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REVEIW ARTICLE

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

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ABSTRACT

Karonda belongs to the Familia: Apocynaceae, Subfamilia: Rauvolfioideae, Tribus: Carisseae, Genus: *Carissa*, Species: *Carissa carandas* L. Karonda (*Carissa* spp.), a lesser-known fruit crop, is extensively utilized by tribal communities in India for its medicinal properties in Ayurveda and Unani medicine. This fruit thrives in tropical and subtropical climates, showcasing its resilience and ability to withstand drought conditions. However, it is not well-suited for areas with heavy rainfall and waterlogged conditions. Karonda holds significant importance in ethno medicine as it serves as a valuable dietary supplement, contributing to the enhancement of our overall health. The plant that produces small fruits has long been employed in the remedy of antiscorbutic, and astringent qualities. Ascorbic acid, lupeol, -sitosterol scabies, intestinal worms, diarrhea, intermittent fever, and is renowned for its aphrodisiac, aperitive, antipyretic,, glucose, galactose, serine, glutamine, alanine, valine, phenylalanine, and glycine are among the numerous chemical components discovered in different components of this plant. This particular plant is commonly employed in the management of various ailments, such as biliousness and anemia. Additionally, it serves as a direct remedy for wounds (in the form of juice), a solution for skin issues, an aphrodisiac for women, an antiparasitic, antifungal, and antibacterial agent. Consequently, it is of great value to examine its therapeutic characteristics and explore its potential utilization in the nutraceutical domain, owing to its extensive nutritional and pharmacological properties. This essay examines the ethnobotanical significance of karonda fruit, leaves, root, and shoot, along with the research that substantiates the notion of their medicinal and therapeutic properties. The Carissa carandas L. popularly known as Karonda or Christ Thorn Tree, belongs to the family Apocynaceae is a hardy, evergreen, spiny and indigenous multipurpose horticultural shrub flourishing well without much care. There are approximately twenty-five species of genus Carissa, out of which five species have originated in India (*Carissa carandas* L, *Carissa spinarum* L, *Carissa congesta* L, *Carissa edulis* L and *Carissa grandiflora* L). *Carissa* species has a lot of socio-economic significance in tribal region of Tripura. It is also grown in Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, Maharashtra . It is believed to be originated near the Himalayas in India. It is distributed in the Himalayas at elevations of 300 to 1800 m, in the Shivalik Hills, The Western Ghats, Nepal, Afghanistan, India, Sri Lanka, Java, Malaysia, Myanmar, Pakistan, Australia and South Africa. Karonda (*Carissa* spp.) plant is used in traditional medicine to treat biliousness and biliary problems as well as stomach diseases rheumatism and diseases of the brain. It is also used as an anthelminthic, astringent, appetizer, and antipyretic. A ccording to earlier research, the plant's extract has cardio tonic, antipyretic, and antiviral properties. Different cardiac glycosides and triterpenoid components as carissone, carissin, and sitosterol as have been identified in various plant sections. Moreover, wild edible fruits which are sources of vitamins, minerals, fiber, antioxidants and compounds of nutritional importance, secondary metabolites such as alkaloids, essential oils, phenols, tannins, etc. play an important role in maintaining livelihood and nutritional security of native communities in the developing countries. Indian tribal people use various portions of this plant as powerful treatments for a variety of illnesses. Family, is a tough, evergreen, spiny, and native shrub that thrives in desert and subtropical climates. It has antiscorbutic qualities, yields well with little maintenance, and is extremely helpful in treating anaemia. Ripe fruits have an odd aroma, a sub-acidic, sweet taste, and an astringent flavour. Karonda is a good source of iron and vit. C. Ripe fruits may be used to make fruit-based foods including jam, sauce, Carissa cream, and jellied salad. According to Bose *et al*. (1999), the unripe fruits may be used to make pickles, sauces, and chutneys since they are tart and astringent. The Karonda tree is utilised in traditional medicine and has a variety of other applications. Modern scientific research has found that the tree has a wide range of beneficial traits. According to Rahmatullah *et al*. (2009), the fruits are traditionally used to cure leprosy, epilepsy, cough, colds, itches, fever, myopatic spasms, dog bites, malaria, epilepsy, and nerve disorders. Cardioprotective, antipyretic, and antiviral properties have been linked to C. carandas plant extract. The fruits have protein (1.1-2.25%), vitamin C (1.6-17.9 mg/100g), and minerals, particularly iron (39.1 mg/100g), calcium (21 mg/100g), and phosphorus (38 mg/100g). Mature fruits have a high pectin content and are used to make a variety of goods that are highly demanded on the global market, including jelly, jam, sauce, syrup, and squash.

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INTRODUCTION

Karonda belongs to the Familia: Apocynaceae, Subfamilia: Rauvolfioideae, Tribus: Carisseae, Genus: *Carissa*, Species: *Carissa carandas* L. (Akhter *et al.,* 2022; Singh *et al.,* 2023; Ahirwar *et al*., 2024'; Wikimedia, 2025; Wikipedia, 2025). English (Bengal-currants, Carandas-plum, Karanda, Christ thorn, Christ's thorn, Karaunda, Karanda, black currants), Hindi (karaunda, garinga, karonda), Bengali (Koromcha), Kannada (Kauli hannu) (Sonal *et al*., 2022). It is also called as Christ's Thorn, Bengal Currants, Jasmine flowered Carissa (Sankara Rao and Deepak Kumar, 2025).

Other vernacular names
Bengali: Koromcha, Karamcha.
Chinese: Cu Huang Guo, Tz'z-Huang-Kuo.
German: Karanda Wachsbaum.
Hindi: Karanda, Karaunda, Karonda.
Indonesia: Karandan, Karendang.
Kannada: Karjige.
Malay: Karaunda, Keranda.
Malayalam: Karakka.
Malaysia: Berenda, Kerenda, Kerandang.
Marathi: Karvand, Karvinda.
Myanmar: Hkan Ping.
Pakistan: Gerna, Karanda, Kakranda.
Portuguese: Carandeira.
Sanskrit: Karonda, Karmard.
Spanish: Caranda.
Tamil: Kalakkai, Kalaka, Kilaakkaai, Perungala.
Thai: Nam Phrom, Namdaeng, Manaao Ho, Naam Khee Haet.
Vietnam: Cay Siro, Xiro, Siro. (Cu Huang Guo, 2024; Ayurwiki, 2021 Ayurwiki, 2021: Singh *et al*., 2020; Shankar *et al*., 2024; Kavita *et al*., 2025; Bibha Mishra *et al*., 2024; Sankara Rao and Deepak Kumar, 2025).

The Karonda, (*Carissa carandas*), belongs to family Apocynaceae. It is a sprawling semi-vine shrub native to India. Being thorny, it is used as live fencing around the fields besides providing tasty fruits. Karonda fruit is used in various preparations and these are increase possibilities for processing. It has remained largely unexploited, Therefore, a study was conducted at Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow. Thirty elite genotypes were identified from Mirzapur, Varansi, Faizabad and Lucknow districts of U.P Vengurla, Belgaun and Gokak area of Karnataka, Ajmer, Chittorgarh and Siroli area of Rajasthan and Neemach (M.P). Floral characterization revealed flowering period was from March to April with full bloom in April first Week under Lucknow conditions . Anthesis was recorded after 1.00 pm, followed with anther dehiscence after few hours. Poor pollen fertility and germinability suggests scope of improvement in the crop yield.The mature fruits analyzed for fruit weight, length, diameter, pulp and seed content, TSS (ºBrix) acidity and ascorbic acid content revealed that there was wide variation among the accessions. The fruit colour was purple and red- white; fruit weight ranged from 1.85 to 6.0 g; fruit length from 0.90 to 2.40 cm; diameter from 0.32 to 2.15 cm; seed weight from 0.26 to 1.40 g and pulp content from 1.35 to 4.67 g; Total Soluble solids (ºBrix) in different accessions varied from 5.20 to 9.50, Titrable acidity varied from 0.45 to2.91% whereas Ascorbic acid content varied from 23.20 to 31.46 mg/100g. On the basis of physico-chemical characters of fruits, 3 accessions viz. CISH Kr-10, CISH Kr-11 and CISH Kr-12 have been identified for multiplication and further evaluation (Singh and Bajpai, 2009). Karonda (*Carissa carandas*), a fruit of dryland which is a widely grown indigenous shrub in India and is able to flourish in marginal and wasteland where other crops of commercial importance are unsuitable. Collection, conservation and evaluation, a process of crop improvement for characterization and selection of elite plants, are being successfully performed in different parts of India and standardized its vegetative technique of propagation. Its fruits have been utilized in processed products such as in the preparation of jam, jelly, squash, syrup and chutney and is in great demand in the international market. Karonda (*Carissa carandas*), a fruit of dryland which is a widely grown indigenous shrub in India and is able to flourish in marginal and wasteland where other crops of commercial importance are unsuitable. Collection, conservation and evaluation, a process of crop improvement for characterization and selection of elite plants, are being successfully performed in different parts of India and standardized its vegetative technique of propagation. Its fruits have been utilized in processed products such as in the preparation of jam, jelly, squash, syrup and chutney and is in great demand in the international market. Karonda (*Carissa carandas*) which is known as 'Christ Thorn Tree' is a hardy, evergreen, spiny and indigenous shrub widely grown in India. It is found wild in Bihar, West Bengal and South India. It is grown commonly as a hedge plant and in commercial plantations in the Varanasi district of Uttar Pradesh. It is a non-traditional fruit crop which thrives well as a rainfed crop. Once established, the plant hardly needs any care and gives yield with minimum management (Banika *et al*., 2012).

Research information on Karonda is lacking in India as well as aboard. However, these hardy, evergreen, spiny and indigenous shrubs widely grown in India have the richest of iron mineral among the fruit crops. Therefore, further research work on; varietals specification including molecular markers for selection among the wild species and preparation of commonly accepted products are needed for this minor fruit crop due to its economic importance and health care. Karonda (*Carissa carandas*) which is known as 'Christ Thorn Tree' is a hardy, evergreen, spiny and indigenous shrub widely grown in India. It is found wild in Bihar, West Bengal and South India. It is grown commonly as a hedge plant and in commercial plantations in the Varanasi district of Uttar Pradesh. It is a non-traditional fruit crop which thrives well as a rainfed crop. Once established, the plant hardly needs any care and gives yield with minimum management. Karonda (*Carissa carandas*), a fruit of dryland which is a widely grown indigenous shrub in India and is able to flourish in marginal and wasteland where other crops of commercial importance are unsuitable. Collection, conservation and evaluation, a process of crop improvement for characterization and selection of elite plants, are being successfully performed in different parts of India and standardized its vegetative technique of propagation. Its fruits have been utilized in processed products such as in the preparation of jam, jelly, squash, syrup and chutney and is in great demand in the international market (Banika *et al.,* 2012).

The karanda plant (*Carissa carandas*) is an evergreen shrub belonging to the *Apocynaceae* family. There is lack of reports in literature on the physico-chemical characteristics and antioxidant potential of the karanda fruit. A study was conducted to determine postharvest quality and antioxidant activity of karanda fruit at three maturity stages, which were whitish-pink, red and purple stages. The experimental design was a complete randomized design and repeated thrice. Analysis of variance was used to test differences in postharvest characteristics and antioxidant activities. Tukey's HSD test was used to determine significant differences of measures. Results showed that there were significant differences between the postharvest quality and antioxidant activity of karonda fruit. The lightness of karonda peel declined while the hue values showed colour changed from red to purple as maturation progressed. The lightness of pulp also decreased and colour change from yellow to red as maturation progressed. The firmness and titratable acidity decreased while the soluble solids concentration (SSC) increased as maturation occurred. The purple-stage karanda fruit exhibited the highest total phenolic content and antioxidant activity evaluated based on the DPPH radical-scavenging activity, FRAP and ABTS assays. The study showed karonda fruit harvested at the purple stage attained high SSC and has strong antioxidant activity. Therefore, this fruit has great potential to be promoted as a nutritious food (Chai and Ding, 2013).

Karondais an evergreen shrub or short stature tree.It grows naturally in the Himalayas and Western Ghats at elevations of 300 to 1800 meters. It is found grown in wild in India, Malaysia, South Africa. In India, it grows in Bihar, West Bengal, Maharashtra, Karnataka and other states. It is cultivated in Rajasthan, Gujarat , Uttar Pradesh states of India. It is a well suitedto arid climate and grown well at higher temperature. It is commonly uses for making ledge for orchards. Karonda fruit is a rich source of iron and contains a fair amount of Vitamin C. Mature fruit contains high amount of pectin The fruits are used for pickle making,. It is also used for Jam. Jelly, Squash, Syrup, Chatney etc. There are good demand Karonda products in market. Karonda has good nutrition value. It is rich in Iron, The fruits also containsvitamin C and It is antiscorbutic and very useful for cure of anaemia. Karonda fruits are used in many ayurvedic formulations and us to their nutritional values. The extract of root is used for Chest pain. The extract of leaves is used for fever. The study conducted at Indian Horticultural Research Institute, Bangalore revealed that the fruit are rich inThiamine (B1),Riboflavin (B2),Pantothenic acid (B5),Pyridoxine (B6),Biotin (B7),Folic acid (B9). Karonda (Carissa carandas) belongs to Apocynaceae family. It produces berry-sized fruits that are commonly used as a condiment or additive to pickles and spices. It is a very hardy, drought-tolerant plant that thrives well in a wide range of soils. There are more than 25 species in genus Carrissa. Out of these, 5 species are indigenous to India. Karonda is a medium-sized, thorny shrub It has a greenish white bark on young shoots and greyish brown on mature stems. The spines are straight and 1-3 cm long. At times, these are also forked. Its leaves are opposite, generally 2-3 cm x 1-1.5 cm, and ovate. They are green with shine above and a dull green shade below. Old leaves keep shedding throughout the year. New buds also keep sprouting through the year, though more during spring.Karonda flowers from February to June. The flower of these are white, scented and produced in clusters of 2 to 5 flowers. The corymbose cymes appear at the ends of twigs. The fruit is a globose berry. It appears from March to August and ripens between May and December. Immature fruits are green in colour and turn to white to reddish purple at maturity. These are round to oblong , sweet, though slightly acidic, juice when fully ripe. Karonda wood is hard, straight-grained and use for firewood purpose. The green plant serves as a protective hedge around agricultural holdings.. Apart from Karonda, Natal plum (*Carissa grandiflora*), *Carissa bispinosa*, Carissaedulis, *Carissa ovata* and Carissa are other cultivated species (Tripathi *et al*., 2014).

Carissa carandas native to India is an underutilized fruit crop with tremendous phyto-therapeutic and nutritive importance. Seven diverse accessions and a released variety were evaluated for morphological, biochemical and molecular diversity. The test accessions varied significantly with regard to all the morphological characters except plant height and number of stipules per node. The accession, CZK2011 and CZK 2031 recorded 30 and 3% higher fruit yield over the variety Pant Manohar while other accessions gave almost equal fruit yield to variety Pant Manohar. The accessions CZK2012, CZK2021 and variety Pant Manohar were found precocious due to first fruiting at three years of age. Karonda (Carissa carandas L.) of family Apocyanacea is an underutilized fruit plant which thrives well throughout tropical and sub tropical climate. It is native to India and also grown widely in other parts of world like Nepal, Afganistan, South Africa, Malaysia, Indonesia, Sri Lanka and Australia. In India, it grows wild in states of Bihar, West Bengal, Uttar Pradesh, lower, outer and middle Himalayas, Uttarakhand, Maharashtra, Rajasthan and parts of southern India. Fruits are edible and rich in minerals such as iron, calcium, magnesium and phosphorus. The presence of vitamin C and anthocyanin enhances the antioxidant properties of karonda fruit. The fruit is used for preparation of jelly, pickle, beverage and preserve. Its fruits and seed latex are used for treating rheumatoid arthritis, piles, cardiac diseases and nerving disorder. The roots are useful in stomach disorder, intestinal worms, scabies, diabetic, ulcer and pruitis. Germplasm of Carissa species have been widely collected from Kolhapur district of Maharashtra with high degree of genotypic and phenotypic variability. C. carandas (karonda) is usually propagated by seeds which need immediate sowing after extraction as they are recalcitrant type. Vegetative propagation has been attempted using air layering but rarely used for propagation. Singh and Ravishankar (2010) attempted softwood grafting with success rate of 40-50% (Meghwal *et al*., 2014)

In India considerable diversity is reported on Northwestern parts of the country particularly Western Ghats and Maharastra. Even though well established varieties of Karonda have not been evolved, it flowers and fruits almost throughout the year and is more productive when interspecific grafts are used. Some cultivated types have been identified and classified primarily on the basis of fruit color. The fruit, which is born in clusters, is sweet when ripe and is particularly suitable for tarts, puddings and jellies. Unripe fruits are sour, astringent, used in domestic pickle industry while there is some scope for processing in the fruit. Carissa carandas is also host for the tusser silk worm. The leaves are fairly rich in tannins (9-15%) and constitute a promising tanning material, particularly in combination with other tan stuffs such as the twig bark of Phyllanthus emblica . Roots are used as purgative and antidote for snakebite and leaves for remittent fever. Other important medicinal property of leaf and fruit extract has been reported recently for anti cancer activity in China for ovarion cancer and lung cancer cell lines, indicating potential usefulness of the crop. It is rich source of vitamin 'C', total antioxidant, phenol content and flavonoid. Micronutrient scavenging capabilities of karonda highlight its importance as a dietary supplement, besides strengthening the local ecologies and improve economy. Value added products like jam, jelly, wine etc. can easily find a place in supermarkets. Processing and value addition protocols are in vogue for karonda and high availability of fruit can be adequately utilized. As the karonda has been traditionally grown for hedging and fruits have been more of a by product, obviously the available germplasm consist of seedlings, which offer a great scope for isolating and characterizing superior germplasm (Singh and Bajpai, 2014).

Carissa carandas Linn. (Karonda) a native plant of Indo-Malaysia is best known for its fruits, which contain about 75 percent juicy edible pulp. The acidic pulp is a common ingredient in culinary preparations such as condiments, curries, beverages, jams in countries where the plant grows naturally. The fruit is pickled in salt solution which is rich of minerals, acids, phenolic compounds, terpenoids, flavonoids, vitamins, peptides and sugars. Ripe fruit is full of acids and micro and macro nutrients which combine well with sugars, and used to prepare a variety of jam. It is now considered as a valuable source of several unique products for the medicines against various diseases and also for the development of some industrial products. The present review includes comprehensive information on the chemical constituents, traditional uses, pharmacological actions and nutraceutical values of raw material and processed products. Karonda is relatively a new item yet to explore the full potential and a fruit that needs promotion and publicity in the international markets. Carissa carandas Linn. (*F. Apocynaceae*) is an important, exotic, minor fruit

commonly known as Karonda 'Christ's thorn' which grows wild in bushes. In India it is cultivated in a limited way in the tropical and subtropical Mediterranean region. It is widely used medicinal plant by tribals throughout India and popular in various indigenous system of medicine like Unani, Ayurveda and Homoeopathy. Traditionally the plant has been used in the treatment of scabies, intestinal worms, diarrhoea, intermittent fever and reputed for its aphrodisiac, antipyretic, appetizer, antiscor-butic, anthelmintic, and astringent properties. The karonda is inhabitant and widespread throughout much of Burma, India and Malacca and dry areas of Ceylon; is rather generally cultivated in these areas as a dodge and for its fruit and the fruit is marketed in urban area. There are about 30 species in genus the Carissa being native of tropics and subtropics of Asia, Africa and Australia; four species in China. It is a perennial plant and very easily maintained a hardy shrub, usually growing up to 12ft (4-5 m) high. The plant produces abundant whitish pink berry-size fruits in the monsoon tropical climate. The fruit is simple, succulent, fleshy, globular, 14–18 mm diameter. The epicarp is thin, whitish pink and of maroon colour when ripe. Mesocarp is acidic soft moist but not juicy. After drying the fruit is shrunk and changed to dark brown colour. The fruit exudes much gummy latex when being cooked but the rich-red juice becomes apparent and is used in cold beverages. The sweeter types may be eaten raw but the more acid ones are best stewed with plenty of sugar. The alcoholic extract of the roots of *C. carandas* had been reported to possess cardiotonic activity and antihypertensive activity. The ripe fruit is cooling and acidic; used to treat sore throat, mouth ulcer and skin disorders. The fruits possess significant amount of jelly grade pectin therefore a large number of factories have been built for making commercial jelly/jam and a product name 'Nakal cherry' which closely resembles the canned cherry fruits. Equal quantity of fresh leaves, fruits and roots bark is grounded and taken once a day with water for eight days for the permanent cure of piles. The plant is used as component in a number of ayurvedic formulations, which includes: Hridya Hahakashaya, Marma Gutika, Kalkantaka Rasa, Kshudrakarvanda Yoga and Marichadi Vati. Ethanolic extract of the plant root has been reported for histamine releasing activity used to assess the intensity of snake poisoning. The chemical investigations on *C. carandas* had led to the isolation of several substances including β-sitosterol, lupeol, mixture of cardenolides, carissone and a new sub-carandas fruits have been used as a dietary supplement or medicinal food for centuries and are of increasing importance to consumers. A natural 'food colourant cum nutraceuticals supplement' was prepared from the ripe karonda fruits. The formulation had been named as 'Lalima'. 1 ml of this pigment suspension formulation is sufficient to give lovely red colour to one serving of any colourless beverage (100 ml) such as lemonade. One serve of such supplemented beverage may in addition contain 469.2 µg anthocyanin, 12.7 mg flavonoids, 14.1 mg phenol, with total antioxidant activities to be 390 µM Trolox Equivalent. At present, many commercial fruit products are available in the market hence the present review will possibly act as bridge between nutraceutical food and industrial pharmaceutical potentials of *C. carandas* (Saini *et al*., 2016).

Anthocyanin is the natural pigment which can easily extract from plants such as blackberry, mulberry and Karonda. Karonda (*Carissa carandas* Linn.) had the fully ripe dark violet fruit contains the large amount of natural anthocyanin. The effect of extraction conditions on anthocyanin content, total phenolic content, and antioxidant activity in the extract was investigated. The extract with highest antioxidant activity was selected to use as natural pigment and antioxidant in Thai traditional fermented pork sausage (Nham). Under controlled extraction condition, type of solvent is the major factor that significantly affected the amount of anthocyanin and phenolic compounds in the extracts, and also antioxidant properties. Extraction of Karanda with 1% HCl in 95% ethanol at the weight ratio of 1:10 and extraction time of 90 minutes yielded the anthocyanin enriched extracts with the highest antioxidant activity. The extract was homogeneously mixed into the batter of Nham prior to stuff into natural casing and ferment at 30°C. The amount of lactic acid bacteria (LAB) and lactic acid content were increased during the fermentation and hence reduce the pH of Nham. At 36 hours of fermentation, the pH of Nham reached to 4.5 and then the reaction was ceased. Anthocyanin did not affect the fermentation of LAB. Nham with Sodium nitrite and 0.50% (w/w) of the extract had the shelf-life at 20 days, which was higher than that of the control (10 days). The consumer accepted the products and could not detect the difference between the sample with Sodium nitrite and 0.50% (w/w) extract (Sueprasarn *et al*., 2017).

Carissa carandas l. (Karaunda) is a widely useful food and medicinal plant of India, Plant-based medicines play an important role in all cultures have been indispensable in maintaining health and combating diseases. Owing to the global trend towards better quality of life, there is a great claim for medicinal plants. *Carissa carandas l.* plant popularly used as a traditional medicinal plant over thousands of years in the Ayurvedic, Unani, and Homoeopathic system of medicine. The major bioactive elements, which impart the medicinal worth of herbs, are alkaloids, flavonoids, saponins, and huge amounts of cardiac glycosides, triterpenoids, phenolic compounds, and tannins. Traditionally, the whole plant and its parts were used in the treatment of various ailments. It contains several phytochemical constituents belonging to the terpenoids category. The root is attributed to bitter, stomachic; antidiarrheal, vermifuge, and ant anthelmintic properties. The medicinally unripe fruit is used as an astringent. The ripe fruit is taken as an antiscorbutic and therapy for nausea. The leaf decoction is appreciated in cases of alternating fever, diarrhea, oral inflammation, and earache. Also, *Carissa carandas* have showing a extensive range of evidence for its cardiotonic, hepatoprotective, free radical scavenging and xanthine oxidase inhibitory, histamine-releasing, antirheumatic, antibacterial, antiviral, and anticonvulsant activity. A higher gross heat value of this species indicates its higher potential to be used as a good fuel source (Bhosale *et al.,* 2020).

The Karonda (*Carissa carandas* L., 2n=22), belongs to the family apocynaceae is a hardy, evergreen, spiny and indigenous shrub grown in India. There are approximately 25 species of genus Carissa, out of which 5 species have originated in India (*Carissa carandas* L, *Carissa spinarum* L, *Carissa congesta*, *Carissa edulis* and *Carissa grandiflora*). Carissa species has a lot socio monetary significance in tribal are of India. It is properly grown Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, Maharashtra (Sawant *et al*., 2002). Being very hardy, it may be without difficulty grown from arid to sub tropics and tropics climatic condition. As it isn't always unique a rained crop, the plant hardly ever wishes any care and offers yield with the minimal management. Karonda is a fruit of dry regions containing honest quantity of nutrition C and minerals. The sweeter fruits of Karonda may be eaten raw but the more acid ones are best stewed with plenty of sugar. The ripe result includes excessive quantity of pectin. Therefore, it's also utilized in making jelly, jam, squash, syrup, tarts and chutney, that are of brilliant call for in global market. The end result, leaves and bark are wealthy in tannins. The Karonda tree has many makes use of as it's far used in conventional medicine, and present-day scientific studies has observed that it has many useful properties. Its leaves feed the tussar silkworm. The fruits have astringent properties and have been used for tanning and dying. Traditionally Karonda has been used to deal with anorexia and insanity (Singh and Singh, 2021).

Carissa carandas is a usable food and remedial herbal plant of India, found to be extensively allocated throughout subtropical and topical areas. The plant has been utilized as a traditional remedial plant over thousands of years in the Ayurveda, Unani, and Homoeopathic system of medicament. Traditionally, whole plant and its parts were utilized in the treatment of various disorders. The major bioactive ingredients, which give remedial value to the plant, are alkaloids, flavonoids, saponins and large quantities of cardiac glycosides, triterpenoids, phenolic composites and tannins. Roots were reported to presence of volatile principles containing 2-acetyl phenol, lignan, carinol, sesquiterpenes (carissone, carindone), lupeol, β-sitosterol, 16 β-hydroxybetulinic acid, α-amyrin, β-sitosterol glycoside, and des-N-methylnoracronycine, however, leaves were testified the presence of triterpenoid constitutes as well as tannins. While, fruits have been reported to contain carisol, epimer of α-amyrin,

linalool, β-caryophyllene, carissone, carissic acid, carindone, ursolic acid, carinol, ascorbic acid, lupeol, and β-sitosterol. Ethnopharmacological content of the plant has been credited due to anti-cancer, anti-convulsant, anti-oxidant, analgesic, anti-inflammatory AQ1,anti-ulcer, anthelmintic effect, cardiovascular, anti-nociceptive, anti-diabetic, antipyretic, hepatoprotective, neuropharmacological, and diuretic action, antimicrobial effect and cytotoxic capabilities, in-vitro anti-oxidant, and DNA damage inhibition, and constipation and diarrheal effect. Keywords: Carissa carandas, flavonoids, hepatoprotective, anti-hyperglycemic action, DNA damage inhibition (Akhter *et al*., 2022).

The aims of this research were to select the basic recipe and develop Thai dipping sauces for chicken from karanda juice, which was used to replace vinegar at 0, 25, 50, 75 and 100%, respectively. The panelists gave the highest score and accepted Thai dipping sauce for chicken from karanda juice at 100% substitution level, especially the odor and taste scores ($p<0.05$). The effect of karanda juice used to replace vinegar on the characteristics and qualities of karanda Thai dipping sauce for chicken was also studied. For physical properties, the color of karanda Thai dipping sauce for chicken 100% was darker, due to the color of karanda fruits and viscosity value was higher than basic Thai dipping sauce ($p<0.05$). For chemical properties, the total soluble solid of karanda Thai dipping sauce for chicken 100% was 64.50±0.01 °Brix, pH value was 2.99±0.03, total acidity was 1.82±0.02%, total phenolic content was 0.75±0.00 mg GEA/g sample and DPPH scavenging radical activity was 6.25±0.00 µmole Trolox/g sample. In addition, karanda juice used to replace vinegar in Thai dipping sauce for chicken was found to have higher carbohydrate content and calorie than basic recipe Thai dipping sauce. Karanda Thai dipping sauce for chicken was safe from pathogens and spoilage microorganisms, which complied with the standard for Thai dipping sauce (Tubbiyam and Manaroje, 2022).

Karanda (*Carissa carandas* L.) fruit has been extensively studied for various applications and used in making a variety of food and nonfood products due to the phytochemical components. In this study, the phenolic content, antioxidant activity, anti-diabetes and antiproliferative activities of the freeze-dried crude karanda juice powder (KJP) and residue powder (KRP) were investigated. The findings revealed a different yield: KJP obtained 7.76 g/100g and KRP obtained 9.89 g/100g ($p\leq0.05$). In addition, the KRP had less moisture and water activity (a_w) than the KJP, which may be associated with the sugar residue content. The KJP revealed that the total phenolic and anthocyanin content were 58.02 mg GAE/g and 0.17 mg/g, respectively. Furthermore, antioxidation activity using the DPPH and FRAP assays demonstrated 38.86 mg GAE/g and 9.08 µmol FeSO4/g, respectively. In terms of anti-diabetes activity, the crude extract of KJP inhibited α-amylase activity (98.70%) and α-glucosidase (50.86%), whereas KRP inhibited α-amylase activity (50.34%) and α-glucosidase (18.30%) when compared to acarbose. The KRP and KJP were both non-cytotoxic and inhibited the growth of human colorectal adenocarcinoma (Caco-2) cells and human liver hepatocellular carcinoma (HepG2), with IC_{50} values of 97.26 µg/mL and 87.06 µg/mL, respectively. Both the KJP and the KRP freeze-dried showed promise as dietary supplements or functional foods for diabetes and cancer prevention (Srithongkerd, 2023). The tough, evergreen, spiky Karonda (*Carissa carandas* L., 2n=22) is an indigenous shrub that grows in India and is a member of the Apocynaceae family. Carissa is a genus that contains about twenty-five species, five of which are native to India (*Carissa carandas* L, *Carissa spin arum* L, *Carissa congesta*, *Carissa edulis*, and *Carissa grandflora*). The Carissa species holds great socio-economic importance in India's tribal regions. It is grown properly in Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, and Maharashtra. Due to its extreme hardiness, it can thrive easily in climatic conditions ranging from arid to subtropical to tropical. The plant rarely needs much attention and can produce a good harvest with little to no maintenance because it isn't necessarily a distinctive rainy crop .The Karonda fruit grows in arid places and a good source of minerals and vitamin C. While the more acidic Karonda fruits are better cooked with lots of sugar, the sweeter fruits can be eaten raw. A ripe outcome with an overabundance of pectin. As a result, it's also used to make chutney, jelly, jam, squash, syrup, tarts, and other foods that are highly sought after on the international market. As a result, tannin content in leaves and bark is high. The Karonda tree has numerous applications because it is still utilized in traditional medicine, and recent scientific research has shown that it possesses a variety of beneficial qualities. The tussar silkworm feeds off of its leaves (Yadav *et al.,* 2023). Karonda (*Carissa carandas* L.) belongs to family Apocynaceae. Karonda is an evergreen shrub, dichotomously branched, with short stem and strong thorns. It is a hardy, drought tolerant plant of the dry land, growing in a wide range of soil and climatic conditions. It grows naturally throughout the India except higher hills (> 1200 m) of Himalayas. Karonda is rich in vitamins and minerals. It is one of the richest sources of iron and has got fair amount of vitamin C. It is very useful for curing anaemia and has antiscorbutic properties. The fruits have antiscorbutic properties and are also useful in prevention of anaemia. Karonda is reportedly useful incurring stomach-ache and is anthelmintic. Karonda fruits are sour and astringent, acidic too sweet in taste with a peculiar aroma and are not popular as a fresh due to its high pectin content. In Ayurveda, the unripe fruits are used as astringent, appetizer, antipyretic, antidiabetic. In general, ripe fruits are used in the processing industry for the preparation of preserves. Karonda is hardy plant. It grows well in arid to very humid regions. Due to wide adoptability and origin of centre, India has lot of genetic diversity in Karonda with respect to tree height, thorniness, leaf characters, fruit size, fruit shape, fruit colour, sweetness and acidity. The wide variability of karonda in different parts of the country has been reported (Tripathi *et al*., 2023).

Karonda (*Carissa carandas*), is a thorny evergreen shrub from Apocynaceae family that grows in the arid and semiarid regions of the world. This shrub bears edible berries in the month of July that ripens by the first week of September. This fruit has limited reach in the advanced markets; however, it has been widely used as pickle, preserve or candy by ethnic peoples. Its application in the indigenous medicine system is also reported. The fruits are rich in dietary fibre, vitamins (especially vitamin C) and minerals like iron. The fruits are also rich in phytochemicals like phenols, flavonoids, anthocyanins, polyphenols, organic acids, carotenoids, and phytosterols. Its' phytochemical richness makes it a potent pharmaceutical source for antidiabetic, adaptogenic, anticancer, anti-diarrhoeal, antiaging, hepatoprotective, nephroprotective, etc. The abundant concentration of cyanidin-3-galactosides (36.25 mg/g extract), an anthocyanin, makes it a significant source of natural colorants in food and pharmaceutical industry. The application of this pigment in the development of intelligent packages is one the recent trends. Apart from traditional utilization, karonda fruits are also effective in development of ready to drink beverages, alcoholic beverages, preservatives, pectin, etc. The current review aims to enhance the karonda fruit utilization by emphasizing potent applications in wide emerging industrial aspects (Bibha Mishra *et al*., 2024). Karonda (*Carissa carandas*), is a thorny evergreen shrub from Apocynaceae family that grows in the arid and semiarid regions of the world. This shrub bears edible berries in the month of July that ripens by the first week of September. This fruit has limited reach in the advanced markets; however, it has been widely used as pickle, preserve or candy by ethnic peoples. Its application in the indigenous medicine system is also reported. The fruits are rich in dietary fibre, vitamins (especially vitamin C) and minerals like iron. The fruits are also rich in phytochemicals like phenols, flavonoids, anthocyanins, polyphenols, organic acids, carotenoids, and phytosterols. Its' phytochemical richness makes it a potent pharmaceutical source for antidiabetic, adaptogenic, anticancer, anti-diarrhoeal, antiaging, hepatoprotective, nephroprotective, etc. The abundant concentration of cyanidin-3-galactosides (36.25 mg/g extract), an anthocyanin, makes it a significant source of natural colorants in food and pharmaceutical industry. The application of this pigment in the development of intelligent packages is one the recent trends. Apart from traditional utilization, karonda fruits are also effective in development of ready to drink beverages, alcoholic beverages, preservatives, pectin, etc. The current review aims to enhance the karonda fruit utilization by emphasizing potent applications in wide emerging industrial aspects (Mishra *et al.,* 2024).

Karonda (*Carissa* spp.), a lesser-known fruit crop, is extensively utilized by tribal communities in India for its medicinal properties in Ayurveda and Unani medicine. This fruit thrives in tropical and subtropical climates, showcasing its resilience and ability to withstand drought conditions. However, it is not well suited for areas with heavy rainfall and waterlogged conditions. Karonda holds significant importance in ethno medicine as it serves as a valuable dietary supplement, contributing to the enhancement of our overall health. The plant that produces small fruits has long been employed in the remedy of scabies, intestinal worms, diarrhea, intermittent fever, and is renowned for its aphrodisiac, aperitive, antipyretic, antiscorbutic, and astringent qualities. Ascorbic acid, lupeol, -sitosterol, glucose, galactose, serine, glutamine, alanine, valine, phenylalanine, and glycine are among the numerous chemical components discovered in different components of this plant. This particular plant is commonly employed in the management of various ailments, such as biliousness and anemia. Additionally, it serves as a direct remedy for wounds (in the form of juice), a solution for skin issues, an aphrodisiac for women, an antiparasitic, antifungal, and antibacterial agent. Consequently, it is of great value to examine its therapeutic characteristics and explore its potential utilization in the nutraceutical domain, owing to its extensive nutritional and pharmacological properties. This essay examines the ethnobotanical significance of karonda fruit, leaves, root, and shoot, along with the research that substantiates the notion of their medicinal and therapeutic properties (Pathania *et al.,* 2024).

ORIGIN AND DISRTIBUTION

C. carandas is patented near the Himalayas; by certain botanists place the fruit's origin to Java. The plant is originate to be distributed in the Himalayas at the heights of 300-1800 m, in the Siwalik Hills, the Western Ghats, in Nepal, Afghanistan, India, Sri Lanka, Java, Myanmar, Malaysia, Australia, Pakistan, and South Africa. In India it is cultivated in the states of Bihar, Maharashtra, Orissa, West Bengal, Chhattisgarh, Gujarat, Rajasthan, Madhya Pradesh, and in the Western Ghats. In Maharashtra, the main area under this crop is distributed in sub mountain area such as Ratnagiri, Kolhapur, and Pune district [5]. Some of the important cultivated Carissa species besides *C. carandas* L. includes: *Carissa grandiflora* DC, *Carissa bispinosa* Desf., *Carissa spinarum* DC, *Carissa ovata*, *Carissa edulis* Vahl., *Carissa inermis* Vahl. Syn., *Carissa macrophylla*, *Carissa paucinervia* D.C., and *C. spinarum* L. Syn., *Carissa diffusa*, *C. carandas* and *C. spinarum* are native to India (Index Kewensis, 1985-190) while *C. grandiflora* is native to South Africa (Akhter *et al.,* 2022).

Karonda is believed to have originated in the Himalayas but it now thrives in regions with -vine shrub that is native to India. As the plant flourishes in regions with high temperatures, it is abundantly found in the Western Ghats of Konkan in the western coastal states of Maharashtra and Goa in India. However, it is also found growing naturally in the temperate conditions Himalayan Siwalik Hills of India and Nepal, where it can be found at elevations of 30 to 1,800 metres. It can also thrive in marginal and wastelands. Rajasthan, Gujarat, Bihar, West Bengal, and Uttar Pradesh are among the states where it is grown on a limited scale (Tripathi *et al*. 2014). It can also be found in other South Asian nations, such as Sri Lanka's lowland rain forests, Pakistan Nepal, Afghanistan, and Bangladesh. Carissa is a genus of roughly 30 species native to the tropics and subtropics of Asia, Africa and Australia, with four species in China (Singh *et al*., 2023). Karonda plant grows well under tropical and sub-tropical climatic conditionIndia, Sri Lanka, Java, Malaysia, Myanmar, Pakistan, Australia, and South Africa are all frequent locations for the plant. Though some botanists attribute the fruit's origin to Java, the berry-like fruits are said to have their origins close to the Himalayas. Its natural range covers several regions of India and reaches from Nepal to Afghanistan. Numerous of Indian locations, such as Siwalik Hills, Bihar, West Bengal, the Western Ghats, Karnataka, and the Nilgiris Hills, are excellent places for the fruit to thrive. The majority of karonda shrubs are decorative; however the fruit is occasionally known to be grown on small-scale among the tribal regions of Madhya Pradesh, Chhattisgarh, Rajasthan, Gujarat, and Jharkhand. It is grown commercially in the districts of Varanasi in Uttar Pradesh and South 24-Parganas in West Bengal. A few of the important cultivated species of karonda are *Carissa carandas* L, *Carissa grandiflora* DC, *Carissa bispinosa* Desf., *Carissa spinarum* DC, *Carissa ovata*, *Carissa edulis* Vahl., *Carissa inermis* Vahl. Syn. *Carissa macrophylla, Carissa paucinervia* D.C, *Carissa spinarum* L. Syn. *Carissa diffusa* Natal plum, an African species (*Carissa grandiflora*), bearing large and dark red fruits are also grown in India (Pathania *et al*., 2024).

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conditions of the Himalayan Siwalik Hills of India and Nepal at elevations of 30 to 1,800 metres (98 to 5,906 ft). In other parts of India, it is grown on a limited scale in Rajasthan, Gujarat, Bihar, West Bengal and Uttar Pradesh. It is also found in other South Asian countries like in the lowland rain forests of Sri Lanka, and in Pakistan, Nepal, Afghanistan, and Bangladesh. It is an introduced species in the Americas and other parts of Asia (Wikipedia, 2025).

- Andhra Pradesh : Kadapa district, West Godavari district, East Godavari district, Chittoor district
- Karnataka : Kolar district, Bengaluru district
- Kerala : All districts of Kerala
- Odisha : Kalhandi district, Ganjam district
- Tamil Nadu: Tiruvannamalai district, Villipuram district, Dharmapuri district, Vellore district, Cuddalore district
- Jharkhand:
- Madhya Pradesh : Hoshangabad district
- Delhi : Delhi
- Uttar Pradesh : Uttar Pradesh
- Punjab : Punjab
- (Sankara Rao and Deepak Kumar, 2025).

TAXONOMY

The following species are recognised

1. *Carissa bispinosa* (L.) Desf. ex Brenan - widespread in E + S Africa from Kenya to Cape Province
2. *Carissa boiviniana* (Baill.) Leeuwenb. - Madagascar
3. *Carissa carandas* L. - India, Bangladesh; naturalized in S China, Mauritius, Nepal, Pakistan, Indochina, Java, Philippines, West Indies
4. *Carissa haematocarpa* (Eckl.) A.DC. - Namibia, Cape Province of South Africa
5. *Carissa macrocarpa* (Eckl.) A.DC. - Kenya + Zaire south to Cape Province; naturalized in S China, Ascension Island, Hawaii, Florida, Texas, Mexico, Central America, West Indies
6. *Carissa pichoniana* Leeuwenb. - Madagascar
7. *Carissa spinarum* L. - Africa, Arabian Peninsula, Indian Subcontinent, Indochina, New Guinea, New Caledonia, Australia
8. *Carissa tetramera* (Sacleux) Stapf - E + S Africa from Kenya to KwaZulu-Natal Formerly included
9. (Tripathi *et al*., 2014).

Important Species of Carissa

The genus Carissa contains approximately 30 species originating from South Africa, Tropical Asia, Australia and Malaysia out of which 5 are indigenous to India (Hu and Shu, 1995). Carissa is mainly cultivated for its small edible berries; however, they are cultivated for ornamental purpose in different parts of the world. The important species are listed below(Singh *et al*., 2023):

1. **Carissa carandas L**. A large, short-stemmed evergreen shrub with a height of 3-6 metres, glabrous except for the inflorescence, and typically with milky latex. Flowers are white in colour, fragrant, borne solitary or in clusters and are bisexual.
2. **Carissa spinarum L**. This species produces somewhat bigger, juicier, and sweeter fruits. It is indigenous to India. This species is the hardiest and is renowned for thriving in harsh, rocky terrain. It is grown all over the nation, especially in Kashmir and Punjab. For its fragrant blossoms, it is cultivated in hedges. Tannin is abundant in leaves.
3. **Carissa inermis.** A tiny tree or huge climbing shrub that is common on the West Coast. Inflorescence is puberulous, terminal and white coloured. Advances in Production Technology of Karonda | 599
4. **Carissa suavissima Bedd**. A tall climber, fairly glabrous. Decurved spines. Berry with milky juice, turns black on ripening.
5. **Carissa arduina.** A small, glabrous shrub with pale-pink sepals, a white corolla, twice-forked spines and scarlet berries.
6. **Carissa acuminate.** Identical to C. bispinosa in appearance, but with less robust or week spines and oval, subcordate, short, forked and axillary leaves. The corolla is twisted to the right in the bud, and the calyx lobes are lance- acuminate in shape.
7. **Carissa bispinosa Desf**. A robust, evergreen shrub with thick, glossy leaves and sharp spines. Flowers are white in colour, fragrant and twisted to the right in the bud. Fruits are similar to the size of cherry and dark red in colour.
8. **Carissa congesta.** Spread throughout the Western Ghats. Jam is produced from these fruits.
9. **Carissa edulis.** This species has its origin in Tropical Africa. It was introduced from the USA into India. It is 10 feet tall straggling bush. Fruits are red to purple in colour.
10. **Carissa bispinosa**. The fruits are borne in bunches and the flowers are tiny. The fruits are identical with the species C. grandiflora.
11. **Carissa grandiflora Syn**. - Arduina grandiflora Also known as Natal plum; it was introduced in India from South Africa. It is popularly cultivated in Maharashtra and Baroda regions of India and are either consumed fresh or used in salad, sauces etc. The fruits have papery exterior, dark red flesh, and a few tiny seeds. Vitamin C is abundant in these fruits.
12. **Carissa ovate**. Small fruits; used to make jam. This species is said to have originated in Australia.

13. **Carissa macrophylla**. These species are native to India and are found growing in abundance in Western Ghats. It is a large shrub with spines approximately 1.5 inch long.
14. **Carissa paucinervia.** Found is Deccan Peninsula. 600 | A Textbook on Advances in Production Technology of Tropical and Subtropical Fruits

Species description: There are 25 species in the genus Carissa and five of which *Carissa carandas* L, *Carissa spinarum* L, *Carissa congesta, Carissa edulis*, and *Carissa grandiflora* are native to India. The Carissa species is mostly grown in Rajasthan, M P, UP, Bihar, WB, and MH. Historically, anorexia and insanity have been treated with Karonda. The vegetation may be trained to form a sturdy hedge. Most of this crop's growing space in Maharashtra is dispersed in submountain regions like Kolhapur, Ratnagiri, and Pune district. While the more acidic Karonda fruits are finest cooked with plenty of sugar, the sweeter ones may be consumed raw (Ahirwar *et al*., 2024). Karwand, scientifically known as Carissa carandas, belongs to the Apocynaceae family. It's a spiny, evergreen shrub native to the Indian subcontinent, particularly prevalent in tropical and subtropical regions. The plant typically grows up to 2-3 meters in height and bears small, oval-shaped leaves with sharp thorns. Karwand produces white, star-shaped flowers that emit a sweet fragrance, followed by round, fleshy fruits that ripen to a dark purple or black color (GBT, 2025). Karwand holds significant historical and cultural importance across various civilizations. In India, it has been mentioned in ancient texts like Ayurveda and the Charaka Samhita for its medicinal properties. Moreover, Karwand holds religious significance in Hinduism, often associated with deities like Lord Shiva and Goddess Parvati. In some regions, Karwand fruits are offered in religious rituals and ceremonies as a symbol of auspiciousness and prosperity (GBT, 2025).

Synonyms

Arduina carandas, Echites spinosus, Jasminonerium carandas (Neelima Kale *et al*., 2025).

Syon/Scientific names
Arduina carandas (L.) Baill.
Arduina carandas (L.) K. Schum.
Capparis carandas (L.) Burm.f.
Carissa carandas L.
Carissa salicina Lam.
Echites spinosus Burm. f.
Jasminonerium carandas (L.) Kuntze
Jasminonerium salicinum (Lam.) Kuntze
Carissa carandas L. is an accepted species. KEW: Plants of the World Online

(Cu huang guo, 2024).

Synonym

Arduina carandas (L.) Baill.
Carissa salicina Lam.
Echites spinosus Burm.f.
(Anon., 2025**).**

Synonyms

Arduina carandas **(L.) Baill.**
Arduina carandas **(L.) K.Schum.**
Capparis carandas **(L.) Burm.f.**
Carissa salicina **Lam.**
Echites spinosus **Burm.f.**
Jasminonerium carandas **Kuntze**
Jasminonerium salicinum **(Lam.) Kuntze**
(WFO, 2025).

BOTANICAL DESCRIPTION

Different colored fruits of karonda from purple to deep red are available in India which is used tomake jam from them. Fresh and undamaged karonda fruits are washed properly and cut them in halves. Take out the seeds and place the fruit in heavy bottom pan containing water. Heat and boil the fruit in water. The moment fruit becomes tender, add sugar if you want the pieces of fruit in the jam and contin-ue stirring. For the preparation of smooth jams the ten-der fruit can be passed through a sieve so a smooth pulp is obtained and then add sugar. Once cool, pack it in a glass bottle. The ripe fruits of karonda are boiled with baking soda and salt. For every cup of juicy pulp half tea spoon of baking soda is added and boiled in one liter of water at 100 °C. The mixture is then boiled down one half of the original quantity, removing the rising scum in the process and juice is again strained. For every cup a quarter cup of sugar is added. The mixture is again boiled for 40 minutes. The cool syrup is poured in to sterilized bottle and sealed (Saini *et al.,* 2016). *Carissa carandas* Linn. Is a dichotomously pronged evergreen shrub with a short branch and strong thorns in pairs, *Carissa carandas* Linn is an evergreen diffuse and spiny shrub occurring through the country. The plant is very valued for the Indian System of medicine mainly Ayurveda. It is used for alleviating Vata and pitta disorders.4 Species is a rank-growing, usually growing to 10 or 15 ft (3-5 m) high, sometimes ascending to the tops of tall trees; and rich in white gummy latex. The branches, many and dispersal, forming dense masses, are set with sharp thorns, simple or forked, up to 2 in (5 cm) long, in pairs in the axils of the leaves. The leaves are evergreen, opposite, oval or egg-shaped, 1 to 3 in (2.5-7.5 cm) long; dark-green, leathery, glossy on the upper surface, lighter green, and dull on the underside. The fragrant flowers are cylindrical with 5 hairy lobes that are twisted to the left in the bud instead of to the right as in other

species. They are white, regularly tinged with pink, and borne in terminal clusters of 2 to 12. The fruit, in clusters of 3 to 10, is oblong, broad-ovoid or round, 1/2 to 1 in (1.25-2.5 cm) long; has fairly thin but tough, purplish-red skin turning dark-purple or closely black when ripe; smooth, glossy; enclosing very acid to equally sweet, often bitter, juicy, red or pink, juicy pulp, radiating flecks of latex. There may be 2 to 8 small brown seeds. The Karanda is common throughout much of India, Burma, and Malacca and dry areas of Ceylon; is rather commonly cultivated in these areas as a hedge and for its fruit, and the fruit is marketed in villages. The karanda was initial fruite in the Philippines in 1915.5 Fruits are rich source of iron and vitamin C, therefore, ethnomedical the fruits are used for curing anemia, as an astringent, antiscorbutic, and as a remedy for biliousness. Its leaf decoction is used in contradiction of fever, diarrhea, and earache, whereas roots help as a stomachic, vermifuge, remedy for itches, and insect repellent (Bhosale *et al.,* 2020).

Type: annual shrub; leaves: opposite, ovate, green colour with glossy appearance from above surface and dull green shade at below surface. Stems: appearance of greenish-white bark on young shoots and greyish-brown bark on matured stems. The spines are erect with 1–3 cm long; flowers: white colour, clusters in 2–5 flowers, scented, seen in February to June and corymbose cymes; fruit: globose berry, appears from March to August and get ripened in the month of May–December; taste: slightly acidic when fully ripened (Singh *et al*., 2020). *Carissa carandas* is an evergreen deciduous small to big shrub height 2-4 m tall. The stem is rich in white latex and the branches contain sharp spines. Flowers are small, diameter of flower 3-5 cm, with white colour. The fruit is a berry, which is formed in clusters of 3-10 fruits. fruits are pinkish white and become red to dark purple when ripe. Ripe fruit colour from white, green and pinkish red depending on the genotype. Flowering month January-February and fruits mature in May-June. Fruits are generally harvested at immature stage for vegetable purpose, fully ripen fruits are consumed fresh or processed. The leaves are oblong and conical, 4-6 inch long and 2-3 inch wide, green on the top and brown below. Flowers: White or yellowish flowers are found in groups. Fruit: The are avoid with 5-1 hard angles curving upwards, glabrous with five to seven wings, woody and fibrous. Bark: The bark is smooth gray. The bark is thick (Singh and Singh, 2021). Karonda fruits are small berries, averaging 1 to 3 centimeters in length, and have an oval to ovoid shape with curved ends. The berries grow in clusters of 3 to 10 fruits and ripen at different stages, giving the shrub a multi-colored appearance. When young, the fruits are green to white, transitioning into a bright red-pink hue, finally ripening into a dark purple, almost black shade with maturity. The thin but tough skin will also change from taut, smooth, and glossy to slightly wrinkled with some give when ripe. Underneath the surface, the flesh ranges from pale red to crimson, depending on the degree of ripeness, and is aqueous and soft, encasing 2 to 8 flat, brown seeds. When harvested, the fruits may also emit a milky white latex that should be removed before eating. Fruits are sour and astringent in taste, and are a rich source of iron and vitamin C (Sonal *et al.,* 2022). *Carissa carandas* is an evergreen deciduous, generally 2-4 m tall plant of the family Apocynaceae. Its stem consists of white latex, with sharp spines on branches; the leaves are oblong and conical with 4-6 inch long and 2-3 inch wide, green in colour on the top and brown below. The plant have white colored flowers, sized 3-5 cm in diameter, the fruit is a berry, which is formed in bunches of 3-10 fruits, with 5-1 hard angles hooked upwards, glabrous with five to seven wings, woody, and fibrous. The fruit shape is globose to broad ovoid containing several seeds. Fresh fruits are pinkish white, while ripe fruit turn into red to dark purple. Ripe fruit color differs from white, green and pinkish red subject to the genotype. Seed 3-5 per fruit, blackish brown in color, flat, eleptical, and light in weight. Flowering starts in the month of January- February and fruits mature in May- June. Fruits are generally collected at the immature stage for vegetable purpose, fully ripen fruits are used up fresh or processed (Akhter *et al*., 2022).

Carissa carandas is a 2-4 m tall evergreen deciduous small to large shrub. Sharp spines can be seen on the branches, and the stem is abundant in white latex. Flowers are tiny, measuring 3-5 cm in diameter, and are white in colour. Fruit, developed in clusters of three to ten, is a berry with pinkish-white colouration when unripe, becoming scarlet to dark purple on ripening. Depending on the genotype, ripe fruit can range in colour from white to green to pinkish red. The leaves are 4-6 inches long, 2-3 inches broad, generally oblong and conical in shape. They are green above and brown underneath. Flowers and fruit description Flowers: Flowers are clustered and are small, 3-5 cm diameter, with white or yellowish flowers. January to February is the flowering season. Karonda fruits are tiny berries with curled ends that range in size from oval to ovoid and are typically 1 to 3 centimeters long. The berries are produced in groups of three to ten colour changes from green to white, then goes through a vivid red-pink colour before maturing into a deep purple, almost black tint. After ripening, the thin, rough skin will also transform from taut, shiny, and smooth to slightly wrinkled with little give. Depending on the level of ripeness, the flesh beneath the skin varies in colour from pale red to crimson and is watery and soft, encasing 2 to 8 flat, brown seeds. Before eating, the fruits should be cleaned of any milky white latex that may have been released during harvest. Fruits have a tart, astringent flavour, and are a good source of vitamin C and iron (Singh *et al.,* 2023).

- **Leaves**: The leaves of the Karonda plant are rectangular and conical, with a green-brown hue. The leaves are 2-3 centimetres long, with a dull green hue behind their glossy green exterior. The plant has thick, sharply-spine grey bark and can reach a height of 4 meters.
- **Flower**: The white, fragrant Karonda flower has tubular shape with lance-shaped late lobes that overlap to the right. The flowers bloom from February to June and are produced in clusters of two to five.
- **Fruit**: It is also referred to as Carandas-plum, black currants, and Bengal currants. The fruit has a luscious pulp and is spherical, tiny, and meaty. It tastes acidic and bitter-sour.
- IV. Bark: On mature stems of the Karonda plant, the bark is grayish brown; on immature shoots, it is greenish white. The prickly shrub known as Karonda can reach a height of four meters. The limbs of the plant are prickly.
- (Yadav *et al*., 2023)

Evergreen deciduous thorny small to big shrub usually with 2-4m tall

Stem: Stem is rough and woody in nature. It is usually brown in colour. It possesses thorns for their protection from herbivores attacks. Stem rich in white, gummy latex having sharp spines on the branches. Branches numerous, spreading and forming dense masses with 2 pair (5 cm in length) of simple or forked thorn form at the axils and nodes.

Leaves: Leaves are 2 inches long. It is simple, bright green coloured above and paler beneath which grows opposite, mostly very dark green in colour, shiny with large spines, coriaceous and glabrous on both sides. It having 2 mm petiole. It secrets milky latex. The shape of the leaf is ovoid-ovate with acute apex and reticulate venation. Simple, opposite, exstipulate, elliptical or ovate, short petioles, acute tip, obtuse base, entire margin, unicostate, reticulate venation, glabrous leaf surface. Leaves are 2 inches long, mostly very dark green in colour, shiny with large spines. It secrets milky latex when it gets injured. Inflorescence: Small fragrant white flowers, with rose stalk, are produced from early spring through late fall. Terminal corymbose cyme, dichasial cyme, linear bracts

Flower: Ebracteolate, pedicellate, bisexual, actinomorphic, pentamerous, hypogynous. Fragrant, whit or pale yellow colour star shaped.
Calyx: 5 sepals, gamosepalous, valvate or imbricate aestivation, fused from the base showing separation at tip.

Corolla: 5 petals, united, gamopetalous, salver shaped, twisted or imbricate aestivation, pubescent.

Androecium: 5 stamens, epipetalous, basifixed, dithecous, introse dehisces longitudinally

Gynoecium: Bicarpellary, syncarpous, superior ovary, 2 locules with 2 ovules in each locules, axile placentation, filiform style, bifid stigma

Fruit: Fruit is berry. The fruit is ovoid-ellipsoid, 1 cm long and 8 mm wide. Before ripening it is greenish white in colour and it turns to dark blackish purple red after ripening. It grows as clusters and it ripen from May through October. Plants raised from seed start bearing two years after planting. Fruits are variable in size, resembles grapes. It contains usually 4 seeds. The fruits harvested after the commencement of rains are not preferred for fresh consumption by customers.

Seed: Oblong, concave fleshy endospermic.

Pollination and dispersal: Entomophilous. (Shankar *et al*., 2024).

It is a tiny, evergreen tree or prickly shrub with a maximum height of about 3-6 meters. It is very popular as a protective hedge plant. It is a very hardy, drought-tolerant plant that thrives well in a wide range of soils including saline and sodic soils throughout tropics and subtropics. However, it cannot survive well in environments with heavy rain and water retention. White latex is abundant in the stem, and the branches have pointed spines. The leaves are 4-6 inches long, 2-3 inches wide, and oblong and conical. They are green above and brown below. The gray bark is slick. The bark is hard but flexible, and it is inside crimson in color. Flowers come in clusters and are either white or yellowish in color. The Flowers are tiny, with a diameter of just 3 to 5 cm. Berries, which are developed in clusters of three to ten fruits. The fruit has a round large oval shape and is seed-filled. Fruits are pinkish-white when young, changing red or dark purple as they ripen. Depending on the genotype, the color of ripe fruit ranges from white to green to pinkish red. Fruits begin to ripen in May and February marks the beginning of flowering. Fruits are frequently picked when they are still immature for use as vegetables; fully ripe fruits are consumed fresh or processed (Pathania *et al.,* 2024).

Caranda is a shrub growing 2 to 3 meters high. Branches are numerous, rigid and spreading, with 2 straight, simple or forked thorns, up to 5 centimeters in length on the axils and nodes. Leaves are smooth, ovate, or oblong-ovate, 4 to 7.5 centimeters in length, 2.5 to 4 centimeters in width, rounded or notched at the base, and blunt tipped. Flowers are fragrant, white or pale rose-colored, clustered in twos or threes. Calyx-segments are very slender, pointed and hairy. Corolla tube is about 2 centimeters long, smooth, with a swollen throat and hairy lobes, the lobes being lanceolate, pointed, spreading and about half as long as the tube. Fruit is a drupe, broadly ovoid, 1.5 to 2.5 centimeters long, bluntly pointed, and blackish or reddish-purple, containing 2 to 4 small, flat seeds. Pulp is reddish-purple and sour. **Growth form**: A woody shrub to a small tree, with climbing…

Growth form: A woody shrub to a small tree, with climbing habit. It can grow up to 5 m tall. **Foliage**: Leaves are broadly ovate to oblong in shape, measuring up to 7 cm long and 4 cm wide, with broadly cuneate to rounded base and apiculate apex. **Stems**: Stems have spines which are simple to slightly forked, measuring about 5 cm. **Flowers**: Inflorescence in cyme arrangement, fragrant white flowers, tubular up to 2 cm long, with lanceolate lobes which are overlapping to right. **Fruit**: Berries, reddish purple, globose to broadly oval in shape, measuring about 2.5 cm x 2 cm. (Cu huang guo, 2024). A big, short-stemmed, evergreen shrub and 3 to 6 meters long. Bark is light grey, scaly, and branchlets often alternate with twin, strong, glabrous spines 2.5 to 3 cm long at their bases. The branches, on the other hand, are typically spineless. Petioles are 0.6 cm long, and the leaves are simple opposite, coriaceous, dark green, obovate, obtuse, sometimes slightly mucronate, glabrous and shiny, base subacute, and tan red at opening before turning dark green. There are thin to stout spines in the leaf axils. Lanceolate, pubescent, very acute, and ciliate calyx. Four to five sepals, persistently imbricate, almost free-floating, and oval in form. The corolla frequently contains hairy or scaly appendages or outgrowths of various sorts. Petals are as numerous as sepals, and the lobes are distorted in the bud. Anthers are yellow, frequently connected in a cone, with filaments as petals and alternate with them in one whorl of the corolla. Whole lobed or scaly discs are frequently seen. Anthers are linear-oblong and contain stamens within the corolla tube. Style is long and straightforward, with a two-lobed, golden color and hairy below stigma. Rarely are there more than two carpels that are joined (connate) or simply linked by styles or stigmas at the ovary. Superior ovary has two glabrous cells with four ovules in each cell and a stigma with a faint penicillation at the tip. Fruit is 2–5cm long, ovoid to ellipsoid, and has a reddish pulp near the skin and a lighter pulp near the seed (Ahirwar *et al.,* 2024).

Flower Structure: Pentamerous flower with a star form and a white colour. Corymbose terminal inflorescence. Calyx: Pink coloured, with five sepals that are nearly united from base to tip of the corolla tube. Corolla: Five white petals joined together at the base to form a 1.5 centimetre long pink corolla tube. Androecium: The filaments of the corolla tube are joined with the short, five, bilobed anthers over its whole length. Gynoecium: Stigma right below the anthers on a single style that is about 1 cm long encourages self-pollination. Flowering: Twice a year, fruit and flowering both occur. The major flowering season occurs in March and April, and fruit matures in August and September, allowing the plants to get the most from monsoon rain. October through November mark the second blossoming season. In the months of August and September, the fruits from the first blossoming reach maturity. The varieties/accessions that produce fruit and blooms twice a year often produce little fruit. Anthesis: Different genotypes showed varying percentages of anthesis. Depending on the location, cultivar, and ambient temperature, the peak phase of anthesis was seen between 3-6 P.M. or 8–10 P.M. Dehiscence: Before anthesis, anthers dehisce between noon and four o'clock. Within an hour, the dehiscence is finished in a longitudinal pattern. The timing and length of dehiscence are influenced by atmospheric temperature and humidity. Stigma: Receptivity Two days prior to and two days following anthesis, stigma is at its most receptive. Mode of Pollination: According to flower structure, which favours self-pollination, most pollination occurs by itself (Ahirwar *et al*., 2024). The Karonda tree, scientifically known as *Carissa carandas*, is a small to medium-sized evergreen shrub that grows up to 3-5 meters in height. It has a bushy and dense growth habit, with dark green, glossy leaves that provide an attractive backdrop for the fruit. The tree also produces fragrant white flowers, which eventually develop into small, round Karonda fruits. The branches of the Karonda tree are thorny, adding to its unique character. The Karonda fruit is small, round, and usually measures about 2-3 centimeters in diameter. It has a smooth, thin, and glossy skin that ranges in color from green to deep purple, depending on its ripeness. The flesh of the fruit is juicy and tart, with a distinct sour taste that is reminiscent of cranberries. Despite its small size, Karonda is packed with essential nutrients, including vitamins A, C, and E, as well as antioxidants and dietary fiber. It is known to aid digestion, boost immunity, and promote overall well-being. Karonda is also used in traditional medicine for its antibacterial and anti-inflammatory properties (Greenverz, 2025). The karanda is a sprawling semi-vine shrub native to India. Leaves are from one-and-a-half to two-and-a-half inches long, very dark green, shiny and opposite and they have large spines like many other Carissas. If the leaves or stems are injured, the white milky sap is seen, which is characteristic of this group of plants. Although carissa karanda can be kept clipped into a shrub, it really

prefers to act much like a vine similar to bougainvillea and will climb to the tops of rather tall trees. Small fragrant three-quarter-inch white flowers, with rose stalk, are produced from early spring through late fall and the clusters of small purplish to black fruit ripen from May through October. Fruit size is variable, but most fruits are about three-quarters of an inch in diameter with a few seeds. Fruits usually occur in clusters somewhat resembling large purple grapes. Fruit quality is excellent in this author's opinion, somewhat resembling that of a blueberry in flavor. Fruits can be eaten fresh or used for jellies or jam (Neelima Kale *et al*., 2025).

1.Plant: The thorny, medium-sized shrub Karonda bark of mature stems is grayish brown, while that of juvenile shoots is greenish white. The spines are straight and measure 1-3 cm in length. Sometimes these are branched as well.[9]

2. Height: two to four meters

3. Wood: incredibly tough;

4. Bark: The bark is greyish brown on older stems and greenish white on young shoots. Its stem is rich in white latex, and its branches have sharp spines. The bark is thick, velvety, smooth, and gray on the outside, with a scarlet inner. Microscopic analysis reveals a wide area of stratified cork with lenticels; the secondary cortex is composed of long, thin-walled parenchymatous cells that contain stone cells; cortical fibers are found alone or sporadically in pairs or threes; secondary phloem containing calcium oxalate crystals is present; and starch grains are scattered throughout the phloem parenchyma and cortical cells.

5. Stem: Round shape, even exterior with an internode, little perceptible fracture, absence of ridges, dark green color. The existence of single-layered epidermal cells surrounded by the cortex and hypodermis is studied at the microscopic level. Four to five layers of parenchyma cells make up the cortex. The cortical region is scattered with lignified fibers. The bicollateral vascular bundles' pericyclic fibers are not lignified. The pith located at the section's middle.

6. Leaves: i) Ovate, leathery, 4.5 cm long, 2.5 cm wide, with a reticulate pinnate venation, an entire edge, a petiole that is 3 mm long, and leaves that, when removed from the stem, exude a white latex [5]. Its leaves are oval, opposite, and typically measure 2-3 cm by 1-1.5 cm. They have a dull green color underneath and a shiny green top. All year long, old leaves continue to shed.

Microscopic analysis: Anisocytic stomata are present in wavy-walled epidermal cells with thin cuticles. There are glandular trichomes and coverings. Single-layered parenchymatous cells make up the upper epidermis, which is followed by bilayered, radially elongated palisade cells. Three to four layers of lower epidermal cells and spongy parenchyma envelop these cells. The upper epidermis and a single layer of parenchymatous hypodermis make up the midrib. Collenchyma beneath the hypodermis is present. Collenchyma cells are girdled bychlorenchymatous cells. Bicollateral vascular packets are followed by calcium oxalate chargers and bounce grains

7. Flowers: These have fragrant, white flowers that are grouped in clusters of two to five. Corymbose cymes and short-stalked, sweet-smelling, bisexual, full, white blooms with a diameter of 3–5 cm form at the tips of branches.

8. Fruit: This ovoid fruit, which is 5–12 mm long and 6 mm in diameter, is green when unripe and lustrous black when ripe. It is a berry that grows in clusters of three to ten fruits. It is glabrous, woody, fibrous, and has five to one hard angle that curves upward. It also has five to seven wings. The fruit is globose to broadly oval in shape and contains several seeds. Young fruits are pinkish white, but ripe fruit turns scarlet to dark purple. Depending on the genotype, ripe fruit might be white, green, or pinkish red in appearance.

9. Seed: Each fruit contains three to five flat, eleptic, blackish brown, and light-weight seeds.

10. Root: Macroscopic: woody, cylindrical, rusty or yellowish-brown, moderately long, frequently irregularly bent, smooth surface, hard fracture, indistinct taste and odor. The secondary cortex, which is composed of one or two layers of very narrow, thin-walled cells; the secondary phloem, which is composed of multiple cavities and is situated directly beneath the secondary cortex in a ray pattern; the presence of stratified cork, which is composed of lignified, tangentially elongated cells; the presence of scattered stone cells in the phloem regions; the phloem rays are uni- or biserriate and contain calcium oxalate prisms; the cambium is not visible; and tracheid, fibers, xylem channels, and even xylem parenchyma comprise secondary xylem. (Kavita *et al*., 2025).

Stems - rich in white latex and sharp spines on the branches; smooth green, dense, soft and red on the inside.
Leaves - oblong and conical, 10-15 cm long and 5-7 cm wide, green on the top and brown below.
Flowers - white or yellowish are found in groups, measuring 3-5 cm in diameter.
Fruits - a berry that is produced in 3-10 fruit clusters, globose to large ovoid, young fruits are pinkish white and when ripe become red to dark purple. Seeds - It has 3 to 4 seeds per fruit. **(**Anon., 2025**).**

Shrubs, small trees, or climbers to 5 m tall. Spines simple or forked, to 5 cm. Leaf blade broadly ovate to oblong, 3-7 X 1.5-4 cm, base broadly cuneate to rounded, apex short apiculate; lateral veins ca. 8 pairs, ascending, convergent, anastomosing near margin. Cymes terminal, usually 3-flowered; peduncle 1.5-2.5 cm; bracteoles minute. Flowers fragrant. Pedicel about as long as calyx or slightly longer. Sepals 2.5-7 mm, with many basal glands inside. Corolla white or pale rose; tube to 2 cm, puberulent inside; lobes lanceolate, ca. 1 cm, acute, overlapping to right, puberulent, ciliate. Ovules numerous in each locule. Berries reddish purple, ellipsoid, 1.5-2.5 X 1-2 cm. Fl. Mar-Jun, fr. Jul-Dec. 2*n* = 22. Branches dichotomous, spreading, glabrous, spines 2-2.5 cm long, stout, mostly straight, sometimes bifurcate. Leaves broadly ovate, 4-8 x 2-3.5 cm, sub-coriaceous, young leaves with pink midribs, margin smooth, base rounded or retuse, apex emarginate. Flowers white, often tinged with pink, c. 2 cm across, bracts subulate, hairy, peduncle pink, c. 1.2-2 cm long. Calyx c. 5 mm long, pubescent, lobes linear. Corolla tube cylindrical, glabrous, swollen and pubescent near the top, 1.5-2 cm long, lobes white tinged with pink, overlapping to the right in bud, lanceolate, acute. Ovary glabrous with 4 ovules in each cell. Fruit 1.25-2.5 cm long, globose, ovoid or ellipsoid berry, when ripe white with red shade then purplish black, having milky juice, 4-8 seeded. Climber, shrub or small tree to 5 m. Branchlets glabrous. Leaves: petiole ca 1–3 mm long; blade

coriaceous, broadly ovate or oblong, 3–7 x 1.5–4 cm, apex rounded or retuse, base obtuse; 4–12 pairs of secondary veins, ascending; glabrous. Inflorescence ca 3.5–5.5 cm long. Sepals ovate, 1.8–3.5 x 1–2 mm, acute; sparsely puberulent or glabrous, ciliate. Corolla white or pale pink; tube 16–21.5 mm long; lobes 7–10 mm long; pubescent outside and inside on tube and lobes. Stamens inserted at 10.5–14 mm from base; filaments 0.3–0.5 mm long; anthers 2–3 x 0.6–0.8 mm. Ovary 1.5–23 mm long, glabrous; style + pistil head ca 1 cm long. Fruit red or black, 15–23 x 12–17 x 12–17 mm (WFO, 2025) (Fig. 1).

		
Treers	**Fruits**	**Bark**
		
Stem	**Root type, depth, color**	**Seedling**
		
Seedling	**Leaves**	**leaf shape, leaf margin, leaf apex**

Continue …..

		
Flower	**Fruits**	**Fruits**
		
Fruits	**Fruit**	**Fruit**
		
Fruit	**Fruits**	**Fruit ready for consumption**
		
Fruits	**Dried fruits**	**Dried Fruits**

Fig. 1. Botanical Description

GENETICS AND CYTOGENETICS

The Karonda (*Carissa carandas* L.), having 2n=22 chromosome numbers and belongs to Apocynaceae (Ahirwar *et al*., 2024). Chromosome no - 22 ; Type of fruit – Berry; Edible portion - Epicarp and Mesocarp (Ahirwar *et al*., 2024).

GENETIC DIVERSITY

Thirty elite genotypes were identified from Mirzapur, Varansi, Faizabad and Lucknow districts of U.P Vengurla, Belgaun and Gokak area of Karnataka, Ajmer, Chittorgarh and Siroli area of Rajasthan and Neemach (M.P). Floral characterization revealed flowering period was from March to April with full bloom in April first Week under Lucknow conditions . Anthesis was recorded after 1.00 pm, followed with anther dehiscence after few hours. Poor pollen fertility and germinability suggests scope of improvement in the crop yield.The mature fruits analyzed for fruit weight, length, diameter, pulp and seed content, TSS (ºBrix) acidity and ascorbic acid content revealed that there was wide variation among the accessions. The fruit colour was purple and red- white; fruit weight ranged from 1.85 to 6.0 g; fruit length from 0.90 to 2.40 cm; diameter from 0.32 to 2.15 cm; seed weight from 0.26 to 1.40 g and pulp content from 1.35 to 4.67 g; Total Soluble solids (ºBrix) in different accessions varied from 5.20 to 9.50, Titrable acidity varied from 0.45 to2.91% whereas Ascorbic acid content varied from 23.20 to 31.46 mg/100g. On the basis of physico-chemical characters of fruits, 3 accessions viz. CISH Kr-10, CISH Kr-11 and CISH Kr-12 have been identified for multiplication and further evaluation (Singh and Bajpai, 2014). The information on genetic variation of Karanda (*Carissa carandas*) in morphological traits and phytochemicals is necessary for further improvement. Thus, the objective of this study was to evaluate genetic variation in 20 accessions of Carissa carandas for morphological and phytochemical traits. Low variations were found among these accessions for stem color, branch color, leaf color, leaf shape, leaf apice, leaf base, leaf attachment, leaf margin, leaf venation, leaf surface, spine color, flower color, inflorescence type, perianth form, sepal number, pistil number, pollen shape, unripe fruit color, ripe fruit color and seed color, but moderate to high variations were found for morphological and phytochemical characters. High variation of leaf length, leaf width, spine length, spine per area, flower number per inflorescence, flower length, petal number per flower, petal length, petal width, pistil length, pollen size, fruit width, fruit length, fruit width/length ratio and seed number per fruit were founded for Karanda accessions, and high variation of total phenolic content (TPC), total anthocyanin content (TAC), total flavonoid content (TFC), titratable acidity, vitamin C and antioxidant activity determined by TEAC, DPPH and FRAP methods were founded for fruit ripening stage. Ripe fruit stage had phytochemical content and antioxidant activity more than unripe fruit stage. The dendrogram based on quantitative morphological traits was classified into six groups and the dendrogram based on phytochemical characters was classified into five groups. The high phytochemical group may be used as good genetic material for increasing phytochemical characters. This information could be useful in Carissa carandas breeding programs for high phytochemical yield (Simla *et al*., 2017).

Carissa carandas Linn. belonging to the family Apocynaceae, is an underutilized fruit plant. *C. carandas* has been used in many ethno medicines. Genetic diversity is a ubiquitous feature of all species in nature. ISSR markers are useful in areas of genetic diversity, phylogenetic studies, gene tagging, genome mapping, and evolutionary biology in a wide range of plant species. In this investigation, 9 ISSR primers were used for fingerprinting of 9 different accessions of *C. carandas* grown in a different location. Of these 9 primers, the amplification of only 8 primers were satisfactory and reproducible. Results of the ISSR fingerprint showed 473 amplified fragments; 134 of them were polymorphic (28.33%). The sizes of the amplified fragments were ranged between 200 and 1700 bp in length. The primer HB-10 showed the highest polymorphism (46.67%), while primer 6 showed the lowest with only (8.70%). The results obtained in this study validate that ISSR is useful markers in genetic diversity studies and offer a promising perspective as a molecular tool for varietal identification and breeding program applications due to the polymorphism level detected by the primers. Tandem repeats flanking microsatellites are highly polymorphic, even among closely related cultivars due to mutations. The results showed a low level of polymorphism (28.33%) among *C. carandas* accessions growing in different locations by ISSR markers and revealed that low genetic diversity among the accessions analyzed, indicating its narrow genetic base and could be used for plantation and making value-added products (Saikia and Handique, 2021). The growth characteristic of 29 accessions of karonda revealed that the plant girth range from 17 to 93 cm it was the highest CHESK-V-9 (93 cm) and the lowest in CHESK-VIII-9 (17 cm). The height of the plant ranged from 1.75 to 3.70 m. It was the highest in CHESK-VI-9 (3.70 m). The accession CHESK-II-6, CHESK-II-7, CHESK-III-4, CHESK-VII-1 were found vigorous growth with plant height of more than 3 meter. The canopy spread was higher (> 7.5 m2) in CHESK-II-3 (8.10 m2), CHESK-II-6 (7.80 m2), CHESK-II-7 (8,61m2), CHESK-V-5 (7.78m2) and CHESK-VI-2 (9.65 m2). The higher plant volume was recorded in CHESK -VI-2 (23.37 m3), CHESK-V-9 (23.03 m3), CHEESK –II-7 (22.30 m3), CHESK-II-6 (20.55 m3). The number of fruits per plant were the highest in CHESK-III-4 (3145 fruits) and the lowest in CHESK II-5. The fruit yield was highest in CHESK-II-7 (21.18 kg/plant) followed by CHESK -V-6 (15.27 kg).The fruit weight ranged from 3.24 g to 3.81 g. The fruit colour of all the accession was dark purple at maturity. The pulp colour was varied from whitish pink, whitish red in most of the accessions but it was white colour in few accessions such as CHESK-II-VIII-7, CHESK-V-2, CHESK-II-5, CHESK-V-5, CHESK-V-10 and red in CHESK-IV-4 and CHESK-II-5. The fruit shape varied from round to oblong. The pulp content was the highest (91.03%) in CHESK-II-7. The seed content ranged from 2.05 to 12.81 percent. The total soluble solids ranged from 12.15 0 Brix (CHESK -VIII-1) to 17.05 0Brix (CHESK-V-4). The titrable acidity ranged from 0.67 to 3.29 percent. The ascorbic acid content range from 10.75mg/100g pulp (CHESK-VIII-1) to 50 mg /100g pulp in CHESK-VII-1. The reducing sugar ranged from 5.80 to 10.12 percent. The total sugar content ranged from 6.19 percent to 10.55 percent. The highest total sugar content was observed in CHESK-III-8 (10.55%). Over all the accessions, the accessions like K-II-7, K-V-6, K-VIII-1, K-VI-11, K-V-10 were found bigger in size coupled with sweetness with less seed content. These accessions may be used as table purpose while accessions like CHESK-II-6, CHESK III-8, CHESK V-2, CHESK VI-2 have smaller size fruit with higher number of fruits per plant. These identified accessions may be used for pickle making purpose (Tripathi *et al*., 2023).

BREEDING

Propagation: Karonda is propagated mainly through seeds and vegetative propagation methods such as cutting, budding and layering (Kumar *et al*. 2015). The propagation methods of karonda are listed below in detail (Singh *et al.,* 2023):

Seed propagation: Karonda plants can readily be propagated by seed. Immediately after harvesting, the seeds should be collected. Seeds planted shortly after extraction germinates better. Seedlings are transferred into polyethylene bags at the 3-4 leaf stage after being grown. After 8-10 months, the plants are ready for planting. Germination is poor in seedless or lightly seeded types. Plants grown from seeds offer a lot of variation in terms of fruit size, colour, and flavour. As a result, it isn't recommended for the multiplication of varieties or elite lines (Singh *et al.,* 2023).

Vegetative propagation: Multiplication of varieties / elite lines is accomplished through stem cutting, budding and air layering to yield true type planting material.

Cuttings: Plants can be multiplied using semi-hard wood cuttings. Generally, cuttings that are 25-30 cm long and 1" in diameter are used. The months of June-July are ideal for planting of cutting. Semi hard wood cutting was found to be more successful than softwood and hardwood cutting in a testing done at CHES, Chettalli. In comparison to hard wood and soft wood cuttings, semi hard wood cuttings planted in July-August had a 30-40% success rate. IBA treatment failed to improve cutting success rates in both hardwood and soft wood cuttings. Table purpose, bold fruit cultivars have a lower success rate than pickle types (Singh *et al*., 2023).

Air layering: Air layering of karonda plants was proven to be successful and effective during June July. In different years, the success percentage ranged from 30 to 60%. The air layers were removed from the plants in September and were planted in polythene bags until they were ready to be planted after 6-7 months (Singh *et al.,* 2023).

Breeding method: Chromosome number 2n = 22. It is highly heterozygous, cross-pollinated fruit crop. Karanda is an underutilized tropical fruit, which many breeding works has not been implemented. Initially, the breeding works was based on natural selection and evaluation of seedling population (Shankar *et al*., 2024).

Biotechnology: Karonda fruit colour extract has been effectively used in the preparation of alternative staining agent against *Staphylococcus aureus* with staining intensity ranging between 1 and 1.2 in individual and in combination with tannic acid respectively. The silver nanoparticles synthesized using aqueous extract of *Carissa carandas* fruit containing flavonoids facilitates the bio-reduction, bio-capping and silver nanoparticle stabilization. The spherical shaped particle varied from 10 nm to 95 nm. The nanoparticles showed efficient antioxidant and antibacterial activity. They exhibit potent use in biological sources against bacterial diseases possessing various pharmacological properties (Mishra *et al.,* 2024).

Varieties

The karonda cultivars can be classified according to their fruit colour, such as pink-white, greenish pink, or reddish purple, or according to its intended use. Pink cultivars have white immature fruits that turn pink as they mature. The colour of reddish, purple types is green when they are immature and turns reddish purple as they reach maturity. The karonda varieties can also be classified into two categories i.e. pickle type varieties and table purpose varieties. During the previous two decades, some karonda cultivars have been developed. Pickle varieties Pant Manohar, Pant Sudarshan, and Pant Suvarna were developed at the GB Pant University of Agriculture and technology. The cultivars have smaller (3.5 g) and acidic fruits, but Konkan bold, CHES K-II-7, and CHES K-35 are large and ideal for table use (Sonal *et al.,* 2022; Singh *et al.,* 2023: Shankar *et al.,* 2024: Ahirwar *et al*., 2024) .

Pant Manohar: Developed by GBPUA&T Pantnagar (Uttarakhand) in 2007. The plants are dense bushes of medium size, with dark pink blushed fruits weighing 3.49g with a dark pink blush on a white background. 3.94 seeds per fruit, 88.27% flesh, 12.77% dry weight, 3.92% TSS, 1.82% total titrable acidity and a yield of 27 kg per plant.

Pant Sudarshan: Developed by GBPUA&T Pantnagar (Uttarakhand) in 2007. This variety produces dense bushes of medium size. Pink blushed fruits on a white background. Fruits get dark brown as they ripen. The average fruit weighs 3.46 g, has 4.68 seeds per fruit, 88.47% flesh, 11.83% dry weight, 3.45% TSS, 1.89% total titrable acidity and a yield of 29 kg per plant (Mishra, 2007).

Pant Suvarna: Developed by GBPUA&T Pantnagar (Uttarakhand) in 2007. Plants are scarce and grow upright. Dark brown blushed fruits against a green background. Average fruit weight 3.62 g, has 5.89seeds per fruit, 88.27% flesh,12.39% dry weight, 3.836% TSS, 2.30%total titrable acidity and yield of 22 kg/plant. The colour of the fruit changes from green to dark brown as it ripens.

Konkan Bold: Released from Konkan Krishi Vidyapeeth, Dapoli (Maharashtra) in 2004. The plants are medium in size and have a good amount of vigour. Under Coorg conditions, it flowers in February-March and fruits ripe in May-June. Fruits are oblong in appearance and weigh 12-15 g. Fruits are dark purple in colour. The fruits are delicious, with a total soluble solid content of 10-12ºBrix. The tree bears abundantly, producing 2000-2500 fruits per year. This variety is suitable for table purpose. 602 | A Textbook on Advances in Production Technology of Tropical and Subtropical Fruits

CHES-K-II-7: This is a promising line identified in the CHES Chettalli from seedling population. The plants are medium in size and flowers in February-March, with fruit ripening in May-June. Fruits are oblong in appearance and weigh 12-13 g. Fruits are dark blackish violet in colour and have a thin skin. The fruits have 0.3 seeds per fruit and are seedless. Four-year-old trees produce between 1800 and 2100 fruits per plant per year. The fruits are sweet, with a processing.

CHES-K-V-6: This is a promising line identified in the CHES Chettalli from seedling population. The plants are medium in size, flowers in January-February and bears fruit in May-June. The average weight of the fruit is roughly 13-15 g, with a dark blackish red colour, red flesh 1.18% acidity, and 21 mg vitamin C per 100g pulp. A four-year-old tree can produce 1200-1500 fruits each year. Fruit is also a good source of vitamin B. This variety is suitable for table purpose.

Maru Gaurav: It has been by Central Arid Zone Research Institute situated in Jodhpur, Rajasthan. It is an outstanding high yielding in September. Fruits are a good source of vitamin C with 35.88 mg/100 g .

Thar Kamal: It has been released in 2015 by Central Institute for Arid Horticulture situated in Bikaner, Rajasthan. It has outperformed many varieties in terms of flowering, fruiting and quality fruit production. The fruit yield is approximately 13 kg per tree. The TSS content is 9.54º Brix. It has a spreading type growth habit, dwarf stature and regular bearing.

Uses

The fruit has a long history of being used in Indian medicine. Its fruit is used in the traditional herbal medicine of ancient India known as Ayurveda to cure a variety of ailments, including anorexia, anaemia, ulcers, fresh and infected wounds, skin problems, urinary issues, and

diabetic ulcers. Ripe fruits can be used to make fruit products including jelly, sauce, Carissa cream, and jellied salad. Ripe fruits have a peculiar aroma and a subacid to sweet flavour. The unripe fruits can be used to make pickles, sauces, and chutneys since they are tart and astringent. Insect-repelling properties, stomachic properties, and anthelmintic properties are all provided by the roots. It is readily accessible in the market after being processed like typical candied murabba in bottled form as pitted cherries (Singh *et al.,* 2023).

In Ayurveda it is widely used as medicine in Ayurvedic system of medicinal practice. It is used to treat acidity, indigestion, ulcer, constipation and other stomach problems. It is also used to treat several skin diseases, wounds, urinary disorders anorexia, insanity, diabetes, bbiliousness and anemia. It is also believed as a blood sugar stabilizer and guard against liver damage. Commercially it is used in the making of jellies, syrups, nutrient mixture as it is rich in vitamin A, vitamin C, calcium, iron, and phosphorus. Most of us must have eaten without realizing. It is the so called cherries which topped on the cakes nowadays. Hence it is commercially called as wild cherry (Shankar *et al*., 2024). In Household karanda fruit is used to make pickles at homes. It is also used to prepare delicious chutney to make a delicious ombo with dosa and idly. Ripe fruits of Karanda exude a white latex which is used to make jelly, jams and syrups in British colonial period of India. The branches and leaves of Karanda used to prepare homemade decoction which is effective medicine to treat fever, earache, diarrhea, headache and dysentery. Homemade wine can be produced from the karanda fruits which contains 14.5 to 15% alcohol and is widely very much liked by wine drinkers (Shankar *et al*., 2024). In Medicine the boiled root extracts can be also used to treat mouth ulcers, chest pain, indigestion, diarrhoea, typhoid fever, nose bleeding, lower abdominal pains in pregnant mothers, headache and fever in children stomach problems, kin problems including itches and allergies as it having anthelmintic properties. It is also used as household insect repellents. Fruit can be eaten as dry in desserts. Mature fruits contain high amount of pectin hence it is used in the preparation of jellies, jam, syrup, squash, sherbet, curries, tarts, puddings and sauce (Shankar *et al.,* 2024).

Nutritional Value

According to Morton (1987) [22], Karonda (Carissa carandas L.) fruits contain 83.17-83.24 g of moisture, 0.39-0.66 g protein, 2.57-4.63 g fat, 0.51-0.94 g carbohydrates, 0.62-1.81 g fiber and 9-11 mg ascorbic acid per 100 gram of fresh fruit. Another study on the food value of karonda fruit published by the National Bureau of Plant Genetic Resources, provides the following nutritional information per 100 g of edible fruit: 42.5 kcal energy, 0.39-1.1 g Protein (negligible), 2.5-4.63 g Fat, 0.51-2.9 g Carbohydrate, 10-15g Fiber, 21 mg Calcium, 28 mg Phosphorous, 1619 IU Vitamin A and 9-11 mg Ascorbic Acid.

Karonda is a nutritious food. It is high in iron, and the fruit also has vitamin C, which is an antiscorbutic and effective anemia treatment. Many ayurvedic preparations make use of karonda fruits and tout their nutritional benefits. For chest pain, a root extract is employed. Fever can be treated with a leaf extract. According to a research done at the Indian Horticultural Research Institute in Bangalore, the fruit is high in foliate (B9) thiamine (B1), riboflavin (B2), pantothenic acid (B5), pyridoxine (B6), and biotin (B7). It is antiscorbutic and effective in treating anemia (Pathania *et al.,* 2024).

Health Benefits

The complete plant has medicinal values. Carissa carandas flowers are used to remedy diverse diseases. It is very high sources in iron, vitamin C, vitamin A, phosphorus and calcium. Anemic disease is controlled by iron found in Karonda. Vitamin C is found in high amounts in Karonda. By which scurvy disease is controlled. Karanda fruit has an Anthelmintic effect withinside the Body which expels the Parasitic Worms. It eliminates impurities from the blood. Eating Karonda mature fruit removes the disease of anorexia. Epilepsy disease is controlled by the use of Karonda leaves. Abdominal pains, dysuria, menorrhagia and ulcer are controlled using the root of Karonda. It is fine in decreasing the blood sugar quantity in curing Diabetes (Singh and Singh, 2021). Its fruit is used in the ancient Indian herbal system of medicine, Ayurvedic, to treat acidity, indigestion, fresh and infected wounds, skin diseases, urinary disorders and diabetic ulcer,[8] as well as biliousness, stomach pain, constipation, anemia, skin conditions. The roots serve as a stomachic, an anthelmintic medicine for itches and also as insect repellents (Neelima Kale *et al*., 2025).

- Alleviates Abdominal Pain
- Rich in fibre, the fruit is extremely beneficial for treating abdominal problems.
- Improves Digestion
- Reduces Fever
- Improves Mental Health
- Strengthens Cardiac Muscles
- Treats Inflammation
- The fruit of Karonda is an astringent, antiscorbutic and acts as a remedy for biliousness i.e. bad digestion, stomach pain and constipation.
- It is also a great cure for anemia.
- It is also used to treat skin conditions.
- Traditionally, it has been used to treat anorexia and insanity.
- Leaf decoction is used to treat fever, diarrhea, and earache.
- The roots serve as a stomachic, an anthelmintic medicine for itches and also as insect repellents.
- The unripe fruits are sour and astringent and can be used for pickles, sauces and chutneys as reported (Sonal *et al.,* 2022).

Karonda may have the following possible nutraceutical qualities (Yadavv *et al.,* 2023)

- **Rich in Antioxidants**: Antioxidants found in Karonda include vitamin C, flavonoids, and polyphenols. These substances aid in the body's fight against oxidative stress, which is connected to aging And the emergence of chronic illnesses.
- **Vitamin C Content**: Vitamin C, which is necessary for collagen formation, immunological function, and antioxidant protection, is abundant in Karonda. Moreover, vitamin C promotes healthy skin and facilitates the body's absorption of iron from plant-based diets.
- **III.Potential Anti-Cancer Properties**: According to some research, Karonda's antioxidants and bioactive substances may have anticancer effects by limiting the growth of cancer cells and blocking the production of free radicals. Nonetheless, additional study in this field is required.

- **IV.Fiber Content**: Dietary fibre, which is essential for gut health, is included in karonda. Fiber supports a healthy gut micro biome and aids in the regulation of bowel motions and constipation.
- **V.Cardioprotective Effects**: Karonda has some chemicals that may help lower blood pressure and cholesterol, which may improve cardiovascular health. The fruit's anti-inflammatory and antioxidant qualities are frequently linked to these effects.

Extract use- Root extract is used in chest pain.

Stem: Chemical analysis of stem showed the presence of sesquiterpene glucoside.

Seed: Palmitic acid, stearic acid, oleic acid, arachidic acid, and linoleic acid are its constituents. Hexadecanoic, Octadecanoic, and Eicosanoic Acids.

Leaves: The various chemical groups found in Carissa carandas leaves, such as alkaloids, flavonoids, gums, reducing sugars, saponins, steroids, and tannins, were examined in the crude methanolic extract of the leaves. Ursolic acid and triterpene alcohol make up this mixture. Carandinol, Betulinic acid, Carissic acid monoacetate, Carissic acid methyl ester. According to reports, fresh leaves of C.congesta contain four pentacyclic triterpenoids, including two previously unknown compounds and a novel ingredient called carissin. It has been determined that the new triterpenoid is 3-?-hydroxy-27-E-feruloyloxyurs-12-en-28-oic acid. Based on 2D NMR research, the protons in the compounds have also been fully assigned.

Flower: A-terpeneol, citronellal, ?-ionone, nerylacetate, linalool, Menthol, Piperitone,p-Cymene, Neryl acetate, and geranyl acetate are among its constituents, along with myrcene, limonene, camphene, canine, farnesol, nerolidol, and dihydrojasmone.
(Kavita *et al*., 2025).

Cosmetic industry

Several products have been developed using karonda fruit extract with the potent use in the cosmetic industry are discussed below (Mishra *et al*., 2024):

Skin toner: A toner developed using 1 g of karonda fruit extract mixed with toner base (composition: 4 % of 70 % sorbitol solution, 2 % propylene glycol, 1 % glycerin, 1 % tween 20, 1 % phenoxyethanol, 0.25 % allantoin) was orange-pink coloured, translucent, and highly stable against temperature and light variations depicting a storage ability at an ambient temperature..

Skin care cream: A silicone emulsion-based skin care cream containing 5 % karanda fruit extract in the optimized formulation of 0.45 % cetyl PEG/PPG-10/1 dimethicone, 2.88 % sodium chloride and 6.66 % cyclopentasiloxane showed greater emulsion stability with optimum particle size. Addition of pharmaceutical aids such as butylene glycol improved the stability of w/o silicone emulsion containing karanda fruit extract and also enhanced the gallic acid stability on storage.

Lipstick: Lipstick developed using *Carissa carandas* fruit extract showed higher consumer acceptability due to its efficient pigmentation property..

Packaging industry: The anthocyanins component of the karonda fruit make it a reliable source for the development of smart active intelligent packaging films. A study towards the preservation of ber fruit using composite edible coating developed from the mixture of beeswax (2 %) and karonda polyphenols (0.5 %, 1 % and 1.5 %) respectively demonstrated a significant decrease in spoilage with efficient firmness observed for a period of 28 days. The mechanism like decreased carotenoid synthesis, decreased activity of pectin methyl esterase and cellulase, cell wall degrading enzymes lead by the coating tend to aid in the preservation process in a dose dependent manner. It has been reported that a smart colorimetric sensing film developed using carboxymethylcellulose (CMC) incorporated with anthocyanins from karanda (CA), butterfly pea flower (BA) and curcumin (CC) demonstrated greater antioxidant capacity and thermal stability. Of all the anthocyanin combinations studied, film with CMC/CA75/BA25 demonstrated effectively significant sensitivity to release of ammonia and alteration in pH marked with the colour change from pink - purple - blue - green. These smart sensing films could be a reliable source of freshness indicator in food packaging system which aid in effective monitoring of food quality deterioration.

Toxicity: When Swiss albino rats of either sex weighing from 150 to 180 g were orally administered with karonda fruit powder extract did not show either the sign of toxicity or mortality up to the dose of 2000 mg/kg body weight. Extract was prepared using Soxhlet extraction with ethanol followed by evaporation and then dissolved in 2 % tween 80. Administration and observation were reported based on OECD guideline no. 424. A similar study reported in male wistar rats weighing 150–250 g divide in 5 groups with 6 rats in each group. It reported that oral administration of 500–5000 mg/kg body weight of acetone extract of karonda fruit (immature, mature and ripe fruits respectively) showed no sign of lethality up to dosage level of 2000 mg/kg for observation period of 24 h. This indicates karonda fruit extract as a safe drug with potent application in pharmacology (Mishra *et al.,* 2024).

CULTIVATION

Since karonda is very hardy and drought tolerant, it also thrives well throughout the tropical and subtropical climates. Heavy rainfall and waterlogged conditions are not desirable. It can be grown on a wide range of soils including saline and sodic soils (Banika *et al.,* 2012). Karonda plants grown as protective hedges require limited fertilization. Manuring however is beneficial. Its plants slowly get exhausted after taking 2 crops and show symptoms of die back. Therefore, 10-15 kg well rotten farmyards manure or compost/plant applied before flowering is useful. The effect of gibberellic acid (0, 250, 500, 750 or 1000 ppm), applied 6 times at monthly intervals on the growth of 9-month-old seedlings of *C. carandas*. Seedling height and stem diameter increased with increasing concentration of gibberellic acid. The best treatment for promoting early growth was gibberellic acid at 1000 ppm. Grew seedlings in sand culture to study the effects of nitrogen supply on growth and uptake of other macro and micro nutrients and to determine the leaf nitrogen concentration required for maximum growth of plants. They found that the

increasing nitrogen supply increased the leaf nitrogen content whereas increasing nitrogen levels decreased the leaf iron content however, when nitrogen was omitted from the nutrient solution, the leaf iron content increased significantly. Other nutrients did not influence by the variable nitrogen supply. For better plant growth and production, the nitrogen level must be maintained in the range of 0.99 to 0.37% (Banika *et al.,* 2012). Variation in flower characteristics, fruit setting and mode of pollination was studied in 10 umbels on each of 12 shrubs of *Carissa carandas*. Variation was found in number of flower buds (14.6 to 22.6) per umbel, lengths of buds, petals and pedicels, petal number (4 to 6), number of umbel segments (1 to 6) and flower colour. There was an initial fruit set of (73.06%) by self-pollination, but this only gave a final set of 24.24%. With natural pollination the fruit set was 32.02%. The initial fruit set was highest in shrubs with the most umbel segments and concluded that the number of segments could therefore be used as a selection index for high yields in the future (Banika *et al*., 2012).

Karonda is a handy fruit. It can be grown successfully is tropical and subtropical climate plant growth is affected in high rain fall and waterlogged areas. High temperature and arid climate is suitable for karonda cultivation. Temperature climate with high frost and snowfall areas are not suitable for this fruit.As the plants are sensitive for low temperature and front injury. The water logged areas of tropical and subtropical regions are not suitable f for it cultivation. Karonda is grown successfully on a wide range of soil types, viz. sandy loams, laterite, alluvial sand, and calcareous soil even it is found growing well in in stony , rocky and less fertile soils.but the better growth and higher yield is obtained in alluvial sandy loam soils with good drainage. The performance of orchards is very poor on clay soil with poor drainage. The can be grown in wide ranges of soil pH ranging from 5.0to 8.0 (Tripathi *et al*., 2014). The soil should be leveled before planting and all the old plants need to be removed. These pits filled with FYM and soil mixture to one by one different time of planting of these June-July. The table purpose variety of Karonda should be planted at 3 meter X3 meter distances in square. The method of planting the pits of 3 ft X3 ft size should be prepared at least one month before planting. These pits should be filled with equal amount of FYM and soil mixture. The proposed time of planting of this is June-July.The land should be cleaned and leveled with a mild slope in the opposite direction of the water source. The hedge plating of karonda is done at 2 fit distances.The hedge planting trench of 1X 1 feet size is done. The pits of 1x1 feet can be also made instead of trench. For planting of orchards, the planting is done at 3x 3 m distance with square system. The pits of 2 ft x2 feet size should dug before rainy season. The rocky soil pits of 3 feet x3 feet size to should be opened. Pit opening is normally recommended in April-May. These pits are filled with topsoil mixed with about 510 kg decomposed compost, 1 kg neem cake, 50 gsingle super phosphate and 50g muriate of potash before the onset of monsoon. Then the soil is allowed to settle with the first few rains and leveled properly. Planting is done during June to July. At the time of planting a hole the size of ball of earth is made in the centre of the pit at the marked point where the plant is fixed and the soil is pressed remove air. Watering is done immediately after planting for proper establishment. Subsequently the plant is regularly irrigated till it is properly established and soil types. Since soil and climate of different places are highly diverse, there is wide variation in the response of fertilizer application. One year old plant should be provided 5 kg of FYM and 100 gm mixture of Nitrogen, Phosphorus and Potash. This growth should be increase in same ratio up to 3 years.

The four and more than 3 year old plants should given 15-20 kg of FYM and 400 g of mixture of NPK. The best time of fertilizer application is June-July after harvesting of fruits (Tripathi *et al*., 2014). Karonda plant has comparatively weaker stem in initially years. Thus it is necessary to provide support after planting. The plant has tendency to produce several branch just above ground surface. The branches which are emerging near the ground surface need to be removed for convenience in cultural operations. Training of the plant in the initial stage is essential to provide the required framework. Unwanted branches should be pruned to provide definite shape and to promote growth of the trunk and crown of the tree. Three to four branches 30-45 cm from ground opposite to each other are allowed to form the proper frame of the tree. The branches should be trained in open centre system for better production. The training of plant is performed only in first two years. Once the plant is big the pruning is required to maintain the size of the plant. The Karonda plant grows slowly in arid areas and required comparatively less pruning but in humid and tropical region of the plant grow very vigorously . Heavy pruning is required every year. This help in maintaining tree size and producing regular yield. Further, water suckers, crowded and crisscross branches are removed to facilitate better growth. The branches with narrow angles are also avoided. Dried, and diseased branches should also be periodically removed. Pruning is generally perform in the month of October in Coorg conditions (Tripathi *et al*., 2014). Karonda planted for hedges purposes need not be trained in this manner and 3-4 branches are allowed to near ground level to make a compact hedge. The hedges are trimmed after harvesting of fruits (Tripathi *et al*., 2014). Karonda is generally grows in dry soil where water facilities are not available some vegetables are can be grow during rainy season. During the initial period of establishment, the space between the plants can be utilized for planting of intercrops. These give additional income in the initial stage of planting without competing with the main crop. Cowpea, french bean, okra, brinjal or other suitable crops of the regions are grown as intercrops. In the mature karonda orchards, green manure cropsmay be grown and incorporated into the soil, which improves its fertility, moisture holding capacity and physical condition (Tripathi *et al*., 2014). Karonda is a hardy plant. The newly planted plants should be given irrigation. Young plants should be irrigated at 10-15 days interval in the winter and 6-7 days in summer season. The basin or flood method of irrigation is normally practiced. However, adoption of drip irrigation has been found to be effective in the economic use of water and enhanced growth. The adults orchards are generally not irrigated. Mulching with dry leaves or residues in the basin helps in moisture conservation (Tripathi *et al.*, 2014).

Harvesting

Karonda plant starts yielding after 3rd year. In Western Ghats flower starts in December to March and fruit mature in the month of April to June. The maturity of fruits is judged on the basis of change in colour. All fruits generally do not mature at one time therefore harvesting is generally done 3-4 times. Harvesting is done manually. The harvesting of fruits with stock helps to minimum the oozing of latex by fruits and enhances quality and storage of fruits (Tripathi *et al*., 2014). A plants may yields 4-5 kg fruits. The promising lines planted as orchard may yield 10-15 kg per tree. The fruits can be stored for 3-4 days under room temperature. The fruits used for making jam, candy and pickles (Tripathi *et al.,* 2014). Karonda plant starts yielding after 3rd year. In Western Ghats flower starts in December to March and fruit mature in the month of April to June. The maturity of fruits is judged on the basis of change in colour. All fruits generally do not mature at one time therefore harvesting is generally done 3-4 times. Harvesting is done manually. The harvesting of fruits with stock helps to minimum the oozing of latex by fruits and enhances quality and storage of fruits. A plants may yields 4-5 kg fruits. The promising lines planted as orchard may yield 10-15 kg per tree. The fruits can be stored for 3-4 days under room temperature. The fruits used for making jam, candy and pickles (Sonal *et al*., 2022).

Maturity indicators

- After flowering, fruit typically takes 87 to 90 days to develop and reach maturity.
- Change in colour from light green to dark green.

- Some types of fruits have a red blush.
- Mature karonda fruits have specific gravity above 1 (1.012).
- Mature karonda fruits have acidity 2.62%, Total Soluble Solids 13.5% and Total Sugar 2.35%.
- (Singh *et al.,* 2023).

Storage: The fruits harvested at maturity can be stored for a week at room temperature whereas fruit harvested at ripe stage are highly perishable and can only be stored for 2-3 days or for 6 months in SO2 solution @ 2,000 ppm as reported (Sonal *et al*., 2022).

Post Harvest Management: The fruits harvested at maturity can be stored for a week at room temperature whereas fruit harvested at ripe stage are highly perishable and can only be stored for 2-3 days or for 6 months in SO 2 solution @ 2,000 ppm as reported (Banika *et al.,* 2012).

Value Addition: The fruits of 2 types of Carissa carandas (Red-green and White-yellow), collected from India in which fruits from the Red-green type were significantly larger (weight, length and width) than those from the White-yellow type, particularly at the mature stage. Differences in seed size followed the same pattern. The length and width of White-yellow fruits were found to differ to a higher degree between the 2 developmental stages compared with the Red-green fruits. White-yellow fruits are more suitable for pulp-based uses like making jam, jelly, chutney, pickles and preserves. Such fruits were less sour than Red-green fruits. The physicochemical changes in karonda (*Carissa carandas*) jelly during storage were found to be organoleptically acceptable for a period of 4-5 months. After that, the jelly started changing to brownish colour at ambient temperature. The total soluble solid, acidity, total sugar, reducing sugar, browning, flavour, texture, taste and after taste increased with storage period while ascorbic acid, non-reducing sugar, colour and appearance and overall acceptability decreased at ambient temperature. Two karonda types *i.e.* pink and green for making pickle and qualitative changes taking place during storage period of four months. The results showed that pH, T.S.S./acid ratio, ascorbic acid, non-reducing sugars, organoleptic values decreased whereas acidity, reducing sugar and browning increased during storage. The TSS and total sugars decreased in pickles prepared from pink and green type and observed that pickles prepared from pink type of karonda was of good quality as compared to sweet pickle (Banika *et al*., 2012).

Processed Product

The nutrients present in *Carissa carandas* fruit, such as calcium, iron, vitamin C, and vitamin A, serve as essential nourishment and are utilized in the management of various health conditions like anorexia, diarrhea, anemia, and blood sugar regulation. This fruit can be stored for an extended duration by refrigeration, freezing, pickling in brine, or canning with sugar. Ayurvedic medicines and formulations often use plant as a component. Treatments for illnesses of the heart, brain, and urinary system involve the use of marmagutika. Therapy for cardiac disease involves the use of hridyamahakashaya. The "juice" or "essence" known as Kalkantaka rasa is used to treat mental illness. The first ingredient of marichadivati, a medication used to treat respiratory ailments, is black pepper (Pathania *et al*., 2024). (Fig. 2).

Chutney

Juice

Jam

Pickle

Chutney

Juice

Fig. 2. Prtoducts

The fruit of the cassia carandas is rich in calcium, iron, vitamin C, vitamin A, and other nutrients that are used as food and to treat a variety of illnesses, including blood sugar stabilization, diarrhea, anorexia, and anaemia. It can be pickled in brine, canned with sugar, or frozen and refrigerated for extended periods.

I. Karonda Jam: You can use Karonda to preserve fruit or make jams. The fruit's acidity complements sweet dishes well, and canning it into jam is a popular method of preserving its flavour.
II. Karonda Pickle: Sometimes, karonda is pickled to produce a tart and flavourful sauce. Pickling is the method of preserving fruit in a concoction of spices, salt, and occasionally oil.
III. Karonda Chutney: Karonda fruit is frequently combined with herbs, spices, and occasionally sugars to make chutneys. These chutneys go well with a variety of foods as condiments.
IV. Karonda Juice: It is possible to prepare and bottle the Karonda juice for human use. It can be taken as a basis for blended fruit juices or as a cool drink.
V. Dried Karonda: Karonda can be dried to produce dried fruit that keeps better in storage. You can eat dried Karonda as a snack or mix it into cereal, trail mixes, or baked products (Yadav *et al.,* 2023).

Homemade fruit recipes: Fruits are used to make jams, pickles, condiments, and syrups in northern India. The intensely sour flavors of fruit are made delectable by being pickled with fiery green chilies and garlic cloves; both components are rich in health benefits and enhance the flavor of the pickle. Karonda pickle is quick to make and ready to eat; it may be preserved for at least four months either fresh or in a jar. The dried Karonda fruit was found with a significantly higher nutrient content than the fresh version, with the exception of vitamin C, which was only about half as abundant in the dried fruit. This was determined by comparing the chemical makeup of the fresh and dried Karonda fruit. The fruit of the plant is full of vitamins, minerals, and nutrients, including protein, carbohydrates, calcium, iron, beta-carotene, vitamin B1, B2, and C, among others (Pathania *et al.,* 2024). India, the karonda fruit comes in a variety of hues, from deep red to purple, and is used to make jam. Karonda fruits that are fresh and undamaged are split in half after being carefully washed. Remove the seeds, then put the fruit in a pan with a heavy bottom that has water. Fruit is heated and boiled in water. If you want the fruit bits in the jam, add sugar as the fruit starts to become tender and keep stirring. The tender fruit can be put through a sieve to get a smooth pulp, which can then be combined with sugar to make smooth jams. Pack it in a glass bottle once it has cooled. The karonda fruit is cooked with salt and baking soda. Half a tea spoon of baking soda is added to each cup of juicy pulp and cooked in one liter of water at 100 °C. The growing scum is then removed from the mixture as it is cooked down to half its original volume, and the juice is once more filtered. A quarter cup of sugar is added for each cup. Once more, the mixture is boiled for 40 minutes. The sterilized bottle is filled with the chilled syrup and then closed (Pathania *et al*., 2024).

Diseases and pests

Anthracnose: The Karonda plants are affected by Anthracnose..The symptoms are developed in the leaves as irregular size black, brown, lesions e. These spots increase and decreasing the size of the leaves. The disease also effects fruits and branches. The diseases may controlled by sprayingof copper based fungicide copper oxide, copper trioxide in the initial stage. The orchards sanitation like burning of fallen leaves and fruits help to reduce inoculums.

Leaf eating caterpillars: Caterpillars cause much damage, mainly by eating leaves.This affects the growth of the plants. Caterpillars may be controlled by through the use of pesticides, biological control and cultural practices. The chemicals, monocrotophos (2ml/l may be used for control of leaf eating caterpillars.

Fruit fly, Bactroceradorsalis, B. caryeaea: Moderate infectation of fruit fly infestation was noticed on karonda. Fruit fly infests the ripened fruits. Its infestation is more in southern states. The female fruit fly lays eggs on the mature fruits with the help of its pointed ovipositor. After hatching the maggots feed on pulp of these fruits and the infested fruits starts rotting and fall down. As a result brown patch appears around the place of oviposition. The maggots come out of the affected fruit and pupate in the soil.Pre-harvest IPM combined with sanitation (Collection and destruction of fallen/infested fruits) + Placing Methyl eugenol trap @ 4-6/acre + In severe infestation spraying of bait spray (Decamethrin (Decis) 2ml+ 100g of jaggery in 1 litre of water) is recommended (Tripathi *et al*., 2014).

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