

## **Postharvest Processing of Large Cardamom in the Eastern Himalaya**

Authors: Singh, Angom Ingocha, and Pothula, Anand Kumar

Source: Mountain Research and Development, 33(4) : 453-462

Published By: International Mountain Society

URL: <https://doi.org/10.1659/MRD-JOURNAL-D-12-00069.1>

---

BioOne Complete ([complete.BioOne.org](https://complete.BioOne.org)) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at [www.bioone.org/terms-of-use](https://www.bioone.org/terms-of-use).

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

---

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

# Postharvest Processing of Large Cardamom in the Eastern Himalaya

## A Review and Recommendations for Increasing the Sustainability of a Niche Crop

Angom Ingocha Singh and Anand Kumar Pothula\*

\* Corresponding author: panand2000@gmail.com

Department of Agricultural Engineering, North Eastern Regional Institute of Science and Technology, Nirjuli, Arunachal Pradesh 791109, India

Open access article: please credit the authors and the full source.

The dried fruits of large cardamom (*Amomum subulatum* Roxb.), 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; scientific improvements are needed in a number of postharvest steps, including marketing. This article reviews the crop's postharvest processing (with emphasis on curing, calyx cutting, packaging, and storage),

quality issues, and trade patterns, and identifies research topics that could contribute to increasing its quality and value and thereby to protecting and promoting the livelihoods of several thousands of people in the value chain.

**Keywords:** Large cardamom; postharvest processing; quality; curing; grading; calyx cutting; trade.

**Reviewed by the Editorial Board:** August 2013

**Accepted:** September 2013

## Introduction

Large cardamom (*Amomum subulatum* Roxb.), a member of Zingiberaceae family under the order Scitaminae is a perennial soft-stemmed plant (Figure 1). The large cardamom plant is 1.5 to 2.5 m tall (Bisht et al 2011). It 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. The Himalayan alder (*Alnus nepalensis*) is often used as a shade tree (Chempakam and Sindhu 2008; Sharma et al 2008). The plant 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 (Sharma et al 2000; Bisht et al 2011). 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).

*A. subulatum* is grown only in the eastern Himalayan countries—Nepal, northeast India, and Bhutan—and originated in Sikkim, India (Sharma et al 2009). 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%). Production data for Nepal, India, and Bhutan for 2008–2011 are presented in Table 1. Taplejung, Panchthar, Ilam, Dhankura, Bhojpur, Terhathum, and Sankhuwasabha are the major large-cardamom-growing districts of Nepal (ECCOS 2010). In India it is cultivated in Sikkim, the Darjeeling district of

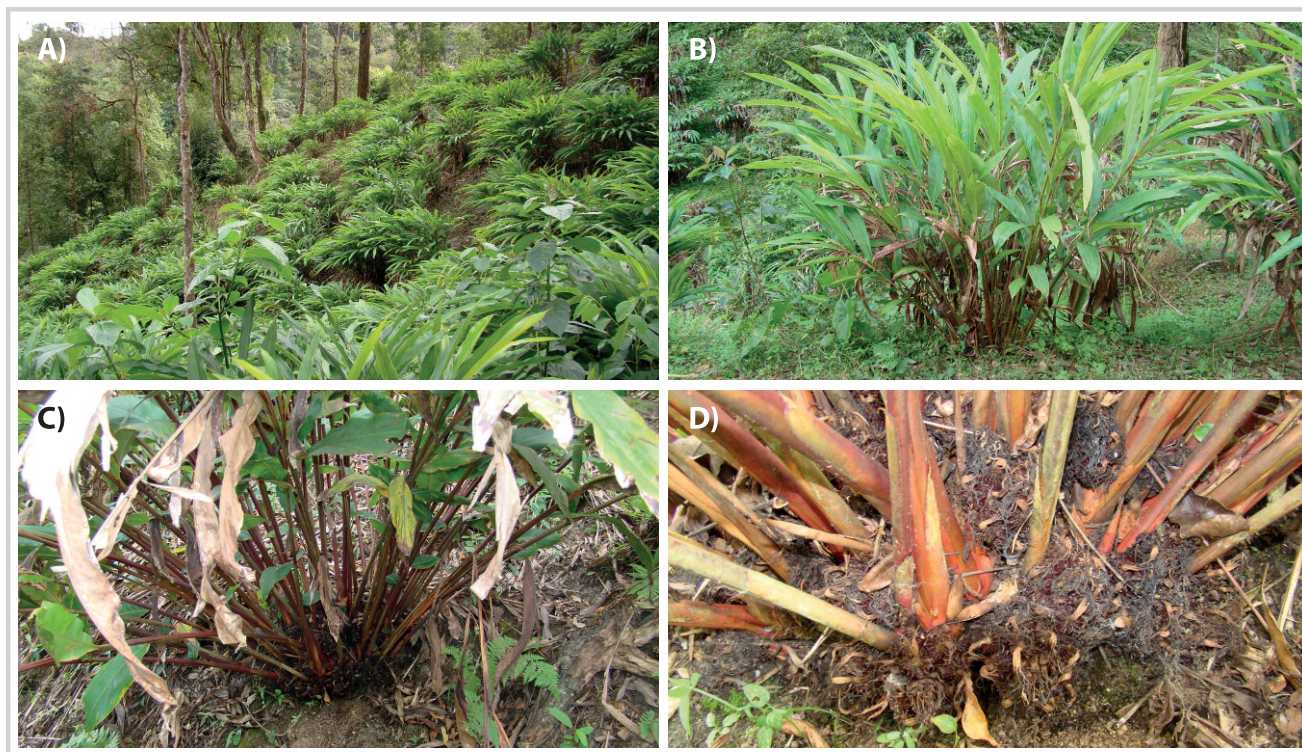
West Bengal, Arunachal Pradesh, Nagaland, and Uttarakhand (Sharma et al 2009; Bisht et al 2010). According to the Spices Board (2012a), the major share of India's production is from Sikkim.

Large cardamom has been a major agricultural cash crop and export commodity of Southeast Asian countries in recent years (Sharma et al 2009). Large cardamom farming is one of the important livelihood sources for mountain people in the Himalayan region. It is a low-volume, high-value crop (Avasthe et al 2011). In India, most of the crop is consumed domestically, and the rest is exported. The main market for Nepal's crop is Siliguri, a town in North Bengal, India (Sharma et al 2009).

In Sikkim, large cardamom is called *alainchii* and is believed to be one of the oldest known spices. Dried large cardamom capsules are used as a spice in various dish preparations, food essences, perfumes, and medicines. It has been important for many centuries in Ayurvedic preparations and the Unani system of medicine (Jafri et al 2001; Madhusoodanan and Rao 2001). Large cardamom can be used to treat several ailments (NIIR 2006). The volatile oil of large cardamom seed contains 1,8-cineole,  $\alpha$ -terpineol,  $\alpha$ -pinene,  $\beta$ -pinene, and allo-aromadendrene (Gurudutt et al 1996). The essential oil of large cardamom is reported to have antimicrobial properties (Agnihotri and Wakode 2010), and many studies have been conducted on it (Mishra and Dubey 1990; Adegoke et al 1998; Naik et al 2004; Gilani et al 2006; Kaskoos et al 2008; Singh et al 2008).

Large cardamom cultivation, harvesting, and processing are carried out in traditional ways with very little scientific influence (Sharma et al 2009). Dried capsules produced in the traditional way fail to meet

**FIGURE 1** (A) Large cardamom plantation at Lyako village, Old Zero, Arunachal Pradesh; (B) single bush of large cardamom; (C and D) close views of mature large cardamom spikes. (Photos by A. Ingocha Singh)



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). 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 (Sharma et al 2000). 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.

This article reviews 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. In cost discussions, the following currency conversion values (as of 1 March 2012) are used: US\$ 1 = 78.81 Nepalese rupees, 49.33 Indian rupees, and 49.08 Bhutanese ngultrum.

## Harvesting

Large cardamom is harvested when the capsules are fully matured. This is usually done during September to November, depending on the altitudes and cultivars. Capsule maturity is commonly assessed by opening the topmost capsule of a spike. 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

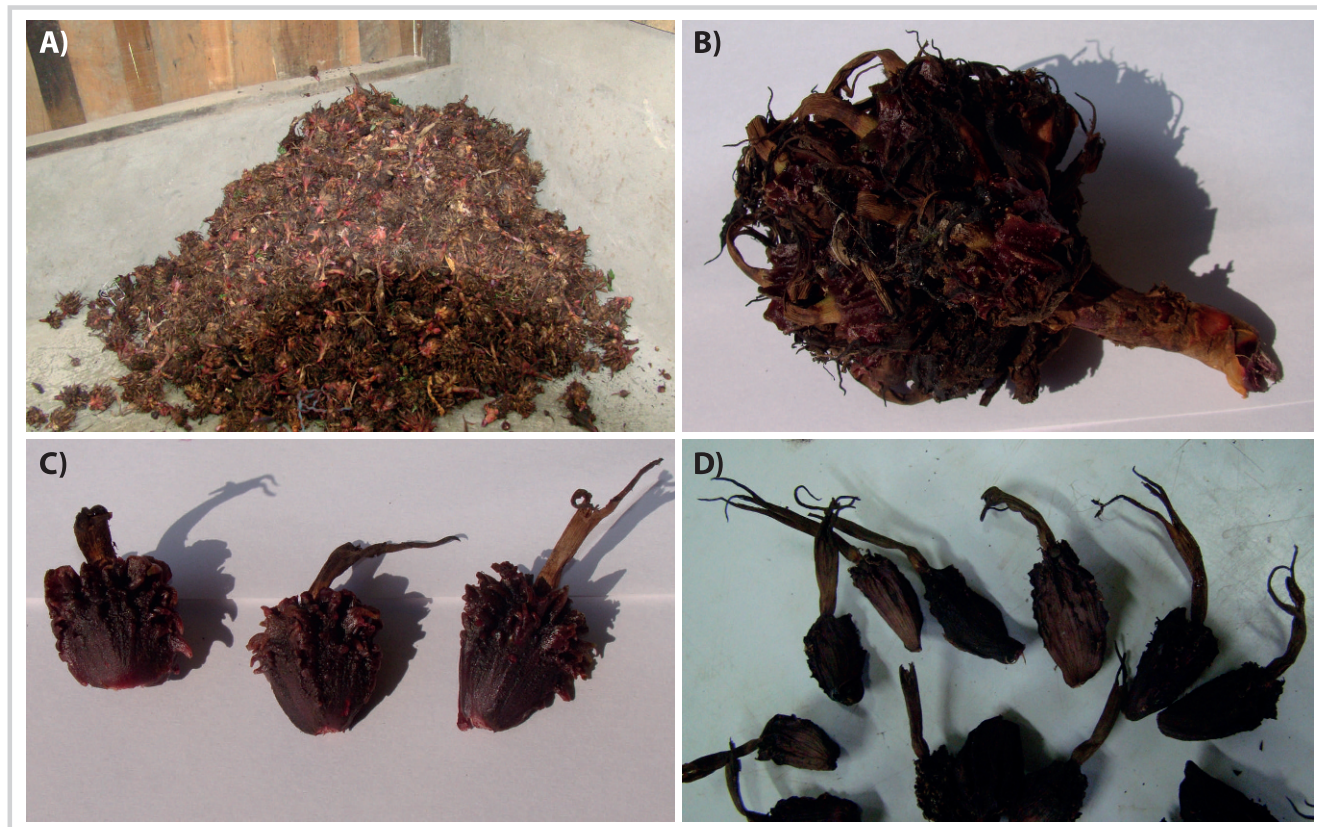
**TABLE 1** Worldwide production of large cardamom (in metric tons), 2005–2011.

Country	2005–2006	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	6-year average
Nepal	6647.00	7150.00	7087.00	7037.00	5233.00	5517.00	6445.17
India	5185.00	4303.00	4920.00	4300.00	4180.00	3918.00	4467.67
Bhutan	1190.00	3477.00	986.90	942.28	433.00	1163.00	1365.36
Total	13,022.00	14,930.00	12,993.90	12,279.28	9846.00	10,598.00	12,278.20

Sources: Nepal: MoAC (2008, 2011), Chapagain (2011); India: Spices Board (2012a); Bhutan: Dema (2011).



**FIGURE 2** (A) Heaped harvested spikes of large cardamom; (B) close view of a spike; (C) mature fresh capsules manually separated from the spike; (D) cured capsules with calyx. (Photos by A. Ingocha Singh)



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 (Spices Board 2001). The spikes are harvested using a special knife known as an *elaichichhuri* (Spices Board 2001). The harvested spikes are stored for 2–3 days after harvesting, which makes it easier to separate the capsules (Spices Board 2001). 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. Figure 2 presents several views of harvested and cured capsules.

### Curing

Fresh capsules have a moisture content of 70–80% (Mande et al 1999). 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 (Figure 2C) to cured capsule (Figure 2D) is 4:1 to 5:1 (Madhusoodanan and Rao 2001).

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). 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). Curing is usually done in traditional *bhattis*. However, as mentioned earlier, a few types of improved curing systems have also been introduced (Deka et al 2003; Anonymous 2006; TERI 2012). The effect of various curing methods on quality is discussed in the sections that follow.

### Traditional *bhatti*

The traditional *bhatti* (Figure 3A) is a drying kiln developed by farmers and used for curing fresh large cardamom capsules (Sharma et al 2000); it is based on a direct heating system, and drying time is 25–40 hours (Mande et al 1999). The fuel efficiency of this system is very poor (Rao et al 2001); it requires 2.5 kg of fuelwood to produce 1 kg of dried capsules (Sharma et al 2009). 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

**FIGURE 3** (A) Traditional *bhatti*; (B) improved *bhatti*. (Photos by A. Ingocha Singh)



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). 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). 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).

#### 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 (Figure 3B). 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). 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 them (Anonymous 2007). Use of a similar curing system in Nepal has also been reported (Stoep 2010).

#### 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). The cost of a diesel-fired system is about US\$ 1317, and that of the electric system varies from about US\$ 2027 to US\$ 3041 (Anonymous 2007). 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.

### Other systems

In India, there are also reports of curing systems developed by other research organizations, such as the G.B. Pant Institute of Himalayan Environment and the Development and Central Food Technological Research Institute in Mysore, but none is in use by farmers so far (Madhusoodanan and Rao 2001; Deka et al 2003). In Nepal, another type of indirect-heating curing system, called the rocket stove dryer, has recently been introduced as part of a Netherlands Development Organization initiative (Stoep 2010). This flue-gas-based system produces less smoke and is reported to have produced high-quality capsules. However, very few niche markets have been identified in which higher-quality capsules will yield a higher price (Stoep 2010). In India also, except for a few growers who participated in the large cardamom auction center at Rangpo, Sikkim, farmers have been unable to negotiate with local dealers for higher prices for the higher-quality products of improved curing systems.

Thus, none of the improved curing systems have been successfully adopted by farmers. Additional research on the reasons for this will be helpful for the further development of new curing systems. Nevertheless, additional modification of the new systems is still recommended to bring down the costs of construction (Chhetri et al 2008).

### Calyx cutting

The calyx or tail of large cardamom capsules (Figure 4A) 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 (Mande et al 1999). The tails are usually manually cut with scissors by the local traders. Capsules with the tail removed (Figure 4B) are graded as *kainchi-cut* and those with the tail intact as *non-kainchi-cut*.

No machine for removing capsule tails has been devised. As revealed by local dealers in Sikkim, extra labor needs to be employed at the cost of about US\$ 0.41 per kg of capsules for this labor-intensive step. However, 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). The Indian Cardamom Research Institute is also in search of alternative capsule-tail-cutting devices. Such a device, if cost effective, will have a strong potential application in the large cardamom value chain.

### Packaging and storage

Dried large cardamom capsules are usually packed in polythene-lined jute bags. Polypropylene and ethylene terephthalate/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).

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 ( $0.016 \text{ kg/m}^3$ ), phosphine ( $0.0015 \text{ kg/m}^3$ ), and ethyl formate ( $0.30 \text{ kg/m}^3$ ) to control insect infestation without affecting quality (Naik et al 2005). 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

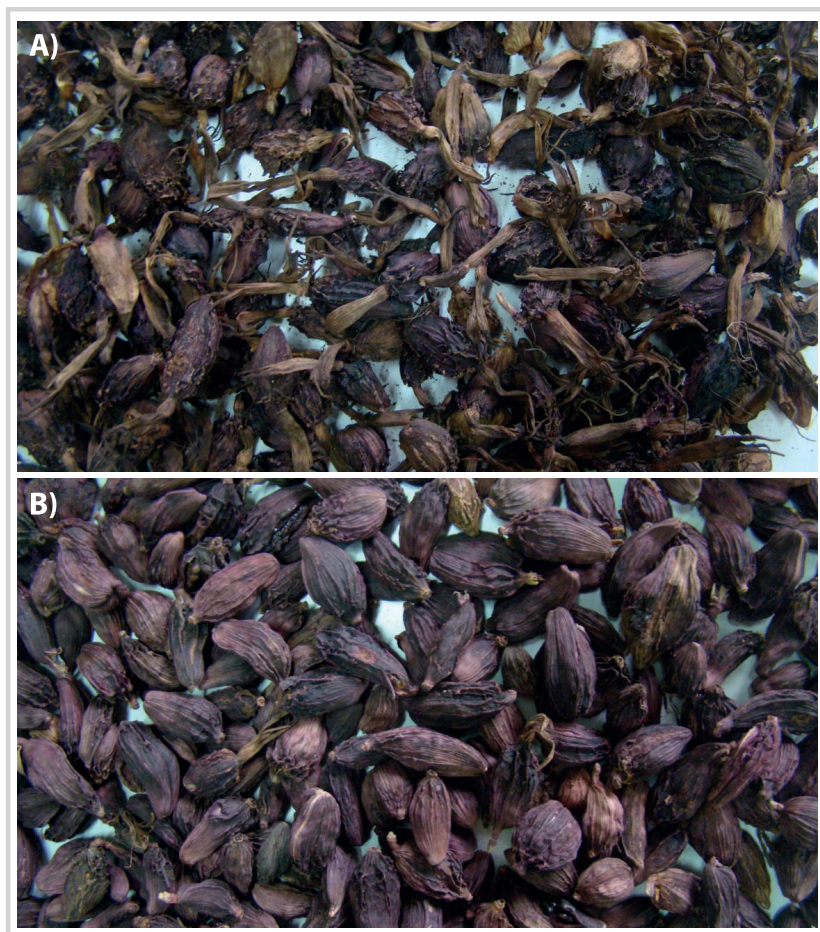
Finished large cardamom capsules are commercially graded in local markets as *badadana* (big capsules) or *chotadana* (small capsules) and, as discussed previously, as *kainchi-cut* (capsule tail removed) or *non-kainchi-cut* (capsule tail intact) (Sharma et al 2009). The difference in capsule size may 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 (BIS 1999) has established quality standards for large cardamom capsules (Table 2) 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

The large cardamom postharvest value chain consists of growers, collectors, traders, and exporters. The primary

**FIGURE 4** (A) Large cardamom capsules with calyx; (B) large cardamom capsules with calyx removed. (Photos by A. Ingocha Singh)



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. The cost per kilogram of processing cardamom capsules has

been estimated at US\$ 0.07 for curing (including fuelwood), US\$ 0.04 for tail cutting, and US\$ 0.02 for grading (cleaning and sorting); the volume losses per kilogram in the value chain have been estimated at US\$ 0.25 (MoAC 2008).

**TABLE 2** Indian government quality standards for large cardamom.

Quality parameters	Requirements
Odor and taste	Free from foreign odor and taste, including rancidity and mustiness
Insects, molds, and other infestations	Not more than 10% on visual observation
Extraneous matter	Not more than 5% (by weight)
Empty and malformed capsules	Not more than 5% (by count)
Immature and shriveled capsules	Not more than 7% (by weight)
Light seeds	Not more than 5% (by weight)
Moisture	Not more than 12% (by weight)
Volatile oil	Not less than 1% (mL/100 g) on dry basis

Source: BIS (1999).

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. The price of 1 kg of cured capsules at the farmer, local trader, wholesaler, and exporter levels are US\$ 2.47, US\$ 2.66, US\$ 2.85, and US\$ 3.17, respectively. The margins at each level are US\$ 0.15, US\$ 0.11, US\$ 0.02, and US\$ 0.19, respectively (MoAC 2008).

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. The prices for 1 kg at the farmer, aggregator, wholesaler, and retailer levels are US\$ 12.16, US\$ 13.38, US\$ 16.26, and US\$ 20.33, respectively. The margins enjoyed by aggregators, wholesalers, and retailers are reported as US\$ 1.22, US\$ 2.71, and US\$ 4.07, respectively (SFAC 2012).

Similar information for Bhutan is not available. Value-added products of large cardamom, such as essential oil and oleoresin, have high market values and export potentials (EXIM Bank 2009). However, no equipment for extracting such products is present in the production region.

## 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 (Table 3). 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.

In 2010–2011, Nepal exported about 4820.85 metric tons (worth about US\$ 25.92 million) to India and Singapore (TEPC 2012) and Bhutan exported 292.5 metric tons (worth US\$ 2.15 million) to Bangladesh and 183.7 metric tons (US\$ 2.37 million) to India (RNR 2011). However, the total volume exported from India in the same year was about 736 metric tons (worth about US\$ 8.58 million). For all three countries, export volumes and values for the years 2008–2009 to 2010–2011 are presented in Figure 5. The export volume decreased for all three countries from 2008–2009 to 2010–2011, whereas the export value increased (except for Nepal in 2009–2010). This pattern might be due to global increases in large cardamom prices in response to market demands. Dema (2011) reported that farmers were paid half as much in 2010 as in 2011, when exporters paid them US\$ 733.48 to US\$ 814.97 per *mon* (a unit equivalent to 40 kg).

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 (MoAC 2008; Stoep 2010). 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 (MoAC 2008; Stoep 2010).

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 (ECCOS 2010; Stoep 2010; SFAC 2012).

Price protection for farmers will be an important aspect in large cardamom trading, as this plays a major role in the value chain. The Spices Board recently introduced auctions with the help of the North Eastern Regional Agricultural Marketing Corporation, a government enterprise. Thus, the Indian large cardamom trade is becoming more organized, except for products from some remote places. In Nepal and Bhutan, growers are compelled to sell their products at prices set by local wholesalers.

## Processing and marketing policies

Large-cardamom-growing countries are implementing various policies to improve the crops. Most such policies seem to emphasize replanting, rejuvenation, and crop maintenance. However, positive interventions are also being undertaken in the area of postharvest processing and marketing.

The government of Nepal set up the National Cardamom Development Centre in Ilam to provide various supports for large cardamom development. Technical know-how in production, processing, and marketing is also offered through District Agricultural



**TABLE 3** Exports of large cardamom from India, 2006–2011. (Table extended on next page.)

Country	2006–2007		2007–2008	
	Quantity (metric tons)	Value (million US\$)	Quantity (metric tons)	Value (million US\$)
Pakistan	1199	2.54	1082	2.24
United Arab Emirates	146	0.39	97	0.27
United Kingdom	81	0.25	67	0.23
South Africa	12	0.03	11	0.03
United States	18	0.08	13	0.06
Canada	17	0.05	10	0.04
Australia	3	0.02	3	0.01

Source: Spices Board (2012b). Conversion at a fixed rate of US\$ 1 = INR 49.325.

Development Offices, the Trade and Export Promotion Centre, and the Agro Enterprise Centre (MoAC 2008).

Similarly, in India, the Spices Board (2013) set up the Indian Cardamom Research Institute in Sikkim. The board is offering assistance worth US\$ 246–444 to farmers for constructing improved *bhatti* under the Export and Development Fund, administered by the Department of Commerce. The Indian Cardamom Research Institute, in collaboration with the Indian Council of Agricultural

Research, is also implementing the National Agricultural Innovation Project on Improvement of Large Cardamom, including popularization of improved *bhatti* in Sikkim (Bhattarai et al 2013). The Ministry of Commerce approved the establishment of a unit for processing and extracting essential oil and oleoresin from large cardamom in 2009–2010 (DoC 2010). In the market sector, the North Eastern Regional Agricultural Marketing Corporation is helping large cardamom growers to sell their products by auction so that they can fetch a better price (NERAMAC 2012).

In spite of these improvement policies, farmers continue to face difficulties in all aspects of improvement of the crop, including postharvest aspects. This may be because of farmers' lack of awareness about the policies, as many of them work in remote places. Better extension services through nongovernmental organizations (NGOs) and state government agencies and other ways of creating awareness among farmers may increase the utilization of existing support.

### Constraints and supports

Large cardamom production has declined in recent years (Sharma et al 2009). One of the main reasons for this is viral diseases like *chirkey* and *phurkey* (MoAC 2008; ECCOS 2010; Stoep 2010). 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 (MoAC 2008; Sharma et al 2009).

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

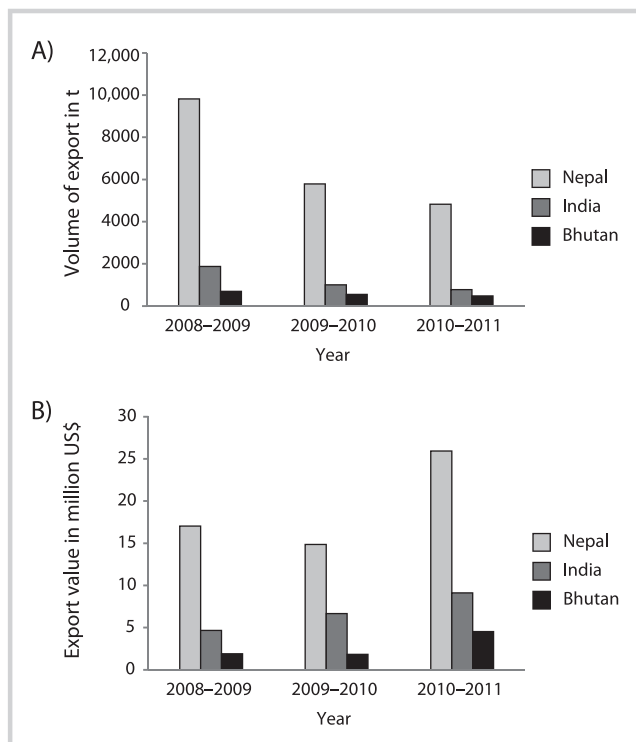
**FIGURE 5** Exports of large cardamom capsules, 2008–2011: (A) by volume; (B) by value.

TABLE 3 Extended. (First part of Table 3 on previous page.)

Country	2008–2009		2009–2010		2010–2011	
	Quantity (metric tons)	Value (million US\$)	Quantity (metric tons)	Value (million US\$)	Quantity (metric tons)	Value (million US\$)
Pakistan	1482	3.33	758	2.42	581	6.55
United Arab Emirates	159	0.46	58	0.26	46	0.77
United Kingdom	92	0.33	79	0.39	39	0.50
South Africa	19	0.06	16	0.08	21	0.38
United States	22	0.11	18	0.11	33	0.24
Canada	7	0.03	16	0.07	7	0.09
Australia	2	0.01	8	0.04	9	0.05

Netherlands Development Organization in Nepal (MoAC 2008). 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 disease. 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 labor-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 2008–2009, the quantity of the cardamom traded in 2010–2011 decreased. However, the export value was greater in 2010–2011, 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.

In spite of several policies implemented to improve the crop, 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.

### ACKNOWLEDGMENTS

The authors wish to acknowledge the Indian Cardamom Research Institute, Regional Research Station, Gangtok, Sikkim, for technical discussions on large cardamom issues and field visits.

### REFERENCES

- Adegoke GO, Rao LJM, Shankaracharya NB, Jagmohan RL. 1998. A comparison of the essential oils of *Aframomum daniellii* and *Amomum subulatum*. *Flavour and Fragrance Journal* 13:345–352.
- Agnihotri S, Wakode S. 2010. Antimicrobial activity of essential oil and various extracts of fruits of greater cardamom. *Indian Journal of Pharmaceutical Sciences* 72(5):657–659.
- [Anonymous]. 2006. *Training Manual of Horticultural Crops*. Gangtok, India: Horticulture and Cash Crop Development Department-Sikkim.

- [Anonymous]. 2007. *Proceedings of the Group Meeting Held on 06-11-2007*. Tadong, Sikkim, India: Indian Cardamom Research Institute, Regional Research Station.
- Avasthe RK, Singh KK, Tomar JMS. 2011. Large cardamom (*Amomum subulatum* Roxb.) based agroforestry systems for production, resource conservation and livelihood security in the Sikkim Himalaya. *Indian Journal of Soil Conservation* 39(2):155–160.
- Bhattarai NK, Deka TN, Chhetri P, Harsha KN, Gupta U. 2013. Livelihood improvement through sustainable large cardamom cultivation in North Sikkim. *International Journal of Scientific and Research Publications* 3(5):1–4.



- BIS [Bureau of Indian Standards]**. 1999. *Spices and Condiments—Large Cardamom—Capsules and Seeds—Specification*. New Delhi, India: Bureau of Indian Standards IS 13446:1999.
- Bisht VK, Negi AK, Bhandari AK, Sundriyal RC**. 2011. *Amomum subulatum* Roxb.: Traditional, phytochemical and biological activities—An overview. *African Journal of Agricultural Research* 6(24):5386–5390.
- Bisht VK, Purohit V, Negi JS, Bhandari AK**. 2010. Introduction and advancement of large cardamom (*Amomum subulatum* Roxb.) in Uttarakhand, India. *Research Journal of Agricultural Sciences* 1(3):205–208.
- Chapagain D**. 2011. Assessment of Climate Change Impact on Large Cardamom and Proposed Adaptation Measures in Eastern Hill of Nepal. Kathmandu, Nepal: Central Department of Environmental Science, Tribhuvan University. [www.climate nepal.org.np/main/downloadFile.php?fn=I5smn4oiz1e.pdf&ft=application/pdf&d=publication](http://www.climate nepal.org.np/main/downloadFile.php?fn=I5smn4oiz1e.pdf&ft=application/pdf&d=publication); accessed on 6 March 2012.
- Chempakam B, Sindhu S**. 2008. Large cardamom. In: Parthasarathy VA, Chempakam B, Zachariah TJ, editors. *Chemistry of Spices*. Wallingford, United Kingdom: CAB International, pp 60–69.
- Chhetri PB, Khatiwada E, Lioret A, Jabegu K**. 2008. Benefits of value addition: A success story from the hills of Nepal. *Enterprise Development and Microfinance* 19(1):69–83.
- Deka TN, Biswas AK, Gopakumar B, Potty SN**. 2003. Large cardamom curing through ICRI improved bhati. *Journal of Hill Research* 16(1):57–60.
- Dema K**. 2011. Happy days are here again! Blog post. [www.kuenselonline.com/2011/?p=19883](http://www.kuenselonline.com/2011/?p=19883); accessed on 3 February 2012.
- DoC [Department of Commerce, Government of India]**. 2010. Trade promotion initiatives in the North East Region. In: *Annual Report 2009–2010*. [www.commerce.nic.in/publications/annualreport\\_chapter13-2009-10.asp](http://www.commerce.nic.in/publications/annualreport_chapter13-2009-10.asp); accessed on 20 August 2013.
- ECCOS [Economics Consultancy Services]**. 2010. *Market Survey Medicinal and Aromatic Products (MAP) Nepal. Report of Economics Consultancy Services, Germany*. [www.includenepal.org/alluploads/Maps%20Market%20Survey%2C%20ECCOS%202010.pdf](http://www.includenepal.org/alluploads/Maps%20Market%20Survey%2C%20ECCOS%202010.pdf); accessed on 3 February 2012.
- EXIM Bank [Export Import Bank]**. 2009. *Sikkim: Export Potential and Prospects*. Occasional paper No. 123. Mumbai, India: EXIM Bank and Quest Publications. [www.eximbankindia.org.in/op/op134.pdf](http://www.eximbankindia.org.in/op/op134.pdf); accessed on 8 August 2013.
- Gilani SR, Shahid I, Javed M, Mehmud S, Ahmed R**. 2006. Antimicrobial activities and physico-chemical properties of the essential oil from *Amomum subulatum*. *International Journal of Applied Chemistry* 2(2):81–86.
- Gurudutt KN, Naik JP, Srinivas P, Ravindranath B**. 1996. Volatile constituents of large cardamom (*Amomum subulatum* Roxb.). *Flavour and Fragrance Journal* 11(1):7–9.
- Jafri MA, Javed KF, Singh S**. 2001. Evaluation of the gastric antiulcerogenic effect of large cardamom (fruits of *Amomum subulatum* Roxb.). *Journal of Ethnopharmacology* 75:89–94.
- Kaskoos RA, Mir SR, Kapoor R, Ali M**. 2008. Essential oil composition of fruits of *Amomum subulatum* Roxb. *Journal of Essential Oil Bearing Plants* 11:184–187.
- Madhusoodanan KJ, Rao YS**. 2001. Cardamom (large). In: Peter KV, editor. *Handbook of Herbs and Spices*, vol. 1. Cambridge, United Kingdom: Woodhead, pp. 139.
- Mande S, Kumar A, Kishore VVN**. 1999. A study of large-cardamom curing chambers in Sikkim. *Biomass and Bioenergy* 16:463–473.
- Mishra AK, Dubey NK**. 1990. Fungitoxicity of essential oil of *Amomum subulatum* against *Aspergillus flavus*. *Economic Botany* 44(4):530–533.
- MoAC [Ministry of Agriculture and Cooperatives]**. 2008. *Final Report: Product Chain Study Cardamom*. Biratnagar, Nepal: MoAC. [www.cadp.gov.np/DocumentUploads/Reports/dd1d5812506492836355.pdf](http://www.cadp.gov.np/DocumentUploads/Reports/dd1d5812506492836355.pdf); accessed on 4 February 2012.
- MoAC [Ministry of Agriculture and Cooperatives]**. 2011. *Area, Production and Yield of Major Spice Crops 2010/2011. Statistical Information on Nepalese Agriculture: 2010/2011. Year Book 2011*. Singha Durbar, Kathmandu, Nepal: Government of Nepal, Ministry of Agriculture and Co-operatives. [www.moad.gov.np/downloadfile/cover\\_1331268679.docx](http://www.moad.gov.np/downloadfile/cover_1331268679.docx); accessed on 19 September 2013.
- Naik HP, Balasubrahmanyam N, Dhanaraj S, Gurudutt KN**. 2000. Packaging and storage studies in flue-cured large cardamom (*Amomum subulatum* Roxb.). *Journal of Food Science and Technology (Mysore)* 37(6):577–581.
- Naik JP, Ramesh BS, Gurudutt KN**. 2005. Fumigation studies on cured large cardamom (*Amomum subulatum* Roxb.) capsules. *Journal of Food Science and Technology (India)* 42(6):531–533.
- Naik JP, Rao LJM, Kumar TMM, Sampathu SR**. 2004. Chemical composition of the volatile oil from the pericarp (husk) of large cardamom (*Amomum subulatum* Roxb.). *Flavour and Fragrance Journal* 19(5):441–444.
- NERAMAC [North Eastern Regional Agricultural Marketing Corporation Limited]**. 2012. *30th Annual Report 2011–2012*. [www.neramac.com/Uploads/File/AR\\_11-12\\_eng.pdf](http://www.neramac.com/Uploads/File/AR_11-12_eng.pdf); accessed on 20 August 2013.
- NIIR [National Institute of Industrial Research]**. 2006. *The Complete Book on Spices & Condiments (with Cultivation, Processing & Uses)*. Delhi, India: Asia Pacific Business Press.
- Rao VG, Mande S, Kishore VVN**. 2001. Study of drying characteristics of large cardamom. *Biomass and Bioenergy* 20:37–43.
- RNR [Renewable Natural Resources]**. 2011. *Statistics on Volume and Monetary Value of Major Exporting Commodities by Countries of Destination*. Thimphu, Bhutan. [www.moaf.gov.bt/moaf/?wpfb\\_dl=846](http://www.moaf.gov.bt/moaf/?wpfb_dl=846); accessed on 3 June 2012.
- Rout PK, Sahoo D, Jena KS, Rao YR**. 2003. Analysis of the oil of large cardamom (*Amomum subulatum* Roxb.) growing in Sikkim. *Journal of Essential Oil Research* 15(4):265–266.
- SFAC [Small Farmers' Agribusiness Consortium]**. 2012. *Value Chain Analysis of Selected Crops in North Eastern States*. New Delhi, India: SFAC. [www.sfacindia.com/PDF/SFAC\\_Value-Chain-Analysis.pdf](http://www.sfacindia.com/PDF/SFAC_Value-Chain-Analysis.pdf); accessed on 8 August 2013.
- Sharma G, Sharma R, Sharma E**. 2008. Influence of stand age on nutrient and energy release through decomposition in alder-cardamom agroforestry systems of eastern Himalayas. *Ecological Research* 23(1):99–106.
- Sharma G, Sharma R, Sharma E**. 2009. Traditional knowledge systems in large cardamom farming: Biophysical and management diversity in Indian mountainous regions. *Indian Journal of Traditional Knowledge* 8(1):17–22.
- Sharma E, Sharma R, Singh KK, Sharma G**. 2000. A boon for mountain populations: Large cardamom farming in the Sikkim Himalaya. *Mountain Research and Development* 20(2):108–111.
- Singh P, Srivastava B, Kumar A, Dubey NK, Gupta R, Tanu**. 2008. Efficacy of essential oil of *Amomum subulatum* as a novel aflatoxin B<sub>1</sub> suppressor. *Journal of Herbs, Spices & Medicinal Plants* 14(3–4):208–218.
- Spices Board**. 2001. *Guidelines for Production of Organic Spices in India*. Cochin, India: Spices Board.
- Spices Board**. 2012a. *Spices Board Annual Report 2010-11*. Cochin, India: Spices Board, Ministry of Commerce & Industries, Government of India. [http://www.indianspices.com/pdf/Spice\\_Annual\\_Report\\_2010\\_11.pdf](http://www.indianspices.com/pdf/Spice_Annual_Report_2010_11.pdf); accessed on 12 June 2012.
- Spices Board**. 2012b. *Major Item/Country-Wise Export of Spices from India*. Cochin, India: Spices Board. [www.indianspices.com/html/maj\\_impcon.htm](http://www.indianspices.com/html/maj_impcon.htm); accessed on 12 June 2012.
- Spices Board**. 2013. *Export Oriented Production & Post Harvest Improvement of Spices*. Cochin, India: Spices Board. [www.indianspices.com/html/prodev\\_sc\\_01.htm](http://www.indianspices.com/html/prodev_sc_01.htm); accessed on 20 August 2013.
- Stoep GAV**. 2010. *Enhancing Competitiveness of Nepal's Large Cardamom Value Chain*. Kathmandu, Nepal: SNV Netherlands Development Organization.
- Sulochanamma G, Ramalakshmi K, Kumar TMM, Indiramma AR, Ramesh BS, Sampathu SR, Naik JP**. 2008. Storage characteristics of large cardamom (*Amomum subulatum* Roxb.) and seeds in different packages. *Journal of Food Science and Technology (Mysore)* 45(2):183–186.
- TEPC [Trade and Export Promotion Centre]**. 2012. *Trade Statistics*. Kathmandu, Nepal: TEPC. [www.tepc.gov.np/tradestatistics/gl-16-major-country-exports-sel-comm.php](http://www.tepc.gov.np/tradestatistics/gl-16-major-country-exports-sel-comm.php); accessed on 12 June 2012.
- TERI [Tata Energy Research Institute]**. 2012. *A New Curing Chamber for Large Cardamom*. New Delhi, India: TERI. [www.teriin.org/index.php?option=com\\_casestudy&task=details&sid=2](http://www.teriin.org/index.php?option=com_casestudy&task=details&sid=2); accessed on 12 June 2012.
- Thomas VP, Sabu M, Gupta U**. 2009. Taxonomic studies on cultivars of *Amomum subulatum*. *Rheedeia* 19(1&2):25–36.
- Yurembam GS**. 2010. *Performance Evaluation of Cardamom Polisher as Large Cardamom Detailing Machine* [B.Tech thesis]. Sikkim, India: College of Agricultural Engineering and Post Harvest Technology, Ranipool.