



REVIEW ARTICLE

ORIGIN, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY, BREEDING AND CULTIVATION OF CARDAMOM

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ABSTRACT

Cardamom belongs to the family Zingiberaceae, genus *Elettaria* and Latin name *Elettaria cardamomum* (L.) Maton. The common names are Capalaga, Ilachi, Green Cardamom, True Cardamom, Ceylon Cardamom. *Elettaria* is a genus of flowering plants in the family Zingiberaceae. They are native to India and Sri Lanka, but cultivated and naturalized elsewhere. One member of the genus, *E. cardamomum*, is a commercially important spice used as a flavouring agent in many countries. Cardamom, "The Queen of Spices," is one of the oldest and most celebrated spices in the world. It is well known for its distinct flavor, aroma, and medicinal properties. It is a naturally growing perennial plant in countries like Nepal, Bhutan, and India. Also, some places like Sri Lanka, Tanzania, and Guatemala farm the cardamom plant. The word *cardamom* is derived from the Latin *cardamōmum*, as a Latinisation of the Greek καρδάμωμον (*kardāmōmon*), a compound of κάρδαμον (*kárdamon*, "cress") and ἄμωμον (*āmōmon*), of unknown origin. The earliest attested form of the word κάρδαμον signifying "cress" is the Mycenaean Greek *ka-da-mi-ja*, written in Linear B syllabic script, in the list of flavorings on the spice tablets found among palace archives in the House of the Sphinxes in Mycenae. The modern genus name *Elettaria* is derived from the root *ēlam* attested in Dravidian languages. Common names in Indian language are in Hindi, Urdu, and Gujarati *elaichi*, and "yelakki" in Kannada and other South Indian languages. It is called *Elakka* in Malayalam, which is the language of Kerala an Indian province that accounts for 70% of Indian cardamom. In South Asia green cardamom, called "Elaichi" in Marathi, Hindi and Urdu. It is called "Yalakulu in Telugu, "elam" in Tamil. In Hebrew, it is known as *Hel*. In Persian it is also known as *Hel*. In Arabic, it is called *Hayl*. *Elettaria cardamomum*, commonly known as green cardamom or true cardamom, is a herbaceous, perennial plant in the ginger family, native to southern India. It is the most common of the species whose seeds are used as a spice called cardamom that has a sharp, strong, punchy aroma. It is cultivated widely in tropical regions and reportedly naturalized in Réunion, Indochina, and Costa Rica. Black cardamom, or *Amomum subulatum*, is a type of cardamom that is native to India, Bhutan, and Nepal. It is a member of the ginger own family and is regularly known as "hill cardamom" because of its cultivation in hilly areas. Black cardamom pods are large and darker than green cardamom pods, with a rough exterior and a smoky, earthy aroma. Black cardamom has been used for thousands of years in traditional Ayurvedic medicine to treat numerous ailments, together with digestive issues, respiratory troubles, and inflammation. It was also used as a flavoring agent in food and beverages. In ancient instances, black cardamom became considered a luxurious item and changed into frequently used as a form of currency. It is native to India and Sri Lanka but is now grown in other parts of the world, including Guatemala, Tanzania, and Papua New Guinea. The spice is generally sold in the form of small pods or as loose seeds. Cardamom has a strong, sweet, and spicy aroma, and a pungent, slightly sweet taste with hints of lemon and mint. It is commonly used in sweet and savory dishes, as well as in hot beverages like tea and coffee. Origin, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding and Cultivation of Cardamom are discussed.

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INTRODUCTION

Cardamom belongs to the family Zingiberaceae, genus *Elettaria* and Latin name *Elettaria cardamomum* (L.) Maton. The common names are Capalaga, Ilachi, Green Cardamom, True Cardamom, Ceylon Cardamom (Myspicer, 2014; Wikipedia, 2024a). *Elettaria* is a genus of flowering plants in the family Zingiberaceae. They are native to India and

Sri Lanka, but cultivated and naturalized elsewhere. One member of the genus, *E. cardamomum*, is a commercially important spice used as a flavouring agent in many countries (Wikipedia, 2024b). Cardamom sometimes cardamon or cardamum, is a spice made from the seeds of several plants in the genera *Elettaria* and *Amomum* in the family Zingiberaceae. Both genera are native to the Indian subcontinent and Indonesia. They are recognized by their small seed pods: triangular in cross-section and spindle-shaped, with a thin, papery outer shell and small, black seeds; *Elettaria* pods are light green and smaller, while *Amomum* pods are larger and dark brown. Species used for cardamom are native throughout tropical and subtropical Asia. The first references to cardamom are found in Sumer, and in Ayurveda. In the 21st century, it is cultivated mainly in India, Indonesia, and Guatemala (Wikipedia, 2024). Cardamom, “The Queen of Spices,” is one of the oldest and most celebrated spices in the world. It is well known for its distinct flavor, aroma, and medicinal properties. It is a naturally growing perennial plant in countries like Nepal, Bhutan, and India. Also, some places like Sri Lanka, Tanzania, and Guatemala farm the cardamom plant (History, 2023). The word *cardamom* is derived from the Latin *cardamōmum*, as a Latinisation of the Greek καρδάμωμον (*kardámōmon*), a compound of κάρδαμον (*kárdamon*, "cress") and ἄμωμον (*ámōmon*), of unknown origin. The earliest attested form of the word κάρδαμον signifying "cress" is the Mycenaean Greek *ka-da-mi-ja*, written in Linear B syllabic script, in the list of flavorings on the spice tablets found among palace archives in the House of the Sphinxes in Mycenae. The modern genus name *Elettaria* is derived from the root *ēlam* attested in Dravidian languages (Wikipedia, 2024). Small cardamom [*Elettaria cardamomum* (L.) Maton. (Family: Zingiberaceae)] capsules (fruits) have been used for traditional medicine applications including for the control of asthma, teeth and gum infections, cataracts, nausea, diarrhea, as well as cardiac, digestive and kidney disorders. The versatile use of cardamom capsules has several other beneficial health effects that are relevant in light of traditional and modern pharmaceutical perspectives (Ashokkumar *et al.*, 2020). Other Names of Cardamom in different languages are in French – Cardamome; German – Kardamom; Italian – Cardamomo, cardamone; Spanish – Cardamomo; Burmese – Phalazee; Chinese – Ts’ao-k’ou; Indian – Chhoti elachi, elachie, ela(i)chi, illaichi; Indonesian – Kapulaga; Malay – Buah pelage; Sinhalese – Enasal; Tamil – Elam; Thai – Grawahn, kravan (Seema, 2024). Common names in Indian language are in Hindi, Urdu, and Gujarati elachi, and “yelakki” in Kannada and other South Indian languages. It is called Elakka in Malayalam, which is the language of Kerala an Indian province that accounts for 70% of Indian cardamom. In South Asia green cardamom, called “Elaichi” in Marathi, Hindi and Urdu. It is called “Yalakulu in Telugu, “elam” in Tamil. In Hebrew, it is known as Hel. In Persian it is also known as Hel. In Arabic, it is called Hayl (Seema, 2024). Cardamomum, is called the Queen of Spices because of its many uses as a medicine and as a flavoring in food and drink. It is an important ingredient in Indian cooking (Niftem, 2024). In countries including Nepal, Bangladesh, Pakistan, Bhutan, and Indonesia, cardamom grows wild throughout the countryside. Today, Guatemala is the world’s largest producer, followed by India and Sri Lanka. The history of cardamom is closely intertwined with the history of spice trade. Cardamom is native to the Indian subcontinent and was first cultivated in India. It was then exported to ancient Egypt and Greece, where it was used as a perfume and an ingredient in medicinal remedies. The Romans also discovered cardamom and used it to flavor their food. By the Middle Ages, cardamom had become a popular spice in Europe, where it was used to flavor cakes and pastries (Niftem, 2024).

Elettaria cardamomum, commonly known as green cardamom or true cardamom, is a herbaceous, perennial plant in the ginger family, native to southern India. It is the most common of the species whose seeds are used as a spice called cardamom that has a sharp, strong, punchy aroma. It is cultivated widely in tropical regions and reportedly naturalized in Réunion, Indochina, and Costa Rica (Wikipedia, 2024a). Large cardamom / black cardamom/ Bengal cardamom/ Indian cardamom/ greater cardamom/ hill cardamom/ winged cardamom/ Nepal cardamom belongs to the family Zingiberaceae, genus *Amomum* and species *Amomum subulatum* Roxb. (Wikipedia, 2024c). *Amomum subulatum*, also known as black cardamom, hill cardamom, Bengal cardamom, greater cardamom, Indian cardamom, Nepal cardamom, winged cardamom, big cardamon, or brown cardamom, is a perennial herbaceous plant in the family Zingiberaceae. Its seed pods have a strong, camphor-like flavour, with a smoky character derived from the method of drying. The pods are used as a spice, in a similar manner to green cardamom pods but with a different flavour. Unlike green cardamom, this spice is rarely used in sweet dishes. Its smoky flavour and aroma derive from traditional methods of drying over open flames. At least two distinct species of black cardamom occur: *Amomum subulatum* (also known as Nepal cardamom) and *Amomum tsao-ko*. The pods of *A. subulatum*, used primarily in the cuisines of India and certain regional cuisines of Pakistan, are the smaller of the two, while the larger pods of *A. tsao-ko* are used in Vietnamese cuisine and Chinese cuisine, particularly that of Sichuan province. In traditional Chinese medicine, black cardamom is used for stomach disorders and malaria. In the traditional medicine of Nepal & India, the decoction of *Amomum subulatum* rhizomes is used in the therapy of jaundice (Wikipedia, 2024c). Black cardamom, or *Amomum subulatum*, is a type of cardamom that is native to India, Bhutan, and Nepal. It is a member of the ginger own family and is regularly known as “hill cardamom” because of its cultivation in hilly areas. Black cardamom pods are large and darker than green cardamom pods, with a rough exterior and a smoky, earthy aroma. Black cardamom has been used for thousands of years in traditional Ayurvedic medicine to treat numerous ailments, together with digestive issues, respiratory troubles, and inflammation. It was also used as a flavoring agent in food and beverages. In ancient instances, black cardamom became considered a luxurious item and changed into frequently used as a form of currency (Sagvekar, 2014a). This spice has an incredibly unique and characteristic flavor. It is pungent and warm, with distinct undertones of eucalyptus and camphor as well as a hint of lemon flavoring. With a taste that is both peppery and citrusy, cardamom has a bit of warmth to it (Niftem, 2024).

Small cardamom, popularly known as ‘Queen of Spices’, is the dried fruit of the tall perennial herbaceous plant, *Elettaria cardamomum* Maton, belonging to the family Zingiberaceae (Korikanthimath, 2000). It is a shade loving plant cultivated at an altitude of 600 to 1200 m above MSL with an annual rainfall of 1500 to 4000 mm and a temperature range of 10 to 35°C (Korikanthimath, 2000). Until recently India was the main producer and exporter of cardamom. Of late Guatemala has emerged as a keen competitor to Indian cardamom in the international spice market. Tanzania, Sri Lanka, El Salvador, Vietnam, Laos, Cambodia and Papua New Guinea are the other cardamom growing countries (Korikanthimath, 2000). In India, cardamom is

cultivated in the southern states of Kerala, Karnataka and Tamil Nadu. Kerala accounts for 60% of the cultivation and production followed by Karnataka 30% and Tamil Nadu 10% (Korikanthimath, 2000). Cardamom oil is used in food, perfumery and liquor and pharmaceutical industries as a flavour and a carminative. Its use in the food industry is in flavouring pickles, meat and canned soups. However, the oil is reported to develop some off flavour in a few days when it contacts with air; its use is therefore restricted to fresh meat products and foods with short shelf-life. Increasing use of cardamom oil is reported in compounded flavours for baked goods, sauces and condiments. Cardamom oil is reported to be gaining increasing use in perfumery, with a trend to spicy tones modifying the dominant lavender group perfumes for women (Korikanthimath, 2000). Cardamom is used as an adjuvant to carminative drugs. It is officially recognised in British and US pharmacopoeias and used as an aromatic stimulant, carminative and flavouring agent. It can be used to ease cigarette addiction. Eating a few seeds of cardamom can safely be recommended to initially minimise the number of cigarettes being smoked, and slowly the smoker may give up the chronic addiction to chain smoking (Korikanthimath, 2000).

Small cardamom (*Elettaria cardamomum* Maton.), popularly called "Queen of Spices", is an important export oriented spice crop (Prasath *et al.*, 2001). India has a rich wealth of genetic resources of cardamom as the crop originated in the tropical forests of Western Ghats (Prasath *et al.*, 2001). Cardamom being cross-pollinated crop, abundant diversity exists in the population which can be exploited both for commercial and scientific interest (Prasath *et al.*, 2001). Assessment of variability for the yield and its components becomes absolutely essential before planning for an appropriate breeding strategy for genetic improvement. Parameters such as genotypic and phenotypic coefficient of variability are useful in detecting the amount of variability present in the germplasm (Prasath *et al.*, 2001). Heritability and genetic advance help in determining the influence of environment on the expression of genotype and the reliability of characters (Prasath *et al.*, 2001). Cardamom, 'Queen of Spices', is the dried fruit of the perennial rhizomatous herb, *Elettaria cardamom urn* Maton, which belongs to the family Zingiberaceae (Prasatha and Venugopal, 2004). It is one of the most ancient and valuable spice crops. This crop is indigenous to South India and Sri Lanka (Prasatha and Venugopal, 2004). The natural habitat of *E. cardamomum* is in the evergreen rainforests of the Western Ghats of South India at altitudes between 600 and 1500 masl. Cardamom is generally cross-pollinated and propagated by seedlings and suckers; occasionally selfing also occurs. Considerable variation is encountered in seedling progenies of cardamom (Prasatha and Venugopal, 2004). The present cardamom-growing area in India is concentrated mainly in those regions that are the natural habitat of the species: between 8°30' and 14°30'N latitude and longitude 75-70°E. This area is an elongated tract from north to south extending over 2000 km, from Sirsi of Karnataka to Thirunelveli of Tamil Nadu. East to west, it is a narrow belt of land distributed over the Western Ghats (Prasatha and Venugopal, 2004). *E. cardamomum* var. *major* Thwaites consists of wild cardamoms that are particularly common in Sri Lanka and Southern India. *E. cardamomum* var. *cardamomum* (syn var. *minor* Watt. var. *minuscula* Burkill) consists of the cultivated cardamoms, which however could better be classified and named as cultivar groups (Prasatha and Venugopal, 2004).

Cardamom, popularly known as the "Queen of Spices," has a checkered history, dating back to the *Vedic* period (ca. 3000 BC) and is among the ingredients poured into the sacrificial fire during the Hindu marriage (Nair, 2006). Today cardamom commands a leading position among the spices of immense commercial importance and is finding its way into the dietary habits of millions around the world, even among people on the European and North American continents, hitherto unaccustomed to its use (Nair, 2006). Cardamom use ranges from a simple dietary constituent to that of immense pharmacological benefits. Although beset with many problems, both agronomic and economic, it is a safe bet that next to black pepper, cardamom will emerge in the world market as a spice of immense commercial importance (Nair, 2006). Although India was the world leader in cardamom production, starting from the 1970s the country began to slide down both in production and productivity, while Guatemala, took the leading position, although the cardamom produced there is of inferior quality (Nair, 2006). Among the primary constraints of production, is the absence of an ideotype that combines many positive traits to boost production potential, while at the same time resisting the ravages of the devastating viral disease *Katte* of the Karnataka State in southern India (Nair, 2006). Cardamom, popularly known as the "Queen of Spices" is the second most important spice crop in the world (Nair, 2006). The description "Queen of Spices" is because cardamom has a very pleasant aroma and taste and is a highly valued spice since time immemorial. It belongs to the genus *Elettaria* and species *cardamomum* (Maton). The term *Elettaria*, which is the generic name, has its origin in the colloquial word *Elettari* (in Tamil, one of the popular South Indian languages) referring to the cardamom seeds (Nair, 2006). In the original description it means a "particle/seed of the leaf." It is a large-sized perennial, herbaceous rhizomatous monocot, which belongs to the Zingiberaceae family (Nair, 2006). The plant is extensively grown in the hilly tracts of southern India at elevation ranging from 800 to 1500 m (Nair, 2006). It grows as an under crop, beneath forest trees as it grows best in shade and cool climate at high elevations. It is grown in Sri Lanka, Papua New Guinea (PNG), and Tanzania on the African continent. Within Latin America, Guatemala is the biggest grower of cardamom. Guatemala is also the biggest competitor to Indian cardamom in the world market (Nair, 2006). Cardamom has an interesting history dating back to Vedic times, about 3000 years BC. In the ancient Indian language Sanskrit, it is referred to as "Ela." In ancient times of the Hindu culture, sacrificial fire was a common ritual and mention of cardamom as an ingredient of the mixture of several materials into the sacrificial fire, solemnizing a Hindu marriage has been mentioned in ancient texts (Nair, 2006). *Charaka Samhita* and *Susrutha Samhita*, the ancient Indian Ayurvedic texts, written in the post-Vedic period (1400–1600 BC) make a mention of cardamom (Nair, 2006). Interestingly reference to cardamom has been seen in the ancient Greek and Roman texts. Spices were the symbols of royalty and luxury and cardamom was used in the manufacture of perfumes during the Greek and Roman times. In addition, cardamom was also used as an aphrodisiac (Nair, 2006).

Significantly, the Greek physician and author of the legendary *Materia Medica*, Dioscorides (40–90 AD) makes a mention of cardamom in his work (Nair, 2006). Cardamom was widely used to aid digestion and that was the most important reason both the Greeks and Romans imported the same in large quantities from India. Thus, it became one of the most popular oriental spices in Greek and Roman cuisine. This led to cardamom being listed as a dutiable item in Alexandria in 176 AD (Nair, 2006). Linschoten

in the *Journal of Indian Travels* (1596) describes two types of cardamom in use in southern India, the “greater” (large) and “lesser” (small) types. This would suggest that the large cardamom found extensively in Nepal must have been finding its way to southern India through land routes, brought by travelers dating back to nearly 4000 years (Nair, 2006). Linschoten writes about lesser cardamom as “it mostly is grown in Calicut and Cannanore, places on the coast of Malabar.” Paludanus, a contemporary of Linschoten, wrote that according to Avicenna, there are two kinds of cardamoms, “greater” and the “lesser” and continues to add that cardamom was unknown to the Greeks such as Galen and Dioscorides (Nair, 2006). Cardamom was considered a minor forest produce. It is only in the beginning of the nineteenth century that cardamom plantations were established, but it was interplanted with coffee. But, its cultivation spread rapidly in the Western Ghats and the region south of Palakkad (the midsouthern district of Kerala) became to be known as Cardamom Hills (Nair, 2006). Principal buyers were Muslims and the best lot, known as “Alleppey Green,” was reserved for export. In the forestland in the state of Kerala, owned by the then British government, cardamom was considered as a “miscellaneous produce,” while in the neighboring Coorg district in the state of Karnataka, forestlands were leased out to private cultivators of cardamom (Nair, 2006). One can surmise from the writings of the British officials that a process of bleaching used to be carried out in Karnataka, and this was done by transporting cardamom to Havre, a place in Dharma district of Karnataka, and the bleaching process was done using the water from a specific well which resulted in enhancement of flavor in the dried product (Nair, 2006). Cardamom cultivation is primarily confined to three South Indian states, namely, Kerala, Karnataka, and Tamil Nadu. Kerala has 59% of the total area cultivated and contributes 70% of the total production. Karnataka has 34% of total area cultivated and contributes 23% to total production, while Tamil Nadu has 7% area and contributes the same percentage to total production (Nair, 2006).

Cardamom of commerce, popularly known as ‘Queen of Spices’, is the dried fruit of the herbaceous perennial *Elettaria cardamomum* Maton, belonging to the Zingiberaceae family (Parthasarathy and Prasath, 2012). It is a shade-loving plant cultivated at an altitude of 600–1200 m above mean sea level (MSL) with an annual rainfall of 1500–4000 mm and a temperature range of 10–35^o C (Parthasarathy and Prasath, 2012). It is used in Ayurvedic medicine preparations because of its healing effect and other properties. It is also used in processed food, perfumes, oleoresins and many other applications (Parthasarathy and Prasath, 2012). Cardamom is known to have been used in India since ancient times. It is known as *Ela* in Sanskrit and references to this can be found in ancient Sanskrit texts (Parthasarathy and Prasath, 2012). The Arab states were the original major traders of Indian spices, including cardamom. Later, in the sixteenth century, the Portuguese started collecting and exporting pepper, ginger and cardamom directly to Europe (Parthasarathy and Prasath, 2012). Only at the beginning of the nineteenth century were plantations established for cardamom cultivation, and even then they were only a secondary crop in coffee plantations (Parthasarathy and Prasath, 2012). It is native to India and Sri Lanka but is now grown in other parts of the world, including Guatemala, Tanzania, and Papua New Guinea. The spice is generally sold in the form of small pods or as loose seeds. Cardamom has a strong, sweet, and spicy aroma, and a pungent, slightly sweet taste with hints of lemon and mint. It is commonly used in sweet and savory dishes, as well as in hot beverages like tea and coffee (Sagvekar, 2014). Cardamom is one of the oldest known spices in the world. Evergreen forests of Western Ghats of South India are considered as the centre of origin as well as natural habitat of cardamom (Ankegowda *et al.*, 2015). Cardamom is commercially cultivated for its dried fruits (capsules), which is also referred as cardamom of commerce (Ankegowda *et al.*, 2015).

Cardamom acclaimed as the 'Queen of Spices' is the true cardamom belonging to the family Zingiberaceae under the natural order Scitaminae (Zakir, 2019). It is herbaceous perennial with underground rhizomes and aerial leafy stems made of leaf sheaths. Cardamom has bisexual flowers, self compatible but cross-pollination is more common (Zakir, 2019). The somatic chromosome number of cardamom is reported to be $2n = 48$. The genetic resource of cardamom is being eroded rapidly with the changes in habitat of the Western Ghats and needs systematic exploration and collection of germplasm (Zakir, 2019). Cardamom germplasm exhibits rich genetic diversity for various agronomic, yield and quality attributing characters. Based on the adaptability, nature of the panicle, shape and size of fruits, the cultivated cardamom is grouped into three botanical varieties *viz.* Malabar, Mysore and Vazhukka (Zakir, 2019). Cardamom is valued for its volatile oil which varies from 6.5 to 10.5 per cent. The major chemical constituents which impart sweet flavour to the oil are terpinyl acetate, linalyl acetate and linalool (Zakir, 2019). *Elettaria cardamomum* (L.) Maton is commonly known as small cardamom, green cardamom, or true cardamom and is grown in India, Guatemala, Sri Lanka, Nepal, Indonesia, Costa Rica, Mexico and Tanzania (Ashokkumar *et al.*, 2020). In India, cardamom is cultivated in altitudes ranging from 900 to 1400 m above msl (mean sea level) covering three southern Indian states (Kerala, Karnataka and Tamil Nadu). In Kerala, it is cultivated mainly in the Indian Cardamom Hills covering an area of 1050 square kilometers designated as Cardamom Hill Reserves (Ashokkumar *et al.*, 2020). The botanical name of cardamom is *Elettaria cardamomum*, originated from the Tamil word “*Elettari*” which refers to the seeds of cardamom (Ashokkumar *et al.*, 2020). In general, the cardamoms are the capsules of dried fruits in different genera of the Zingiberaceae family, primarily *Elettaria*, *Amomum* and *Aframomum*. Among them, *Elettaria cardamomum* (L.) Maton is most important and is grown predominantly in southern India (Ashokkumar *et al.*, 2020). The false cardamom, large cardamom, or black cardamom from the allied genus *Amomum* is native to Nepal, Sikkim, Bengal and southeast Asian countries (Ashokkumar *et al.*, 2020). African cardamom, which is botanically known as *Aframomum danielli* (Hook.f.) K. Schum., is native to south east Africa especially in Tanzania, Cameroon, Madagascar and Guinea (Ashokkumar *et al.*, 2020). Small cardamom is extensively cultivated in Nepal and Sikkim and to a limited extent with the large cardamom (*Amomum subulatum* Roxb.). However, international trade is now limited to Asian countries as far as small and large cardamom are concerned because of high prices. Worldwide, cardamom is recognized as the “queen of spices” for its pleasant aroma and taste, and is the third most expensive spice after saffron and vanilla (Ashokkumar *et al.*, 2020). For centuries, cardamom capsules have been used for culinary and traditional medicine applications including controlling asthma, teeth and gum infections, digestive and kidney disorders, cataracts, nausea, diarrhea and cardiac disorders. The essential oil and other bioactive metabolites accumulated in cardamom capsules contribute to their characteristic aroma and utility as a functional food, pharmaceutical, and nutraceutical (Ashokkumar *et al.*, 2020).

Cardamom (*Elettaria cardamomum* Maton) is herbaceous, perennial monocotyledonous plant belongs to the family Zingiberaceae of the natural order Scitamineae (Nadukeri *et al.*, 2020). It is an ancient spice mentioned in ancient Indian Ayurvedic texts, *Charaka Samhita* and *Sushruta samhita*, written in the post-epic period 1400-600 BC (Nadukeri *et al.*, 2020). The ancient Greeks and Romans also used it in food, medicines and perfumes (Nadukeri *et al.*, 2020). The cardamom of commerce is a dried fruit (capsule) known for its sweet delicate aroma, Hence, it is considered as “Queen of spice” (Nadukeri *et al.*, 2020). Small cardamom is a perennial bushy herb with mauve-marked, orchid-like white flowers and very long, lance-shaped leaves. Indian cardamom is unique in terms of aroma, flavour, size and colour (green) due to warm humid climate, loamy soils rich in organic matter, well distributed rainfall and special cultivation and processing methods (Nadukeri *et al.*, 2020). Cardamom is a major flavouring agent in food products, beverages such as tea, cocoa and coffee, baked foods and in confectionaries (Nadukeri *et al.*, 2020). Cardamom is cross-pollinated crop and propagated through seedlings and suckers, occasionally selfing also occurs (Nadukeri *et al.*, 2020).

Cardamom is the dried fruit of a perennial herbaceous plant in the Zingiberaceae family (Ashokkumar *et al.*, 2021). It's a shade-loving plant that grows at an altitude of 600–1200 metres above sea level, with annual rainfall ranging from 1500–4000 mm and temperatures ranging from 10 to 35°C (Ashokkumar *et al.*, 2021). *Elettaria cardamomum* (Maton.) is the scientific name for cardamom, which comes from the Tamil word Elettari, which means “seeds of cardamom” (Ashokkumar *et al.*, 2021). In India, Sri Lanka, Malaysia, Indonesia, Nepal, Costa Rica, Tanzania, and Mexico, cardamom is widely used (Ashokkumar *et al.*, 2021). South India and Sri Lanka are the only places in the world where this crop grows naturally. *E. cardamomum* natural habitat is in the evergreen rainforests of South India's the Western Ghats, at altitudes ranging from 600 to 1500 metres above sea level (Ashokkumar *et al.*, 2021). Cardamom is commonly cross-pollinated and propagated by seedlings and suckers, with selfing occurring on rare occasions (Ashokkumar *et al.*, 2021). Cardamom capsules have been used for centuries in both ayurvedic and traditional medicine to treat colds, coughs, diuretics, carminatives, digestive illnesses, asthma, bronchitis, teeth and gum infections, urinary and kidney disorders, pulmonary tuberculosis, and irritation of the eyelids (Ashokkumar *et al.*, 2021). Cardamom has been used in Chinese herbal medicine to treat constipation, stomach aches, dysentery in infants, and women's bladder problems. In Ayurvedic medicine, cardamom has long been used to treat food poisoning. Cardamom capsules taken with honey regularly will help to improve eyesight and bad breath (Ashokkumar *et al.*, 2021). Plant-based cosmetics have been attracted by the traditional use of cardamom to treat skin disorders, and spice is also used in hand creams and soaps (Ashokkumar *et al.*, 2021). Cardamom also used in processed foods, perfumes, oleoresins, and a variety of other products. Cardamom essential oil (CEO) and its active chemical constituents accumulated in capsules, contributing to their distinctive fragrance and usefulness as a functional food, medicinal, and nutraceutical ingredient (Ashokkumar *et al.*, 2021).

Cardamom is known as “Queen of spices” belongs to the monocotyledonous family Zingiberaceae, besides that cardamom is indigenous to South India and Sri Lanka, and is believed the plant has been originated in the moist evergreen rainforests of the Western Ghats of South India (Heryanto and Syukur, 2021). Cardamom can grow in mid-elevation until high elevation about the altitude of 600-1300 m asl (Heryanto and Syukur, 2021). Based on plant botany, cardamom is divided into 3 genera, namely *Elettaria*, *Amomum*, and *Aframomum*. However, in the world of international trade, cardamom divided into three types, namely green cardamom, black cardamom, and Madagascar cardamom (Heryanto and Syukur, 2021). The basic chromosome number of cardamom is $x = 12$ and $2n = 48$ which indicates a balanced tetraploid nature (Heryanto and Syukur, 2021). Cardamom has bisexual flowers, is self-compatible, but crosses occur frequently. The blooming period of cardamom flowers occurs for 8-15 hours per day. The peak flowering is spread over a period of six months from May to October (Heryanto and Syukur, 2021). The essential oil content in cardamom is Alpha pinene, sabinene, beta pinene, cineole (Heryanto and Syukur, 2021). Cardamom propagation generally using seed and suckers, its showing considerable variation in cultivation (Heryanto and Syukur, 2021). Cardamom is used as an additive flavor, perfumery, and traditional medicine (Heryanto and Syukur, 2021). There are two types of cardamom that grow in Indonesia, namely Java cardamom (*Amomum cardamomum / compactum*) and green cardamom (*Elettaria cardamomum*) (Heryanto and Syukur, 2021). Java cardamom is native plant from Indonesia and grows wild in the forests on the Java Island. Currently, Java cardamom is widely cultivated in various regions in Indonesia, such as Central Java, East Java, West Java and West Sumatra, which are center production area of *Amomum compactum* (Heryanto and Syukur, 2021). Green cardamom is also called small cardamom, true cardamom, and green cardamom which grows in India, Guatemala, Sri Lanka, Nepal, Indonesia, Costa Rica, Mexico and Tanzania (Heryanto and Syukur, 2021). Green cardamom grows in the moderate to highlands between 600 m above sea level - 1400 m above sea level (Heryanto and Syukur, 2021). The genetic diversity and heritability of a plant is an important component in plant breeding program. Plant genetic diversity is enhanced through introduction, conventional (crossover), and biotechnology (mutation, transgenic, gene transfer). The genetic diversity determines the effectiveness of selection; therefore, selection will be effective if the diversity in the high population. Genetic diversity can be observed in intra-species, inter-species, segregated populations or mutant plant populations (Heryanto and Syukur, 2021).

Elettaria cardamomum Maton or small cardamom is one of the most valued spices worldwide for its versatile flavour and a pleasant aroma. The dried mature fruit capsule which forms the spice is also referred to as the ‘Queen of Spices’ (Mathew *et al.*, 2022). The cardamom plant, a shade-loving monocot, has a rhizomatous herbaceous perennial habit and is indigenous to the moist evergreen forests of the Western Ghats of south India (Mathew *et al.*, 2022). India, formerly the foremost producer, consumer and exporter of small cardamom, is second to Guatemala which fortuitously is currently the largest producer of cardamom (Mathew *et al.*, 2022). India has reported substantial diversity in small cardamom and is considered to be the centre of origin of *E. Cardamomum* (Mathew *et al.*, 2022). The distribution of abundant genetic variability of the species in the Western Ghats substantiates the hypothesis that it is the major centre of genetic diversity of small cardamom. However, more impetus has to be given in broadening the genetic base, developing new varieties with wide adaptability, and strategies to reduce crop vulnerability by promoting genetic diversity rather than monocultures, which would certainly help sustainable production (Mathew *et al.*, 2022)

Cardamom, popularly called as 'Queen of Spices', and the economic part of which is the dried fruit of the perennial rhizomatous herb belonging to the family zingiberaceae (Preethy *et al.*, 2022). It is one of the costliest and most ancient and valuable spice crops since ancient times. The crop is indigenous to south India and Sri Lanka but Guatemala is the largest producer and exporter of the crop (Preethy *et al.*, 2022). The natural habitat of the crop used to be in the evergreen rainforests of the Western Ghats of south India at altitudes between 600 and 1500 m above MSL (Preethy *et al.*, 2022). Cardamom is generally cross-pollinated and propagated by seedlings and suckers; occasionally, selfing also occurs (Preethy *et al.*, 2022). The area is an elongated tract from north to south from Sirsi of Karnataka to Thirunelveli of Tamil Nadu. East to west, it is a narrow belt of highland distributed over the Western Ghats (Preethy *et al.*, 2022). *E. cardamomum* var. *major* Thwaites consists of wild cardamoms that are common in Sri Lanka and southern India. *E. cardamomum* var. *cardamomum* (syn var. *minor* Watt. var. *minuscula* Burkill) consists of the cultivated cardamoms, which could be classified and named as cultivar groups (Preethy *et al.*, 2022).

In Traditional Chinese Medicine Culture: Cardamom was used in traditional Chinese medicine to cure several ailments, such as nausea, vomiting, and stomachaches. Moreover, it was used to treat respiratory problems and chest pain (History, 2023). Cardamom was thought to warm the body and assist in controlling the flow of qi, or life force. In Chinese culture, people would frequently mix it with other energizing plants like ginger and cinnamon for better digestion and increased blood flow (History, 2023). In Chinese medicine, cardamom was also believed to be a treatment for respiratory conditions like coughs, bronchitis, and asthma (History, 2023). It is said to have an expectorant effect, assisting with the release and expulsion of phlegm from the lungs (History, 2023). Also, it has vital significance in traditional Chinese tea ceremonies. Therefore, it was also one of the essential ingredients in Moroccan mint tea (History, 2023). In Ancient Greece: The usage of Cardamom commenced in Greece after the Hellenistic era, which started in the late 4th century BC. Although cardamom is not the native spice of Greece, Greeks were fascinated by its taste and aroma (History, 2023). As a result, they began using cardamom right away in both their cooking and healing (History, 2023). Also, the benefits of cardamom were popular among the Greeks. In his first-century AD book *De Materia Medica*, the Greek physician Dioscorides discussed the therapeutic benefits of cardamom. He suggested cardamom as a treatment for a variety of illnesses, such as infections, coughing, and stomach issues (History, 2023). In ancient Greece, cardamom was also used to flavor wine and other liquids. As the Greeks thought cardamom had sensual qualities, they frequently used it in beverages given at banquets and other special occasions. Also, they used it to flavor slices of bread, pastries, and other baked foods (History, 2023). The Greeks would also use cardamom for religious purposes by using it as an element in incense for religious rites and rituals (History, 2023). In ancient Greece, cardamom was a priceless and exotic spice that was used as a symbol of luxury and sophistication. Since it was expensive and frequently imported from faraway places, only the wealthy and elite could afford to consume it (History, 2023). In Ancient Rome, cardamom was a costly and exotic spice that was primarily imported from India and the Middle East. However, it had some applications in Roman food and medicine (History, 2023). The Romans would use cardamom to make pastries and other sweet meals. It was frequently used with other spices, such as cinnamon and nutmeg, to make rich and complex mixtures (History, 2023). Not to mention, it also worked wonders in the medicinal aspects for the Roman people. They would timely use it to care for illnesses related to their gut or respiratory system (History, 2023). Furthermore, it also found its way into beauty products like body fragrances and beauty cosmetics (History, 2023).

Cardamom is a herbaceous, perennial monocotyledonous plant originating from the Western Ghats of South India and Sri Lanka (Horn *et al.*, 2023). Cardamoms comprise the basic chromosome number $X = 12$ and $2n = 48$, a balanced tetraploid in nature (Horn *et al.*, 2023). Cardamom is divided into 3 genera: *Elettaria*, *Amomum*, and *Aframomum*. Diversity has been reported in the wild and cultivated forms of cardamom, especially those found in southern India (Horn *et al.*, 2023). In the search for productive genotypes, there is a need to collect and evaluate germplasms to identify the level of variation in the cardamom germplasm. Various studies on the analysis of intraspecific variation in cardamom using genome size, cytological studies, and molecular marker data revealed the existence of genetic variability among cardamom accessions and a significant difference in their genome size. These include molecular tools such as simple sequence repeats markers (ISSR) used in analyzing cardamom accessions and revealed variability in yield traits (Horn *et al.*, 2023). Genetic resource conservation aims at maintaining species with a known or potential value to ensure that it is accessible for use to both current and future generations to ensure that it is accessible for use to both current and future generations (Horn *et al.*, 2023).

Small cardamom (*Elettaria cardamomum* Maton), the queen of spices, is the third most expensive spice in the world after saffron and vanilla, valued highly for its aroma and taste (Gaikwad *et al.*, 2023). This perennial herbaceous plant is a native of coastal parts of Southern India and displays a significant amount of morphological diversity (Gaikwad *et al.*, 2023). Its genetic potential has not been exploited due to lack of genomic resources limiting our understanding of the genome and important metabolic pathways which give it the economic advantage in the spice industry (Gaikwad *et al.*, 2023). Small cardamom is a monocot species belonging to the family Zingiberaceae with $2n=4x=48$ (Gaikwad *et al.*, 2023). This species is believed to have originated in the rainforests of the Western Ghats of South India (Gaikwad *et al.*, 2023). As it is a shade loving plant, it is mainly grown under canopies which provides suitable environment for plant growth. In India, it is majorly grown in the three southern states of Kerala, Karnataka and Tamil Nadu, with Kerala alone accounting for more than 58% of the annual production (Gaikwad *et al.*, 2023). Owing to its pleasant taste and aroma, cardamom is commonly referred to as the 'Queen of spices'. The seeds and fruits of cardamom are the economically important parts and have found wide applicability across the culinary and traditional medicine spectrum (Gaikwad *et al.*, 2023). The medicinal properties of cardamom are attributed to the essential oil which is extracted from its fruits. This oil possesses antibacterial, anti-inflammatory and antispasmodic activities (Gaikwad *et al.*, 2023).

Cardamom, is popularly called as 'Queen of Spices', and the economic part of which is the dried capsule fruit of the perennial rhizomatous herb belonging to the family Zingiberaceae (Preethy *et al.*, 2023). It is one of the costliest and most ancient and valuable spice crops since ancient times. Although the crop is indigenous to south India and Sri Lanka, Guatemala is the largest

producer and exporter (Preethy *et al.*, 2023). The natural habitat of the crop used to be in the erstwhile evergreen rainforests of the Western Ghats of south India at altitudes between 600 and 1500 m above MSL (Mean Sea Level) (Preethy *et al.*, 2023). The cardamom-growing areas in India are concentrated mainly in those regions that were the natural habitat of the spices lie between 8°30' and 14°30'N latitude and 75–70°E longitude. The area is an elongated tract from north to south from Sirsi of Karnataka state to Tirunelveli of Tamil Nadu state. From east to west, it is a narrow belt of high uplands distributed over the Western Ghats (Preethy *et al.*, 2023). Sufficient variability for economic traits must exist in the cardamom germplasm for profitable utilization in crop breeding programmes (Preethy *et al.*, 2023). Cardamom is generally a cross-pollinated crop and propagated by seedlings and suckers; occasionally, selfing also occurs. Considerable variation is encountered in seedling progenies of cardamom (Preethy *et al.*, 2023). Based on the nature of panicles, three varieties of cardamom are recognized. The var. *Malabar* is characterized by prostrate panicle, and the var. *Mysore* possesses erect panicle. The third type var. *Vazhukka* is considered as a natural hybrid between the two, and its panicle is semi-erect or flexuous (Preethy *et al.*, 2023). Cardamom, a highly aromatic spice known for its exquisite blend of sweetness and spiciness, has a long and storied history dating back many years (Spice Shuttle, 2024). Indian Cardamom, a valuable spice, find its origins in the captivating landscapes of India. It may be traced back to the beautiful regions of modern-day India, Sri Lanka, and Nepal (Spice Shuttle, 2024). Cardamom, scientifically known as *Elettaria cardamomum*, is a magnificent plant that belongs to the distinguished Zingiberaceae family (Spice Shuttle, 2024). Cardamom has been used since ancient civilizations such as India and Egypt. As contemporary trade networks began to emerge throughout history, cardamom quickly rose to prominence, establishing itself as a highly desired one that readily linked the eastern and Western regions (Spice Shuttle, 2024). Cardamom is still widely utilized in a variety of culinary traditions and cultures all over the globe. It continues to play an important role in a wide variety of traditional culinary creations, beverages, and sweet delights, as well as a variety of cultural customs and thoroughly pleasant celebrations (Spice Shuttle, 2024).

Cardamom, a humble seed with a rich history, traces its origins back to the lush green landscapes of ancient India (IFL, 2024). Born in the warm embrace of Kerala, a region celebrated for its spices, cardamom embarked on a journey that would shape cultures, trade routes, and cuisines worldwide (IFL, 2024). In the vibrant tapestry of ancient India, cardamom found its roots along the Western Ghats in South India (IFL, 2024). Blessed with a warm climate and fertile soil, Kerala provided an ideal environment for cardamom plants to flourish. The Western Ghats in Kerala have nurtured cardamom cultivation for centuries, making it a prized spice in the region (IFL, 2024). Used both as a spice and for its health benefits, cardamom became an integral part of traditional Indian cuisine, reflecting its significance in the local culture (IFL, 2024). As the people of ancient India embraced cardamom, it found its way into the bustling spice trade that connected nations (IFL, 2024). The intricate web of trade routes facilitated the exchange of fragrant goods from the East, including cardamom, cinnamon, cloves, and pepper (IFL, 2024). Arab sailors played a crucial role in introducing cardamom to the Middle East and beyond, contributing to the establishment of vital trade routes (IFL, 2024). This spice trade not only transformed culinary practices but also fostered cultural exchange and economic growth, as Indian spices reached distant lands, altering food customs forever (IFL, 2024). The aromatic allure of cardamom extended beyond India, reaching ancient Egypt, where it became a cherished ingredient in perfumes and incense (IFL, 2024). Its fragrant properties elevated the sensory experience of the time, and it was offered to the gods in religious ceremonies, adding a spiritual dimension to its significance (IFL, 2024). In the culinary realms of Greece and Rome, cardamom found favour, enhancing the flavours of both sweet and savoury dishes. Its inclusion in cookbooks of the time highlights its popularity as an essential element for achieving culinary excellence (IFL, 2024). The spice trade continued to flourish through the medieval period, and cardamom maintained its esteemed status in the culinary practices of societies like Greece and Rome (IFL, 2024). As the Renaissance dawned, a renewed interest in spices emerged, propelling cardamom into the spotlight for both cooking and medicinal purposes (IFL, 2024). Cooks during the Renaissance showcased the spice's unique flavour in elaborate and exotic meals, while researchers explored its potential health benefits, paving the way for its integration into traditional medicine (IFL, 2024). In the contemporary culinary landscape, cardamom remains a global delight, gracing dishes in homes worldwide. Its versatility allows it to shine in various cuisines, from Indian soups to Middle Eastern sweets, enriching the taste profile of diverse dishes (IFL, 2024). Beyond the kitchen, cardamom continues to be valued for its potential health benefits. Widely recognised for aiding digestion, reducing inflammation, and combating free radicals, cardamom has become a staple ingredient in medical and wellness products. Its essential oil, a key player in aromatherapy, contributes to relaxation and mental clarity, reflecting its enduring influence on well-being practices (IFL, 2024).

Cardamom is one of the world's very ancient spices and also known as the queen of all spices. It is native to the East originating in the forests of the Western Ghats in southern India, where it grows wild. Cardamom is grown in Kerala, Tamil Nadu and Karnataka (Seema, 2024). It is the dried fruit of a herbaceous perennial plant. Warm humid climate, loamy soil rich in organic matter, distributed rainfall and special cultivation and processing methods all combine to make Indian cardamom truly unique-in aroma, flavour, size and it has parrot green colour (Seema, 2024). It has well established culinary values, and it is used in a wide range of sweets and confectionery. It is an important ingredient of gram masala, a combination spice for many vegetarian and non-vegetarian dishes. Cardamom acts as a mouth-freshener after meals. Tea and coffee made with cardamom are pleasantly aromatic and refreshing (Seema, 2024). There are three grades in which Indian cardamom is well known in the International market, 'Alleppey Green Extra Bold' (AGEB), 'Alleppey Green Bold' (AGB) and 'Alleppey Green Superior' (AGS). Cardamom oil is an essential factor in food items and in preparation of certain medicines. Indian cardamom is known worldwide for its quality and is exported to various countries (Seema, 2024). Today it also grows in Sri Lanka, Guatemala, Indo China and Tanzania. The ancient Egyptians chewed cardamom seeds as a tooth cleaner; the Greeks and Romans used it as a perfume. Vikings came upon cardamom about one thousand years ago, in Constantinople, and introduced it into Scandinavia, where it remains popular to this day (Seema, 2024). Cardamom is an expensive spice, second only to saffron. It is often adulterated and there are many inferior substitutes from cardamom-related plants, such as Siam cardamom, Nepal cardamom, winged Java cardamom, and bastard cardamom. (Seema, 2024). However, it is only *Elettaria cardamomum* which is the true cardamom. Indian cardamom is known in

two main varieties – Malabar cardamom and Mysore cardamom. The Mysore variety contains higher levels of cineol and limonene and hence is more aromatic (Seema, 2024).

Cardamom belonging to the, family *Zingiberaceae*, known as the “Queen of Spices” is an important plantation crop of India (Saxen, 2024). The name cardamom is used for species within three genera in the Ginger family (*Zingiberaceae*). One of these genera is *Amomum*, where the species are mainly found in Asia and Australia. Another, *Aframomum*, is distributed in Africa and Madagascar, and *Elettaria* is distributed from India to W. Malaysia (Saxen, 2024). Cardamoms are the dried fruits of perennial herbs. The seeds have a pleasant aroma and a characteristic warm, slightly pungent taste. There are two kinds of cardamoms found in the spice world: 1. True cardamom (or small cardamom) is *Elettaria*, 2. Large cardamom, Nepal cardamom or the black cardamom belongs to the genus *Amomum*. Its seed pods have a strong camphor-like flavor, with a smoky character derived from the method of drying. Cardamom is perhaps the costliest among all the spices (Saxen, 2024). Cardamom is often named as the third most expensive spice in the world (after saffron and vanilla), and the high price reflects the high reputation of this most pleasantly scented spice (Saxen, 2024). Cardamom (*Elettaria cardamomum* Maton) is one of the oldest known spices in the world. Evergreen forests of Western Ghats of South India are considered as the centre of origin as well as natural habitat of cardamom (Vikaspedia, 2024). Cardamom is commercially cultivated for its dried fruits (capsules), which is also referred as cardamom of commerce (Vikaspedia, 2024). Origin, Taxonomy, Botanical Description, Genetics and Cytogenetics, Genetic Diversity, Breeding and Cultivation of Cardamom are discussed.

ORIGIN AND DISTRIBUTION

Cardamom is native to India. From Kerala in south-east India, in the mountains of the same name: the Cardamom Mountains. Traces of its use date back to 3000 BC. It arrived in Europe in the early Middle Ages, carried by the Arabs and sold to the Greeks and Romans. It was found in their perfumes and was much used in their cooking. Following Vasco da Gama's arrival on the Malabar coast on May 20, 1498, cardamom and other spices were exported en masse to Europe. But it was supplanted by pepper and ginger, which Europeans preferred. Nevertheless, it was considered for its therapeutic virtues. Today, with the attraction of new cuisines and spice discoveries, it's back in the spotlight (MD, 2021). Cardamom has an interesting past that goes back to the colorful scenery of old India. It was actually born in the green state of Kerala. Kerala is located in the southern part of the Indian region.

The Western Ghats in Kerala have been home to cardamom cultivation for over 2,000 years (Thomas, 2023). Cardamom, popularly known as Queen of Spices is native to the evergreen rainy forests of Western Ghats in South India (TNAU, 2024). The earliest reference to cardamom is a clay tablet from the ancient city of Nippur, Sumaria, dated 2000 BC. Cardamoms are reportedly described in the Ayurvedic literature in India (3rd century BC), where they were recommended for stomach and urinary disorders. Cardamom was an article of trade between India and Greece during the 4th century BC. Inferior grades were known as amomon, superior ones as kardamomon, but it is still debated whether these were the same cardamoms or just those currently known as the large and small cardamom of today. References to the use of cardamom in ancient literature are scanty compared to spices like black pepper, cinnamon or cassia. Cardamom was a natural forest product until the early 19th century, and its large scale organized cultivation started only in the mid 19th century when the demand for cardamom increased Worldwide (Module, 2024). Cultivation of cardamom is mostly concentrated in the ever green forests of Western Ghats in South India. Besides India, cardamom is grown as a commercial crop in Guatemala and on small scale in Tanzania, Sri Lanka, El Salvador, Vietnam, Laos, Thailand, Cambodia, Honduras, and Papua & New Guinea. The optimum altitudinal range on growing cardamom is 600 to 1500 mtr above MsL.

The cardamom growing regions of South India lies within 8 - 30 degree N latitudes and 75-78 degree longitudes (Indianspices, 2024). The earliest reference to cardamom is a clay tablet from the ancient city of Nippur, Sumaria, dated 2000 BC. Cardamoms are reportedly described in the Ayurvedic literature in India (3rd century BC), where they were recommended for stomach and urinary disorders. Cardamom was an article of trade between India and Greece during the 4th century BC. Inferior grades were known as amomon, superior ones as kardamomon, but it is still debated whether these were the same cardamoms or just those currently known as the large and small cardamom of today. References to the use of cardamom in ancient literature are scanty. Cardamom was a natural forest product until the early 19th century, and its large scale organized cultivation started only in the mid 19th century when the demand for cardamom increased worldwide. Nowadays cardamom production is concentrated mainly in India and Guatemala. India has been the largest producer, consumer and exporter till 1980, but afterwards its position was taken over by Guatemala (Indianspices, 2024a). Cardamom is native to South India and Sri Lanka. Although these countries are the largest producers of cardamom, only a small part of production is exported because of large domestic demand. The main exporting country today is Guatemala, where cardamom cultivation was introduced less than a century ago and the crop is grown entirely for export (Seema, 2024). Because the seeds lose fragrance rather quickly, the fruits (pods) are normally sold and often used whole, or chopped with the seeds (Seema, 2024). The earliest reference to cardamom is a clay tablet from the ancient city of Nippur, Sumaria, dated 2000 BC (Weiss, 2002). Cardamoms are reportedly described in the *Ayurvedic* literature in India (3rd century BC), where they were recommended for stomach and urinary disorders. Cardamom was an article of trade between and India Greece during the 4th century BC. Inferior grades were known as *amomon*, superior ones as *kardamomon*, but it is still debated whether these were the same cardamoms or just those currently known as the large and small cardamom of today. References to the use of cardamom in ancient literature are scanty compared to spices like black pepper, cinnamon or cassia. Cardamom was a natural forest product until the early 19th century, and its large scale organized cultivation started only in the mid 19th century when the demand for cardamom increased worldwide (Saxen, 2024).

TAXONOMY

Cardamom belongs to the genus *Elettaria* and species *cardamomum* (Maton). The name is derived from the root Elettari, which in the popular South Indian language Tamil, means granules of leaf. The genus consists of about seven species. Only *Elettaria cardamomum* (Maton) grows in India which is of economic importance. Closely related to *E. cardamomum* (Maton) is *E. ensal* (Gaertn) Abeywick. *E. major* (Thaiw.) is a native of Sri Lanka which is a much larger and sturdier plant (Nair, 2006).

Cardamom (*Elettaria cardamomum* Maton) belongs to the natural order Scitaminae under the family Zingiberaceae. The genus *Elettaria* consists of a small number of spices distributed in India, Sri Lanka, Malaysia and Indonesia. Two botanical varieties have been distinguished based on the size of the fruits, one for the wild taxon and one for the cultivated forms (Parthasarathy and Prasath, 2012):

- *Elettaria cardamomum* var *major* Thw. comprising the 'wild' indigenous cardamom of Sri Lanka, also known as greater oblong cardamom or long cardamom.
- *Elettaria cardamomum* var *minor* Watt (syn *Elettaria cardamomum* var *minuscule* Burtkill) comprising all the cultivated groups. This cultivated cardamom can be grouped into many cultivar groups, the two most important ones being *Malabar* and *Mysore*.

There are two main types of cardamom: green cardamom and black cardamom. Green cardamom is the most common type and is frequently used in Indian and Middle Eastern cuisine. It has a sweet and flowery aroma and a slightly sweet taste. Black cardamom, on the other hand, has a smoke-filled and earthy aroma and a strong, pungent taste. It is generally used in savory dishes like curries and stews (Sagvekar, 2014).

The two main types of cardamom are (Wikipedia, 2024):

True or green cardamom (or white cardamom when bleached) comes from the species *Elettaria cardamomum* and is distributed from India to Malaysia. What is often referred to as white cardamom is actually Siam cardamom, *Amomum krervanh*. Black cardamom, also known as brown, greater, large, longer, or Nepal cardamom, comes from the species *Amomum subulatum* and is native to the eastern Himalayas and mostly cultivated in Eastern Nepal, Sikkim, and parts of Darjeeling district in West Bengal of India, and southern Bhutan. The two types of cardamom, καρδάμωμον and ἄμωμον, were distinguished in the fourth century BCE by Theophrastus.

There are two main types of cardamom (Saxen, 2024):

- Small green cardamom (*Elettaria cardamomum*) and
- Large red/black cardamom (*Amomum subulatum* Roxb).

The most common type is the small green cardamom while large cardamom is mainly grown in India, with some in Nepal and Bhutan. They both come from the Zingiberaceae family of plants.

There are two main types of cardamom (Seema, 2024):

- Elettaria* (commonly called cardamom, green cardamom, or true cardamom) is distributed from India to Malaysia.
- Amomum* (commonly known as black cardamom, brown cardamom, Kravan, Java cardamom, Bengal cardamom, Siamese cardamom, white or red cardamom) is distributed mainly in Asia and Australia.

The Sanskrit name for cardamom is "ela". In Urdu/Hindi/Gujarati and some Southern Indian languages. It is called "elaichi" or "elchi" (Fig. 1).

Green cardamom pods are common, presenting a vibrant green husk. In contrast.

Black cardamom pods are larger, with a deep brown or black coloration, and a rougher texture.

The distinctive colors, including infrequent

White cardamom pods (which are bleached green pods), serve as visual cues to their variety.

Green: Herbaceous with a bright hue

Black: Dark with a coarser surface

White: Light tone, less common

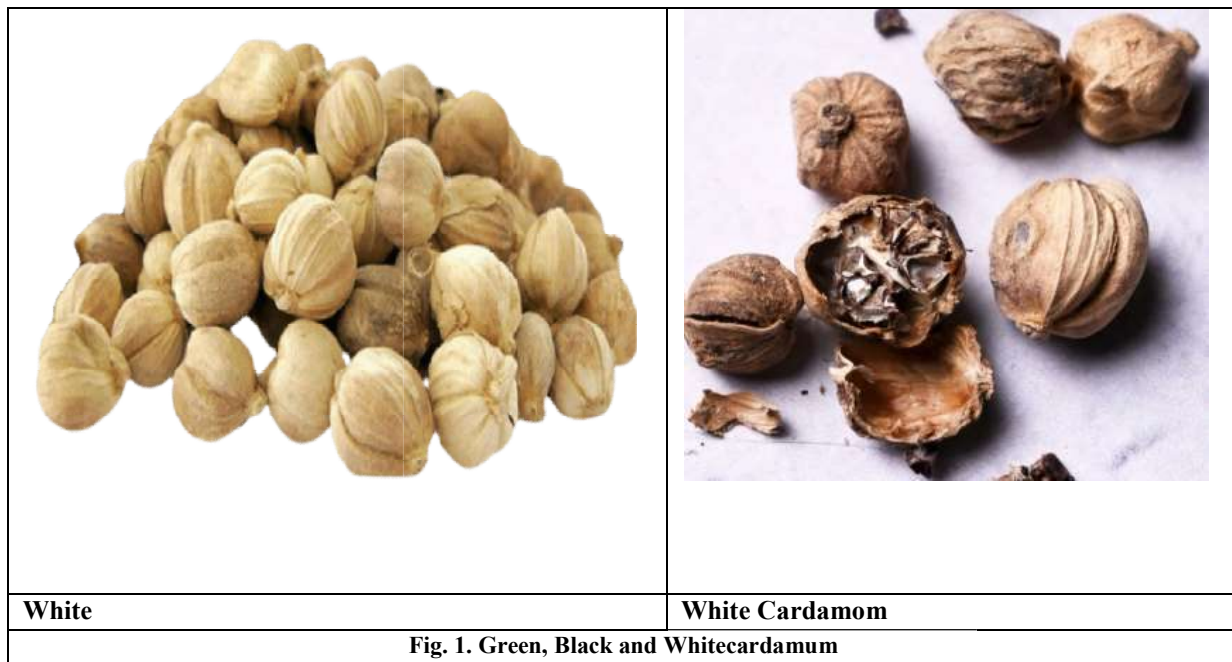
Synonyms (Wikipedia, 2024a).

Amomum cardamomum L.

Amomum repens Sonn., illegitimate superfluous name
Amomum racemosum Lam., illegitimate superfluous name
Alpinia cardamomum (L.) Roxb.
Cardamomum officinale Salisb.
Zingiber cardamomum (L.) Stokes
Matonia cardamomum (L.) Stephenson & J.M.Churchill
Cardamomum verum Oken, illegitimate superfluous name
Elettaria repens Baill., illegitimate superfluous name
Elettaria cardamomum var. *minor* Watt, not validly published
Cardamomum elletari Garsault, rejected name
Zingiber minus Gaertn.
Amomum ensal Raeusch.
Amomum uncinatum Stokes
Cardamomum malabaricum Pritz.
Cardamomum minus (Gaertn.) Kuntze
Elettaria cardamomum var. *minuscula* Burkill, without description.

	
<p>Green</p>	<p>Green Cardamom</p>
	
<p>Black</p>	<p>Black Cardamom</p>

Continue



BOTANICAL DESCRIPTION







Cardamom is an herbaceous perennial (2–5 m in height) with underground (subterranean) rhizomes, with aerial pseudo stems (tillers) made of leaf sheaths. Studies of vegetative growth indicate that suckers continue their growth for a period of about 18 months from time of emergence. The rate of linear growth is at its maximum during June and July, when the suckers have attained an age of about one year. The development of reproductive buds (panicles) can be seen in 89 % of them, indicating that the suckers require about 10–12 months to attain maturity. It takes almost ten months for a vegetative bud to develop and about a year for the panicle to emerge from the newly formed tillers. A study was carried out a round-the-year study on the phenology of the tiller and panicle in three varieties of cardamom. They found that it took around 90–100 days for the emergence of the first flower from the panicles, irrespective of the variety. The inflorescence is a long panicle with racemose clusters rising from the underground stem, but coming up above the soil (Parthasarathy and Prasath, 2012). The advancement of regenerative buds (panicles) takes place in about 10 to 12 months. Inflorescence is a long panicle emerging from the underground stem, but comes up above the soil. The direct development of panicles stretches over a period of seven months. The growth habit of the panicles and the shape as well as the size of the capsules shifts in various developed varieties of cardamom. Flowers are arranged in bunches (known as cincinni) subtended by scale leaves. Flowers are bisexual, bracts linear, oblong and persistent, sepals 3, petals 3, unequal, lip longer with violet tinge carpels 3, style 1, ovary - trilobular, axile placentation, ovules-many in each carpel. Normally flowering in cardamom could be seen throughout the year on panicles formed during the current as well as in previous year. The peak flowering is spread over a period of six months from May to October (Zakir, 2019).

Cardamom is a herbaceous perennial with underground rhizomes that are propagated by rhizome division. It can reach a height of 2-5 metres. The leaves are dark green in colour and lanceolate in form with an acuminate tip, and the aerial stem is formed by encircling the leaf sheaths. Tillers arise from the axils of the underground stem. The majority of vegetative buds develop during the monsoon season. The inflorescence is a long panicle with racemose clusters growing above the soil from the underground stem. 2 to 4 panicles emerge from the swollen base of tillers in most cultivars, and some cultivars have panicles with multiple branches. The flowers are white with a pink central lip and develop in a loose spike 30–60 cm long that emerges from the rhizome. Different cultivated varieties of cardamom have different panicle growth habits and different capsule shapes and sizes. After four months, flowers emerge on the panicle, and flowering lasts for six months. A cincinnus grows in each flower cluster. Bracts are linear, oblong, and persistent, and the flowers are bisexual. Three racemose sepals and three unequal petals, with a longer lip and three violet carpels. The flower has one style and two-lobed anthers that are adnate to the filament and dehisce vertically. Pollen grains range in size from 75 to 120 microns in diameter. The stigma has cilia around a small cavity and is funnel-shaped. The ovary is trilobular, and the placentation is axile. Each carpel contains a large number of ovules. Anthesis usually begins at 3.30 a.m. and lasts until 7.30 a.m., with the peak pollen bursting to occur between 5.30 and 6.30 a.m. In about 120 days after flowering, the fruits are fully mature. Trilobular, ellipsoidal, nondehiscent, green-yellow fruits measure 1-2 cm in length and are trilobular, ellipsoidal, non-dehiscent. The ripe seeds are black in colour and covered in a white mucilaginous layer, and each capsule contains 12 to 32 seeds, depending on genotypes. Honeybees are the only pollinators of cardamom, which is heavily cross-pollinated (Ashokkumar *et al.*, 2021).

Elettaria cardamomum is a pungent, aromatic, herbaceous, perennial plant, growing to about 2–4 m in height. The leaves are alternate in two ranks, linear-lanceolate, 40–60 cm long, with a long pointed tip. The flowers are white to lilac or pale violet, produced in a loose spike 30–60 cm long. The fruit is a three-sided yellow-green pod 1–2 cm long, containing several (15-20) black and brown seeds (Wikipedia, 2024a). Cardamom comes from the seeds of a ginger-like plant. The small, brown-black sticky seeds are contained in a pod in three double rows with about six seeds in each row. The pods are between 5-20 mm long, the larger variety known as 'black', being brown and the smaller being green. White-bleached pods are also available. The pods are roughly

triangular in cross section and oval or oblate. Their dried surface is rough and furrowed, the large ‘blacks’ having deep wrinkles. The texture of the pod is that of tough paper. Pods are available whole or split and the seeds are sold loose or ground. It is best to buy the whole pods as ground cardamom quickly loses flavour. Bouquet – Pungent, warm and aromatic. Flavour – Warm and eucalyptine with camphorous and lemony undertones. Black cardamom is blunter, the eucalyptus and camphor suggestions very pronounced (Seema, 2024). The cardamom plant is a 2-4 m tall herbaceous perennial with branched subterranean rhizomes from which several leafy shoots arise, forming a clump. Leafy shoots have a limited life span; the first year is mainly for vegetative growth, the second year for reproductive growth (flowers and fruits), and the third year a senescence and death stage. New buds are formed from the base of the old shoots in the first and second year and thus, in a clump of old shoot. Young shoots and buds can be seen in varying numbers. Flowers are borne on erect, prostrate or semi-erect (flexuous) inflorescences depending on the variety. The leaves are lanceolate in shape, and lamina tapers into a sharp tip, 25-90 cm long and 5-15 cm wide. Leaves are dark green and shiny on the upper surface and pale green on the lower surface.

The lower surface of the leaf could be smooth (glabrous) or pubescent (hairy) depending on the variety. The inflorescence arises from the base of the leafy shoots and is 45-120 cm long. Flowers are borne in racemes, they are hermaphrodite, zygomorphic and about 4 cm long and 1.5 cm wide. The calyx is tubular green and shortly three-toothed and persistent. The corolla tube is as long as the calyx tube, with narrow spreading pale green lobes. Flowers have an attractive petaloid labellum which is made of modified stamens, about 1.8 cm long with an undulating edge. The labellum is white in color with violet streaks radiating from the center. There is only one functional stamen which has a short, flat, broad filament, with a longer anther and connected with a short crest. The inferior ovary consists of three united carpels with numerous ovules in axile placentation and a slender style with a small capitate stigma which sits on the top to the anther along the crest. Flower initiation takes place along with the onset of the rains (March-April in India). From initiation to full bloom it takes 25 to 35 days, and from bloom to maturity, 110 to 140 days. The fruit is a trilocular capsule, ovate-globose, dark green to pale green in color. On ripening the capsule turns yellow in color; it contains 15-30 seeds which are dark brown, angled, aromatic and about 3 mm long with a thin mucilaginous aril (Saxen, 2024). Botanical Description of green cardamom is given in Fig.2.

		
<p>Intact and opened cardamom pods, showing the seeds</p>	<p>Cardamom seeds</p>	<p>Seedlings</p>
		
<p>Seedlings</p>	<p>Seedling planted</p>	<p>Leaves of cardamom</p>

Continue













		
<p>Plant (one year old)</p>	<p>Plants</p>	<p>Flowers</p>
		
<p>Flower</p>	<p>Plants</p>	<p>Plantation</p>
		
<p>Plants with pods</p>	<p>Pods</p>	<p>Harvesting</p>
		
<p>Winnoing</p>	<p>Drying the seeds</p>	<p>Pods</p>

Fig. 2. Botanical Description Green Cadamom

Pollination

Cardamom has bisexual flowers, self-compatible but cross-pollination is more common. Apis cerana and Apis dorsata are the predominant pollinators. Cardamom flowers remain in bloom for 15-18 hours and stigma receptivity and pollen viability were reported to be maximum during morning hours between 8 AM and 10 AM. Pollination during this time result about 72% fruit set. Thereafter, the stigma receptivity declined gradually giving in the minimum fruit set of 24%. The active foraging of bees is observed in the morning hours of the day providing higher fruit set in cardamom. The extent of fruit set noted in various months implied that there was high percentage of fruit set (50 to 59 percent) during June, July, August and September because of humid atmosphere that prevailed during this period. However, during the dry season from December to March, there was actually very little fruit set (Zakir, 2019). The time required to a full bloom stage from flower/bud initiation ranges from 26 to 34 days and capsule development takes about 110 to 120 days from the full bloom stage. As a rule, most extreme number of flowers open during early hours of the day 3.30 - 8.00 AM immediately followed by the anthesis. The dehiscence of anthers took place immediately followed by anthesis with maximum pollen bursting between 5.30-6.30 AM. The pollen grains were round and mostly found in single, measured on an average 87.6 μ in diameter. Studies on the viability of the pollen grains indicated only 6.5% viability after 2 hours of storage and 0% after 6-8 hours of storage. However cardamom pollen can be stored successfully in liquid nitrogen (Zakir, 2019).

Pollination management: The number of honeybee colonies required for effective pollination of cardamom is a minimum of four colonies (about 5000 foragers per colony) per hectare (3000 plants). Bee pollination resulted in a 9–13 % yield increase and better quality capsules of uniform size and shape. Mulching during flowering hinders bee pollination, resulting in a 33–44 % reduction in fruit set. Thus, de-mulching is recommended after the pre-monsoon showers to facilitate better honeybee movement and capsule setting. Promoting the use of beekeeping for pollination of cash crops will be of benefit to both the beekeeper, who will receive money for the pollination services of his honeybees as well as harvesting more honey, and the farmer whose income will be increased through boosting crop productivity as a result of the pollination services of the bees (Parthasarathy and Prasath, 2012).

GENETICS AND CYTOGENETICS

The chromosomal numbers for cardamom are $2n = 48$ and $2n = 52$. Cardamom is considered to be a balanced tetraploid. The Mysore and Malabar varieties of cardamom possess $2n = 50$ and $2n = 48$ chromosomes, respectively, and aneuploidy as well as structural alterations in the chromosome have contributed to the varietal Differentiation. Earlier researchers have reported that cardamom is of amphidiploid origin from wild species, and the two species considered to be the putative parents are the Sri Lankan cardamom *E. major* and the Malaysian species *E. longituba* (Parthasarathy and Prasath, 2012). The somatic chromosome number of cardamom is reported to be $2n = 48$ and $2n=52$. Variations in chromosome numbers were seen in Mysore and Malabar varieties of cardamom implied that aneuploidy as well as structural alterations in the 17 chromosome contributed to the varietal differentiation. Earlier researchers have reported that cardamom is of amphidiploid origin from wild species, which are probably extinct (Zakir, 2019). Small cardamom, *E. cardamomum* (L.) Maton belongs to the Zingiberaceae family. The basic chromosome numbers $x = 12$ and $2n = 48$ demonstrate the presence of a balanced tetraploid. *Elettaria* is a genus of about seven species, one of which is *E. cardamomum*, which is only grown in India (Ashokkumar *et al.*, 2021).

GENETIC DIVERSITY

Investigation was undertaken to quantify the available variability in small cardamom (*Elettaria cardamomum* Maton.) based on nine quantitative characters, to identify desirable genotypes based on performance, and to select promising donors for various characters which may be used in hybridization programme to obtain useful recombinants and to create genetic variability. The study was conducted at Indian Institute of Spices Research, Cardamom Research Centre, Appangala, Madikeri, Kodagu (Dt.), Karnataka, which is located in heavy rainfall region (2500-3500 mm/annum) at an elevation of 1000 MSL. The experimental material comprised 119 Malabar (prostrate panicle types) accessions spaced at 2 m x 2 m between the rows and plants. The accessions, represented collections and distinct morphotypes from cardamom growing tracts such as Waynad, Anamalais, Manjoli Hills, Nelliampathy, Lower Pulneys, Meghamalai and Cardamom Hills. Uniform suckers were planted during 1997 and the observations were recorded during 1999-2000 crop season on plant height, total tillers, bearing tillers, panicle length, number of nodes/panicle, internodal length, number of capsules/plant and yield/plant as recommended in IPGRI descriptor 1994. The mean value obtained were used for determining phenotypic coefficient variation (PCV) and genotypic coefficient of variation (GCV) (Comstock and Robinson, 1952), heritability (Allard, 1960) and expected genetic Advance. The analysis of variance (ANOVA) for nine characters indicated that there is a considerable variation in respect to all the characters studied. However, absolute variability in different characters cannot be the criteria for deciding, as to which character is showing the highest degree of variability. For this, computation of phenotypic variance (V_p), genotypic variances (V_g) and coefficient of variation was done. Maximum variation in Malabar type was exhibited by number of capsules! followed by yield/plant and number of panicles both at genotypic and phenotypic levels. The variance was very low for characters like plant height and internodal length. GCV was less compared to that of PCV for all the characters indicating a considerable influence of the environment on their expression. The GCV, which exhibits the extent of genetic variability in the population, ranged from 21.46 (plant height) to 129.89 (yield/plant). The GCV values were considerably high for characters such as yield/plant, number of capsules/plant and number of panicles. The above mentioned characters having higher range of variation have a better scope for improvement through selection. Characters such as plant height, panicle length and number of nodes/panicles had nearly equal PCV and GCV values indicating least influence of the environment on their expression. In such a situation, selection can be effective on the basis of the phenotype alone with equal probability of success (Prasath *et al.*, 2001).

Study aims to determine genetic diversity and relationship between 100 cardamom lines based on their morphological characteristics. The seeds used are 100 lines from cross-pollination of cardamom parents. Seeds are planted in a 30 cm x 30 cm polybag filled with soil and manure. Morphological traits parameters observed divided into two categories are a quantitative and qualitative character. Morphological quantitative traits include plant height, number of tillers, number of leaves, stem diameter, leaf length, leaf width, and leaf thickness. Whereas qualitative morphological characteristics are leaf color, leaf shape, leaf base shape, and leaf tip shape. The value of genetic diversity, which is big shown by the morphology characteristics is the number of tillers, number of leaves, stem diameter, and leaf thickness where shows the coefficient variety value more than 25%. Cluster analysis created three major groups. In this study, based on the coefficient of variation value, the high level of accession diversity was indicated by morphological characteristics, namely the number of tillers (61.37%), number of leaves (47.46%), stem diameter (39.66%), and leaf thickness (37.55%). The results of the kinship analysis showed that the 100 cardamom lines were divided into three major groups (Heryanto and Syukur, 2021).

Three-hundred-and-ten accessions of cardamom germplasm were evaluated for 16 characters. Nine of the characters showed high variability. Following non-hierarchical Euclidean cluster analysis all the genotypes were grouped into three clusters with a variable number of genotypes. Accessions of three cultivar groups often grouped together in the same cluster, suggesting some degree of ancestry between the three groups (Prasatha and Venugopal, 2004). The result of the present investigation from the ANOVA showed that, all the growth characters shown significant difference at 1 and 5 per cent level except for the trait leaf breadth. Phenotypic coefficient of variation is slight higher than genotypic coefficient of variation for all the growth characters. Highest GCV (23.5%) and PCV (24.3%) were recorded for the trait number of leaves per tiller. High heritability (99.0%) and genetic advance over mean (48.2%) was noticed for the trait number of vegetative buds per clump (Nadukeri *et al.*, 2020). Sixty seven cardamom accessions were studied for genetic diversity by evaluating fourteen characters for three years (2006-2009) continuously. Almost all accessions showed significant variability for the biometric and biotic stress characters. The results indicated a great amount of genetic diversity in small cardamom in the evergreen tropical forest of the Western Ghats (Preethy *et al.*, 2022).

Variations among the germplasm collections in morphological and biometrical characters as well as for yield have been studied in 196 germplasm accessions of small cardamom. Accessions with distinct morphological marker characters, such as compound panicle types, terminal panicle bearing, narrow leaf types, pink pseudostem types, dark green bold capsules with high-yield potential and biotic-stress tolerant types, are being evaluated and conserved in this repository.

The assessment of genetic diversity is an essential prerequisite for undertaking crop breeding activities to evolve suitable area and region-specific variety. Sixty-seven cardamom accessions were studied for genetic diversity by evaluating 14 unique characters for 3 years (2016–2018). Almost all accessions have shown significant variability for most of the biometric and biotic stress characters. Results have indicated a greater magnitude of genetic diversity of small cardamom present among accessions representing whole evergreen tropical forest of the Western Ghats (Preethy *et al.*, 2023).

BREEDING

Germplasm: India is recognized as a rich source of genetic diversity for cardamom. Today, the conservation and use of the genetic resources of cardamom constitute one of the priority programmes adopted by the Indian Institute of Spices Research. Numerous exploration missions have been carried out leading to the collection of about 310 accessions. The collected germplasm accessions are conserved in *ex silo* and *in vitro* germ plasm repositories (short and long term). Accessions with distinct morphological marker characters, such as compound panicle types, terminal panicle bearing, narrow leaf types, pink pseudostem types, dark green and bold capsules and high-yielding biotic-stress tolerant types, are conserved in the repository. The genetic resource of cardamom is being eroded quickly with the changes in habitat of the Western Ghats and wants systematic exploration and collection of germplasm. A good collection of cardamom is maintained at IISR, Indian cardamom Research Institute, Myladumpara and many centres of All India Coordinated Research Project on Spices.

Cardamom being a vegetatively propagated crop, germplasm is currently protected in clonal repositories in the field which is labour intensive and exposed to hazards such as outbreak of pests, diseases and drought. Field repositories of cardamom are also exposed to diseases such as „kutte“ and rhizome rot resulting in considerable loss. Therefore, *in vitro* conservation of germplasm, in addition to field gene banks, would give safety of germplasm collections (Zakir, 2019). In India, currently, six research organizations, namely, ICAR-Indian Institute of Spices Research (IISR), Kozhikode, Kerala; Cardamom Research Centre, Appangala, Karnataka; Indian Cardamom Research Institute (ICRI), Myladumpara, Kerala and its Regional Research Station, Sakleshpur, Karnataka; Regional Research Station, Mudigere (the University of Agricultural and Horticultural Sciences) and Cardamom Research Station (CRS), Pampadumpara (Kerala Agricultural University, Kerala) are engaged in research for the improvement of cardamom. Those research institutions have begun conducting routine surveys for different accessions or germplasm lines to exploit desirable genes using a variety of traditional and modern crop improvement techniques. Various centres are preserving the collections of a significant number of indigenous lines. The Cardamom Research Station (CRS), Pampadumpara, has collected and conserved 190 germplasm lines until 2020 (Ashokkumar *et al.*, 2021). As part of AICRP on Spices, a total of 200 germplasm accessions of small cardamom are being maintained at Cardamom Research Station Pampadumpara as field gene bank repository (Preethy *et al.*, 2022).

Table 1. Cardamum germplasm in India

Research station/Institutions	Number of germplasm holdings	Number of wild and related taxa holding
Cardamom Research Station (CRS), Kerala Agricultural University (KAU), Pampadumpara, Idukki, Kerala, India	190	15
Indian Cardamom Research Centre, Myladumpara, Idukki, Kerala, India	660	12
Indian Institute of Spice Research, Regional Station, Appangala, Coorg, Karnataka, India	314	13
Regional Research Station, (University of Agricultural and Horticultural Sciences.), Mudigere, Karnataka, India	245	7
Horticultural Research Station, Tamil Nadu Agricultural University, Yercaud, Tamil Nadu	35	-
United Planters Association of South India, UPASI, Valparai, Tamil Nadu	45	-

Objectives of Breeding

Cardamom crop improvement methods include clonal selection, hybridization, polycross breeding, mutation breeding, and polyploidy breeding. The cardamom crop improvement programme are as follows:

- To create more adaptable varieties.
- To develop high-yielding accessions with improved capsule characteristics.
- To require varieties resistant to biotech stress, such as fungi (rhizome rot), pests (thrips, root grubs, nematodes), and viral disease (*katte*).
- Develop drought-resistant and high-yielding varieties.

Breeding Methods (Parthasarathy and Prasath, 2012).

Breeding methods such as selection, hybridisation, mutation breeding and polyploidy breeding have been employed in cardamom improvement. The major objectives of the crop improvement program in cardamom are:

- To develop varieties having wider adaptability to different agro-ecological conditions;
- To evolve high-yielding genotype with superior capsule characters;
- To breed varieties having resistance to biotic stress such as, thrips, root grub, nematodes, fungal (rhizome rot) and viral diseases (*katte* and *kokke kandu*);
- To evolve drought-tolerant high-yielding varieties.

Clonal selection: The improved varieties have been evolved by selecting superior plants with desirable characteristics such as higher yield and superior capsule characteristics from land race populations. The highly heterozygous nature of the crop and the ability to multiply selections by clonal propagations has contributed to this success. Selections are made '*in situ*' in planters, fields and forests. The selected plants are multiplied clonally, subjected to preliminary evaluation and subsequently evaluated in a comparative yield trial and a multi-location trial to confirm their superiority and adaptability. Selection of cardamom is highly location-specific to their agroecological requirements. The improved selections are much superior to the local clones with regard to yield and capsule characteristics. Salient features of varieties in vogue are summarised in Table 2 (Parthasarathy and Prasath, 2012; Ashokkumar *et al.*, 2021; Ecours, 2024).

Intervarietal hybridization: Since cardamom is amenable to both sexual and vegetative propagation, hybridisation is a very useful tool for crop improvement. Research at various institutes has led to the isolation of high-yielding recombinants and heterotic hybrids. A novel hybridisation technique, known as the straw tube technique, for simple, easy and effective hybridisation was reported. The elite selections were compatible with each other; however, the degree of compatibility varied with the parents selected for hybridisation (Parthasarathy and Prasath, 2012; Ashokkumar *et al.*, 2021; Ecours, 2024).

The hybrids MHC 18, MHC 10 and MHC 12 showed vigour with regard to yield and yield-contributing characteristics. Appreciable heterosis was recorded over the standard parent, with desirable yield characteristics and high-yielding mosaic-resistant hybrids were identified. Genetic analysis of diallel hybrids revealed the influence of dominance and over-dominance in the manifestation of quantitative characteristics. The resistance of the cardamom plants to CdMV (cardamom mosaic virus) is quantitative, with possibly two major factors, and is dependent on gene dosage with completely dominant gene action (Parthasarathy and Prasath, 2012; Ecours, 2024).

Table 2. Cardamum varieties released in India

Variety	Year of release	Breeding method	Pedigree/parentage and plant type
Mudigere 1	1984	Selection	Clonal selection from <i>Malabar</i> type
Mudigere 2	1996	Selection	Clonal selection from open pollination of <i>Malabar</i> type
PV 1	1991	Selection	A selection from Walayar collection, a <i>Malabar</i> type
PV 2	2001	Selection	A selection from OP seedlings of PV-1, <i>Malabar</i> type
ICRI 1	1992	Selection	Selection from Chakkupallam collection, <i>Malabar</i> type
ICRI 2	1992	Selection	Clonal selection from germplasm collection, <i>Mysore</i> type
ICRI 3	1993	Selection	Selection from <i>Malabar</i> type
ICRI 4	1997	Selection	Clonal selection from Vadagaraparai area of lower pullenys, a <i>Malabar</i> type
ICRI 5	2006	Hybridization	MCC260 X MCC 49
ICRI 6	2006	Selection	Clonal selection
IISR Suvashini	1997	Selection	Clonal selection from OP progenies of Cl.37
IISR Avinash	1999	Selection	Clonal selection from OP progenies of CCS-1
IISR Vijetha	2001	Selection	Clonal selection from Natural <i>katte</i> escapes (NKE 12)

Polycross breeding: Carried out studies on the impact of selection in a polycross progeny population. Since cardamom is a cross-pollinated crop, the polycross method of breeding is ideal to evolve superior types. Elite clones, having predominantly desirable characteristics, are planted together on an isolated plot. Beehives are maintained in the plot for assured pollination so that maximum fruit set and a high number of seeds per capsule can be obtained (Parthasarathy and Prasath, 2012; Ashokkumar *et al.*, 2021; Ecours, 2024).

Intergeneric hybridisation: Although a few improved high-yielding varieties of cardamom have been evolved, combining yield and cardamom mosaic resistance has not been possible. To achieve this objective, intergeneric crosses were made using *Ammomum subulatum*, *Alpinia neutans*, *Hedychium fl avascene* and *Hedychium coronarium* as male parents. A few fruits have been obtained in the cross involving *Alpinia neutans*; in other crosses no seeds were set.

Therefore, the results of intergeneric crosses are not encouraging. Compatibility barriers prevented the formation of fruits in these cross-combinations (Parthasarathy and Prasath, 2012).

Mutation breeding: To develop clones tolerant to the cardamom mosaic (*katte*) virus, drought seeds and rhizomes of cardamom have been subjected to x-rays, nitrosomethyl urea (NMU), diethyl sulphate (DES) and ethyl methane sulphate (EMS). No desirable mutant has so far been obtained. However, sterility and lack of macromutations in the M1 generation were also reported (Parthasarathy and Prasath, 2012; Ashokkumar *et al.*, 2021; Ecours, 2024).

Polyploidy breeding: Polyploids were induced in cardamom by treating the sprouting seeds with 0.5 % aqueous solution of colchicine. The tetraploid lines exhibited an increase in the layers of epidermal cells, a thick cuticle and a thicker wax coating on the leaves. These characteristics are generally associated with drought tolerance (Parthasarathy and Prasath, 2012; Ashokkumar *et al.*, 2021; Ecours, 2024).

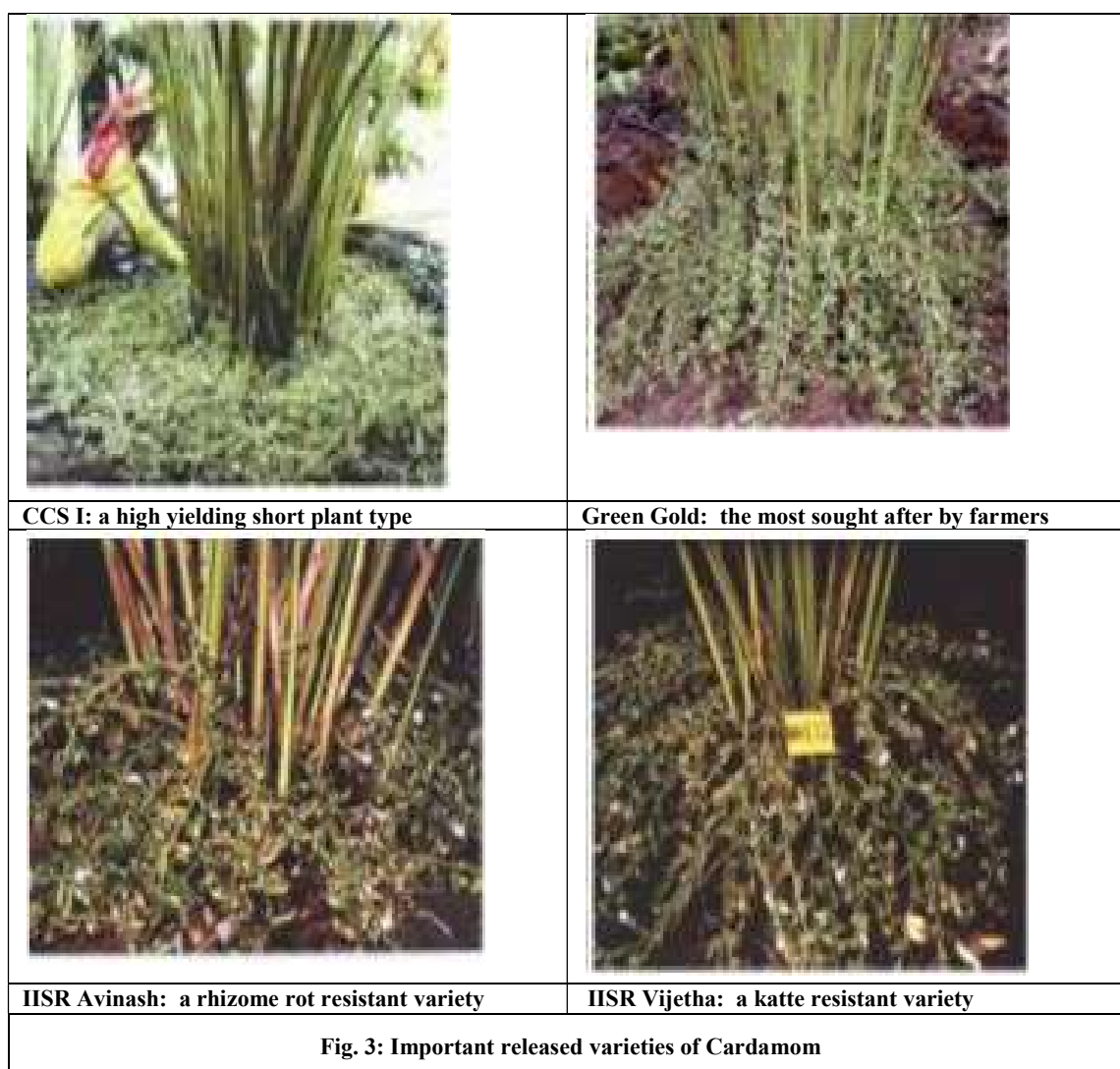
Micropropagation and Somaclonal Variation: Since cardamom is a cross-pollinated crop, micropropagation is ideal for producing virus-free planting material from high yielding clones. It was stated that immature floral buds were successfully converted to vegetative plantlets and that inflorescences are an excellent source for reducing culture contamination, particularly because other sources are prone to high contamination rates. The spice board conducted a field evaluation of tissue cultured cardamom plants over a 100-hectare area, and the results revealed that micropropagated plants outperformed suckers (Ashokkumar *et al.*, 2021).

The main focus of Cardamom breeding in addition to high yield are resistance to biotic stress *viz.*, viral diseases like 'katte' and 'kokke kandu' and fungal diseases such as rhizome rot, clump rot and capsule rot; drought tolerance; plants with bold capsules with more number of seeds/fruit; higher percentage of capsule dry recovery (>22%), higher percentage of essential oils, α -terpenyl acetate which is responsible for the aroma and flavor and varieties with wide adaptability. Cardamom breeding depends on selections from germplasm and from open pollinated progenies of popular cultivars. Twelve high yielding varieties of cardamom were released for cultivation (Table 3). IISR Vijetha is katte virus tolerant line while IISR Avinash and ICRI 4 are relatively tolerant to rhizome rot. PV 1 has long and bold capsules. The variety CCS 1 has compact growth habit and is good for high density planting (Fig. 3). Hybridization between NKE, RR, extra bold and Multi-branch types are in progress with an aim to evolve desirable types. (Zakir, 2019).

Table 3. Cardamom varieties released in India for yield and quality characters

Sl. No.	Variety	Source	Yield (kg/ha)	Essential oil %	1,8 cineole %	α -Terpenyl acetate %	Capsule shape	Areas recommended for cultivation
1.	IISR Coorg Suvasini	IISR, CRC Appangala	409	8.7	42	37	Oblong	Kodagu&Hassan districts of Karnataka
2.	PV-1	KAU, Pampadumpara	260	6.8	33	46	Long	All cardamom tracts of Kerala & Karnataka
3.	Mudigere 1	UAS, Bangalore	275	8.0	36	42	Oval	Malnad region of Karnataka
4.	Mudigere 2	UAS, Bangalore	476	8.0	45	38	Round	Traditional cardamom growing Tracts of hill zones of Karnataka
5.	ICRI-1	ICRI, Myladumpara	325	8.3	29	38	Round	South Idukki zone of Kerala
6.	ICRI-2	ICRI, Myladumpara	375	9.0	29	36	Oblong	Vandanmettu & Nelhiampathi zones of Kerala
7.	ICRI-3	ICRI, Myladumpara	439	6.6	54	24	Oblong	Hill zones of Karnataka
8.	ICRI-4	ICRI, Thadiyankudisai	455	6.4	--	--	Globose	Lower Pulneys in Tamil Nadu
9.	IISR Avinash	IISR, CRC, Appangala	847	6.7	30.4	34.6	Oblong	Rhizome rot infested areas
10.	IISR Vijetha 1	IISR, CRC, Appangala	643	7.9	44.9	23.4	Oblong	Moderate to high shaded mosaic infested areas
11.	PV-2	KAU, Pampadumpara	982	10.45	--	--	Long	Cardamom hill reserves of Kerala
12.	Njallani Green Gold	Farmers Selection	1600	--	--	--	bold	All cardamom growing regions

All the existing improved varieties have been evolved by selection for desirable characters such as higher yield and superior capsule characters. Selection in cardamom is based on both qualitative and quantitative characters from preliminary, comparative yield trial and multi-location trials to confirm the superiority of the selected clone. (Zakir, 2019). Inter-varietal hybridization was made between identified superior cultivars for deriving lines with high yield, „katte“ resistance and drought tolerance. On farm trials of these varieties are in progress. The promising lines from these trials are given in Table 4 (Zakir, 2019). A large number of crosses have been made to combine high yield and resistance to rhizome rot and cardamom mosaic diseases, which are currently under evaluation at Indian Institute of Spices Research, Appangala. Varying degrees of significant positive heterosis was recorded in both the seedling and pre bearing stage of cardamom crosses. Based on per se performance, heterosis and combining ability, 15 hybrid combinations are short listed Review on Breeding Method and Achievements of Cardamom and Future Prospects for further evaluation. Plant height, total tillers, bearing tillers and yield per plant were under the influence of non additive gene action (Zakir, 2019).



In an effort to bring Katte resistance from wild relatives to cultivated cardamom, inter-generic crosses were made using *Ammomum subulatum*, *Alpinia neutans*, *Hedychium flavascence* and *Hedychium coronarium* as male parents. Cross with *A. neutans* set a few fruits and in other cases no fruit formation was noticed. Compatibility barriers prevented the formation of fruits in these cross combination (Zakir, 2019).

Table 4. Promising cardamom hybrids

Hybrid combinations	Projected yield (kg/ha)
MCC 16 x MCC 40	610
MCC 61 x MCC 40	675
MCC 21 x MCC 16	650
MCC 21 x MCC 40	870
MCC 16 x MCC 61	800

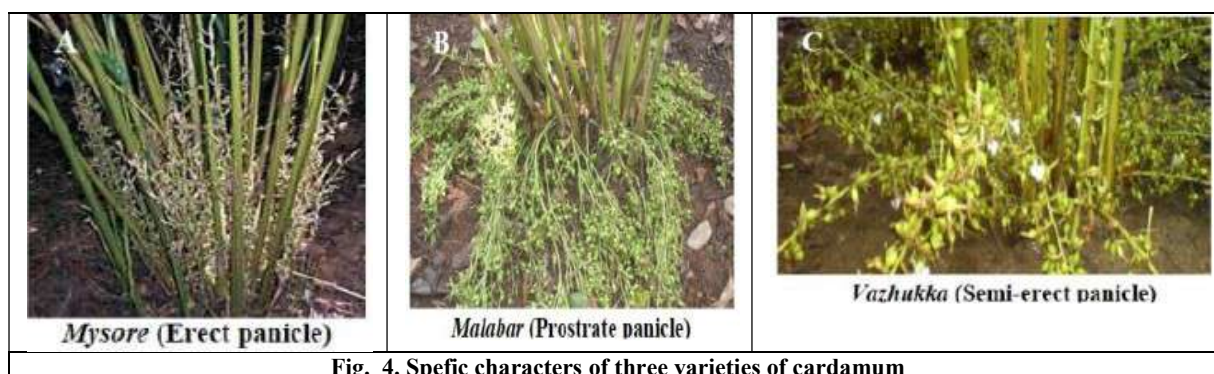
Effort has been made to develop genotypes tolerant to cardamom mosaic (katte) virus, drought, and better quality through treatment of cardamom seeds and rhizomes with different mutagens such as γ -rays and Nitrosomethyl Urea (NMU), Diethyl Sulphate (DES) and Ethyl Methyl Sulphate (EMS) but no desirable mutant could be identified so far. (Zakir, 2019).

Polyploids were induced in cardamom by treating the sprouting seeds with 0.5 per cent aqueous solution of Colchicine. The polyploidy lines exhibited increased layer of epidermal cells, thick cuticle and thicker wax coating on the leaves which are the general characters associated with drought tolerance in nature. (Zakir, 2019).

The three natural varieties of green cardamom plants are: Based on the adaptability, nature of the panicle, shape and size of fruits, the developed cardamom is categorized into three botanical varieties viz. Malabar, Mysore and Vazhukka. Usually, the cultivars are grouped as 'Malabar' (prostrate panicle), 'Mysore' (erect panicle) and 'Vazhukka' (semierect panicle). The characteristic features of those cultivar groups are given in Table 5 and Fig. 4. (Ankegowda *et al.*, 2015; Wikipedia, 2024a; Seema, 2024; Vikaspedia, 2024).

Table 5. Specific characters of three varieties of cardamom

Characters	var. Malabar	var. Mysore	var. Vazhukka
Adaptability	Lower altitudes 600-900 m a.s.l.	Higher altitudes 900-1200 m a.s.l.	Wide range
Areas of cultivation	Karnataka	Kerala and parts of Tamil Nadu	Kerala
Plant growth	Medium	Robust	Robust
Panicles	Prostrate	Erect	Semi erect
Capsules	Round or oblong	Bold, elongated	Round to oblong
Leaf petiole	Short	Long	Long
Capsule colour at maturity	Pale/golden/yellow	Green	Green



Recently, a few planters isolated high-yielding plants and started multiplying them on a large scale. The most popular high-yielding variety is 'Njallani', which is a unique high-yielding cardamom variety developed by an Indian farmer, Sebastian Joseph, at Kattappana in the South Indian state of Kerala. K. J. Baby of Idukki District, Kerala, has developed a purely white-flowered variety of Vazhuka type green cardamom having higher yield than 'Njallani'. The variety has high adaptability to different shade conditions and can also be grown in waterlogged areas

Cardamom plants are divided into three classes based on the shape of their panicles. The difference between three types of cardamom were summarized in Table 6 (Ashokkumar *et al.*, 2021):

Mysore type: Suited to elevations between 900 and 1200 metres above mean sea level. Plants are strong and reach a mature height of 3–4 metres. Panicles are completely erect. Kerala and Karnataka have a large population of them. Cured capsules are ribbed and have three corners, and they are slightly longer than *Malabar* style capsules, measuring around 21 mm in length (Ashokkumar *et al.*, 2021).

Malabar type: The Malabar type is best suited to lower elevations between 600 and 1000 metres above mean sea level. Medium-sized plants reach a mature height of 2–3 metres. Panicles have completely prostrate. Thrips and shoot borer infestations are less common. In Kerala and Tamil Nadu, it can expand in low-rainfall areas. Capsules that have been cured are usually round and around 18 mm long (Ashokkumar *et al.*, 2021).

Vazhukka type: The Vazhukka variety is a natural cross between the Mysore and Malabar varieties. It combines the best of both worlds. This variety thrives at elevations between 900 and 1200 metres above sea level. Plants are sturdy, with semi-erect panicles. Capsules are large, globose, or ovoid-shaped capsules (Ashokkumar *et al.*, 2021).

Parameters	<i>Mysore</i>	<i>Malabar</i>	<i>Vazhukka</i>
Adaptability	Higher elevation (900–1200 m msl)	Lower elevation (600–1000 m msl)	Higher elevation (900–1200 m msl)
Drought tolerance ability	Requires well distributed rain	Withstands long dry spell (4–6 months)	Requires well distributed rain
Plant stature	Tall (3–5 m)	Dwarf (2–3 m)	Tall (3–5 m)
Leaf petiole	Long	Short	Long
Panicle	Erect	Prostrate	Semi-erect
Bearing nature	Late, long-flowering span	Early, short span of flowering	Late, long-flowering span
Capsule colour at maturity	Green	Pale/golden/yellow	Green
Cultivation	Kerala and Karnataka	Kerala and Tamil Nadu	Kerala

The important areas of cultivation are (Prasatha and Venugopal, 2004; Parthasarathy and Prasath, 2012):

- Kerala State-Nelliampathy, Wynad and Idukki in the Travancore Cochin (Malabar) region;
- Karnataka-Uttar Kannada, Shimoga, Hassan and Chickmagalur, and the hills of Kodagu (Coorg);
- Tamil Nadu-Northern and Southern foot hills of Nilgiris, Madurai, Salem and Tirunelveli, Anamalai and parts of Coimbatore districts.

The growth habit of the panicles and the shape and size of the capsules vary in different cultivated varieties/types of cardamom. These panicles either grow erect (Mysore), prostrate (Malabar) or in a semi-erect manner (Vazhukka). Multiple branching (compound panicle) of panicles appears in certain cultivars. In such cases, the central peduncle undergoes further branching of secondary and tertiary branches producing compound panicle types. These new cardamom varieties, named IISR Manushree and IISR Kaveri, showcase advanced drought tolerance. The release of these varieties is seen as a breakthrough for the cardamom industry, which has been grappling with moisture stress affecting crop yields (Ankegowda, 2024a).

Harvesting and post-harvest processing: Cardamom plants start bearing two years after planting. Panicles appear from the base of the plant from January onwards; flowering is between April and December, and may extend further. Peak flowering is observed during June–August and fruits mature in about 120 days after flowering. Fruits have trilobular capsules containing 15–20 seeds and, on maturity, the seeds turn black in colour. Due to staggered and prolonged flowering, cardamom capsules mature and are ready for harvesting successively at 10–15 day intervals over an extended period of 8 months (August–March). Harvesting is carried out at an interval of 15–30 days and is completed in eight to nine rounds. Fruits (capsules) that are fully matured have a dark green coloured rind (peel) with black coloured seeds, indicating that they are ready for harvesting. Harvesting at an over-ripe stage leads to a loss of the green colouring in the rind, and the capsule is at risk of splitting during curing. Percent recovery of dry capsules varies from 20–24 % in ripe capsules, 18–20 % at the physiologically mature stage and 14–16 % at the immature stage. Hence, it is ideal to harvest cardamom at the physiologically mature stage (green coloured rind and black coloured seeds). After harvesting, the capsules are cleaned and cured to reduce the moisture content from 80 % to 8–12 % in an optimum environment for retaining green colour to the maximum extent. The colour of processed cardamom is an important factor in the consumer market. Different chemical treatments have been tried to retain the green colour of harvested capsules because such a product fetches premium price in the market. Soaking green capsules immediately after harvest in 2 % sodium carbonate solution for 10 minutes results in retention of the green colour during subsequent drying and storage. Immature capsules also retain greater intensity of green colour (Parthasarathy and Prasath, 2012).

Common uses

Even today, cardamom continues to be used mainly in the Near and Far East. This spice features in curries and is often included in a variety of Indian sweet dishes and drinks. In pilaus (rice dishes), it is an essential ingredient. Unlike other spices such as cumin that are used quite heavily, cardamom is considered more of a festive spice. The reason for this is—at least in part—due to its high price. Cardamom ranks among the top three most expensive spices in the world. Other common uses for cardamom include the seasoning of pickles and pickled herring dishes. It is used to flavor punches and mulled wines and is even sometimes found in meat, poultry and shellfish recipes. Both custards and some Russian liqueurs benefit from the unique aroma and unparalleled flavor profile of cardamom. In the West, it is commonly used in Scandinavian-style cakes and pastries, akavit, and Dutch “windmill” biscuits. In parts of the world such as the East Indies where cardamom is abundant and readily available, it is often chewed habitually. In addition, this spice is an essential flavoring component of both Arab and Turkish coffees (Niftem, 2024).

Culinary Uses: In Indian and Middle Eastern cuisine, cardamom is very popular in curries and is generally one of the spices used in their typical spice blends. In Asia, this spice is often used to make cardamom tea, a traditional drink. It is also a very popular spice in many Scandinavian recipes such as mulled wine and glogg. It is used in all types of sweet pastry and bread dishes (Myspicer, 2014). Cardamom has been used medicinally for thousands of years. It has been most commonly used to treat indigestion, asthma and bad breath (Myspicer, 2014). Cardamom is a versatile spice that is utilized in both sweet and savory dishes. It is a far more popular element in Indian and Middle Eastern cuisine and is used to flavor curries, stews, and rice dishes. In Scandinavian nations, it is used to flavor pastries and baked goods. In addition to its use in cooking, cardamom is also used to flavor hot beverages like tea and coffee. It is typically used to make masala chai, a famous spiced tea from India (Sagvekar, 2014).

Black cardamom is usually used in garam masala for curries. It is occasionally used as a garnish in basmati rice and other dishes. It is often referred to as fat cardamom due its size (‘Moti Elaichi’). Individual seeds are sometimes chewed, in much the same way as chewing-gum. In Northern Europe, cardamom is commonly used in sweet foods, pastries or cakes. It has also been known to be used for gin making. Green cardamom in South Asia is broadly used to treat infections in teeth and gums, to prevent and treat throat troubles, congestion of the lungs and pulmonary tuberculosis, inflammation of eyelids and also digestive disorders. It is also reportedly used as an antidote for both snake and scorpion venom bite. Amomum is used as a spice and as an ingredient in traditional medicine in systems of the traditional Chinese medicine in China, in Ayurveda in India, Japan, Korea and Vietnam (Seema, 2024).

Medieval Cuisine and Medicine: Cardamom dominated the medieval diet and medicine. This intriguing age adored this versatile spice for its unique taste and smell. Cardamom was used in medieval cuisine. Its wonderful aroma scented a variety of delectable desserts and pastries. This odd chemical was used in medieval medicine to cure stomach disorders (Spice Shuttle, 2024). Cardamom is used in Indian cookery. For decades, this versatile spice has enhanced Indian dishes. Cardamom is used extensively in Indian cuisine. This versatile component is used in chai tea, curries, and desserts. Cardamom is used in cooking and religious rites (Spice Shuttle, 2024). Cardamom has had a significant impact on Middle Eastern cuisine. Its perfume and flavor have boosted the cuisine of this area. Middle Eastern meals are fashioned like cardamom. This fragrant spice is used in spice mixes, coffee drinks, and pastries. Many Middle Eastern dishes are spiced (Spice Shuttle, 2024). Cardamom is a favorite spice among Scandinavians. This roasted, somewhat sweet spice has long been used in Scandinavian cuisine. Cardamom adds flavor to baked products. Cardamom is essential in Scandinavian Christmas dishes. Swedish “lussekatter” and “pepparkakor” make use of pricey saffron. Saffron perfumes these delectable delicacies (Spice Shuttle, 2024).

Uses in Food and Beverage: Besides use as flavourant and spice in foods, cardamom-flavoured tea, also flavoured with cinnamon, is consumed as a hot beverage. Cardamom has a strong taste, with an aromatic, resinous fragrance. Black cardamom has a more smoky – though not bitter – aroma, with a coolness some consider similar to mint. Green cardamom is one of the most expensive spices by weight, but little is needed to impart flavor. It is best stored in the pod, as exposed or ground seeds quickly lose their flavor. Grinding the pods and seeds together lowers both the quality and the price. For recipes requiring whole cardamom pods, a generally accepted equivalent is 10 pods equals 1½ teaspoons (7.4 ml) of ground cardamom. Cardamom is a common ingredient in Indian cooking. In Asia, both types of cardamom are widely used in both sweet and savoury dishes, particularly in the south. Both are frequent components in such spice mixes as Indian and Nepali masalas and Thai curry pastes. Green cardamom is often used in traditional Indian sweets and in masala chai (spiced tea). Both are also often used as a garnish in basmati rice and other dishes. Individual seeds are sometimes chewed and used in much the same way as chewing gum. It is used by confectionery giant Wrigley; its Eclipse Breeze Exotic Mint packaging indicates the product contains "cardamom to neutralize the toughest breath odors". It is also included in aromatic bitters, gin, and herbal teas. In Korea, Tavoy cardamom (*Wurfbainia villosa* var. *xanthioides*) and red cardamom (*Lanxangia tsao-ko*) are used in tea called jecho-tang (Wikipedia, 2024).

Traditional medicinal uses: The major medicinal properties of cardamom essential oil are its antiseptic, carminative, digestive, diuretic, stimulant, stomachic, tonic and antispasmodic, antimicrobial and anti-inflammatory activities. It is also used as an aphrodisiac; it is helpful in countering the irritation experienced during premenstrual tension; and it works well on the respiratory system to ease coughs and to warm the body. The seeds of cardamom are considered cooling and stimulating and a carminative, stomachic, diuretic, cardi tonic and abortifacient. They have been used to treat bronchitis, haemorrhoids, stangury, renal and vesical calculi, anorexia, dyspepsia and gastropathy. Powdered cardamom seeds mixed with ground ginger, cloves and caraway have been used mainly for combating digestive ailments.

Use of cardamom checks nausea and vomiting (Parthasarathy and Prasath, 2012). Cardamom seeds can lessen inflammation, as well as being useful for headaches. They are chewed to prevent bad breath and to prevent pyrosis (excessive watering in mouth). Powdered seeds of cardamom, boiled with tea-water, impart a very pleasant aroma to the tea, which can be used as medicine for scanty urination, diarrhoea, palpitation of the heart, exhaustion due to overwork and depression among other things. Gargling with an infusion of cardamom and cinnamon is thought to cure pharyngitis, sore throats and hoarseness, during the infective stage of flu. It is believed that eating a cardamom capsule daily along with a tablespoon of honey improves eyesight, strengthens the nervous system and thus improves the general health of the person. Cardamom is considered capable of destroying Kapa and poison, helps to promote a good skin complexion and to relieve itching, pustules and akotha. It is also used to help relieve the symptoms of asthma, burning sensations, colds and coughs, diseases of the bladder and kidney, flatulence, heart weakness and piles (Parthasarathy and Prasath, 2012). Ayurvedic medicine in India promotes the health advantages of cardamom. Benefits for digestion, respiratory health, and overall well-being. Indian Cardamom has been used for millennia in Ayurveda medications and tonics to cure a variety of diseases (Spice Shuttle, 2024).

Applications in the food industry: The major use of cardamom worldwide is for culinary purposes in the whole or ground form. In India, cardamom seeds are widely used for flavouring during cooking of food. It is an essential ingredient in 'garam masala'. In the Islamic Republic of Iran, cardamom is used in making confectionery, bakery and meat preparations to add flavour and aroma to the products. In European countries and North America, cardamom is used mainly in ground form by food industries as an ingredient in curry powder, a few sausage products, soups, buns, breads, cookies, desserts, wine and, to small extent, in flavouring tobacco and cigarettes. In Scandinavia, it is used widely in bakery products (Parthasarathy and Prasath, 2012).

Composition: The essential oil content of cardamom seeds depends on storage conditions and may be as high as 8%. The oil is typically 45% α -terpineol, 27% myrcene, 8% limonene, 6% menthone, 3% β -phellandrene, 2% 1,8-cineol, 2% sabinene and 2% heptane. Other sources report the following contents: 1,8-cineol (20 to 50%), α -terpenylacetate (30%), sabinene, limonene (2 to 14%), and borneol. In the seeds of round cardamom from Java (*Wurfbainia compacta*), the content of essential oil is lower (2 to 4%), and the oil contains mainly 1,8-cineol (up to 70%) plus β -pinene (16%); furthermore, α -pinene, α -terpineol and humulene are found (Wikipedia, 2024).

Health benefits of cardamom

This spice is bursting with health benefits. Among the most notable benefits and uses of cardamom are the following:

- Detoxifies the bodily organs
- Acts as a mild antidepressant
- Treats halitosis
- Inhibits growth of bacteria, fungus, viruses, and mold
- Reduces pain and swelling
- Acts as a powerful aphrodisiac
- Helps the body combat infections
- Cleanses digestive tract by removing waste, excess water, toxins and salt
- Relieves symptoms of colds, and flus
- Helpful in treating bronchitis and coughs
- Cures mouth ulcers as well as infections of the mouth and throat

- May be useful in preventing cancer
- Helps to eliminate hiccups
- Prevents blood clots
- Effective in treating intestinal and stomach cramps
- Counteracts digestive problems including gas, heartburn, bloating, nausea and constipation. (Niftem, 2024).

CULTIVATION

Propagation: Propagation by vegetative means through suckers is considered to be the most preferred method. Production of planting materials from seeds and through tissue culture are alternative methods of propagation. Seedling propagated plants may not be true to its parent (Ankegowda *et al.*, 2015).

Planting: In Karnataka, 10 month old seedlings are preferred for planting in the main field, while In Kerala and Tamil Nadu 18 month old seedlings are commonly used. To ensure a balanced canopy, lopping of branches is carried out on all sides of the shade trees. Preferably, South-Western slopes should be provided with more shade than North-Eastern slopes. For planting, pits of required size are prepared before commencement of the monsoon season (April-May). For planting Malabar types, pits of size 45 cm × 45 cm × 45 cm are prepared and for Mysore and Vazhukka types, 90 cm × 90 cm × 45 cm or 90 cm × 90 cm × 90 cm are recommended. The pits are filled to one third with topsoil. Application of well decomposed farmyard manure or compost or leaf litter and 100 g of rock phosphate along with the topsoil will help in proper establishment and quick growth of suckers. Planting is normally done during June-July with the commencement of monsoon. Ideal time for planting in the low-lying areas would be after the cessation of heavy monsoon showers. Ten to 18 month old cardamom seedlings are selected for planting in the pits. While planting, 15 g of carbofuran (banned in Kerala) or 50 g neem cake and rock phosphate (50 g) are applied to the pit. Deep planting should be avoided, as it results in suppression of the growth of new shoots and might result in death of the plants. Stakes may be provided to avoid the damage caused by wind and the plant base need to be covered with suitable mulching material. Planting diagonally to the slopes helps to prevent run off. Trench system of planting (60 cm × 30 cm) with a spacing of 2 m × 1 m is generally preferred over pit system, as it results in better establishment of the plants, higher yield and greater moisture retention. In sloppy lands, contour terraces need to be prepared and pits are taken along the contours at 2 × 1 m spacing. Based on slope, terraces are made at 2-3 m between the contours. For Mysore and Vazhukka cultivars, plant to plant distance can be 3 m × 3 m (1111 plants/hectare) and 2.4 m × 2.4 m (1736 plants/hectare) respectively. A spacing of 1.8 m × 1.8 m or 2.0 m × 2.0 m is ideal for Malabar types in Karnataka (2500-3000 plants/ha) (Vikaspedia, 2024).

Irrigation: It is essential to irrigate the crop during January to May. Plants may be irrigated at an interval of 10-15 days till the onset of monsoon, by adopting a convenient method of irrigation either by hose/sprinkler/mini-sprinkler/drip. In case of drip irrigation, it needs to be supplemented with sprinkler irrigation once in a month. On gentle sloppy areas, opening of rectangular silt pits (1.0 × 0.5 × 0.6 m) between four plants will help in soil and water conservation. If the slope is steep, construct stone pitching walls at 10 to 20 m interval across the slope and erecting water collecting trenches along drainage channels would strengthen soil and water conservation measures (Vikaspedia, 2024).

Weeding: Cardamom being a surface feeder, in the first year of planting, weeding at frequent intervals is necessary. Later, depending on the intensity of weed growth, 2-3 rounds of hand weeding at the plant base during May, September and December/January and slash weeding in the interspaces are recommended. Mechanical weed cutters can be used for weeding (Vikaspedia, 2024).

Mulching: Entire plantation and particularly the plant bases should be mulched at 5-10 cm thickness using fallen leaves of the shade trees, except during periods of heavy monsoon (June- September). To facilitate honey bee movement, remove mulch during May-June after the receipt of pre-monsoon showers. Areas where soil has become compact and hard, forking the plant base to a distance up to 90 cm and to a depth of 9-12 cm promotes better root penetration. Forking could be done with the cessation of north east monsoon during November/December with least damage to the root system (Vikaspedia, 2024).

Trashing: Trashing may be carried out once in a year with the onset of monsoon under rainfed conditions and 2-3 times in high-density plantation provided with irrigation facilities. Trashing from November onwards may be avoided, due to summer. Pruning may be done during January and September which coincides with peak thrips population. Earthing up of the plant base and root zone with topsoil is recommended during October- December. In valleys and high rainfall areas with medium slopes, suitable drains (45 cm depth and 30 cm width) are provided in between two rows of cardamom. To provide adequate light during monsoon, shade regulation may be taken up before the commencement of rainy season (May). The principal pollinating agent in cardamom is honey bee. Maintaining four bee colonies per hectare during the flowering season is recommended to increase pollination, promoting fruit set and production of more number of capsules. To maintain higher productivity undertake replanting once in 8-10 years. Replanting may also be taken up, once the yield starts declining below the economic level (Vikaspedia, 2024).

Harvesting and processing: Cardamom plants start bearing two or three years after planting suckers or seedlings, respectively. The capsules ripen within a period of 120-135 days after its formation. Harvesting period commences from June-July and continues till January-February in Kerala and Tamil Nadu. While in Karnataka, harvesting begins in August and prolongs till December- January. Usually harvesting is done at an interval of 15 -30 days. The capsules are harvested when they attain physiological maturity, which is indicated by dark green colour of rind and black coloured seeds. Harvesting of ripened capsules is

avoided as it leads to the loss of green colour and also causes splitting of capsules during curing process. Immature capsules on processing yields uneven sized, shriveled and undesirably coloured produce. Freshly harvested capsules are washed in water to remove the soil particles and other dirt adhering to it and to get good quality commodity. Storage of capsules after harvest for longer duration adversely affects quality of the end product. Curing of cardamom is the process by which moisture of freshly harvested capsules is reduced from 80 to 10-12 per cent through indirect heating. Maturity of capsules and curing temperature influences the colour and quality of processed cardamom. During curing a temperature range of 40-45°C is maintained during all the stages of drying which helps in good retention of green colour. Gradual increase of drying temperature to 50-60°C in the last two hours of curing enables easy removal of floral remnants during polishing. During curing, if temperature exceeds the threshold levels, capsules develop brownish streaks due to heat injury. An increase in drying temperature also results in loss of oil from the seeds (Vikaspedia, 2024). The cardamom plants start bearing 2-3 years after planting seedlings or suckers. Panicles appear from the bases of plants from January onwards and flowering continues from April-August or even later. Generally flowering is highest during May-June. Fruits mature in about 120 days after flowering. Fruits are small trilobular capsules, containing 15-20 seeds. On maturity, seeds turn dark brown to black in color. A healthy cardamom plant, on average, produces annually about 2000 fruits weighing (Nair, 2006).

Cardamom is dried by adopting two methods (Vikaspedia, 2024).

- Natural (Sun drying)
- Flue curing

Natural (Sun drying): Freshly harvested capsules are directly dried under sun for a period of five to six days or more depending on the availability and duration of sunlight. Natural drying does not retain green colour of capsules and also leads to splitting of the capsules. During cloudy and rainy weather conditions, proper drying of capsules cannot be accomplished and hence the quality of the capsules deteriorates. In general, sun dried capsules are not preferred for export. Sun drying is commonly practiced in some parts of Karnataka.

Flue curing: It is one of the best methods of drying by which high quality green cardamom can be obtained. A traditional firewood based curing house consists of a furnace for burning the wood, flue pipes for conveying the hot air and drying racks for stacking the trays. A drying chamber with dimensions of 4.5 m in length and breadth is sufficient for a plantation, which has a production capacity of 2 tonnes of fresh cardamom. In general, 3-4 kg of firewood is consumed for drying 1 kg of fresh cardamom.

The capsules are evenly spread as a single layer on the trays. After staking the trays on the racks in the drying chamber, the curing room is closed. Hot air generated by burning firewood in the furnace is circulated through the flue pipes, which are placed few centimeters above the floor. This process enhances the room temperature to 45-55°C, which is maintained for a period of 3-4 hours. During this period, the capsules sweat and give off the moisture. The drying process is facilitated by opening the ventilators for sweeping out the water vapour generated from the drying capsules. Exhaust fans are also used for the speedy removal of moisture. After complete removal of water vapour, the ventilators are closed and the temperature inside the chamber is again maintained at 45-55°C for a period of 18-24 hours. In the final stage of curing process, the temperature is further raised to 60-65°C for another 1-2 hours. The temperature is raised to hasten the cleaning process by which debris like stalks attached to the capsules can be removed easily. Temperature inside the curing chamber is maintained around 65°C to avoid splitting of the capsules and also to prevent the loss of volatile oil. Under these conditions, it is possible to obtain high quality green cardamom in about 24-30 hours. Efficient and highly automated cardamom dryers have been developed and being widely used with alternative sources of fuels such as kerosene, Liquid Petroleum Gas (LPG) and diesel or with combination of fuels. Such kind of improved systems has the advantage of retaining high quality of produce with respect to colour and duration of curing is also substantially reduced to 16-18 hours. Dried capsules are polished either manually or with the help of machines. Polishing is carried out by rubbing the dried capsules in hot state against a hard surface. The polished produce is subsequently graded based on the quality parameters such as colour, weight per volume, size and percentage of empties, malformed, shrivelled and immature capsules.

Production: In India, Kerala is the largest producer of the cardamom crop. In Kerala the major cardamom growing zones are (a) Udumbanchola taluka (b) Peeremedu taluka and (c) Devikulam taluka. Karnataka is one of the main areas where cardamom cultivation is seen. In Karnataka, Shimoga district is one of the main areas where cardamom cultivation can be found. Koppa, Sringeri, NR Pura, Siddapur, Yellpur, Joida, Sagar, Thirthahalli and Hosanegare are the main areas in the district where large-scale cardamom cultivation can be seen. In Shimoga, approximately 5850 hectares of area is under cardamom cultivation. Of these, yielding area of cardamom comes only 4310 hectares. Total area under cardamom in the state is 55,000 hectares. Area under Cardamom cultivatio was around 94.3 thousand hectares in 1997-98. This reduced to 84.8 thousand hectares in 1999-2000. It increased to 95.6 thousand hectares in 2003-04 and was 98.2 thousand hectares in 2006-07 (Saxen, 2024). In 2022, world production of cardamom (included with nutmeg and mace for reporting to the United Nations) was 138,888 tonnes, led by India, Indonesia and Guatemala, which together accounted for 85% of the total (Wikipedia, 2024). It is cultivated in about 1, 00,000 ha mainly confined to the Southern States viz; Kerala, Karnataka and Tamil Nadu accounting for 60,31 and 9% of the total area respectively. Our annual production is about 40000 metric tonnes and nearly 40% of which is exported to more than 60 countries earning a foreign exchange of nearly 60 million rupees (TNAU, 2024).

Trade: Cardamom is produced in several international locations around the world, along with India, Sri Lanka, Guatemala, Tanzania, and Papua New Guinea. India is the biggest producer and exporter of cardamom in the world. Cardamom is traded as

whole pods or as loose seeds. The rate of cardamom can range depending on the sort and quality of the spice, as well as marketplace demand (Sagvekar, 2014).

Cardamom production's demand and supply patterns of trade are influenced by price movements, nationally and internationally, in 5 to 6-year cycles. Importing leaders mentioned are Saudi Arabia and Kuwait, while other significant importers include Germany, Iran, Japan, Jordan, Pakistan, Qatar, United Arab Emirates, the UK, and the former USSR. According to the United Nations Conference on Trade and Development, 80 percent of cardamom's total consumption occurs in the Middle East (Wikipedia, 2024).

In the 19th century, Bombay and Madras were among the principal distributing ports of cardamom. India's exports to foreign countries increased during the early 20th century, particularly to the United Kingdom, followed by Arabia, Aden, Germany, Turkey, Japan, Persia and Egypt. However, some 95% of cardamom produced in India is for domestic purposes, and India is itself by far the most important consuming country for cardamoms in the world. India also imports cardamom from Sri Lanka. In 1903–1904, these imports came to 122,076 kg (269,132 lb), valued at Rs. 1,98,710 (Wikipedia, 2024).

Cardamom commerce is dominated by India, Guatemala, and Sri Lanka. This fragrant spice is exported and imported, making it economically significant (Spice Shuttle, 2024). Historians and explorers have long been fascinated by the spice trade and the Silk Road. Cardamom went to previously unknown Silk Road destinations. Cardamom was transported via the Silk Road. It travelled to Europe with other spices from the Mediterranean (Spice Shuttle, 2024).

It is an elongated tract from north to south extending over 2000 km, from Sirsi of the Karnataka region to Thirunelveli of the Tamil Nadu region. east to west, it is a narrow belt of land distributed over the Western Ghats. The important areas of cultivation include Nelliampathy, Wynad and Idukki, which are in the Travancore Cochin (Malabar) region of the Kerala state; Uttar Kannada, Shimoga, Hassan and Chickmagalur, which are in the hills of the Kodagu (Coorg) district in Karnataka; and the northern and southern foothills of Nilgiris, Didigul, Theni, Salem and Tirunelveli, which are part of the Coimbatore district in Tamil Nadu. In India, the amount of cardamom cultivated has fluctuated over the years (Parthasarathy and Prasath, 2012).

Curing

- Soaking green (wet) -2 per cent sodium carbonate solution for 10 min -Fixes green colour during subsequent drying and storage.
- Quick dip of capsules in hot water at 40 °C and dipping capsules for 10 min in 2 per cent sodium carbonate - Better retention of green colour of cured capsules.
- Pre-soaking of capsules in copper formulations and chemicals like NAA, IAA, GA and magnesium sulphate- retain more chlorophyll (Niftem, 2024).

Drying

- Cardamom capsules carry moisture levels of 70-80% at harvest.
- For proper storage, the initial moisture level has to be brought down to 8-10%.
- Cardamom capsules need to be dried within 24 h, any further delay would result in deterioration of green colour and appearance (Niftem, 2024).

Grading

- Bold is a popular export grade where 90 percent of the cardamom pods have a diameter of 6.5mm or above. The product has a mature green coloration with a weight in grams per liter of 415 grams.
- Super Bold is a high quality variety where all pods should have a diameter of 8mm or above. The product has a mature green coloration with a weight per liter of over 450 grams.
- Extra Bold is also a popular export grade where all pods will have a diameter of 7 mm or above. The product has a mature green coloration with a weight in grams per liter of 435 grams.
- Bulk is cardamom that has not been graded. As such, it contains all sizes, both mature and immature capsules, as well as black, yellow and/or split cardamom. Small is a grade with pods that measure between 5.5 mm and 6.5 mm in diameter. The weight in grams per litre is approximately 385 grams.
- Open/Splits is lower quality cardamom where over 60 percent of the pods are “open” (i.e. seeds exposed) and the colour of the pods may be greenish/pale yellow. All pods will be mature with a diameter of 6.5 mm or above
- Seeds are the black/brown seeds of the cardamom pods (i.e. husk fully removed). The weight in grams per litre is typically 550 to 600 grams.
- Fruit are generally over matured pods with slight yellowish in colour. The weight in grams per litre is 425 grams or above
- (Niftem, 2024).

Storage

- Dried cardamom capsules must be stored in moisture-proof containers away from direct sunlight.
- For long term bulk storage, polythene-lined gunny bags inside wooden boxes are used.

- The polythene bags help to preserve the green colour of the pods.
- It is essential that the capsules are fully dry before they are placed in the gunny bags for storage
- (Niftem, 2024).

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