In this system, the firewood is converted into producer gas first and the gas is burnt below the cardamom bed to generate clean flue gases required for drying. In such dryer, the thermal efficiency is high, the producer gas combustion is clean and the cardamom bed is not exposed to smoke (Oli, 2011). This helps in producing dried capsules with natural color and greater volatile oil content (Oli, 2011). Pothula and Singh, (2013) have mentioned that the better quality of dried capsules were produced by improved dryer than that of capsules dried in traditional *bhatti.*

One modified drier with several wooden trays (containing the wire-mesh base) in which improvement is made on flue pipe curing house (Rao *et al.,* 2001). The fresh cardamom capsules are spread over trays, where flue gas obtained through burning the firewood in the furnace, is supplied in the curing house through the flue pipes. This unit operates on the principle of space heating. Surrounding room air is heated through pipe by natural convection and radiation (Rao *et al.,* 2001).

Pothula and Singh, (2013) reported another dryer containing mechanical trolley system operated by diesel or electricity. This curing system consists of a blower, a heating unit, and a multi-tray curing chamber, similar to a mechanical cabinet tray dryer. This system works effectively and produces high quality capsules. Its capacity is 600 kg and curing time is 12 hours. Another dryer having indirect heat curing system (Pothula and Singh, 2013) has also reported and is called the rocket stove dryer, which has been introduced as part of a Netherlands Development Organization initiative in Nepal. This flue-gas-based system produces less smoke and is reported to produce high-quality capsules (Stoep, 2010). There are several reports of curing systems developed in India by research institute, G.B. Pant Institute of Himalayan Environment and the Development and Central Food Technological Research Institute in Mysore (Pothula and Singh, 2013), but none are in use by farmers so far. These dryer are not cost effective as compared to traditional cured capsules dryers. Hence, use of modified dryer is very rare.

Tail removing

The cardamom capsule has a tail and capsules without the tail get a higher price. Generally, tails are removed with a scissor. However, it adds labor cost. The tail portion can be removed easily by rubbing capsules on wire mesh if the cardamom is dried well (Mande *et al.,* 1999; Pathak, 2008). No sophisticated and modern method or machine are devised till the date to remove tails from the cardamom capsules. Cardamom polisher is under evaluation in Sikkim, India for possible use as a tail-cutting machine. Capsules without tail and with intact tail both have different prices on market and graded as two different categories (Pothula and Singh, 2013). These tails are byproducts and utilized on making *agarbathi* (incense sticks) (Chhetri *et al.,* 2013). Apart from this, tails are also used as a source of fire energy with wood during curing process. There would be other possibilities to utilize these byproducts for the manufacturing different marketable products such as manure, fire starter, floor cleaner etc. in the future. Additionally, these byproducts might be used as an alternative source of cooking energy in traditional households. Hence, comprehensive research and study are recommended to utilize the byproducts in effective and efficient way for the economic and environmental perspective.

Grading

Cardamom is usually graded by their color and size. Dark colored with larger sized capsule is considered as a higher grade cardamom (Ali, 2007). Commercially, finished large cardamom capsules are graded from bigger to smaller capsules and capsules with or without tail (Sharma *et al.,* 2009). Manual grading is widely used method for sorting based on size and color. Mechanical grading machines are also popular and manually operated sieves are used only in Nepal (Oli, 2011). Quality grading is not achieved on a local farmer level. Generally, labor cost in large cardamom producing region of South and South-East Asia are relatively low, so grading in whole seller and stocking company are intensively labor based.

Packaging

Cured hot capsules are first placed in bags, cooled and then sealed, which are stored on wooden platform to avoid contact with environmental moisture (Pothula and Singh, 2013). There are no recommended specialized packaging and handling systems for large cardamom. Generally, dried capsules are packaged in polythene-lined jute bags (Pothula and Singh, 2013) on different sizes based on the market demand. Their common size ranged from 40 to 100 Kg (Kafle, 2013). The sealers machines can be used to seal the bags (Ali, 2007). One of the major loss associated with packaging and storage loss is by insects. The moisture content of capsules is around 10-13%, which is ideal for the growth of insects (Naik *et al.,* 2005). Fumigants like methyl bromide (0.016 kg/m3), phosphine (0.0015 kg/m3), and ethyl formate (0.30 kg/m3) are recommended to control insects growing on dried capsules without interfering capsules' quality (Naik *et al.,* 2005).

Chemical composition

Composition of large cardamom differs with variety and age of cardamom. Likewise, it also varies with the region and climate where it is cultivated (Chempakam and Sindhu, 2008). Dried fruit of large cardamom generally contains volatile oil 2.80-4%, protein 6 %, starch 43 %, total ether extract 5 % and total ash 4 % (Madhusoodanan and Rao, 2001; Oli, 2011). Similarly, seeds of large cardamom contain moisture 8.5%, protein 6%, volatile oil 2.8%, crude fiber 22%, starch 43.2%, ether extract 5.3% and alcohol extract 7% (Shankaracharya *et al.,* 1990). Additionally, 100 g of large cardamom seeds contains 666.6 mg calcium, 412.5 mg magnesium, 61 mg phosphorous and 14.4 parts per million fluoride (Bhandari *et al.,* 2013). It is well-known that large cardamoms are rich in active components that are responsible for its unique flavour and tastes. These bioactive components are mainly associated with aesthetic quality and ultimately the quality and cost. Essential oil and oleoresin are most important chemical constituents of this Himalayan spice (Yadav, 2013).

Essential oil and Oleoresin

Some studies reported that 1,8-Cineole (77.4% of total essential oil) (Ali *et al.,* 2008; Singh *et al.,* 2008; Satyal *et al.,* 2012) is the dominant component of essential oil in large cardamom fruits. The fruit also contained β-myrcene (5%), α-terpineol (4.9%), hexanoic acid (3.0 %), toluene (2.4%), t-caryophyllene (2.3%) and terpinen-4-ol (2.3%) (Ali *et al.,* 2008). Smaller amounts of formic acid, α- thujene, butanoic acid, decatriene and caryophyllene oxide are also reported (Ali *et al.,* 2008). More than seventy compounds are identified in the seed oil and sixty-four in the rind oil of large cardamom (Satyal *et al.,* 2012). Both seed and rind oils are dominated by 1,8- cineole (60.8% and 39.0% on seed and rind oil respectively). Moreover, essential oils contained α-pinene (6.4% and 4.8%), β-pinene (8.3% and 17.7%), α-terpineol (9.8% and 12.3%), and terpinen-4-ol (3.4% and 3.2%) and Spathulenol (3.4%) (Satyal *et al.,* 2012).

The major components of oleoresin are 1,8-cineole; 5-(hydroxymethyl)-2-furaldehyde; β-sitosterol; α-terpineol; 2,3-dihydrobenzofuran (coumaran); terpinen-4-ol; eugenol; *trans*-nerolidol; n-heptacosane and n-nonacosane (Singh *et al.,* 2008). The yield and chemical composition of oleoresin is affected by the production conditions and nature of the solvent used for extraction (Singh *et al.,* 2008).

Chemistry of volatiles

Components of volatile oil are the major aroma driving compound present in large cardamom. Steam distillation of the crushed seeds gives dark brown oil (2.5%) with a cineol-like aroma (Gopal *et al.,* 2012). The highest level of volatile oil content was recorded on *Golsey* Dwarf variety amounting 3.32%, whereas the lowest on White *Ramna* variety amounting 1.95% (Chempakam and Sindhu, 2008).

The pungency in large cardamom is attributed to high content of cineole, while terpenyl acetate contributes the pleasant aroma (Chempakam and Sindhu, 2008). Kikuzaki et al. (2001) isolated protocatechualdehyde, 1,7-bis (3,4-dihydroxyphenyl) hepta-4E, 6E-dien-3-one, protocatechuic acid, and 2,3,7-trihydroxy-5-(3,4-dihydroxy-E-styryl)-6,7,8,9-tetrahydro-5H-benzocycloheptane from the cardamom and reported that these aforementioned compounds were responsible for its unique pungency and fragrance. Gopal et al. (2012) reported that seeds accommodate cardamonin (2'.4'-dihydroxy-6'-methoxyalcone) and alpinetin (7-hydroxy-5-methoxyflavanone) and glycosides viz., petunidin 3,5-diglucoside, leucocyanidin-3-O-β-D-glucopyranoside and a new aurone glycoside subulin, whose structure was established as 6,3',4',5'-tetrahydroxy-4-methoxyaurone-6-O-α-L-rhamnopyranosyl (1-4)-β-D glucopyranoside.

Apart from aforementioned compounds, there are non-volaitle pigments also, which makes large cardamom chemistry unique on its own. Methanolic HCl extraction of fresh large cardamom yielded deep pinkish (cyanidin 3-glucoside) and red (cyanidin 3, 5-diglucoside) pigments at the ratio of 1:2 (Naik *et al.,* 2004). There is a need of extensive medical or chemical study to get exact understanding on benefits of these pigments and other non-volatile components

Bioactivity

Large cardamom has been recognized for its wide range of physiological and pharmacological properties. The essential oil present in large cardamom has a typical characteristic flavor and possesses medicinal properties like stimulant, stomachic, alexipharmic and astringent. For this reason, this species has been used for the treatment of indigestion, vomiting, biliousness, abdominal pains and rectal diseases (Bisht *et al.,* 2011).

The ethanolic and aqueous extract of large cardamom with a dose of 100mg/ml and 200mg/ml respectively showed anti-inflammatory activity (Alam *et al.,* 2011). The spice is used mostly to treat infections in teeth and gums, throat troubles, congestion of lungs and pulmonary tuberculosis, inflammation of eyelids and also digestive disorders (Chempakam and Sindhu, 2008). Seed oil showed notable inhibition of germination in both lettuce (*Lactuca sativa*) and perennial ryegrass (*Lolium perenne*) seeds (Satyal *et al.,* 2012) and this phytotoxicity has been attributed to high level of 1,8-cineole and α-terpineol (Satyal *et al.,* 2012). Furthermore, methanolic extract of seeds of *A. subulatum* at higher dose (more than 100 mg/kg) and ethyl extract (above 200 mg/kg) demonstrated remarkable analgesic effect (Shukla *et al.,* 2010). This spice has been used since prehistoric time as antidote for scorpion and snake venom (Chempakam and Sindhu, 2008). However, there is no clear scientific evidence and safety precautions be adapted if extracts are used to replace the drugs.

Antimicrobial activity

Large cardamom has a wide variety of secondary metabolites such as tannins, alkaloids and flavonoids, some of these metabolites are believed to have antimicrobial properties. Petroleum ether extracts of large cardamom showed antimicrobial against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* (Kumar *et al.,* 2010; Satyal *et al.,* 2012) and *Bacillus cereus* (Satyal *et al.,* 2012). Similarly, the acetonic, methanolic and ethanolic extracts (Hussain *et al.,* 2011) of *A. subulatum* showed antimicrobial inhibitory activity against two bacteria causing dental caries, *Streptococcus mutans* and *S. aureus*; and two fungi *Candida albicans* and *Saccharomyces cerevisiae* (Aneja and Joshi, 2009). Antimicrobial activities against some bacteria and fungi are presented in Table 2. Role of essential oil (from seeds) against various keratinophilic and dermophytic fungi (Jain and Agarwal, 1976) are not limited but they are believed to have much broader antifungal spectrum as discussed by Singh et al. (2008). Hence, it is necessary to explore and conduct study in the future regarding "broad spectrum fungal inhibition" property of essential oils' compounds from large cardamom.

Antioxidant and scavenging activity

The 1,8-cineole, alphaterpineol, protocatechualdehyde, protocatechuic acid extracted from seeds have antioxidant property against lipid peroxidation (Kikuzaki *et al.,* 2001; Hafidh *et al.,* 2009)) and have much potential health benefits (Jessie and Krishnakantha, 2005). These aforementioned or some other active components from seed have been associated with antioxidant role in hepatic, cardiac antioxidant enzymes (Verma *et al.,* 2010) and activate other antioxidant enzymes as well (Dhuley, 1999). High level of phenolic compounds (Hafidh *et al.,* 2009) present in essential oil are believed to be associated with significant activities on antioxidant assays (Singh *et al.,* 2008). Moreover, these polyphenols content are reported to have strong reducing and inhibiting characteristics against lipid peroxidation in rat liver homogenate (Yadav and Bhatnagar, 2007). Eventually, those polyphenols will be working as superoxide radical scavenging compounds (Yadav and Bhatnagar, 2007).

Table 2: Biological activities of *Amomum subulatum* essential oils

Bioassay	Seed oil	Rind oil
Antimicrobial (MIC, µg/mL)		
Bacillus cereus	625	313
Staphylococcus aureus	313	625
Escherichia coli	625	1250
Pseudomonas aeruginosa	625	1250
Aspergillus niger	313	19.5
C. elegans nematocidal (LC_{50}, µg/mL)	341	not tested
Insecticidal (LC_{50}, , µg/mL)		
Drosophila melanogaster	441	493
Solenopsis invicta × *richteri*	1500	1150

Source: Satyal et al. (2012)

Table 3: Specifications of large cardamom in Nepal and India

Parameters	Nepal	India
Capsules		
Extraneous matter	Not more than 5% by weight	Not more than 1% by weight
Volatile oil % (ml/100g)	Not less than 1% by weight	Not less than 1% by weight
Color and flavor	Natural and characteristic	Natural and free from added colors
Moisture	………..	Not more than 14% by weight
Insect damaged capsules	………..	Not more than 5% by weight
Seeds		
Extraneous matter	Not more than 2% by weight	Not more than 2% by weight
Volatile oil % (ml/100g)	Not less than 1% by weight	Not more than 2% by weight
Color and flavor	Natural and characteristic	Natural and characteristic
Moisture	………..	Not more than 13% by weight
Insect damaged capsules	………..	Not more than 2% by weight
Total ash	………..	Not more than 5% by weight
Ash insoluble ash	………..	Not more than 2% by weight
Moulds and insects	………..	Absent
Powder		
Moisture	Not more than 15% by weight	Not more than 11% by weight
Total ash	Not more than 8% by weight	Not more than 8% by weight
Volatile oil % (ml/100g)	Not less than 1% by weight	Not less than 1% by weight
Ash insoluble in dilute HCl	Not more than 3% by weight	Not more than 2% by weight
Color and flavor	Natural and characteristic	Natural and characteristic

Source: (Nepal Food Standard, 2006; Oli, 2011; Chempakam and Sindhu, 2008)

Other activities

Crude methanolic extract of the fruits shows anti-ulcer activity in albino rats (Jafri *et al.*, 2001). Similarly, methanolic fraction, petrol soluble fraction, ethyl acetate soluble fraction and ethyl acetate soluble fraction have reported to play significant role against ethanol induced ulcer (Sen *et al.*, 2009; Farah *et al.*, 2005), lower aspirin induced gastric ulcer by 60 % (Farah *et al.*, 2005), possesses hepato-protective activity against ethanol-induced liver damage in rats (Parmar *et al.*, 2009) and protect acute or severe stress induced myocardial damages respectively (Verma *et al.*, 2010). It is useful in treatment for patients with Ischemic Heart Disease (IHD) (Bisht *et al.*, 2011). Therefore, regular consumption of large cardamom can be associated with many health benefits. Benefits and usefulness are discussed on lower section of this paper on broader perspectives.

Uses

According to Chempakam and Sindhu (2008), the quality and uses of large cardamom is based mainly on appearance, visual superiority (particularly: color, uniformity of size, shape, consistency, texture) and flavor (influenced by the aromatic compounds). Nepal Food Standard (2006), Oli (2011) and Bureau of Indian Standards (Chempakam and

Sindhu, 2008) have given specifications for capsules, seeds and powder of large cardamom which is shown in Table 3. It is believed that cleaned, sound, free from fungal growth or foreign material with bold and uniform sized cardamom capsules having dark pink colorations have high commercial values in the market (Mande *et al.*, 1999). Cardamom seeds, whole or in powdered form, are used as one of the most valuable spices; often employed in the preparation of curry powder, pickles, sausages, cakes and confectionery. The powdered seeds are sometime supplied as a flavoring to coffee, liquors and tobacco. Traditionally, they are used for the culinary and therapeutic purposes. Perhaps, there could be other possible applications such as cosmetic and decorating products but advised for further studies.

Culinary uses

Large cardamom pods can be used as a whole or in split in some of the south Asian (mostly Nepalese and Indian) cuisines. It is incorporated in sweet dishes, drinks like punches and mulled wines, milk tea, curries, different rice dishes, pickles etc (Chempakam and Sindhu, 2008). Some people used to chew it as such habitually (like nuts). It is often used in Scandinavian bakeries (like in Danish pastries) and cardamom coffee (symbol of hospitality in Arab world) because cardamom is one of the popular spices in Arab world (ACCESO, 2011; Gopal *et al.*, 2012). The small amount of cardamom on coffee cake also adds a tempting flavor. Taste of flans, rice puddings and porridges are much more enhanced by adding cardamoms (Gopal *et al.*, 2012). Smoky grounded cardamom seeds are an optional ingredient in mixed preparations and spice *masala* mixtures. There is a literature (Chempakam and Sindhu, 2008) on cardamom flavored soda as well. All these culinary use envoys cardamom as a useful spice. There could be possibilities of introducing new drinks varieties such as cardamom flavored dairy products and cardamom flavored seafood items in near future.

Therapeutic uses

Large cardamom also possesses curative properties, and been one of the major spices which are mentioned in Ayurveda and Unani medicine (Chempakam and Sindhu, 2008). From pre-historic time, large cardamom seeds have been used to cure dyspnoea, cough, thirst, vomiting, disease of mouth, nausea, itching, indigestion, biliousness, abdominal pains and rectal diseases in local villages and cities (Gopal *et al.*, 2012). Ayurveda experts prescribe large cardamom to inflammation of the eyelids, treat and prevent throat troubles, congestion of the lungs and pulmonary tuberculosis (Gopal *et al.*, 2012). Medicinally, those seeds have diuretic, antidote for snake and scorpion venome, stimulant, stomachic, alexipharmic and astringent properties (Gopal *et al.*, 2012). Cardamom capsules and seeds are used to treat gonorrhea, congestive jaundice, headache, and stomatitis and to control insects (Satyal *et al.*, 2012) as shown previously on Table 2. Antioxidant properties of bioactive component are key players on therapeutic perspectives (Dorman and Deans, 2000; Cai *et al.*, 2004). Antimicrobial properties of oleoresins and essential oils have been used as a preservative (Singh *et al.*, 2009) for different types of juices and are free from hazardous harmful substances indicating their superiority to synthetic preservatives.

Conclusions

Large cardamom is a very popular commercially important aromatic spice, is highly preferred in many indigenous and other food cuisines especially in south Asia. Whole or powdered cardamom, essential oil and oleoresins have much wider applications in food cuisines and in pharmaceutical medicines. The processing methods and extraction conditions must be optimized for higher retention of bioactive compounds. Hence, development of commercial and advance process for the treatment and production systems and their possible allopathic and industrial applications are some of the major challenging issues. Many bioactive compounds are responsible for allelopathic, analgesic, anti-inflammatory, antimicrobial, antioxidant, antiulcer, cardio-adaptogen and hypolipidaemic properties. It is highly valued for its acceptable taste, flavor and aroma and also possesses curative properties as mentioned in the Ayurveda and Unani medicine. Very limited research has been carried out on clinical studies of bioactive components of large cardamom. Hence, this is challenging area for the scientists to explore its bioactive compounds. Additionally, there would be possibility of presence of other health beneficial compounds which are not identified yet. Recommendations is on intense and through research on large cardamom in upcoming days to identify the potential medicinal values. Additionally, agro-economic perspectives must be focused on market expansion and market values during large cardamom research and development.

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