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Post-harvest and value chain management of large cardamom in hills and uplands

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Abstract
Amomum subulatum Roxb. is cultivated largely in the eastern Himalayan region viz., Nepal, Bhutan and Indian states comprising of Sikkim, Uttaranchal and Darjeeling district of West Bengal. It is widely used in foods, beverages, perfumes and having enormous medicinal values. Some popular cultivars include Ramsey, Sawney, Golsey and Varlangey. Curing is the most crucial step in processing as capsule quality largely depends on curing conditions and methods. Optimum curing temperature is 45–55 °C and is usually done in traditional *bhattis*. Dried capsules are usually packed in polythene-lined jute bags for storage at 11% moisture content. The postharvest value chain consists of growers, collectors, traders, and exporters. The primary processing steps required by the present market are curing, tail cutting and grading. Curing is carried out by the farmers, and the remaining steps are done by wholesalers. India exports large cardomom to Australia, Canada, Pakistan, UK, etc. Singtam, Gangtok, Jorethang, Rongli, and Mangan etc., are the major local markets in Sikkim while Siliguri is the main trade junction from where it is distributed to Guwahati, Kolkata and Delhi. Well processed quality capsules have great demand in the market and help the growers by protecting and promoting their livelihood. This article reviews the agrotechniques of cultivation, postharvest processing, quality issues and trade patterns of large cardamom towards increasing its quality and value and thereby to protect and promote the livelihoods of several thousands of people in the value chain.

Keywords: *Amomum subulatum*, agrotechniques, post-harvest, value chain, marketing, hills and uplands

Introduction
Large cardamom (*Amomum subulatum*Roxb.) commonly known as '*bada elaichi*' is one of the world's most ancient spices. It belongs to the family Zingiberaceae and is a perennial soft-stemmed low-volume, high-value crop (Avasthe *et al.*, 2011) [3]. Originating in Sikkim (India), the crop is grown only in the eastern Himalayan countries viz., Nepal, northeast India, and Bhutan (Sharma *et al.*, 2009) [34] at altitudes ranging from 1000 to 2000 m MSL. In India, it is cultivated as one of the main cash crops in Sikkim, Nagaland, Uttaranchal, Darjeeling district of West Bengal (Bisht *et al.*, 2010) [8] and some other parts of the North Eastern region. Hence, the worldwide production of this crop is estimated as the sum of production in these three countries. Total world production is about 12,278.20 metric tons. Nepal leads in the production of large cardamom (52%), followed by India (37%), and Bhutan (11%). Taplejung, Panchthar, Ilam, Dhankura, Bhojpur, Terhathum, and Sankhuwasabha are the major large cardamom growing districts of Nepal (ECCOS 2010). According to the Spices Board (2012), the major share of India's production is from Sikkim. Mountain people in the Himalayan region find large cardamom farming as one of the important livelihood sources.

The plant grows in the vicinity of mountain streams in swampy, cool, and humid areas in the shade of forest trees, of which nitrogen-fixing trees are the more suitable shade trees. It can grow at altitudes ranging from 600 to 2000 m above mean sea level and in areas with an annual rainfall varying from 2800 to 3500 mm. It is a perennial bush having a sheathed stem which may reach upto 1.5 to 2.5 m in height (Bisht *et al.*, 2011) [7]. It has a large tuberous rhizome and leaves of about 30–60 cm length and 5–15 cm width. The trailing leafy stalk which grows from the base of the plant at ground level bears the seed pod. Green flowers with a white-purple vein tip are produced in a dense short spikes arising directly from base of the plant. The useful portion of large cardamom is the dried capsule, which has 40 to 50 small seeds and is grayish brown to dark red brown. The capsules are held together inside the spike with viscous sugary pulp and are 20–25 mm long and oval to globule in shape (Thomas *et al.*, 2009) [50]. It is harvested before it ripens to avoid the capsules from splitting during the drying process.

Large cardamom is used as a spice and also in several Ayurvedic preparations including the Unani system of medicine (Madhusoodanan and Rao 2001) [17]. It can be used to treat several ailments. The volatile oil of large cardamom seed contains 1, 8-cineole, α-terpineol, α-pinene, β-pinene, and allo-aromadendrene (Gurudutt *et al.*, 1996) [16]. It contains 2–3% essential oils. It possesses carminative, stomachic, diuretic and cardiac stimulant properties and is also a remedy for throat and respiratory trouble. The essential oil of large cardamom is reported to have antimicrobial properties (Agnihotri and Wakode 2010) [2]. The seeds have a pleasant aromatic odour for which can extensively be used for flavouring vegetable curries and many food preparations in India. The decoction of seeds is used as a gargle in infection of teeth and gums. Large cardamom seeds are considered as an antidote to either snake venom or scorpion venom and also used as preventive as well as curative measure for throat troubles, congestion of lungs, inflammation of eyelids, digestive disorders and in the treatment of pulmonary tuberculosis. The literature in the areas of value chain and quality study of large cardamom is very much scanty except a few (Singh and Pothula, 2013). This article reviews the agrotechniques of cultivation, postharvest processing, quality issues and trade patterns of large cardamom towards increasing its quality and value and thereby to protect and promote the livelihoods of several thousands of people in the value chain.

Climatic and soil requirements

The crop grows well under the shade of forest trees in the sub Himalayan Mountains with rainfall of 3000 to 3500 mm distributed in about 200 days a year. Cultivars suited to higher altitudes can tolerate lower temperatures and those suited to lower altitudes to marginally higher temperature regimes. Large cardamom grows well in forest loamy soils with gentle to medium slopes. Deep and well-drained soils with loamy texture are best suited. Large cardamom growing soil is generally rich in organic matter and nitrogen, medium in available phosphorous and medium to high in available potash. A pH range of 6-7 is most favourable for the availability and effectiveness of most of the nutrients. Usually cardamom growing soils are acidic with 4.5-6.0 pH. Even though the crop can be grown in undulating and steep terrains, land with moderate slope is preferred. Water logged condition is detrimental to the growth of the plants.

Table 1: Important varieties of large cardamom (The following Table 1 to be inserted here)

Sl No	Variety	Altitudes	Description	Susceptible to
1	Varlangey	This cultivar is found to grow in high altitude areas. (Above 1200m).	Plants height is 1.5-2.5m, robust type and resembles. Size of the capsule is bold with 50-70 numbers of bold seeds. Flowering starts during June-July. Consequently harvesting is delayed upto the end of November in high altitudes.	-
2	Sawney	Widely adaptable cultivar, mostly suited to medium and high altitude areas of 1350 m a msl and above	Plants are 1.5 to 2.0 m tall, robust in nature, leaves are ovate and broad and the colour of tiller is moroonish. Capsules are bigger and bold with 35-50 seeds. Flowering starts from March to May and harvest begins in September-October and may extend up to November in high altitude areas.	Susceptible to both Chirke and Foorkey diseases.
3	Dzongu Golsey	Suitable below 1500m MSL	Plant height is 1.0 to 1.5m and not as robust. The tillers are green in colour and the leaves are narrow and erect. Capsules are big and bold and contain about 50-70 seeds. Flowering starts in March and harvesting is done in September-October.	Tolerant to Chirke but susceptible to Foorkey and leaf streak diseases.
4	Ramsey	High altitudes above 1200m amsl and can be cultivated even in steep slopes.	Plants are 1.5 to 2.0 m tall, robust with large number of tillers withmaroonishcolour Flowering starts in May and harvested during October-November. Capsules are smaller in size with 25-40 seeds.	Viral diseases like Chirkey&Foorkey

Cultivars

There are mainly four popular cultivars viz. Ramsey, Sawney, Dzongu Golsey, Varlangey etc. The other cultivars which are grown in hilly areas likeSeremna. Bebo, Boklok Tali, Jaker, Belak etc.

Agrotechniques of large cardamom cultivation

Large cardamom grows in hills abundantly, but often without following any scientific agrotechniques. However this area demands greater attention to have a sound value chain of this unique crop. Propagation of large cardamom is done through seed and suckers. The propagation through seeds enables production of large numbers of seedlings. Virus diseases are not transmitted through seeds and therefore seedlings are free from viral diseases, if adequate care is taken to isolate and protect the nursery from fresh infection.

Seed are generally shown in September to October. Select a site which is open, well-drained and near a source of water. Dig the land 30 cm deep and prepare beds of 6mx1mx30cm. Spread a thin layer of jungle soil over the nursery. 80-100 gm of seeds is sown in lines 10 cm apart and cover them with another layer of thin fine soil. Mulch with dry grass and water every day in the morning and evening. Remove the mulch on the commencement of germination and protect the seedlings by providing shade. Ensure regular weeding and plant protection. Nursery beds of 6 m x 1 m x 3 0 cm are prepared. Mix well-decomposed cattle manure and wood ash with top layer of soil. This will help the seedlings to establish well and grow vigorously. During June-July the primary seedlings are transplanted to the secondary nursery at a spacing of 25-30cm. Shade should be provided before transplanting. Regular watering during dry months, weeding, application of fertilisers, control of pests and diseases and mulching are essential operations for the maintenance of the secondary nursery. One month before uprooting, the overhead shade should be removed to encourage better tillering.

The best month for planting cardamom is during May–July, with the onset of the monsoon. Under best conditions, the crops will start bearing fruits in 36 months. Flowering starts from March–May and harvesting begins from September–October, and may extend up to November in higher altitudes. About 30 important tree species are used to provide shade to the cardamom plants. The Himalayan alder (*Alnusnepalensis)*, a deciduous, nitrogen fixing and fast growing tree, is the

species most commonly preferred as shade tree (Sharma *et al.*, 2008) [33]. In addition to providing shade, it is also used for fuelwood. Other species of shade trees are used are Bomchusing (Dzo.) *Mecaranga denticulate* (decomposes very fast) Ambakay (Nep.) *Jambosafarmosa* Walp, Sokeyshing (Dzo) *Castronopsis indica*, Puyum (Dzo.) *Schimawallichi*, Siris (Nep.) *Albizzialebbek* etc. The old trees are cut and young plants coming up are allowed to grow in cyclic order. The quick decomposing leaf litter of *A. nepalensis* also fertilises the cardamom plants. The nitrogen added to the soil in this way has been found to be as high as 249 kg/ha.

Planting is done in June-July when there is enough moisture in the soil. The land selected for planting is cleared of all under growth, weeds etc. for new planting or if it is replanting, old plants may be removed. Pits of size 30 x 30 x 30 cm are prepared on contour at a spacing of 1.5 x 1.5 m after the onset of rains. Wider spacing of 1.8 x 1.8 m are recommended for robust cultivars like sawney, varlangey and Ramsey. The pits are left for weathering for a fortnight and then filled with top soil mixed with cowdung or compost @1-3 kg/pit. Seedlings/suckers are planted in the centre of the pits. Care should be taken not to plant the seedling /rhizome very deep in the pit. After planting the seedling is staked and the base of the plant mulched. For a sustained production the soil fertility should be maintained to its optimum. Well decomposed cattle manure/compost or organic products, non-edible cakes may be applied @ 2 kg/plant at least once in two years in April-may. If all the crop residues are recycled in the plantation, application of inorganic fertilizers may not be necessary. In plantations with high productivity, fertilizers @ 20:30:40 kg NPK per hectare may be applied in two split doses with full P and half of N and K in April and half dose of N& K in September. Mulching the base of plants after application of second dose helps plants in the intake of nutrients.

Weed control in the plantations is important for the maximum utilisation of the available moisture and nutrients by the plant. Three rounds of weeding are required for effective control of weed growth in the initial two to three years. Weeding can be either hand weeding or sickle weeding depending upon the intensity of weed growth. In Bhutan weed slashing is done in June July is locally known as *Phulghor* whereby weeds around clumps are slashed down to expose the flowers to pollinating agents and to enhance better radiation to plantation. The second operation is locallty known as *Ngahalghor* whereby slashing of weeds is done before harvest (August- September) to enhance picking during harvesting. This crop is mainly grown in highly steep terrain. The topography and climatic condition permits soil erosion to considerable extent. Intensive operations, which loosen and expose soil will increase soil erosion and therefore minimum tillage operations should be followed. In some of the large cardamom plantations water sources are available which can exploit to irrigate the crop by gravity flow, either through pipes, sprinklers or flood irrigation through open channels. It is observed that productivity is higher in plantations where irrigation is provided. For sustainable and better yield, the plants may be watered during dry months. Depending on availability of water sources hose or sprinkler or flood irrigation through channels can be adopted. Hose irrigation can be done @40-50 litre per plant at fortnightly intervals. In case of sprinkler, irrigation equivalent to 35-45 mm or rain at fortnightly interval is recommended.

Although there are many species of insects and pests, large cardamom is free from major attack of any major pests except for the sporadic incidence of leaf eating caterpillars. Aphids are found in most of the areas which transmits virus diseases viz. Chirke (Mosaic disease) and Foorkey (stunted). Initially the caterpillar of the moth *Artona Chorista* feeds on the leaf lamina from under the surface of the leaf and finally defoliates the leaf completely leaving only the midribs. Their incidence is noticed in May-July and October-March. At present these insects are kept under control by their natural enemies. If insecticides are used to control them, then their natural enemies will also disappear which may lead to an outbreak of these pests in epidemic form. The best method of control is to inspect the plantations during May-July and October-March, to handpick the infected leaves along with the caterpillars and destroy them by burning.

Fungal or bacterial diseases are seldom reported in large cardamom. Only minor diseases like leaf streak or rot diseases are found in isolated areas. The major threat to large cardamom is the widespread occurrence of viral diseases, viz., chirke and foorkey. These diseases are seen throughout the large cardamom growing tracts of hilly areas and cause considerable crop loss. These diseases have spread due to drastic change in the ecosystem, inadequate rain in dry months and absence of good agricultural practices by the farmers. Many cardamom farmers failed to plant varieties suitable to their altitude.

An insect *Micromyzuskalimpongensis* (Basu and Ganguly, 1958) is the vector which carries the virus and activity is highest in spring. Flowering and fruiting are also adversely affected. Regular visit of field at least once in 15 days during monsoon, use of tolerant variety (Majumder, 1966) [18] roguing and destruction of affected plants, regular sprays of systemic insecticide (Rogor @0.1%) use of disease free, healthy planting materials are required to be done.

Clump rot disease

Caused by fungi *Pythium* and *Rhizoctonia sp.* Collar region of the plant turns pale, water soaked, soft and can easily be pulled out. Rot extends to rhizome and discolour and decompose it. Removal of affected plants and spraying or drenching with Bordeaux mixture (1%), Blitox 50 (1%) or Thiram (0.2%) is necessary.

Table 2: Calendar of events to be followed for quality production of large cardamom

Month	Activities
January	Removal of infected plants
February	Watering at 15 days interval in case of dry conditions water can be sourced from upstream through naturalgradient in hill. Provide mulch
March - April	Clearing of leaf litter to facilitate flowering and fruiting. Weeding is to be done
May-June	Planting of healthy disease-free suckers and replacement of oldplants
July	Completion of planting of suckers; checking for pestinfestation; weeding
August	Removal of diseased plants and destruction; best options are deep burial or burning. Adoption of rodent control measures like clearing of the surroundings; weeding
September-October	Harvesting the ripe fruits. Drying/curing of cleaned capsules
November	Completion of post harvest activities (drying and packing).Removal of old stumps, infested plants and destroy
December	Mulching and repairing ofraisers.

Harvesting

Harvesting and processing of large cardamom are carried out in traditional ways with very little scientific influence (Sharma *et al.*, 2009) [34]. Dried capsules produced in the traditional way fail to meet some contemporary market requirements, resulting in lower prices to farmers. Mature capsules are manually removed from the spikes after they are harvested. Curing of fresh capsules, which have about 80% moisture content, is accomplished in a traditional *bhatti* (furnace-based curing structure), which often results in poor quality (Rao *et al.*, 2001) [27]. A number of improved drying systems have been developed; these have yielded better quality, but farmers are not yet convinced of their value as each system has some problems. The capsule tail (calyx) is removed manually using scissors, a laborious and time-consuming process. Capsules are graded according to size, but no reports of use of mechanical graders have been found. The harvesting and postharvest processing methods (curing, calyx cutting, packaging, and storage), quality issues and their impacts on the value chain, and trade patterns; it also suggests approaches for future research and development that could make the crop more sustainable.

Ripening of large cardamom capsules on a spike is not uniform, however; the topmost capsules ripen first and those on the bottom last. The full maturity of a capsule is indicated by the brown color of its seeds. Harvesting at the correct stage of maturity is essential to produce high-quality capsules. 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. The spikes are harvested using a special knife known as an *elaichichhuri* (Gudade *et al.*, 2013) [15]. The harvested spikes are stored for 2–3 days after harvesting, which makes it easier to separate the capsules (Gudade *et al.*, 2013) [15]. Separation is done by hand, and no device is available for this operation so far. The separated capsules are also manually cleaned from other plant materials before curing.

Fresh capsules have a moisture content of 70–80%. In curing, the moisture content is reduced to a level that is safe for storage, about 10–12%. Curing substantially reduces the weight of the capsules; the final weight depends on several parameters, including initial size, final moisture content, method of curing, and curing temperature. Depending on capsule size and curing methods, the weight ratio from fresh to cured capsule is 4:1 to 5:1 (Madhusoodanan and Rao 2001) [17]. Curing is the most crucial step in large cardamom processing, as capsule quality largely depends on curing conditions and methods. It is obvious that a certain amount of easily evaporable substances that are part of the essential oil content of large cardamom are lost during curing (Rout *et al.*, 2003) [27]. Curing at too high a temperature results in loss of volatile oil and charring of capsules, and curing at too low a temperature results in longer drying times and increased chances of mold growth. Optimum curing temperature is 45–55 °C (Deka *et al.*, 2003) [12]. Curing is usually done in traditional *bhattis*. However, as mentioned earlier, a few types of improved curing systems have also been introduced (TERI 2012). The effect of various curing methods on quality is discussed in the sections that follow.

Traditional *bhatti*

The traditional *bhatti* is a drying kiln developed by farmers and used for curing fresh large cardamom capsules. it is based on a direct heating system, and drying time is 25–40 hours The fuel efficiency of this system is very poor (Rao *et al* 2001) [27]; it requires 2.5 kg of fuelwood to produce 1 kg of dried capsules (Sharma *et al.*, 2009) [34]. The quality of large cardamom capsules cured in traditional *bhattis* is poor. They are dark brown and have a smoky flavor; the quantity of charred and cracked capsules is high, as is the loss of volatile oil. However, the cost of building and maintaining a *bhatti* is low. A traditional *bhatti* can easily be made using locally available materials and requires no scientific knowledge.

Gasifier-based system

Gasification is a thermochemical conversion process that converts organic matter into high-value fuel gas. The Tata Energy Research Institute developed and introduced a gasifier-based curing system consisting of an updraft-type biomass gasifier connected to a traditional *bhatti*. Instead of direct burning of fuelwood, it burns producer gas from the gasifier, functioning as a kind of smoke-free kiln. The institute found the quality of these dried capsules to be better than that of capsules dried in traditional *bhatti* (TERI 2012) [49]. The gasifier system has several advantages over traditional *bhatti*, including better conversion efficiency (above 70%), controlled combustion, production of clean flue gases, a better controlled flame, and fuelwood savings of up to 65% (Rao *et al*., 2001) [27]. It also produces dried capsules that have a more attractive color and greater volatile oil content. Nevertheless, presently no such curing system is being used by farmers in Sikkim. Chipping of fuelwoods and the additional cost of installing the gasifier might be the reason. The cost of this curing system is about US$ 243 (Deka *et al.*, 2003) [12].

Improved *bhatti*

The Indian Cardamom Research Institute developed an improved *bhatti*, an indirect heating system that uses heated air and a flue gas pipe arrangement to dry the capsules. The capacity of this *bhatti* varies from 200 kg to 400 kg of fresh capsules. Drying time is reported as 17–24 hours, and it gives excellent product quality with maroon color and volatile oil content of 2–2.4%. One such unit costs about US$ 102 (Deka *et al.*, 2003) [12]. Improved *bhattis* are used by a few farmers in Arunachal Pradesh state in India. They were also introduced in the state of Sikkim by the Spices Board of India, but farmers are reluctant to adopt those (Anonymous, 2007) [1]. Use of a similar curing system in Nepal has also been reported (Stoep 2010) [47].

Mechanical-trolley system

The Indian Council of Agricultural Research has developed another indirect-heating curing system, which can be operated by diesel or electricity. This curing system consists of a blower, a heating unit, and a multitray 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 (Anonymous 2007) [1]. However, because of the difficulty of transporting it in the hilly terrain and its high initial cost, there is no report of farmers using this system.

Calyx cutting

The calyx or tail of large cardamom capsules is partially detached when it is rubbed against a wire mesh just after curing. In this way, the bristly outer layer of capsules can also be removed. The tails are usually manually cut with scissors by the local traders. Capsules with the tail removed are graded as *kainchi-cut* and those with the tail intact as *non-kainchi-*

cut. No machine for removing capsule tails has been devised. The College of Agricultural Engineering and Post-Harvest Technology in Ranipool, Sikkim, and the Indian Cardamom Research Institute (Spices Board) in Tadong, Sikkim, jointly evaluated a cardamom polisher for possible use as a tail-cutting machine (Yurembam 2010) [54].

Packaging and storage

Dried large cardamom capsules are usually packed in polythene-lined jute bags. Polypropylene and ethylene terepthalate/polyethylene have been reported to considerably reduce moisture and volatile oil exchange under normal storage conditions (Sulochanamma*et al.,* 2008). The hot capsules taken out of the curing chamber are allowed to cool and then are placed into the bags, which are sealed and stored on wooden platforms to avoid moisture absorption, which could lead to mold growth. Storage stability has been maintained for large cardamom capsules with up to 11% moisture content (Naik *et al.*, 2000) [20].

Loss of capsule weight and insect damage can also occur during storage. Moisture content of 13–15% is conducive to insect breeding; therefore, the Central Food Technological Research Institute in Mysore has recommended use of fumigants like methyl bromide (0.016 kg/m^3), phosphine (0.0015 kg/m^3), and ethyl formate (0.30 kg/m^3) to control insect infestation without affecting quality (Naik *et al.*, 2005) [21]. No report addresses the need for consumer packs (smaller packages) suitable for local markets, which may also have benefits in this regard.

Grading and quality standards

For commercial grading in local markets, the finished large cardamom capsules are categorized as *badadana* (big capsules) or *chotadana* (small capsules) and as *kainchi-cut* (capsule tail removed) or *non-kainchi-cut* (capsule tail intact) (Sharma *et al*., 2009) [34]. The difference in capsule size may be due to cultivar difference or preharvest conditions. For example, capsules of the Golsey cultivar are generally bigger. Size grading can be done using manual screens. Use of mechanical grading machines is so far not reported, except for manually operated sieves in Nepal. Quality grading is only done by local dealers and wholesalers, who employ large numbers of laborers for this purpose.

The Bureau of Indian Standards has established quality standards for large cardamom capsules based on the Prevention of Food Adulteration Act of 1954. Some importing countries allow only the product that conforms to these standards. However, awareness about the standards is minimal among growers and traders.

Value chains

Large cardamom (*Amomum subulatum* Roxb.) dried fruit has a high-value, low-volume spice crop grown only in the three eastern Himalayan countries, are widely used in foods, beverages, perfumes, and medicines. Production is currently declining, and improved postharvest management would be one way to help ensure the sustainability of this niche crop. The value chain for large cardamom consists largely of traditional practices which should be scientifically refined during a number of postharvest steps including marketing. The large cardamom postharvest value chain consists of growers, collectors, traders, and exporters. The primary processing steps required by the present market are curing, tail cutting, and grading. Curing is carried out by the farmers, and the remaining steps are done by wholesalers. In Nepal, large cardamom is marketed to village traders, road head collectors (local collectors), regional traders, national traders or exporters, and finally buyers and consumers abroad. In India, large cardamom moves through 2 market channels. In the first, farmers sell cured capsules through aggregators, and in the second, farmers sell them through contractors or bidders in an auction center (SFAC 2012). In both channels, the capsules then move on to wholesalers, then retailers, and finally consumers.

Trade

In India, a major portion of the product is consumed in the domestic market. The rest is exported to other countries, including Australia, Canada, Pakistan, South Africa, the United Arab Emirates, the United Kingdom, and the United States. Pakistan has the largest share of the market, as the product is exported to other countries is through Pakistan. Delhi, Kolkata, and Guwahati are the major Indian domestic markets. About 90% of large cardamom produced in Nepal is exported to India (ECCOS 2010). Less than 9% of the product is exported directly to Afghanistan, Pakistan, the United Arab Emirates, and other Gulf countries.

The large cardamom trade involves a number of groups in between producers (farmers) and end users. In Nepal, local dealers (or wholesalers) collect the product from farmers and sell it to exporters based in Birtamod and Biratnagar. Export price fluctuation is the major problem for farmers and traders. Marginal farmers used to take advances from local traders before the harvest season and repay the amount with interest by selling their products to them. Another system is the *dahadani*, the selling of crops in the field to local merchants, in which farmers display the harvested produce after drying (Stoep 2010) [47]. These systems of marketing are common among large cardamom growers of Nepal who are in need of cash in advance, but the price they get is lower because of it (Stoep 2010) [47]. The Indian large cardamom market is a complex structure, as product inflow and outflow take place simultaneously. However, it is apparent that a large quantity is consumed in the domestic market, as the Indian export volume is comparatively low. The Spices Board of India controls and monitors the spice trade in this country. Local dealers or wholesalers collect dried large cardamom capsules from the farmers, perform minimal quality grading, and sell in bulk to exporters. In this system, the price of the commodity is fixed between the farmer and the local dealer, and farmers are usually paid less than the market average. Singtam, Gangtok, Jorethang, Gyalshing, Naya Bazar, Rongli, and Mangan are the major local large cardamom markets in Sikkim (Anonymous 2006). Siliguri in North Bengal is the main trade junction for Indian large cardamom; from there, it goes to other collection centers, such as Guwahati, Kolkata, Delhi, and Amritsar (SFAC 2012).

Constraints and supports

Large cardamom production has declined in recent years (Sharma *et al*., 2009) [34]. One of the main reasons for this is viral diseases like *chirkey* and *phurkey* (Stoep 2010) [47] and also using the same planting material year year after year. Improved curing methods known to produce higher-quality capsules are difficult for farmers to adopt because of their cost. Moreover, these *bhattis* are designed to be used only for one harvesting season in a year, and hence, it is difficult for farmers to pay back the costs invested. Lack of effective grading mechanisms also limits farmers' ability to charge higher prices for their products. Market channelization for

quality capsules is also a major challenge (Sharma *et al.*, 2009) [34]. However, many governmental organizations and NGOs are being engaged to encourage large cardamom farming in the sub-Himalayan region, such as the National Cardamom Development Center and the Netherlands Development Organization in Nepal. In India, the Indian Cardamom Research Institute, Department of Horticulture and Cash Crop Development, Government of Sikkim, and North Eastern Regional Agricultural Marketing Corporation are providing supports in crop development, postharvest technology, and marketing.

Conclusions and future prospects

The worldwide production of large cardamom, a high-value, low-volume crop, has fallen in recent years due to several factors, including diseases and pests. Adoption of proper postharvest processing techniques can help to compensate for decreased production by reducing postharvest losses and adding value. Improved *bhattis* yield better quality than traditional *bhattis*, but these devices have not been well accepted by farmers. Farmers need a low-cost curing system that can produce good-quality capsules. Several other labour intensive postharvest processing operations—such as separating capsules from spikes, cleaning, tail cutting, and grading—have not received the attention they need from researchers. Mechanical systems that reduce human drudgery and make postharvest processing more efficient will decrease losses and increase the value of the capsules produced.

Apart from primary processing, it is also necessary to explore other ways to add value to this crop, such as production of essential oil and oleoresin. Compared with 2013–2014, the quantity of the cardamom traded in 2013–2014 decreased. However, the export value was greater in 2013–2014, which shows the increased value and demand for the crop. Therefore, an increase in production of this important crop will improve the livelihoods of many mountain people in the sub-Himalayan region. Large cardamom farmers still face difficulties in postharvest management. Better extension services by NGOs or government agencies or both will improve awareness about the policies among farmers and help ensure their successful implementation. Organizations like the North Eastern Regional Agricultural Marketing Corporation can also help farmers get better prices by acting as a link between farmers and traders. Finally, proper pricing for high-quality product can also help to make large cardamom farming an attractive and profitable livelihood.

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