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REVIEW ARTICLE OPEN ACCESS

ORIGIN, DISTRIBUTION, TAXONOMY, BOTANICAL DESCRIPTION, CYTOGENETICS, GENETIC DIVERSITY AND BREEDING OF Okra *(Abelmoschus esculentus* (L.) Moench.)

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ABSTRACT

Okra, (*Abelmoschus esculentus*), herbaceous hairy annual plant of the family Malvaceae. Okra originated somewhere around the Ethiopia, and was cultivated by the ancient Egyptians by the 12th century B.C. Its cultivation spread throughout Middle East and North Africa. There are two hypotheses concerning the geographical origin of *A. esculentus*. Some authors argue that one putative ancestor (*A.tuberculatus*) is native to Uttar Pradesh in northern India, suggesting that the species originated from this geographic area. Others, on the basis of ancient cultivation in East Africa and the presence of the other putative ancestor (*A. ficulneus*), suggest that the area of domestication is north Egypt or Ethiopia, but no definitive proof is available today. Although about 50 species have been described, eight are most widely accepted. Most of cultivated varieties are amphidiploids with 2n=130. *A. esculentus* is noted for its chromosome polymorphism and 2n ranges from 72 to 144. It tolerates addition or deletion of one or a few chromosomes. Okra or bhendi is a common vegetable in India. The common names are Ladies Finger, Okra, Bhindi (Hindi), Dhenras (bengali), Vendai (Tamil), bhindo (Gujarati), Bendekayi (Kannada), Ventaykka (Malayalam), Asra-pattraka (Sanskrit). Okra has many interesting uses and is known to be an economically important vegetable crop because its fresh leaves, buds, flowers, pods, stems and seeds all have value. It can be used in salads, stews, fresh or dried, and fried or boiled. It is used as a thickening agent in Charleston gumbo. Breaded, deep fried okra is served in the southern United States. The immature pods may also be pickled. The composition of okra pods per 100 g edible portion is water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 µg, riboflavin 0.08mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg. Protein, carbohydrate and vitamin C contains of okra. It's medicinal value has also been reported in curing ulcers and relief from hemorrhoids. Unspecified parts of the plant were reported in 1898 to possess diuretic properties this is referenced in numerous sources associated with herbal and traditional medicine. Okra has found medical application as a plasma replacement or blood volume expander. It is also good source of iodine which is useful in the treatment of simple goiter and source of other medically useful compound. In okra, we follow the breeding methodologies of autogamous plants. This includes crossing or controlled hybridization of parents selected based on their better-combining abilities. This is followed by the pedigree selection of the segregating population for the traits of interest like biotic and abiotic stress tolerance and yield. The major breeding objectives are nearly the same across all the okra-growing countries: high yield, tolerance to various pests and diseases, better organoleptic qualities, appealing color and size of the harvestable fruits. Bhendi varieties and cultivars differ in growth habit, height of plants, presence of purple pigmentation on plant parts, length, colour and number of ridges of fruit. It is commercially grown in India, Turkey, Iran, West Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, West Bengal, Burma, Japan, Malaysia, Brazil, Ghana, Ethiopia, Cyprus, and the southern USA. In this review article origin, distribution, taxonomy, botanical description, cytogenetics, genetic diversity, breeding, uses, nutritional value, and health benefits of okra are discussed.

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INTRODUCTION

Okra belongs to the family Malvaceae, genus *Abelmoschus* and species *A. esculentus* ((WIKI, 2023a; IBP, 2023). Although about 50 species have been described, eight are most widely accepted (Ogunbor, 2020). However, Hinsley (2022) reported 13 accepted species in the genus *Abelmoschus* (Hinsley, 2022). Fou species of *Abelmoschus* are crops. *Abelmoschus esculentus* (okra) and *Abelmoschus caillei* (West African okra) are grown for their fruits (used as vegetables), *Abelmoschus manihot* (aibika) as a leaf vegetable, and *Abelmoschus moschatus* (ambrette, musk mallow) for its seeds. Some species are also grown as ornamentals (Hinsley, 2022). There are significant variations in the chromosome numbers and ploidy levels of different sepceis in the genus Abelmoschus. The lowest number reported is 2n=56 for A. angulosus, whereas the highest chromosome number reported are close to 200 for A. manihot var. caillei, The chromosome number within A. esculentus, s 2n = 72, 108, 120, 132 and 144 are in regular series of polyploids with n = 12 (Ogunbor , 2020). Okra is known by many local names in different parts of the world. It is called lady's finger in England, gumbo in the United States of America, guino-gombo in Spanish, guibeiro in Portuguese and bhindi in India. It is quite popular in India because of easy cultivation, dependable yield and adaptability to varying moisture conditions. Even within India, different names have been given in different regional languages (Chauhan, 1972). Common Names of Abelmoschus esculentus *in other countries are* Bentwood, Common Ivy, Gobbo, Gumbo, Ivy, Ivy Gum Plant, Ladies' Fingers, Love United, Ochro, Okra, and Okro (NCSU, 2023). Common Names of okra are (VIKAS, 2023) Ladies Finger, Okra, Bhindi (Hindi), Dhenras (bengali), Vendai (Tamil), bhindo (Gujarati), Bendekayi (Kannada), Ventaykka (Malayalam), Asra-pattraka (Sanskrit). It is grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Malayasia, Brazil, Ghana, Ethiopia, Cyprus and the Southern United States (Chauhan, 1972).

Okra *Abelmoschus esculentus* L. (Moench), is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on large commercial farms. India is the largest producer of okra in the world. It is also used as a vegetable in Brazil, West Africa and many other countries. In India, major okra growing states are Uttar Pradesh, Bihar and West Bengal (Eagri, 2023). Okra was apparently discovered in the Abyssinian centre of origin of cultivated plants, an area that includes present-day Ethiopia, the mountainous or plateau portion of Eritrea, and the eastern, higher part of the Anglo-Egyptian Sudan. People have been growing okra in the U.S. for centuries. While records of okra during early American colonial times are lacking, it must have been common among French colonists. It was being grown as far north as Philadelphia since the mid-1700s (Axe, 2021). There are two hypotheses concerning the geographical origin of *A. esculentus*. Some authors argue that one putative ancestor (*A. tuberculatus*) is native to Uttar Pradesh in northern India, suggesting that the species originated from this geographic area. Others, on the basis of ancient cultivation in East Africa and the presence of the other putative ancestor (*A. ficulneus*), suggest that the area of domestication is north Egypt or Ethiopia, but no definitive proof is available today (Rao et al., 2019). *A. esculentus* is found all around the world from Mediterranean to equatorial areas as may be seen from the geographical distribution of cultivated and wild species (Tripati *et al.,* 2011). The okra pods are harvested when immature and high in mucilage, but before becoming highly fibrous. Generally the fibre production in the fruit starts from 6th day onwards of fruit formation and a sudden increase in fibre content from 9th day is observed. Okra plants continue to flower and to fruit for an indefinite time, depending upon the variety, the season and soil moisture and fertility. Infact the regular harvesting stimulates continued fruiting, so much that it may be necessary to harvest every day in climates where growth is especially vigorous (Tripati *et al*., 2011). Okra belongs to category of explosive spreaders *i.e.*plants in which the fruits explode at maturity and shoot the seeds several feet away from the mother plant. The seeds of okra may spread up to 2-3 m upon shattering (Tripati *et al.,* 2011). *A. esculentus* shows a particular kind of seed dormancy, called delayed permeability caused due to structure of the seed coat and particularly by the chalazal plug. There is observed a direct relationship between the seed moisture content and delayed permeability with variances between cultivars and moisture contents. Normal seeds harvested from the plants of the cultivars does not exhibit seed dormancy (Tripati *et al*., 2011). Magnitude of genetic variability was observed as high for number of fruits per plant, plant height, onset of flowering, number of nodes, stem diameter, leaf color and leaf shape (Dhankhar and Mishra, 2005). Bhendi varieties and cultivars differ in growth habit, height of plants, presence of purple pigmentation on plant parts, length, colour and number of ridges of fruit etc. (Eagri, 2023). The major breeding objectives are nearly the same across all the okra-growing countries: high yield, tolerance to various pests and diseases, better organoleptic qualities, appealing color and size of the harvestable fruits (Mishra *et al*., 2021). Various methods like plant introduction (Perkin's Long Green), single plant selection and pure line selection from local collections (Pusa Makhmali, Salkeerthi), selection from bi-parental crosses (Pusa Sawani from IC 1542 x Pusa Makhmali) and selection from complex crosses (sel 2 from (Pusa Sawani x Best 1) x (Pusa Sawani x IC 7194) were used (Eagri, 2023). Early flowering, double haploids, early multilocation trials and marker-assisted selection help in speeding up of the conventional breeding in okra, while nonconventional methods like mutation breeding and genetic engineering result in the development of varieties within shorter period of time (Dhankhar and Koundinya, 2020). Interspecific crosses have been attempted. The sterility is attributable to various reasons such as chromosomal differences (in case of *A. tuberculatus* and *A. ficulneus*) and genomic differences leading to irregular gamete formation (in case of *A. manihot*) (Tripati *et al*., 2011). Shoot and fruit borer *i.e*. *Earias* sp. being the most destructive pest in okra crop, efforts have been made to develop insect resistant okra varieties by incorporating cry1Ac gene from *Bacillus thuringiensis*, commonly known as Bt okra. The Bt okra developed by M/s Maharashtra Hybrid Seeds Company Limited containing cry1Ac gene (Event OE-17A) is under safety evaluation and confined field trials (Tripati *et al.,* 2011). Among viral diseases, Yellow Vein Mosaic virus being major disease of okra, attempts are being made by M/s Arya Hybrid Seeds Ltd., for incorporation of specific genes such as CP (coat protein) gene and antisense RNA gene for elevated viral resistance (Tripati *et al*., 2011).

Okra has many interesting uses and is known to be an economically important vegetable crop because its fresh leaves, buds, flowers, pods, stems and seeds all have value. It can be used in salads, stews, fresh or dried, and fried or boiled (Axe, 2021). Fruit is useful against genitor-urinary disorders, spermetorrhoea and chronic dysentery. Fruits are also dried or frozen for use during off-season. (Eagri, 2023). Dried fruit contain 13-22% edible oil and 20-24% protein and is used for refined edible oil. Dry fruit skin and fibres are used in manufacture of paper, card board and fibres. Root and stem are used for clearing cane juice for preparation of jaggery. (Eagri, 2023). Bast fibre from the stem of the plant has industrial uses such as the reinforcement of polymer composites. The mucilage produced by the okra plant can be used for the removal of turbidity from wastewater by virtue of its flocculant properties. Having composition similar to a thick polysaccharide film, okra mucilage is under development as a biodegradable food packaging (WIKI, 2023a). **Nutrients in 1 cup of okra (**CJ, 2017) are Energy 33 Calories, Fiber 3.2 g, Protein 1.9 g, Carbohydrate 7.5 g, Fat 0.2 g, Magnesium 57 mg, Calcium 82 mg, Potassium 299 mg, Sodium 7mg, Vitamin C 23 mg, Vitamin K 31.3 mg, Folate (vitamin B9) 60 µg, Vitamin A 716 IU, Thiamin (vitamin B1) 0.2 mg and Vitamin B6 0.2 mg. Many health benefits of okra have also been reported. In this review article origin, distribution, taxonomy, botanical description, cytogenetics, genetic diversity, breeding, uses, nutritional value, and health benefits of okra are discussed.

ORIGIN AND DISTRIBUTION

Okra plant or lady' finger was previously included in the genus *Hibiscus*, section *Abelmoschus* in the family Malvaceae. The section

Abelmoschus was subsequently proposed to be raised to the rank of distinct genus. The wider use of *Abelmoschus* was subsequently accepted in the taxonomic and contemporary literature. The genus *Hibiscus* by the characteristics of the calyx, spatulate, with five short teeth, connate to the corolla and caducous after flowering (Ogunbor, 2020). According to Zeven and Zhukovsky (1975), okra is believed to have originated in the Hindustani Centre of Origin, chiefly India, Pakistan and Burma. However, according to some other authors, *A. esculentus* originated in India, Ethiopia, West Africa and Tropical Asia (Vidhi, 2023). *A. esculentus* is cultivated as a vegetable in most tropical and subtropical regions of Africa, India and America. In West Africa, Siemonsma (1982) has clearly demonstrated that the species has preference for the Sudano-Sahellan zone. However, *A. esculentus* is also found in forest regions in smaller quantities. It is a case of ecological adaptation to photoperiodic response and to parasitism (different in savannah and forest areas). But in this Guinean bioclimatic zone, Siemonsma (1982) has given prominence to a new cultivated species provisionally called "Guinean" okra, which can be found in the forest regions of Ghana, Guinea, Ivory Coast, Liberia and Nigeria. *A. esculentus* is found all around the world from Mediterranean to equatorial areas. Cultivated and wild species clearly show overlapping in Southeast Asia, which is considered as the centre of diversity. The spread of the other species is the result of their introduction to America and Africa. There are two hypotheses concerning the geographical origin of *A. esculentus*. Some authors argue that one putative ancestor (*A. tuberculatus*) is native to Uttar Pradesh in Northern India, suggesting that the species originated from this geographic area. Others, on the basis of ancient cultivation in East Africa and the presence of the other putative ancestor (*A. ficulneus*), suggest that the area of domestication is North Egypt or Ethiopia, but no definitive proof is available today (Tripati *et al.*, 2011). Eight *Abelmoschus* species occur in India. Out of these, *A. esculentus* is the only known cultivated species. *A. moschatus* occurs as wild species and is also cultivated for its aromatic seeds, while the rest six are truly wild types. The wild species occupy diverse habitats. The species *A. ficulneus* and *A. tuberculatus* is spread over the semi-arid areas in North and Northwestern India; *A. crinitus* and *A. manihot* (*tetraphyllus* and *pungens* types) in tarai range and lower Himalayas; *A. manihot* (*tetraphyllus* types), *A. angulosus*, and *A. moschatus* in Western and Eastern Ghats; and *A. crinitus* and *A. manihot* (mostly *pungens* types) in the Northeastern region, depicting their broad range of distribution in different phytogeographical regions of the country. Intra as well as interspecific variations do exist in different phyto-geographic areas. Existence of different *Abelmoschus* species in different areas of India was observed (Tripati *et al*., 2011).

Concerning the geographical origin of cultivated okra (*A. esculentus*) two controversial hypotheses have been suggested, *viz.,* Ethiopian domestication and Asian origin, but supportive evidences for former are still unexploited. Moreover, cultivated and wild species of *Abelmoschus* clearly show an overlapping distribution in Southeast Asia which has been considered as the center of diversity (Waalkes, 1966). Among the putative wild progenitor of *A. esculentus*, existence of diversity of *A. ficulneus* with *A. tuberculatus* provide further support to the theory of an Asiatic origin of *A. esculentus* (Vredebregt, 1991). Additionally, linguistic evidence as mentioned in Sanskrit language, *tindisha* and *gandhamulla* meaning okra in Indian literature has supported the view of Asiatic origin for okra (Patil *et al*., 2015). The species of *Abelmoschus* are naturally distributed throughout the tropical and subtropical countries (Vredebregt, 1991). Majority of the species occur in South Asia and Southwest Pacific. Apart from the morphological diversity, species of *Abelmoschus* also differ in their geographical distribution and habitat requirements (Patil *et al.,* 2015). In case of tender, juicy, immature fruit bearing cultivated species, *A. esculentus* popularly known as 'bhendi' has a wide distribution in India. Among the states of India, Karnataka and West Bengal are the highest okra producing states followed by Uttar Pradesh, Assam, Bihar, Orissa and Maharashtra (FAOSTAT, 2010). Apart from India, it is also grown in Nigeria, Sudan, Pakistan, Ghana, Egypt, Benin, Saudi Arabia, Mexico and Cameroon (FAOSTAT, 2010). Interestingly, okra is known by different names in different parts of world such as bamia in Middle East, gumbo in Southern USA, lady's finger in England, *quiabo* in Portuguese and Angola, *quimbombo* in Cuba, *gumbo* in France, *mbinda* in Sweden, and lastly in Japan as *okura* (Patil *et al.,* 2015).

Contradicting evidence exists on the geographical origin of *A. esculentus*. One putative ancestor (*A. tuberculatus*) is native to Uttar Pradesh in North India, suggesting that *A. esculentus* originated in India. The other evidence is based on the plants cultivation in ancient times, and the presence of another putative ancestor (*A. ficulneus*) in East Africa, suggesting Northern Egypt or Ethiopia as the geographical origin of *A. esculentus*. So far *A. caillei* (2n = 196 to 200) has been located only in WCA, so this region can be recognized as its origin and is believed to be amphipolyploids between *A. esculentus* (2n = 130 to 140) and *A. manihot* (2n = 60 to 68) (Ravindrakumar and Shanthakumar, 2019). There are two hypotheses concerning the geographical origin of *A. esculentus*. Some authors argue that one putative ancestor (*A. tuberculatus*) is native to Uttar Pradesh in northern India, suggesting that the species originated from this geographic area. Others, on the basis of ancient cultivation in East Africa and the presence of the other putative ancestor (*A. ficulneus*), suggest that the area of domestication is north Egypt or Ethiopia, but no definitive proof is available today (Rao et al., 2019). Okra originated somewhere around the Ethiopia, and was cultivated by the ancient Egyptians by the 12th century B.C. Its cultivation spread throughout Middle East and North Africa (Ogunbor , 2020) . Okra is grown in many parts of the world, especially in tropical and sub-tropical countries. This crop can be grown on a large commercial farm or as a garden crop. Okra plants are grown commercially in many countries such as India, Japan, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Myanmar, Malaysia, Thailand, India, Brazil, Ethiopia, Cyprus and in the Southern United States (Ogunbor, 2020). Okra was discovered in an area that includes presene-day Ethiopia, the mountainous or plateau portion of Eritrea, and the Eastern, higher part of the Anlo-Egyptian Sudan. The words Okra and Gumbo is believed to be of Portuguese origin, quingombo of the word quillobo, native name for the plant in the Congo and Angola area of Africa. It is believed okra was taken into Egypt by Muslims from the East who conquered Egypt in 7th century, then taken from Ehiopia to Arabia across the Red Sea or narrow strait at its Southern end. French colonists most likely brought okra to the U.S. It was grown as far North as Philadelphia in 1748 and known in Virginia before 1781, according to Thomas Jefferson. Some of the World's most powerful women, Cleopatra of Egypt and Yang Guifei of China, loved to eat okra. One of the earliest account of okra was by a Spanish Moor visiting Egypt in 1216. Okra was introduced to the New World before 1658, reaching Brazil from Africa, and was found in Surinam in 1686. Modern travelers have found okra growing along the Nile river (Axe, 2021).

Okra originated in tropical and subtropical Africa. Existence of a large number of related species with wide variability and dominant characters suggest possible role of India as a secondary centre of origin (Eagri, 2023). The geographical origin of okra is disputed, with supporters of South Asian, Ethiopian and West African origins. Supporters of a South Asian origin point to the presence of its proposed parents in that region. Supporters of a West African origin point to the greater diversity of okra in that region; however, confusion between okra and *A. caillei* (West African okra) casts doubt on those analyses. The Egyptians and Moors of the 12th and 13th centuries used the Arabic word for the plant, *bamay*, suggesting it had come from the east. The plant may have entered southwest Asia across the Red Sea or the Bab-el-Mandeb strait to the Arabian Peninsula, rather than north across the Sahara, or from India. One of the earliest accounts is by a Spanish Moor who visited Egypt in 1216, who described the plant under cultivation by the locals who ate the tender, young pods with meal. From Arabia, the plant spread around the shores of the Mediterranean Sea and eastward. The plant was introduced to the Americas by ships plying the Atlantic slave trade by 1658, when its presence was recorded in Brazil. It was further documented in Suriname in 1686. In compound farms in the rainforest of Southeastern Nigeria, farmers have developed a multi-

crop system that provides a diversified and continuous production of food, combining species with different maturity periods such as yams, cassava, cocoyams, bananas, plantain, maize, okra, pumpkin, melon, leafy vegetables and a variety of trees and shrubs, 60 of which provide food products. This ensures a balanced diet but also reduces the need for storage in an area where post-harvest losses are high. Okra may have been introduced to Southeastern North America in the early 18th century. It was being grown as far north as Philadelphia by 1748. Thomas Jefferson noted it was well established in Virginia by 1781. It was commonplace throughout the Southern United States by 1800, and the first mention of different cultivars was in 1806 (Liqui, 2023)

The geographical origin of okra is disputed, with supporters of Southeast Asian, South Asian, Ethiopian and West African origins. The Egyptians and Moors of the 12th and 13th centuries used the Arabic word for the plant, *bamya*, suggesting it had come into Egypt from Arabia, but earlier it was probably taken from Ethiopia to Arabia. The plant may have entered southwest Asia across the Red Sea or the Bab-el-Mandeb strait to the Arabian Peninsula, rather than north across the Sahara, or from India. One of the earliest European accounts is by a Spanish Moor who visited Egypt in 1216 and described the plant under cultivation by the locals who ate the tender, young pods with meal. From Arabia, the plant spread around the shores of the Mediterranean Sea and eastward. The plant was introduced to the Americas by ships plying the Atlantic slave trade by 1658, when its presence was recorded in Brazil. It was further documented in Suriname in 1686. Okra may have been introduced to Southeastern North America from Africa in the early 18th century. By 1748, it was being grown as far north as Philadelphia. Thomas Jefferson noted it was well established in Virginia by 1781. It was commonplace throughout the Southern United States by 1800, and the first mention of different cultivars was in 1806 (WIKI, 2023a). It is commonly grown through the warmer parts of temperate Asia, southern Europe, northern Africa, the United States, and in all parts of the tropics. It is adapted to climates with relatively short rainy seasons, hence its special acceptance in North-East Brazil where it is considered a crop that never fails. In India, okra is commercially grown in the states of Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh, West Bengal, Assam, Rajasthan, Tamil Nadu, Karnataka, Haryana, and Punjab (Vidhi, 2023).

TAXONOMY

This genus *Abelmoschus* is distinguished from the genus *Hibiscus* by the characteristics of the calyx, spathulate, with five short teeth, connate to the corolla and caducous after flowering (Terrell and Winters, 1974). *Abelmoschus* was formerly included within *Hibiscus*, but is now classified as a distinct genus. The genus name derives from Arabic meaning 'father of musk' or 'source of musk' referring to the scented seeds (Wikipedia, 2023). Okra was earlier included in the genus *Hibiscus,* section *Abelmoschus* in the family Malvaceae. The section *Abelmoschus* was subsequently proposed to be raised to the rank of distinct genus. The wider use of *Abelmoschus* was subsequently accepted in the taxonomic and contemporary literature (Hochreutiner, 1924). About 50 species have been described by taxonomists in the genus Abelmoschus. The taxonomical revision undertaken by Waalkes (1966) and its continuation by Bates (1968) constitutes the most fully documented studies of the genus *Abelmoschus*. Taking classification of Waalkes (1966) as the starting point, an up-to-date classification was adopted at the International Okra Workshop held at National Bureau of Plant Genetic Resources (NBPGR) in 1990 (IBPGR 1991). Authentic number of species included in the genus Abelmoschus is still uncertain, as they have not been studied in detail with respect to their taxonomic delimitation. Over fifty species were described from the world (Charrier, 1984) that comprised many synonyms and misidentifications (Vredebregt, 1991). Although about 50 species have been described, eight are most widely accepted (Singh et al., 2014). There are four known domesticated species of *Abelmoschus*. Among these, *A. esculentus* (common okra) is most widely cultivated in South and East Asia, Africa, and the southern USA. In the humid zone of West and Central Africa (WCA), *A. caillei* (West African okra) with a longer production cycle, is also cultivated. Plants of *A.manihot* sometimes fail to flower and this species is extensively cultivated for leaves in Papua New Guinea, Solomon Islands and other South Pacific Islands. The fourth domesticated species, namely, *A. moschatus,* is cultivated for its seed, which is used for ambretee in India and several animism practices in South Togo and Benin (Ravindrakumar and Shanthakumar, 2019). India is a rich treasure house of various species of *Abelmoschus* and all 11 species are found either in the wild, semi-wild or under cultivation. The genus Abelmoschus has a tortured systematic history. The ambiguity in nomenclature and lack of strong morphological characters for the delimitation of species has made the circumscription the genus rather controversial and created problems in breeder's selection efforts (Patil *et al*., 2015).

Abelmoschus is a genus of annual, biennial or perennial malvaceous herbs placed in subfamily Malvoideae and tribe Hibisceae of the angiosperm family Malvaceae *sensu APG*. It is a segregate of *Hibiscus*, of which it was historically often treated as a section. It is distinguished from *Hibiscus* by the possession of a deciduous circumscissile spathaceous calyx. However DNA sequence data shows *Abelmoschus* is nested within *Hibiscus*, being related to other segregate genera such as *Fioria* and *Kosteletzkya* (some species - *Kosteletzkya* is polyphyletic), and sections such as Trionum, Striati, Muenchchusia and Venusti (Hinsley, 2022). Species of *Abelmoschus* are annual or perennial herbs or shrubs, often hispid or tomentose, with mostly simple hairs. The foliage is alternate, stipulate and petiolate. The stipules are linear or filiform, and caducous (soon falling off) or persistent [sources contradictory]. The leaf-blades are palmately lobed, with crenate or dentate margins. The flowers are borne solitarily in leaf axils, or in terminal racemes. They possess an epicalyx of from 4 to 16, depending on species, mostly caducous, bracteoles. The calyx is spathaceous, that is split to the base on one side as the flower opens, and lobed or toothed at the apex. It is deciduous, falling off with the corolla and staminal column. The corolla is funnel-shaped, yellow or red, rarely white or pink, often with a darker eye, and usually large. The staminal column bears anthers throught out its length, and has a five-toothed apex.. The anthers are unilocular. The ovary is 5-locular, the locules pluriovulate, and the style single with 5 sessile or subsessile flattened capitate stigmas. The capsule is elongate, often 5-angled, beaked or mucronate, pubescent or hispid, and dehiscent (5-valved). The seeds are numerous, and are subreniform, and sometimes pubescent or squamose (Hinsley, 2022).

The number of species (excluding two described in 2013) recognised varies from 6 to 15. The genus has generally high chromosome numbers (*Abelmoschus caillei* has the highest known chromosome count in Malvoideae, although it is exceeded in Bombacoideae and Tilioideae), and includes several allopolyploids. There is considerable variation in chromosome counts from single species, and it is not clear whether this is the result of the difficulty in counting the chromosomes, polymorphism in chromosome count, or the presence of cryptic species. I have been able to identify 14 species (one apparently unnamed), but I haven't resolved every name in the genus (Hinsley, 2022). Twelve species have been identified by Wikipedia (2023). Four species of *Abelmoschus* are crops. *Abelmoschus esculentus* (okra) and *Abelmoschus caillei* (West African okra) are grown for their fruits (used as vegetables), *Abelmoschus manihot* (aibika) as a leaf vegetable, and *Abelmoschus moschatus* (ambrette, musk mallow) for its seeds. Some species are also grown as ornamentals (Hinsley, 2022).

However, Hinsley (2022) described the following 13 species in the genus *Abelmoschus:*

1. *Abelmoschus angulosus* Mast.: *Abelmoschus angulosus* is a wild species recorded from Sri Lanka, India (Gujarat, Kerala, Maharashtra, Tamil Nadu), Pakistan, Cambodia, Laos, Vietnam, Java and Sumatra. Hooker's Flora of British India describes two varietes - var. *grandiflorus*, with scabrous (not hispid) petioles, yellow petals, and subpyriform seeds, and var. *purpureus*, with rigid spreading hairs

on the petiole, purple petals and globose seeds. The subspecific taxonomy was subsequently reviewed by Sivarajan et al.

2. *Abelmoschus caillei* (A. Chev.) Stevels: *Abelmoschus caillei* is a cultivated species from West Africa, where it originated as an allopolyploid hybrid between *Abelmoschus manihot* and *Abelmoschus esculentus*. The same allopolyploid has been produced experimentally in Japan, where it was given the names Nori-Asa and *Abelmoschus glutino-textile*.

3. *Abelmoschus crinitus* Wall.: *Abelmoschus crinitus* is a wild species from Southern China (Guangxi, Guizhou, Hainan, Yunnan), India, Nepal, Myanmar, Thailand and Vietnam. It is a perennial herb, growing to between 0.5 and 2m in height. The root is fusiform. The plant has an indumentum composed of 5-6mm long yellow hairs and a minute gray puberulence. The corolla is around 10 to 13 cm in diameter, and is yellow with a purple center. The staminal column is around 2 cm long , with scattered anthers. The style is branched, with 5 arms, each with a flat (discoid?) stigma.

4. *Abelmoschus enbeepeegearensis* K.J.John, Scariah, Nissar, K.V.Bhat & S.R.Yadav: *Abelmoschus enbeepeegearensis* is a recently described species native to the Western Ghats of India. (It was published as *Abelmoschus enbeepeegearense*, but as *Abelmoschus* is masculine the epithet is to be corrected to *enbeepeegearensis*. The epithet refers to India's National Bureau of Plant Genetic Resources or NBPGR.

5. *Abelmoschus esculentus* (L.) Moench.: *Abelmoschus esculentus* is a species of unknown origin. It may be a cultigen. Origins in South Asia, North East Africa, and West Africa have been proposed. I incline to a South Asian origin on the grounds of the cytological evidence that it is an allotetraploid with the South Asian *Abelmoschus tuberculatus* as one parent. *Abelmoschus esculentus* is an annual herb growing to 1 to 2 m. The corolla is white or yellow with a purple centre, and 5 to 7 cm in diameter. The fruit is an elongated capsule with a circular or pentagonal cross-section. It is 10 to 25 cm long, and 1.5 to 2 cm in diameter. When young it is edible. *Abelmoschus esculentus* has 130 chromosomes. *Abelmoschus esculentus* is widely cultivated in tropical and warm temperate regions as a vegetable. Production is greatest in South Asia (3,650,000 tonnes in 2005), West Africa (985,000 tonnes) and the Middle East (225,000 tonnes). Smaller quantities are produced in South America (Guyana is the largest producer), East Africa, Central America, Mexico, the United States, and South East and East Asia.

6. *Abelmoschus ficulneus* L. (Wight & Arn.): *Abelmoschus ficulneus* is found in the Indian subcontinent, Australia, Madagascar, and in the Sahel zone of Africa, including Niger and northern Nigeria, but may be native, rather than naturalised, only in the first. *Abelmoschus ficulneus* is a prickly annual herb, with palmately 3-5-lobed glabrous leaves.

7. *Abelmoschus manihot* (L.) Medik.: *Abelmoschus manihot* is native to India, Nepal and southern China. It is an annual or perennial herb growing to 1 to 2 m. The corolla is yellow with a purple centre, and about 12 cm in diameter. *Abelmoschus manihot* has c.68 chromosomes.

8. *Abelmoschus moschatus* Medik.: *Abelmoschus moschatus* is native to India, continental south east Asia and southern China. It is an annual or perennial herb growing to 1 to 2 m. The corolla is yellow with a purple centre, and about 7 to 12 cm in diameter. *Abelmoschus moschatus* is grown commercially for its musk scented seeds. It is also sometimes grown as an ornamental.

9. *Abelmoschus muliensis* Feng: *Abelmoschus muliensis* is endemic to southwest Sichuan, where at occurs on grassy slopes between 1200m and 2100m altitude. It is a velutinous herb reaching 1m in height, with a stem about 0.5cm in diameter, and most parts with a dense covering of yellow hairs. The foliage is alternate, stipulate and shortly petiolate. The stipules are narrow, and 1 to 1.5 cm long. The petiole is 1 to 4 cm long. The blades of the lower leaves are 6-9 cm in diameter, and have a rounded-cordate base, and obtuse or acute apex and a broadly dentate margin. Those of the upper leaves are ovate-sagittate, 7-10 cm long and 5-7 cm wide, with a broadly dentate margin and an obtuse apex. The flowers have not been observed; however from the fruiting stage it is known that the flowers are borne singly or in clusters in the leaf axils, and that the epicalyx is composed 12 filiform lobes which are 2-3mm wide and 1.5-3 cm long.

10. *Abelmoschus palianus* Sutar, K. V. Bhat et S. R. Yadav: *Abelmoschus palianus* was described in 2013 from central India. It is similar to *Abelmoschus angulosus*, but differs in fruit and epicalyx characters.

11. *Abelmoschus sagittifolius* (Kurz) Merr.: *Abelmoschus sagittifolius* is often classified as a subspecies (*tuberosus*) of *Abelmoschus moschatus*. However it has a different karyotype (2n=36 versus 2n=72), and therefore I follow the Flora of China in treating it as a separate species. It is found in southern China (Guangdong, Guangxi, Guizhou, Hainan, Yunnan), mainland south east Asia, extending to eastern India, and also in the Kimberley and Arnhem Land areas of northern Australia. In China it is found in pine forests, on grassy slopes, and in other habitats. It is also grown as an ornamental. It is a perennial herb, growing to 40 to 100 cm, or rarely 200 cm, tall. Most vegetative parts are densely pubescent, and are sometimes also setose or stellate-hairy. It has a fleshy, radish-shaped, rootstock, reaching to 5 cm in thickness. The flowers are white, pale yellow or pink, and 4 or 5 cm in diameter. They are borne solitarily in the leaf axils, on slender but densely scabrous, 4-7 cm long, petioles. The epicalyx is composed of 6 to 12 filiform, sparsely hirsute, spreading or reflexed, bracteoles. These are around 15 mm long, and 1 to 1.7 mm wide. The petals are 3 to 4 cm long with an obovate/oblong shape.

12. *Abelmoschus tetraphyllus* Wall.: *Abelmioschus tetraphyllus* is sometimes classified as a subspecies of *Abelmoschus manihot*. However it has a different cytotype (2n=c.138 versus 2n=c.68), and I treat it as a separate species. A 2016 molecular study confirms its separation, finding it more closely related to *Abelmoschus ficulneus* than to *Abelmoschus manihot*.

13. *Abelmoschus tuberculatus* Pal & Singh: *Abelmoschus tuberculatus* is a wild species from India, morphologically similar to, and long confused with *Abelmoschus esculentus*. However it has a different karyotype (2n=58 versus 2n=130), and hybrids between it and *Abelmoschus esculentus* are sterile. Morphologically it can be distinguished by the tuberculate fruits, and by being smaller in most parts, especially the fruit. *Abelmoschus tuberculatus* is resistant to the spiny bollworm *Eirias insulana* and to Okra yellow vein mosaic virus, and therefore is of interest for the potential transfer of those traits to *Abelmoschus esculentus*.

Okra belongs to the family Malvaceae, genus *Abelmoschus* and the species ***Abelmoschus esculentus*** (L.) Moench (Dhankhar and Mishra, 2005; WIKI, 2023a). Cultivated okra or bhendi belonging to Malvaceae was earlier placed under *Hibiscus esculentus* L. Since its calyx, corolla and staminal column are fused together and fall down at anthesis (caduceus), it was renamed as *Abelmoschus esculentus* L. (Eagri, 2023).

The Synonyms of *Abelmocus esculentus are as follows* (WIKI, 2023a; IBP, 2023):

1) *Abelmoschus bammia* Webb
2) *Abelmoschus longifolius* (Willd.) Kostel.
3) *Abelmoschus officinalis* (DC.) Endl.
4) *Abelmoschus praecox* Sickenb.
5) *Abelmoschus tuberculatus* Pal & Singh
6) *Hibiscus esculentus* L.
7) *Hibiscus hispidissimus* A.Chev. nom. illeg.
8) *Hibiscus longifolius* Willd.

9) *Hibiscus praecox* Forssk

BOTANICAL DESCRIPTION

The genus comprises annual and perennial herbaceous plants, growing to 2 m tall. The leaves are 10–40 cm long and broad, palmately lobed with 3-7 lobes, the lobes are very variable in depth, from barely lobed, to cut almost to the base of the leaf. The flowers are 4–8 cm diameter, with five white to yellow petals, often with a red or purple spot at the base of each petal. The fruit is a capsule, 5–20 cm long, containing numerous seeds. (Wikipedia, 2023). Okra plant is mostly robust, erect (occasionally branched), annual herb with well developed tap root system; stem, petiole, leaf veins with or without red pigmentation; leaves alternate, palmately lobed, hirsute and serrate; flowers solitary, usually axillary with lobed epicalyx. Calyx generally non-lobed, tubular; corolla with 5 large yellow petals, purplish red pigmentation on one or both sides of claw; tubular staminal column with numerous stamens, attached to the corolla base; stigma 5-10 lobed, velvety red/purplish; fruit 5-10 chambered, beaked capsule, with or without sutures/ridges; seed dark green, grey or dark brown, rounded. Flowering starts from 3rd to 7th node from the base and continues along with the growing stems/branches.

Stigma becomes receptive 2 hours before anthesis (protogyny) and receptivity persists till 3-4 hours after anthesis with varying degree of receptivity. Anthers dehisce at the time of anthesis. It takes about 45-50 days from sowing to flowering and fruit set. The fruits develop to marketable (unripe harvest) maturity in 5-6 days and to drying and seed har- vest in 30-32 days from anthesis (Dhankhar and Mishra, 2005). Okra plants are characterized by indeterminate growth. Flowering is continuous but highly dependent upon biotic and abiotic stress. The plant usually bears its first flower one to two months after sowing. The fruit is a capsule and grows quickly after flowering. The greatest increase in fruit length, height and diameter occurs during 4th to 6th day after pollination. It is at this stage that fruit is most often plucked.

Stem: Its stem is semi woody and sometimes pigmented with a green or reddish tinges color. It is erect, variable in branching, with many short branches that are attached to thick semi woody stem. The stem attains height from 3 feet in dwarf varieties to 7 or 8 feet in others.

Leaves: The woody stem bear leaves that are lobed and are generally hairy, some reaching up to 12 inches in length.

Okra Plant

Leaf

Plant with flower

Plant with flower

Flower

Plant with white fruits

Plant with green fruits

Plant with purple fruits

Plant with long fruit

Mature pods

Seeds

Seeds

Fig. 1. Botanical Description

Leaves are cordate (heart-shaped), simple, usually palmately 3-7 lobed and veined. Leaves are subtended by a pair of narrow stipules. The okra leaf is dark green in color and resembles a maple leaf.

Flowers: The flowers are borne vertically only on the orthotropic axis every two or three days. The flower is axillary and solitary, borne on a peduncle 2.0 – 2.5 cm long. The flowers are large around 2 inches in diameter, with five white to yellow petals with a red or purple spot at the base of each petal. Flower lasts only for a day. Each blossom develops a small green pod. The flowers are almost always bisexual and actinomorphic. The perianth consists of 5 valvate, distinct or basally connate sepals and 5 distinct petals that are usually basally adnate to the androecium. The androecium consists numerous monadelphous stamens with apically divergent filaments bearing 1-celled anthers. The gynoecium is a single compound pistil of two to many carpels, an equal number of styles or style branches, and a superior ovary with two to many locules, each bearing one to numerous ovules. The calyx is completely fused to form a protective case for the floral bud and splits into lobes when the bud opens. The calyx, corolla and stamens are fused together at the base and fall off as one piece after anthesis. The erect sexual parts consist of a five to nine part style, each part with a capitate stigma, surrounded by the staminal tube bearing numerous filaments (Purewal and Randhawa 1947, Purseglove 1968). The petals wilt in the afternoon and usually fall off the following day.

Fruit: The fruit is an elongated, conical or cylindrical capsule, comprising for the most part, five cavities containg ovules (Fig.). The fruit is actually long pod and generally ribbed, developing in the leaf axil and spinelesss in cultivated kinds. The fruit is normally yellowish green to green, but is sometimes purple or whitish green. The pods are the edible portion, which are harvested while still tender and immature. They grow rapidly into long (10-30 cm) and narrow (1-4 cm) pod with a tip that is either pointed like a beak or blunt.

Seeds: The okra fruit contains numerous oval, smooth, striated and dark green to dark brown seeds.

Root: Okra plant has a deep taproot system (Fig. 1, 2, 3) (Tripati *et al.,* 2011).

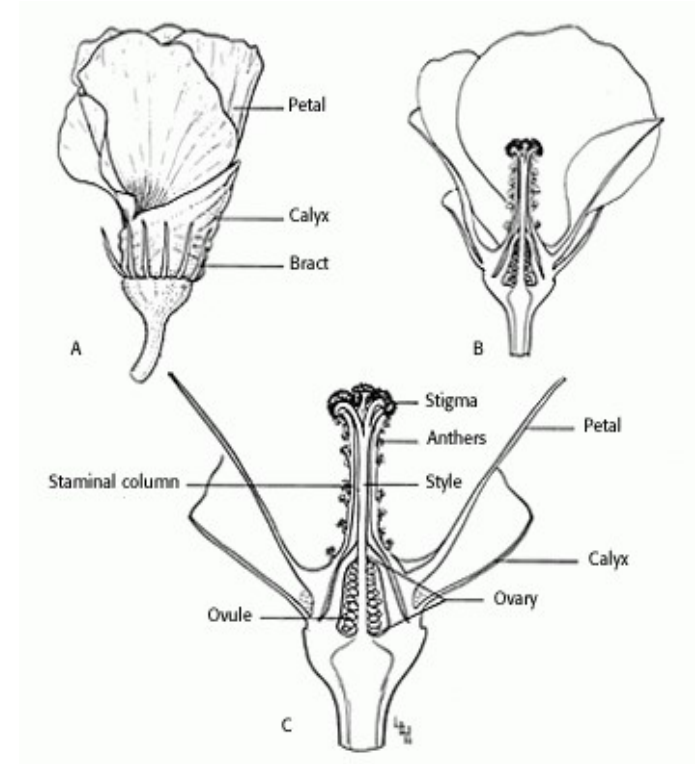

Fig. 2. Okra flower. A. Side view, B. Longitudinal section, C. Longitudinal section of stamina column

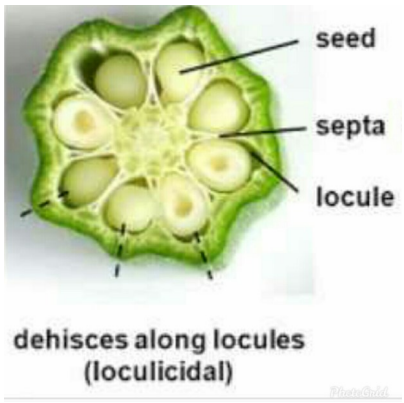

Fig. 3. Cross section of fruit

Okra is an upright annual herbaceous plant, 1-2 m tall and has hibiscus-like flowers. It has deep taproot system. Stem is semi-woody, usually green and occasionally, pigmented with green or reddish tinge colour. It is erect, having 3-5 branches. The leaves are alternate, 3-7 lobed palmate, hirsute and serrate. Leaves are subtended by a pair of narrow stipules. Okra leaf colour is dark green and leaf resembles a maple leaf. Flowers are solitary, axillary having epicalyx (up to 10). Flower peduncle is 2-2.5 cm long. Flowers are large, around 3 cm in diameter, with 5 white to yellow petals with red or purple spot at the base of each petal. Flowers last only for a day. Each blossom develops a small green pod. The flowers are hermaphrodite and actinomorphic. There are 5 valvate, distinct or basally connate sepals. Okra leaves are heart-shaped and three- to five-lobed. The flowers are yellow with a crimson centre. The fruit or pod, hairy at the base, is a tapering 10-angled capsule 10–25 cm in length (except in the dwarf varieties) that contains numerous oval dark-coloured seeds (Ogunbor, 2020). The species is a perennial, often cultivated as an annual in temperate climates, often growing to around 2 metres tall. As a member of the Malvaceae, it is related to such species as cotton, cocoa, and hibiscus. The leaves are 10–20 cm long and broad, palmately lobed with 5–7 lobes. The flowers are 4–8 cm in diameter, with five white to yellow petals, often with a red or purple spot at the base of each petal. The pollens are spherical and approximately 188 microns in diameter. The fruit is a capsule up to 18 cm long with pentagonal cross-section, containing numerous seeds (WIKI, 2023).

Okra is an upright annual herbaceous plant, 1-2 m tall and has hibiscus-like flowers. It has deep taproot system. Stem is semi-woody, usually green and occasionally, pigmented with green or reddish tinge colour. It is erect, having 3-5 branches. The leaves are alternate, 3-7 lobed palmate, hirsute and serrate. Leaves are subtended by a pair of narrow stipules. Okra leaf colour is dark green and leaf resembles a maple leaf. Flowers are solitary, axillary having epicalyx (up to 10). Flower peduncle is 2-2.5 cm long. Flowers are large, around 3 cm in diameter, with 5 white to yellow petals with red or purple spot at the base of each petal. Flowers last only for a day. Each blossom develops a small green pod. The flowers are hermaphrodite and actinomorphic. There are 5 valvate, distinct or basally connate sepals. Androecium consists of numerous monoadelphous stamens with apically divergent filaments. Gynoecium is a single compound pistil of 2 to many carpels with equal number of styles or style branches. Ovary is superior with 2 to many locules each having several ovules. Calyx is completely fused to make a protective case for flower bud and splits into lobes when the bud opens. Calyx, corolla and stamens are fused together at the base and fall off as one piece after anthesis. The erect sexual parts consist of 5 to 9 part-style, each part with a capitate stigma, surrounded by the staminal tube bearing numerous filaments. Fruit is elongated, conical capsule, comprising 5 cavities containing ovules. Okra fruit contains 20-50, oval, smooth, dark green to dark brown seeds (Vidhi, 2023).

Annual herbs, 2 m tall; stems and branches hirsute white bristly hairs. Leaves simple, alternate, spiral; stipules ca. 7-10 mm long, filiform;

petiole ca. 15-35 cm, long hirsute, often with pubescent adaxial groove; lamina ca. 6-12 x 4-10 cm, variable, palmately 3-7-lobed to palmately partite, with widely triangular, ovate, oblong or lanceolate, acute or acuminate at apex, coarsely dentate-serrate, upper sagittate; secondary nerves 5-7 pairs. Flowers axillary, solitary; pedicel ca. 1-5 cm, sparsely strigose; epicalyx lobes 10-12, filiform, ca. 5-18 × 1-2.5 mm, sparsely hirsute; calyx campanulate, 2-3 cm, densely stellate puberulent; corolla yellow or white with dark purple centre, 5-7 cm in diam.; petals obovate, ca. 3.5-5 × 3-4 cm; Filament tube ca. 2-2.5 cm; staminal column short, at apex 5 toothed; style distally divided into 5, spreading branches. Capsule cylindric to tower-shaped, ca. 10-25 × 1.5-3 cm, long beaked, sparsely strigose. Seeds 5-15 per locule, ca. 3-6 mm, dark brown or grey, globose to reniform, striate, and minutely warty (IBP, 2023).

Seed Dormancy

A. esculentus shows a particular kind of seed dormancy, called delayed permeability caused due to structure of the seed coat and particularly by the chalazal plug. There is observed a direct relationship between the seed moisture content and delayed permeability with variances between cultivars and moisture contents. Normal seeds harvested from the plants of the cultivars does not exhibit seed dormancy (Tripati *et al.,* 2011).

Floral Biology

The okra flowers are 4-8 cm in diameter, with five white to yellow petals, often with a red or purple spot at the base of each petal and the flower withers within one day. The flower structure combines hermaphroditism and self compatibility. Flower bud appears in the axil of each leaf, above 6th to 8th leaf depending upon the cultivar. The crown of the stem at this time bears 3-4 underdeveloped flowers but later on during the period of profuse flowering of the plant there may be as many as 10 undeveloped flowers on a single crown. As the stem elongates, the lower most flower buds open into flowers. There may be a period of 2, 3 or more days between the time of development of each flower but never does more than one flower appear on a single stem. A flower bud takes about 22-26 days from initiation to full bloom. The style is surrounded by a staminal column which may bear more than 100 anthers. The pollen may come in contact with the stigmas through a lengthening of the staminal column or through insect foraging (Thakur and Arora, 1986). Thus the flowers of okra are self fertile. The pollen grain is large with many pores, and every pore is a potential tube source; therefore, many tubes can develop from one pollen grain (Purewal and Randhawa, 1947).

Pollination and Fertilization

From studies made on six okra varieties, Sulikeri and Swamy Rao (1972) concluded that flower buds are initiated at 22-26 days and the first flower opened 41-48 days after sowing. Once initiated, flowering continues for 40-60 days. Anthesis was observed between 6 a.m and 10 a.m. Anthers dehisce before flower opening and hence self pollination may occur at anthesis. The dehiscence of anthers is transverse and complete dehiscence occurs in 5-10 minutes (Purewal and Randhawa, 1947). Pollen fertility is maximum in the period between an hour before and an hour after opening of the flower (Srivastava, 1964). Pollen stored for 24 hours at room temperature (27° C) and 88% relative humidity was not viable. The stigma was most receptive on the day of flowering (90-100%). Stigma receptivity was also observed the day before flowering (50-70%) and the day after (1-15%). Flowers open only once in the morning and close after pollination on the same day. The following morning the corolla withers. Okra has perfect flowers (male and female reproductive parts in the same flower) and is self-pollinating. If okra flowers are bagged to exclude pollinators, 100% of the flowers will set seed. It has been found experimentally that there is no significant difference in fruit set under open-pollinated, self-pollinated (by bagging alone) and self-pollinated (hand pollination of bagged flowers), indicating that it is potentially a self-pollinated crop (Purewal and Randhawa, 1947). The inbreeding depression well pronounced in cross-pollinated crops has not been reported in this crop. Although insects are unnecessary for pollination and fertilization in case of okra, the flowers are very attractive to bees and the plants are cross-pollinated. The cross pollination upto the extent of 4-19% (Purewal and Randhawa, 1947) with maximum of 42.2% (Mitidieri and Vencovsky, 1974) has been reported. The extent of cross-pollination in a particular place will depend upon the cultivar, competitive flora, insect population and season.

GENETICS AND CYTOGENETICS

An indicative account of inheritance of characters presented in Table 1. (Dhankhar and Mishra, 2005).

Table 1. Gene effects and inheritance of principal characteristics of okra

Characteristic	Observation
Plant height	Dominance gene action Non-additive gene action Both additive and dominance high heritability (79%)
Internode length	High heritability (79%)
Dark red stem	Simple inheritance
Pubescence of foliage	Incomplete dominance
Light red petiole	Simple inheritance
Degree of leaf lobing	Simple inheritance (cut/lobbed)
	Monogenic with incomplete dominance
Resistance to Jassids	Dominant, polygenic control
Resistance to YVM virus	High heritability (70%) Digenic control (recessive) Monogenic
Earliness	Simple inheritance
Days to flowering	High heritability (65%)
	Non-additive gene action
Calyx color	Simple inheritance (Dominance)
Petal blotch	-do-
Base color	-do-
Petal venation color	-do-
Pod color	Simple inheritance (multiple alleles) Two dominant genes One dominant gene (white/ green)
Pubescence of pods	Complex inheritance
	Simple inheritance Incomplete dominance
Fruit shape	Two genes Digenic with epistasis (angular/ round)
	Several genes
Characteristic	Observation
Weight of fruit	Average heritability (48%)
Pods per plant	Additive gene action and Average heritability
	High heritability
Seeds per pod	Very high heritability (94%)
Seed weight	High heritability (77%)
Yield	High heritability (63%)

(Dhankhar and Mishra, 2005).

There are significant variations in the chromosome numbers and ploidy levels of different sepceis in the genus *Abelmoschus.* The lowest number reported is 2n=56 for *A. angulosus* (Ford, 1938), whereas the highest chromosome number reported are close to 200 for *A. manihot* var. *caillei* (Singh and Bhatnagar, 1975). Despite of enormous morphological diversity, there has been no strong consensus among the cytologists to the actual number of chromosome counts that constitute the species of *Abelmoschus*. On the basis of cytogenetical observations Siemonsmo (1982a) suggested that taxonomical classification at species level is much more complex than elaborated by Waalkes (1966). With the massive morphological variation, the genus constitutes a polyploid complex ranging from 2*n*=38 to 2*n*=200. The most frequently observed somatic chromosome number, however, is 2n=130, although Dutta and Naug (1968) suggest that the numbers 2n=72, 108, 120, 132 and 144 are in regular series of polyploids with n=12. The existing taxonomical classifications at the speices level in the genus Abelmoschus are unsatisfactory. Detailed cytogenetical observations on Asian material

of okra and related species are likely to provide more examples of the existence of amphidiploids in the genus (Dutta and Naug, 1968; Siemonsma, 1982a). Most of cultivated varieties are amphidiploids with 2n=130. *A. esculentus* is noted for its chromosome polymorphism and 2n ranges from 72 to 144. It tolerates addition or deletion of one or a few chromosomes. The chromosome number of *A .esculentus* is 2n=130 which is evolved by crossing. *A. tuberculatus* (2n=58) with *A. ficulneus* (2n=72). The F1 developed was subjected to colchicines treatment to make it an amphidiploid. *A. esculentus* (2n=130) (Eagri, 2023).

Fig. 4. Variability for fruit shape, color and size

From careful perusal of published data, it is known that Indian representative taxa of *Abelmoschus*, including *A. esculentus*, indicate that the taxonomic units of *Abelmoschus* are heterogeneous in nature thereby exhibiting deviant chromosome numbers. The occurrence of different somatic chromosome numbers ranging from 2n=58 to 2n=200 in the genus suggest that the classification at the species level is much more complex than elaborated by Waalkes (1966). Siemonsma (1982) classed West African Guinean okra (2n = 185-198) as a separate species different from A. esculentus (2n = 130), as the former are tropical, short day types, late flowering with high seed content in the fruits. This group of West African okra has very low homogeneity within itself which can be used for improving tropical as well as temperate okra, particularly for imparting dark green fruit color and YVM resistance. Genetic diversity exists for number of characters. Genetic resistance involving interspecific crosses have been exploited commercially for Yellow Vein Mosaic virus. Hybrids are very much popular in this crop and the hybrid seed production is based on hand emasculation and hand pollination. Proper isolation is necessary between two fields of two varieties for maintaining the genetic purity of the stock (Dhankhar and Mishra**,** 2004). In *A. esculentus* types, *i.e.,* cultivated okra, genetic diversity exists for number of ridges and their presence/partial presence or absence on fruits, extent of hairiness and pigmentation on plant parts including fruits, ratio between length and width (diameter) of fruits, attachment of fruits on plant, lobing and lamina surface of leaves and also branching and height of the plant. Some of these characters are also influenced by environmental conditions (Dhankhar and Mishra, 2005). Magnitude of genetic variability was observed as high for number of fruits per plant, plant height, onset of flowering, number of nodes, stem diameter, leaf color and leaf shape. High correlation coefficients (r = 0.4) were found in case of color characteristics of cotyledons–(stem and leaf), leaves (vein base, petiole of first leaf) and pods, and simply indicated that anthocyanin (red color) tends to be produced in various organs at the same time. Total seed yield is related principally to number of pods per plant and secondly to seeds per pod (Dhankhar and Mishra, 2005). Genetic variability, heritability

and genetic advance of 13 quantitative characters in 17 okra genotypes were studied. Significant differences among genotypes were observed for all the characters under study. The characters plant height and number of branches per plant showed high phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). High heritability was recorded for all the characters studied except days to 50 per cent flowering which exhibited moderate heritability. The characters viz., plant height, number of branches per plant, number of nodes per plant, internodal length, number of fruits per plant, number of seeds per fruit, harvest index and total yield per plant exhibited high heritability coupled with high genetic advance over mean (GAM) which indicated that there was more number of additive factors and therefore, further improvement could be brought by selection (Ramanjinappa et al., 2011). 29 okra accessions sourced from different agro-ecological regions in Nigeria were evaluated for genetic diversity using principal component analysis (PCA) and single linkage cluster analysis (SLCA). The accessions were classified into six and five cluster groups by PCA and SLCA respectively. The mean contributions of plant height, days to flowering, branches per plant, fresh pod width, mature pod width, fresh pod length, pod weight per plant, pod per plant, seeds per pod, and seed weight per plant were relatively high in the principal axes confirming the major contributions of these traits to seed yield in okra. The first four principal axes accounted for over 60% of the total variation among the 18 characters describing the accessions. Accessions 29, 9 and 14, which appears to be the most diverse may be useful as source for variable characters in okra improvement among the accessions studied been the most distant (Nwangburuka *et al.,* 2011).

Inter-simple sequence repeat (ISSR) markers were employed to investigate the genetic diversity and differentiation of 24 okra genotypes. In this study, the PCR products were separated by electrophoresis on 8% nondenaturing polyacrylamide gel and visualized by silver staining. The 22 ISSR primers produced 289 amplified DNA fragments, and 145 (50%) fragments were polymorphic. The 289 markers were used to construct the dendrogram based on the unweighted pair-group method with arithmetic average (UPGMA) cluster analysis. The dendrogram indicated that 24 okras were clustered into 4 geographically distinct groups. The average polymorphism information content (PIC) was 0.531929, which showed that the majority of primers were informative. The high values of allele frequency, genetic diversity, and heterozygosity showed that primer-sample combinations produced measurable fragments. The mean distances ranged from 0.045455 to 0.454545. The dendrogram indicated that the ISSR markers succeeded in distinguishing most of the 24 varieties in relation to their genetic backgrounds and geographical origins (Yuan *et al*., 2014). Sixty eight (68) accessions belonging to four wild *Abelmoschus* species [*Abelmoschus caillei* (A. Chev.) Stevels, *Abelmoschus manihot* (L.) Medik., *Abelmoschus moschatus* (L.) Medik. and *Abelmoschus tuberculatus* Pal et Singh] and eight okra varieties were characterized and evaluated for phenological characters including biotic stresses under natural epiphytotic condition. The wild species examined consisted of 18 accessions (16 exotic and 2 indigenous) of *A. caillei*, 29 accessions of *A. manihot*, 16 accessions of *A. moschatus* and 5 accessions of *A. tuberculatus.* All the wild *Abelmoschus* species exhibited high diversity (as measured by Shannon Diversity Index) for 3 qualitative characters viz. intensity of stem colour, leaf shape, epicalyx shape, 13 quantitative characters and 3 biotic stress parameters. Resistance to YVMD was found in accessions belonging to three wild species viz. *A. caillei*, *A. manihot* and *A. moschatus* while resistance to shoot and fruit borer and leaf hopper was found in accessions of all the four wild species. The resistant accessions can further be used for introgressing biotic stress resistance through pre-breeding into cultivated okra species (Gangopadhyay *et al.,* 2016). For effective conservation and proper deployment of germplasm, a study on diversity analysis of okra germplasm was conducted with DNA markers. Microsatellite/Simple sequence repeat (SSR) markers were utilized to evaluate the genetic diversity among 96 accessions of *Abelmoschus*, of which 92 accessions were of *A. esculentus* and one accession each of *A. tuberculatus, A. moschatus, A. oschatus* subspecies *tuberosus* and A. *manihot*. A set of 40 SSR primers were tested, of which 30 primers gave reproducible amplification which were used further for diversity analysis. With a mean of 7.1 bands per SSR, DNA amplification with 30 SSRs generated a total 213 bands, of which 60.66 % were recorded polymorphic. Polymorphic information content ranged between 0.11 and 0.80 with an average of 0.52, indicating that the majority of primers were informative. The Jaccard's coefficient ranged from 0.107 to 0.969. The UPGMA analysis grouped *Abelmoschus* genotypes into three main clusters at a cut-off of 0.20. Results of present study revealed that sufficient variation exists among the studied accessions and GAO-5 which was found highly diverse can be exploited for okra improvement. The outcome of present research would assist to make use of *Ablemoschus* germplasm for okra breeding (Kumar *et al,* 2017**).** Therefore, it is proposed to undertake investigations with a prime objective of a comprehensive study to understand the quantum of genetic diversity and ascertain genomic relationships among species of *Abelmoschus*, including *A. esculentus* which are important to systematists, evolutionary biologists, cytogeneticists, molecular biologists and plant breeders as well. The study is expected to find solutions to overcome the taxonomic dilemma that exists in the genus using cytogenetical and molecular approaches in both the cultivated and wild relative species from the Indian sub-continent. Thus, an attempt has been made to analyze the existing genetic variation among these plants in natural habitat to assess the quantum and range, and also to define the genetic basis for the same (Rao *et al*., 2019).

Molecular marker-based approaches have been successful in characterizing variations both at inter- and intra-specific levels since they generate new genetic diversity parameters to define. Such parameters often extend beyond species boundaries and boast of a great value and significance in diagnostic applications. In the present study, three single primer amplification methods *viz.*, random amplified polymorphic DNA (RAPD), inter-simple sequence repeats (ISSR) and directed amplification of minisatellite DNA regions (DAMD) were utilized (individually and cumulatively) to comprehend the genetic variation that exist both at intra- and inter-specific levels in cultivated and wild species of *Abelmoschus* taxa. RAPD markers were able to easily distinguish the differences and similarities among 43 genotypes based on their randomness in their genetic make-up (as found in chromosome counts also) by clustering them into four distinct clusters, each cluster representing the respective species. Only one accession belonging to *A. tetraphyllus* var. Satyawada Rama Rao, Rihunlin H. Nongsiang and Merita Keisham Devi *tetraphyllus* (AT-2) behaved as an out-group, which can be visibly noted, not only from its gel profile but also from its collection site *i.e.* Nepal. *A. angulosus* var. *grandiflorusis* shown to have close affinity towards *A. tetraphyllus* var. *tetraphyllus* which is evident from the successful F1 hybrids from this cross. *A. esculentus* with a stable chromosome number, 2n=130 is considered low in genetic diversity and genetic similarity individuals in a given population. On closer analysis it is confirmed that RAPD analysis of *A. esculentus*, the cultivated taxon Pusa Sawani, AE-39 and AE-41 had shown the genetic similarity of 100% among genotypes in the population. When species relationships were probed, *A. esculentus* showed close affinity towards *A. tetraphyllus* and *A. angulosus* var. *grandiflorus*, while *A. moschatus* ssp. moschatus has been clustered separately from the rest. DAMD marker also revealed high polymorphism across the 43 genotypes of the Indian representative *Abelmoschus* belonging to four species. *A. angulosus* var. *grandiflorus* showed the close proximity towards *A. tetraphyllus* by clustering together, while *A. esculentus* was distantly related from *A. tetraphyllus*. *A. moschatusssp. moschatus* was closely related to *A. esculentus* (Rao *et al*., 2019).

The molecular phylogenetic analysis of various *Abelmoschus* taxa has been carried out using DNA sequence data of three chloroplast loci *viz*., accD, atpB and psbK-psbI which revealed different topologies in all the four tree building methods. The clustering pattern of accD and atpB sequences were almost similar, though with some exceptions in the positions of the species may differ in the tree. It was recorded that

atpB had the highest percentage of conserved sites while the highest percentage of variable sites were recorded in intergenic spacer, psbK-psbI. The lowest percentage of sequence divergence substitution was recorded as 2.19 in atpB, confirming that nucleotide substitutions occur at a relatively slow rate in cpDNA (Curtis and Clegg,1984). These sequence comparisons have further revealed that, although the genome as a whole change slowly, certain genes change either more rapidly or more slowly than the average. The region is highly conserved in Abelmoschus and relatively few sites in the aligned data matrix are parsimony informative, a variety of relationships among the species are revealed by the analyses, some of which are congruent with the known species relationships. In the present study, the coding gene accD and atpB, and intergenic spacer region psbK-psbI has been combined into a single matrix for a collective approach analysis to obtain greater phylogenetic resolution. The concatenate topologies of the trees constructed by ML, MP, BI and NJ for the consensus sequence were consistent with the clustering of A. caillei and A. tetraphyllus var. tetraphyllus, in all the methods, thereby it supports our earlier hypothesis that A. tetraphyllus var. tetraphyllus may be one of the probable progenitor species of A. caillei. Since cpDNA is maternally inherited, one can conclude that *A. esculentus* and *A. caillei* were essentially identical with those of diploid *A. tuberculatus* and allopolyploid, *A. tetraphyllus* var. *tetraphyllus* respectively, thereby either of the latter two species served as the maternal parents in the inter-specific hybridizations which gave Okra- an important vegetable crop of India (Rao *et al.,* 2019).

Okra [*Abelmoschus esculentus* (L.) Moench] landraces found in Nigeria are being examined as sources of genetic variation offering potential to improve agro-morpho-nutritional traits and broaden the gene pool. Objectives of this investigation were to: (1) assess variability of agro-morpho-nutritional traits in okra landraces sourced from five agroecological zones in Nigeria, and (2) estimate divergence among the germplasm. The landraces were evaluated in field experiments over a period of 2 years at the research farm of the Federal University of Agriculture, Abeokuta, Nigeria. Principal component analysis, cluster analysis, and Mahalanobis D^2 statistics were employed to study the diversity pattern. Differences existed for all evaluated traits among landraces. Genotypes NGB00378b, NGB00297, NGB00347, NGB00293, and NGB00350 combined high seed mineral concentrations with high yield potential. Heterosis breeding could be effectively used to improve K and Mg, as these traits expressed high variation and broad-sense heritability coupled with moderate GA. Using D^2 divergence analysis, landraces were separated into seven distinct clusters, with no phylo–agroecological pattern of diversity. Based on the present study, selection for a trait in 1 year may not provide the same benefit in other years due to year-to-year fluctuations in environmental conditions, evaluation in more than 1 year is required (Alake, 2020). To provide information to efficiently improve okra cultivars, this study aimed to characterize and assess the genetic diversity of a Brazilian collection by using the Ward-MLM (Modified Location Model) multivariate procedure. Both quantitative and qualitative variables can be simultaneously considered in this strategy. Forty-six okra accessions from the active germplasm bank of Embrapa Hortaliças and the open-pollinated 'Santa Cruz 47' were characterized according to descriptors lists. Seven groups were identified comprising seven, six, fourteen, six, five, seven, and two genotypes, respectively. Group VII was the most distant in relation to the other groups, probably because of the greatest vegetative development and lowest fruit production. Variability was observed for most morphological traits. The grouping information will be useful for germplasm conservation management and for crossing strategies. Leaf length, leaf width, petiole length, stem diameter at plant base, and first flowering height contributed the most to genetic variation. The genetic variability verified in this study suggests a high potential for breeding new okra cultivars (Silva *et al.,* 2021).

Sufficient genetic diversity has been reported among the parents and crosses for selection to be effective for okra hybrid production. Although both additive and dominant gene actions were found regulating the phenotypic expression of various characters, dominant gene action is considered more important (Mishra *et al.,* 2021). Over a decade, the taxonomy of the genus Capsicum in Nigeria has remained largelyunrevised, unclassified and unidentified. As such, there is a dearth of information on the proper identification of Capsicum spp and relatives found in the country. The aim of this study was to re-examine the taxonomic status of the Capsicum in Nigeria in order to establish genetic diversity between them for proper identification and classification. Sodiumdodecyl polyacrylamide gel electrophoresis of total seed protein was performed on five varieties of Nigerian Capsicum spp., following standard procedures. Six protein bands were observed across the five cultivars of Capsicum, of which 12-14 Kda was the only polymorphicband. Only C. fructescens var. ijosi and C. fructescens var. sombo were unique for manifesting 20-24 and 15-16 Kda bands respectively. Dendrogram of analysis obtained resolved the taxa into two distinct groups. In the first group were cultivars of C. fructescens var. ijosi and sombo while in the second group were C. chinense, which was distinctlyseparated from C. fructescens var. bawa and C. annum. Artificial dichotomous key was constructed for the identification of members of the genus Capsicum available in Nigeriabased on the protein profiles of their seeds (Adepoju *et al.,* 2021). There is great variation among the forty genotypes of okra fruits studied with respect to qualitative traits in Nigeria (Fig. 5) (Komolafe *et al*., 2021).

Fig. 5. Variability in okra fruits in Nigeria

In the present investigation, a total of 96 okra genotypes were undertaken for morpho-genetic diversity analyses using 13 morphological parameters and 65 SSR markers. Out of 65 SSRs, 50 primers were polymorphic and the mean polymorphic information content (PIC) value was 0.38. The polymorphic loci AVRDC OKRA 64 revealed a maximum PIC value of 0.71 and the number of alleles per locus varied from 2 to 7, with an average of 3.34 alleles per locus. The neighbour-joining (N-J) tree grouped the genotypes into three distinct clusters (I-III), of which Cluster I comprised of cultivated species, *A. esculentus* and *A. caillei*, while, Cluster II and III consisted of other related wild species. Furthermore, the population structure analysis distinguished the okra genotypes into two distinct genetic groups comprising cultivated (*A. esculentus*) and wild-type okra (Anjan Das *et al.,* 2022). A study was conducted to evaluate fourteen genotypes of okra for yield and various yield attributing traits at Rajendranagar, Hyderabad. The data were utilized to estimate the genetic variability in terms of mean, genotypic and phenotypic

coefficients of variation, heritability, expected genetic advance and expected genetic advance as per cent mean. The present investigation showed that phenotypic coefficient of variation was higher than genotypic coefficient of variation for all traits suggesting the influence of environment in their expression. The estimates of GCV, heritability and heritability coupled with genetic advance as per cent of mean were higher for number of fruits plant-1, internode length and plant height. The correlation study indicated that the yield plant-1 had high positive association with number of fruits plant-1, plant height, internode length and fruit girth at both genotypic and phenotypic levels. Among the traits studied, number of fruits plant-1 had maximum direct contribution on yield and indirect contribution via plant height, internode length and fruit girth (Rani *et al*., 2022). No research has been done to assess the genetic diversity of Okra (*Abelmoschus esculentus*) genotypes in Ethiopia based on the combination of agromorphology and biochemical traits of the crop. Such an assessment would assist in the development of high fruit yield and nutritionally good cultivars. Therefore, 36 okra genotypes were evaluated for 29 agromorphological and biochemical traits at the Melkassa Agricultural Research Center (Ethiopia). Generally, the research results indicated the presence of wide genetic variations among studied okra genotypes for fruit yield and nutritional content. There was high heritability in most of the traits of the crop. The results suggest that there is a high chance to develop high fruit yield and good nutritional varieties through selection and/or hybridization (Mohammed *et al*., 2022).

The experiment was conducted with 60 genotypes of okra crop using 20 quantitative traits. The analysis of variance found that genotypes were significant (P 0.05 and P 0.01) for all of the traits tested. The fruit yield plant-1 ranged from 176.40 to 438.40 g, with 347.42 g being the average. In all the traits studied, the phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV). The closeness of PCV and GCV values suggested that the environment had little influence on manifestation of the characters under examination. GCV (1.89-13.98) and PCV (4.06-16.61) levels were found to be moderate (10-20) and low (<10), respectively, in the study. Heritability ranged from 21.73 (days to first fruit harvest) to 97.19 (plant height) percent. At 5% selection intensity, the genetic advance (GA)% mean ranged from 1.82 (days to first fruit harvest) to 27.38 (plant height). Plant height (13.68, 13.48), internodal length (16.61, 13.98), first fruiting node (13.00, 10.89), number of fruits plant-1 (13.19, 11.91), number of marketable fruits plant-1 (13.36, 11.97) and fruit yield plant-1 (13.75, 12.29) showed high heritability and high GA% mean. Thus, the above-mentioned characteristics are additive genetic control and direct selection in okra has good potential for improvement in fruit yield (Reddy *et al.,* 2022). Twenty six genotypes of okra including indigenous and exotic lines were evaluated for fourteen yield and yield attributing traits. The analysis of variance (ANOVA) revealed significant differences for all the fourteen traits under study suggesting the existence of required genetic variation in the breeding material. Higher PCV and GCV estimates were recorded by plant height, fruit length, fruit yield per plant, shoot and fruit borer incidence on fruits, number of fruits per plant and yellow vein mosaic virus percent disease incidence. Moderate PCV and GCV was registered by fruit weight, internodal length, fruit diameter, number of nodes at first flowering, days to initiation while days to 50% flowering, number of locules per fruit and number of ridges per fruit recorded low PCV and GCV. High to very high heritability (broad sense) was observed for all the traits except number of ridges per fruit, number of locules per fruit and individual fruit weight. These three traits registered moderate heritability. High Genetic Advancement as percent of mean was recorded by some of the traits except internodal length, fruit diameter, Number of nodes at first flowering, fruit weight, days to initiation, number of ridges per fruit, number of locules per fruit and days to 50% flowering. The presence of variability in the germplasm helps in progressing the elite genotypes to utilise in breeding programme (Srivarsha *et al.,* 2022). West African okras are characterized by many morphological and physiological differences from the normal okra. West African okras have less epicalyx segments, very red leaf veins, late flowering when planted in the summer, pods mounted at right angles to the stem, and large numbers of seeds per pod. In addition, pods of the East African type tend to be short, with a relatively long sterile tip (Fig. 6) (Vidhi, 2023).

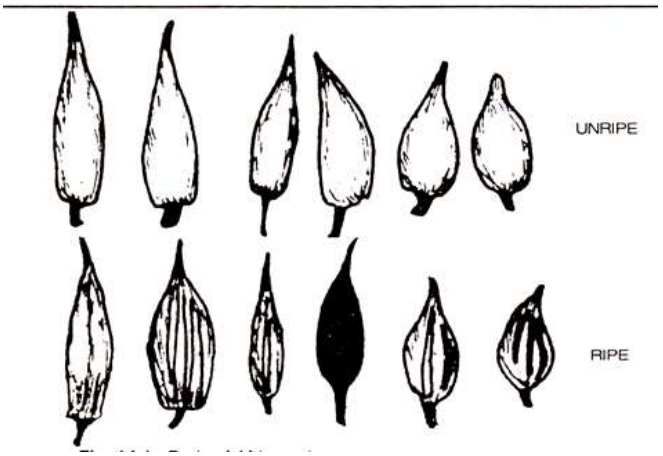

Fig. 6. Pods of African okras

BREEDING

Germplasm Conservation:

More than 2,500 accessions of cultivated and wild species are maintained both as base collection in the National Genebank at National Bureau of Plant Genetic Resouces, NBPGR, (long-term storage at - 20oC) and as active collection under medium term storage (4oC) at NBPGR Regional Station in Akola, Maharashtra. In addition, working collections are maintained at Indian Institute of Horticultural Research (IIHR), Bangalore; Marathwada Agricultural University (MAU), Parbhani; Orissa University of Agriculture & Technology (OUAT), Bhubaneswar; Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar; Punjab Agricultural University (PAU), Ludhiana; Chandra Sekhar Azad University of Agriculture & Technology (CSAUAT), Kanpur; Tamil Nadu Agricultural University (TNAU), Coimbatore; Anand Agricultural University (AAU), Anand, Gujarat; and Indian Agricultural Research Institute (IARI), New Delhi. As per recent International Plant Genetic Resources Institute (IPGRI) germplasm database, more than 46 institutions in different countries worldwide possess about 11,000 accessions of cultivated okra and wild related species. Major institutions are holding more than 100 accessions (Tripati *et al*., 2011).

Breeding Objectives

Breeder's objectives are as follows (Tripati *et al*., 2011; Mishra *et al.,* 2021; Vidhi, 2023):

- To breed early maturing and late senescing varieties.
- To evolve high yielding varieties and hybrids capable of an increased marketable yield of dark green, tender, long, smooth pods. High yield of seed would be an added advantage.
- To develop varieties resistant to virus diseases such as YVM and leafcurl; fungal diseases such as vascular wilt, Cercospora blight, powdery mildew, fruit rot and damping off; insect pests such as shoot and fruit borer, leafhopper, apdhids, whitefly etc.
- To breed varieties with optimum seed setting ability for rapid multiplication.
- To develop varieties suitable for export market. e.g. short, smooth fruit
- To evolve varieties and hybrids for wider adaptability.
- To develop multiple disease–resistant and pest resistant varieties, with special emphasis on combining yellow vein mosaic virus resistance with resistance to fruit and shoot borer.
- Dark green, tender, thin, medium long, smooth, 4-5 ridged pods at marketable stage

- Pods free from conspicuous hair, seed bulging and yellow ring at base

- Short plant with more number of nodes, short internodes
- Pods suitable for processing industry and export market
- Tolerance to abiotic stresses (low temperature, excessive rains, saline and alkaline soils)

Selfing and Crossing of Okra:

Selfing: (i) Cover unopened flower bud with half-length wheat pollination paper-bag and staple or clip the bag securely along peduncle. Put a thread-ring at the peduncle. The pod will come out piercing through the bag. The thread-ring acts as identification mark for selfed pods during harvesting. and (ii) Tie circular thread around pedicel/peduncle and put a knot around the unopened flower petals with the same piece of thread. The petals shall bulge out below the tied thread during flower opening and the stigma inside remains protected from unwanted pollen grains. The thread tied at pedicel is the identification mark for selfed-pod at harvesting (Vidhi, 2023).

Emasculation: The flowering in okra starts from below to upwards. Dehiscence usually occurs around 8-10 am, about 20 minutes after anthesis flowers remain open for the three-fourth of the day and wither in the afternoon. Stigma is receptive during anthesis, hence pollination is not very successful at bud stage. Emasculation is done in the late afternoon. A plump, big size, unopened bud is selected. Two long and opposite slits are made on the calyx with forceps. Both the halves of the sepal are pulled downwards and removed. Now, entire corolla and anthers are removed and the emasculated bud is covered with paper-bag which is secured with U clip on the pedicel (Vidhi, 2023).

Floral Biology and Pollinatin: Flowers are bisexual and often cross-pollinated. Time of anthesis is 8.00-10.00 a.m. Dehiscence of anthers occurs 15-20 minutes after anthesis and is completed in 5-10 minutes. Pollen fertility is maximum in the period between one hour before and after opening of flower. It takes 2 to 6 hours for fertilization after pollination. Stigma is receptive at opening of flower and hence, bud pollination is not effective in okra. Fruit is a capsule. Usually fibre development starts from fifth to sixth day (Eagri, 2023). Flowers just to open fully are collected. Calyx and corolla are removed and the dehiscing anthers are brushed over stigma of the buds emasculated on preceding afternoon. One male flower can be used to pollinate 3-4 female flowers. After pollination, the buds are again covered with pollination paper bag and a label having name of male parent along with date of pollination is tied at the pedicel of the pollinated flower bud (Vidhi, 2023).

Breeding Methods

Okra [*Abelmoschus esculentus* (L.) Moench.], a member of the family Malvaceae, is an important vegetable crops grown extensively in tropical to subtropical climates. Genetic improvement mainly depends on the amount of genetic variability present in the population. In any crop, the germplasm serves as a valuable source of base population and offer major source of variability (Ramya and Senthil Kumar, 2009).

Pure-line Selection: This is applicable to landraces/cultivars collected from Farmers' field, for example, Pusa Makhmali was bred from a material collected from West Bengal. Similarly, Co 1 is a single plant selection from Red Wonder (Vidhi, 2023).

Pedigree Method: This method is applicable to the segregating generations after hybridization between desirable promising donors. The individual plant selection starts in the F_2 generation and continues till F_5 or F_6. For example, Pusa Sawani was developed through this method in an inter-varietal cross. Punjab Padmini, Parbhani Kranti, P_7, Arka Anamika and Arka Abhaya are examples following interspecific hybridization (Vidhi, 2023).

Mutation Breeding: There are not significant achievements in okra through this breeding method so far. Phadvibulya *et.al.* (2009) have reported some success in developing YVMV resistant selections in Thailand based on induced mutations. These scientists irradiated seeds of two okra varieties, Annie and Okura with gamma rays at doses of 400 and 800 Gy. Screening of YVMD resistant plants was conducted for M_3 and M_4 plants under field conditions and greenhouse conditions using whitefly transmission. One M_4 plant of Okura irradiated at 400 Gy was reported to be highly resistant, but none of Annie. M_5 plants of M_4 plant showing resistance to YVMD were screened further for YVMD under both greenhouse and field conditions. Ten resistant lines obtained by screening for YVMD resistance up to the M7 generation were selected for yield trial. Three of the mutant lines were further evaluated at location where YVMD was seriously widespread. However, only a small portion of plants of mutant lines appeared to be resistant throughout the whole growth duration, others eventually, exhibited the yellow vein symptoms. Thus, the net result could not lead to commercialisation of the mutant. Therefore, mutation breeding for YVMD resistance in okra should be initiated with heavy odds against it and the breeder should be realistic in approach (Vidhi, 2023).

Heterosis Breeding: Heterosis in okra has been reported for various economic traits, viz. early and late flowering, plant height, number, weight and size of pods, number of ridges, marketable and total yield. Using hand emasculation and pollination, commercial hybrids are developed. There are promising hybrids under private sector seed companies in India. The current seed market of okra in India is approximately 4000 tons for open-pollinated cultivars and 1000 tons for hybrids (Vidhi, 2023). Hand pollination is the most commonly used method of hybrid seed production in okra and improving yield and ensuring its sustainability under adverse conditions through resistant hybrids is the major objective of heterosis breeding (Mishra *et al.,* 2021).

Inter-varietal hybrids in okra have, of late, been found useful. Some of the examples are given in Table 2 (Dhankhar and Mishra, 2005.).

Table 2. Some studies showing promising heterosis

Improved characters	F1 hybrid combinations
Early flowering, early maturity, higher fruit weight and yield	H 398 × Pusa Sawaniand H-398 × Pusa Makhamali
Higher germination, early flowering, more plant height and higher yield	Local 5 (Malaysian) × Emerald (American), Local 7 (Malay.) × Gold Coast (Amer.), Local 5 (Malay.) × Gold Coast (Amer.), Local 7 (Malay.) × Emerald (Amer.)
More fruits/plant and higher yield	Pusa Sawani × Smooth Long Green
More plant height and higher yield	American Seven Ridged × Pusa Sawani
Improved yield	New Selection × AE 91
Higher plant height, fruits/plant and fruit weight	Balady × Gold Coast

In okra, the breeding methodologies of autogamous plants is followed. This includes crossing or controlled hybridization of parents selected based on their better-combining abilities. This is followed by the pedigree selection of the segregating population for the traits of interest like biotic and abiotic stress tolerance and yield (Mishra *et al.,* 2021). Yellow vein mosaic virus disease being a serious problem in okra cultivation, concerted effort was made to develop high yielding as well as YVMV resistant varieties in the country. With development of YVMV resistant variety, Pusa Sawani, most of the primitive low yielding local cultivars has become less significant. After break down of resistance of Pusa Sawani, research on virus resistance was intensified at various research centres in India and it resulted in development of a number of YVMV resistant varieties (Eagri, 2023). Various methods like plant introduction (Perkin's Long Green), single plant selection and pure line selection from local collections (Pusa Makhmali, Salkeerthi), selection from bi-parental crosses (Pusa Sawani from IC 1542 x Pusa Makhmali) and selection from complex crosses (sel 2 from (Pusa Sawani x Best 1) x

(Pusa Sawani x IC 7194) were used (Eagri, 2023). Yellow Vein Mosaic Virus is the most important and destructive viral disease in okra that infects crops at all the stages growth. The fruits of the infected plants become pale yellow to white in color, deformed, small and tough in texture. The disease causes 50-100% loss in yield and quality if the plants get infected within 20 days after germination (Ogunbor, 2020).

Examples

- YVMV resistant variety Susthira developed at the Kerala Agricultural University is *A. caillei.*
- Pedigree selection in the segregating populations of resistant YVMV varieties resulted in Hisar Unnat (Sel 2-2 x Parbhani Kranthi) and Varsha Uphar (Lam selection 1 x Parbhani Kranthi).
- Related wild species were also utilized in development of YVMV varieties like Parbhani Kranti (*A. esculentus* cv. Pusa Sawani x *A. manihot* ssp. *manihot*),
- Punjab 7 (*A. esculentus* cv. Pusa Sawani x *A. manihot* ssp. *manihot* cv. Ghana) and
- Arka Abhay (*A. esculentus* x *A. manihot* ssp. *tetraphyllus*).
- MDU 1 and Punjab 8 (EMS 8) were developed through mutation breeding using gamma rays and EMS respectively.

Among the diverse wild gene pool of okra, it holds resistant source of gene for many biotic stresses. However, solving the problem of diseases and pests infestation in okra by traditional breeding approach is one of the value added steps for resistant variety released in the recent past. Now, the advancement in molecular and biotechnological techniques enhances the okra improvement programmes by advancing in marker assisted selection and resistant gene transfer (Table 3) (Chowdhury and Kumar, 2019).

Table 3. Disease resistance sources in okra

Major diseases	Wild species
YVMV	*A. caillei* (MR)
	A. tetraphyllus (HR)
	A.crinitus (HR)
	A. angulous (HR)
	A. pungens (HR)
	A. moschatus (MR)
	A. manihot (HR)
OELCV	*A. tetraphyllus* (R)
	A. ficulneus (HR)
	A. crinitus (HR)
	A. angulous (HR)
	A. pungens (HR)
	A. tuberculatus (R)
	A. moschatus (MR)
	A. manihot (MR)
Cercospora leaf spot	*A. caillei* (MR)
	A. crinitus (R)
	A. angulous (R)
	A. pungens (R)
	Moschatus (R)
	A. manihot (R)
Powdery mildew	*A. caillei* (MR)
	A. tetraphyllus (R)
	A. crinitus (R)
	A. angulous (MR)
	A. pungens (MR)
	A. moschatus (R)
	A. manihot (MR)

R= Resistant, HR= Highly resistant and MR= Moderately resistant.

Interspecific Hybridization

Interspecific crosses have been attempted. The sterility is attributable to various reasons such as chromosomal differences (in case of *A. tuberculatus* and *A. ficulneus*) and genomic differences leading to irregular gamete formation (in case of *A. manihot*) (Tripati *et al.,* 2011). In *Abelmoschus*, though artificial crossing method is easy and simple to use but rate of success is still an important constrain in interspecific hybridization. Studies revealed that, it is more difficult to cross cultivated species with wild species of *Abelmoschus* and to this context several attempts have been made for interspecific hybridization between ploidy level 1, 2 and 3 species by various authors (Patil *et al.,* 2015). Regarding failure of fruit and seed set in interspecific hybridization of *Abelmoschus*, various reasons such as chromosomal differences, genomic differences, pre- and post-fertilization barriers may be attributable (Patil *et al.,* 2015).

Status of Biotechnological Interventions

Shoot and fruit borer *i.e. Earias* sp. being the most destructive pest in okra crop, efforts have been made to develop insect resistant okra varieties by incorporating cry1Ac gene from *Bacillus thuringiensis*, commonly known as Bt okra. The Bt okra developed by M/s Maharashtra Hybrid Seeds Company Limited containing cry1Ac gene (Event OE-17A) is under safety evaluation and confined field trials (Tripati et al., 2011). Among viral diseases, Yellow Vein Mosaic virus being major disease of okra, attempts are being made by M/s Arya Hybrid Seeds Ltd., for incorporation of specific genes such as CP (coat protein) gene and antisense RNA gene for elevated viral resistance (Tripati *et al.,* 2011).

Varieties of Okra (Vidhi, 2023*;* IIVR, 2023; Eagri, 2023)

Important varieties of okra are described as follows.

Pusa Makhmali: It was developed by H.B. Singh and S.M. Sikka in 1955 at the then Plant Introduction Division, IARI, New Delhi, as a result of selection from the local material collected from West Bengal. It is an early variety. Pods are smooth, straight, 5-edged, attractive, light green, slender, 15-20 cm long. The yield potential is 100 q/ha.

Pusa Sawani: It was bred by H.B. Singh in 1957-58 at the then Plant Introduction Section, Division of Botany, IARI, New Delhi. It is derived from a cross of IC-1542 (field resistance to yellow vein mosaic virus) and Pusa Makhmali. Plants are 120-180 cm tall in rainy season. The pods are smooth (slightly hairy on the edges), 5-edged, dark green and 18-20 cm long. It is distinguished by the presence of a purple patch at the base of the yellow petal on both the sides (a character of the parent IC 1542), whereas in most okra varieties the patch is present only on the inner side. Initially, it was reported to be free from the YVM. But at present it has been found to be susceptible. The variety is still popular for growing in the plains of northern India in virus free period (spring summer). It has been notified by the central seed committee in 1969 for general cultivation throughout the country. Yield potential is 100 q/ha.

***Co 1*:** It was developed by the Tamil Nadu Agricultural University, Coimbatore in 1976. It is a single plant selection from a population of Red Wonder collected from Hyderabad. The plants are medium tall (90-120 cm) with 5-8 branches. Stem, shoots, petioles, midrib and basal veins of the lower surface of the lamina are prominently scarlet red. Leaves are deeply lobed (5-7 lobes). The first fruit is borne on the 5th node and each plant yields on an average 20 fruits weighing around 300 g. The pods are long, slender, 5-ridged, glossy, smooth and scarlet red, but colour disappears on cooking. It has field tolerance to YVM but susceptible to fruit borer and powdery mildew. It is suitable for rainy, winter and summer seasons in Tamil Nadu. It was notified by the central seed committee in 1978.

MDU 1: It was evolved by the Tamil Nadu Agricultural University, Coimbatore in 1978. It is an induced mutant, isolated from 'Pusa Sawani'. On an average, there are 13 nodes/plants. Stem is green with light purple pigmentation. Fruiting begins from 4-5th node. It takes 33 days to first flowering and 43 days to first picking. Fruits are light green, about 20 cm long. It has been notified by the central seed committee in 1985.

***Punjab Padmini*:** It was evolved by B.R. Sharma in 1982 at the Punjab Agricultural University, Ludhiana from a cross between Abelmoschus esculentus and A. manihot ssp. manihot.F_1 plant of a cross A. esculentus cv. 'Reshmi' X A. manihot ssp. manihot cv. Ghana was hybridized with an F_2 (OP) plant of a cross A. esculentus cv. Pusa Sawani X A. manihot ssp. manihot cv. Ghana. Continuous selection for resistance to yellow vein mosaic virus and desirable horticultural traits in the subsequent generations led to the isolation of Ludhiana Sel-1 in the F_8 generation which was later named as 'Punjab Padmini'. Plants are tall (180-200 cm). Stem, shoots, petiole and basal veins of the lower surface of the lamina are mildly scarlet red. Leaves are large, dark green, hairy, with 3-5 moderate lobes. It flowers in 45-50 days and first picking starts about 55 days after sowing. Fruiting starts from 6-8th node onwards. Pods are fast growing, dark green, shining, smooth, thin, 15-20 cm long, 5-ridged and remain tender for 3-4 days. It has field resistance to YVMV and tolerance to jassids and cotton boll worm. It is suitable for cultivation during both spring/summer and rainy seasons under north Indian conditions. Yield potential is 100-125 q/ha of green pods and 12.5 q/ha of seed. It was notified by the central seed committee in 1983 for general cultivation.

***Gujarat Bhindi-1*:** It was developed at the Gujarat Agricultural University in 1983. It is a pure line selection from an unknown bulk seed sample received from IARI, New Delhi. Plants are about 60 cm tall .in summer season and 90 cm in rainy season. There is purple tinge on stem. Leaves are broad, dark green with purple tinge on veins. Fruiting starts from 4-5th node. Fruits are 5-ridged, 14-15 cm long and 6-7 cm in girth. Green pod yield is about 70 q/ha. It has been notified by the central seed committee.

***Harbhajan*:** The original 'Perkins Long Green' or Sel-6 has been named as Harbhajan in the memory of the most dedicated Vegetable Scientist, Dr. Harbhajan Singh of IARI, New Delhi by T.A. Thomas and R. Prasad. Plants are very tall, thick and prolific bearer. Leaves are large, moderately lobed with rough surface and prominent veins. Fruits are long, tapered, bright green, spineless and mostly 8-edged. It is notified by the central variety release committee.

Selection 2: It was evolved by H.B. Singh and his colleagues in 1973-74 at IARI, New Delhi. It is a derivative of the cross (Pusa Sawani Best-1) x (Pusa Sawani x IC 7194). Plants are 110 cm tall with occasional branching tendency. Flowers have purple petal base colour. Fruits are green, long, 5-edged, tender and are available for market after 50 days of sowing. The duration of the harvest is 40-50 days. It is tolerant to YVMV. The green pod yield potential is about 100 q/ha. It was identified by the all India coordinated research project on vegetables in 1985.

***Parbhani Kranti*:** It is a YVM resistant variety evolved by N.D. Jambhale and Y.S. Nerkar of Maratha Wada Agricultural University, Parbhani in 1985 from an interspecific cross between A. esculentus cv. 'Pusa Sawani' and A. manihot, an African species carrying resistance to YVMV. BC_2 with Pusa Sawani was subjected to selfing and selection up to F_8. Plants are tall, single stemmed with dark green foliage. Leaves are deeply lobed with narrow leaflets in the top 1/3rd portion. Fruit stalk is funnel shaped. First fruit is borne on the 5-6th node. Marketable fruit size (8-9 cm) is attained 7-8 days after anthesis. The fruits are extremely dark-green, smooth, tender, slender, 5-ridged with long and narrow tip. On an average, green fruit yield is 85-90 q/ha during summer and 115 q/ha during rainy season. Seed yield of 10 q/ha from the rainy season crop and 5-6 q/ha from the summer crop is possible. It has been notified by the central seed committee in 1986 for cultivation throughout the country. Now it is susceptible to YVMV.

P 7: It is a YVM virus-resistant variety developed by M.R. Thakur and S.K. Arora in 1985 at PAU, Ludhiana from a cross between A. esculentus cv. 'Pusa Sawani' and A. manihot ssp. manihot, a species from Ghana carrying resistance to YVM. The F_1 was back-crossed to 'Pusa Sawani' four times and selection was practiced in the selfing generations up to F_8. Plants are medium tall with short internodes and grow upto 105 cm in the rainy season and 85 cm in the spring season. Stem carries splashes of pigmentation. Leaves are deeply lobed up to the base of the petiole and leaf margins are less serrated. The basal portion of the petiole is deeply pigmented. Stem, leaves and petiole are sparsely hairy. Fruits are medium long, green, tender and 5-ridged. The top of the fruit is blunt and slightly furrowed. It flowers in about 45-50 days and is ready to first picking after 54 days of sowing. The first fruit is borne on the 5-6th node. Yield potential is about 95 q/ha during rainy season and 50 q/ha during spring season. On an average, it yields 4- 8 q seed/ha.

***Arka Anamika*:** It is YVM virus resistant variety evolved in 1984 at IIHR, Bangalore. It is of interspecific origin between A. esculentus and a wild species A. manihot ssp. tetraphyllus. Plants are medium tall (about 100 cm) with short inter-nodal length and less branched. Splashes of purple pigmentation are present on the stem, petiole and lower surface of the basal leaves. Leaves are green, small and deeply lobed. Stem, petiole and leaves are sparsely hairy. Fruits are medium green, rough, 5-ridged and start after 5-6th node onwards. Yield potential is 115 q/ha of green pods. It has been identified for general cultivation by the all India coordinated vegetable improvement project in 1990.

EMS-8 (Punjab 8): It has been developed by B.R. Sharma and S.K. Arora in 1989 at PAU, Ludhiana. It is an induced mutant derived from Pusa Sawani treated with 1% EMS. The final selection was made in the M_8 generation. Plants are tall. Stem, petioles, and basal portion of the lower surface of the leaves have splashes of purple pigmentation. Fruits are medium long, thin, tender, green and 5-edged. It has field resistance to YVMV and tolerance to fruit borer. On an average, it gives 95 q/ha marketable yield of green pods.

Pusa A 4: This variety has been released by IARI in 1994 as a substitute for Pusa Sawani. The plants are dark-green with sparse pigmentation (occasional) on stem and petiole, with usually single stem having short internodes (2-4 cm). The leaves are broad and medium lobed. The fruits are 5-ridged, attractive dark-green, 12-15 cm long having excellent shelf-life. It is resistant to YVMV and tolerant to jassids and shoot and fruit borer. Green fruit yield during summer season ranges 10-12 tonnes/ ha while during kharif and late kharif it could give still higher yields. It also responds to pruning to extend the summer crop for added harvests during kharif season.

***Arka Abhay*:** The variety has been released by IIHR, Bangalore as resistant to YVMV. It is a sister line of Arka Anamika. The plants resemble Arka Anamika in appearance as well as YVMV resistance. It carries tolerance to fruit borer and may suit pruning for a ratoon crop.

Varsha Uphar (HRB 9-2): This variety has been developed by Haryana Agricultural University, Hisar from the cross, Lam Selection 1 x Parbhani Kranti following pedigree selection method. It was released in 1992 and notified in 1995 by the Central Sub-Committee on Crop Standards. It has resistance to YVMV and field tolerance to leaf hopper and suits to disease prone rainy as well as disease-free spring- summer season. Plants are medium tall (90-120 cm) with short internodes, producing 2-3 branches each. Petiole is pigmented. It takes 40 days to first flowering and 50 days to first picking. Fruit bearing starts from 4th node. Fruits are smooth, dark-green, attractive with long tapering tip and measure 18-20 cm on full maturity. Average number of seeds per fruit is 55-60. It is a prolific bearer with an average fruit yield of 10 tonnes/ha.

Hisar Unnat (HRB 55): Developed by Haryana Agricultural University, Hisar from the cross, Se.1 2-2 x Parbhani Kranti, has been released by the Central Variety Release Committee and notified in 1996. It is resistant to YVMV, early (first picking in 46-47 days) and high yielding (12-13 tonnes/ha green fruits) variety. Plants are medium tall with short internodes producing 3-4 branches each. Foliage is green, petioles occasionally pigmented. Petal base is pigmented on inner side only. Fruits are green, attractive, 5 ridged

and measure 15-16 cm in length on full maturity. It is suitable for growing during summer as well as rainy season.

Kashi Ageti*:* Early maturing variety. Plant height 58-61cm. Bears 9-10 pods per plant. Pods are 9 -10 cm long, attractive, with 8-9 numbers of seeds per pod. Average pod weight is 9-10 g. Seed to seed duration is 95-100 days however, picking starts from 60-63 days after sowing. Pod yield is 95- 105 q/ha. Shelling % is 48.5 to 50. Resistance to shattering. Tolerant to leaf minor & pod borer. Recommended for release and cultivation in the states of Uttar Pradesh, Punjab, Bihar and Jharkhand. Vide gazette notification number S.O. 2277(E), 17.08.2015.

Kashi Shristi (VROH-12) F1 Hybrid*:* Very high yield potential (18-19 t/ha), Medium tall and short internodes and narrow angled 2-3 branch. Tolerant to YVMV, dark green fruits, medium fruit length. Suitable for both summer and Kharif season. Recommended for cultivation in Uttar Pradesh, vide gazette notification number S.O. 692(E), dated 05.02.2019.

Kashi Lalima (VROR-157)**:** Redish purple fruits tolerant to YVMV and OLCV, Medium tall and short internodes with fruit yield of 14-15 t/ha. Rich in anthocynin and phenolics. Suitable for both summer and Kharif season. Recommended for cultivation in Uttar Pradesh, vide gazette notification number S.O. 692(E), dated 05.02.2019.

Kashi Chaman VRO-109*:* Plant are medium tall (120-125 cm). Flowering starts in 39-41days after sowing and fruiting period lasts from 45-100 days. Fruits dark green with fruit length of 11-14 cm. Plants are resistant to YVMV and OLECV under field conditions. Yield 150-160 q/ha. Suitable for both summer and rainy season. Notified by CVRC as a variety also in February 2019 for UP state, vide gazette notification number S.O. 692(E), dated 05.02.2019.

Kashi Vardaan *:* This variety is suitable for both summer and rainy seasons. The yield potential is around 140-150 q/ha. The variety is resistant to both YVMV and OLCV, while moderately tolerant to major pests under field conditions. Plants are medium-tall with short internodes along with 2 to 3 branches. Fruits are medium, dark-green, easily cooked, good for both table and export purposes. Recommended for cultivation in Uttar Pradesh, Bihar, Jharkhand & Punjab, vide gazette notification number S.O. 2277(E), 17.08.2015

Shitla Jyoti*:* This hybrid is suitable for warm humid climate with relatively long day length. Plants are medium tall, height 110-150 cm, flowering starts on 30-40 days after sowing at 4-5 nodes. Fruit are green, 12-14 cm long at marketable stage, yield 180-200 q/ha. This is resistant to YVMV and OLCV. This has been released and notified for the cultivation in Rajasthan, Gujarat, Haryana, and Chhattisgarh, Orissa and A.P.

Shitla Uphar*:* Plants are medium tall, height 110-130 cm, flowering starts at 38-40 days after sowing at 4-5 nodes. Fruits are green, 11-13 cm long at marketable stage and yield 150-170 q/ha. This is resistant to yellow vein mosaic virus and OLCV. It has been notified and released for the cultivation in Punjab, U.P., Bihar, M.P.

Kashi Satdhari*:* Plant height is 130-150 cm with 2-3 effective branches, flowering at 42 days after sowing at 3rd to 4th nodes. A plant bears 18-25 fruits with seven ridges, length 13-15 cm at marketable stage and yield 110-140 q/ha,resistant to YVMV under field conditions. This has been notified during the XII meeting of Central Sub Committee on Crop Standard Notification and Release of Varieties for Horticultural Crops for the cultivation in U.P., and Jharkhand.

Kashi Vibhuti*:* his is a variety with dwarf growth habit, plant height 60-70 cm during rainy and 45-50 cm during summer seasons. It bears 2-3 branches with short inter-nodal length. Flowering starts on 4th to 5th nodes after 38-40 days after sowing. A plant bears 18-22 fruits with 8-10 cm length at marketable stages; yield 170-180 q/ha. This is resistant to YVMV and OLCV.

Kashi Mangali*:* This variety has been developed through pure line selection. Plants are tall, height 120-125 cm, flowers at 4 to 5 node after 40-42 days after sowing, fruits five ridges, light green; yield 130 -150 q/ha. This is resistant to YVMV and OLCV under field conditions and stands high temperature during summer season. This has been identified for the cultivation and release through AICRP for the cultivation in Punjab, U.P. Jharkhand and Chhattisgarh, Orissa and A.P.

Kashi Mohini*:* Plants are tall, height 110-140 cm, flowers at 4-5 node during summer and 5-7 nodes during rainy season after 39-41 days of sowing, fruits five ridges, 11.3-12.6 cm long at marketable stage, suitable for summer and rainy season cultivation; gives yield of 130 - 150 q/ha. It tolerate high temperature during summer season and resistant to YVMV under field conditions. This has been identified for the cultivation and release through AICRP for all the okra growing regions of the country.

Hybrid- Kashi Bhairav*:* Plants of this hybrid are medium tall with 2-3 branches; fruits are dark green with 10-12 cm length at marketable stage; yield 200-220 q/ha. This is resistant to YVMV and OLCV under field conditions. This has been released and notified during the XII meeting of Central Sub Committee on Crop Standard Notification and Release of Varieties for Horticultural Crops for the cultivation in the entire okra growing region of the country.

The prominent hybrids in Indian (Vidhi, 2023)
Mabyco: MH10, MH64; Nunhems: Sonal ; Syngenta: Syn 16, 152 ; Bio-seeds: Avantika; Krishdhan Seeds: Hyb 215 and 577 ; KVS 215 and KVS 577. These hybrids have high yield potential and high level of tolerance to yellow vein mosaic virus. The hybrids to survive in the market should be highly tolerant to YVMV along with other desirable features, like shiny green or dark green pods, shorter internodes, pods without seed bulging and free from yellow ring at the base. Pods should be smooth and easy to harvest. Hybrid okra market is going to be very competitive.

USES
Okra is cultivated for its green non-fibrous fruits or pods containing round seeds. The fruits are harvested when immature and eaten as a vegetable. Okra fruit can be cooked in a variety of ways.The roots and stems of okra are used for clarification of sugarcane juice from which gur or brown sugar is prepared (Chauhan, 1972). Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries. Mature fruits and stems containing crude fibre are used in the paper industry. Extracts from the seeds of the okra is an alternative source for edible oil. The greenish yellow edible oil has a pleasant taste and odour, and is high in unsaturated fats such as oleic acid and linoleic acid. The oil content of the seed is quite high at about 40%. In Iran, Egypt, Lebanon, Israel, Jordan, Iraq, Greece, Turkey and other parts of the eastern Mediterranean, okra is widely used in a thick stew made with vegetables and meat. In Indian cooking, it is sautéed or added to gravy-based preparations and is very popular in South India. It became a popular vegetable in Japanese cuisine towards the end of the 20th century, served with soy sauce and katsuobushi or as tempura. It is used as a thickening agent in Charleston gumbo. Breaded, deep fried okra is served in the southern United States. The immature pods may also be pickled. Okra leaves may be cooked in a similar manner as the greens of beets or dandelions. The leaves are also eaten raw in salads. Okra leaves may be cooked in a similar way to the greens of beets or dandelions. Since the entire plant is edible, the leaves are also eaten raw in salads. Okra seeds may be roasted and ground to form a caffeine-free substitute for coffee (Singh *et al*., 2014).

Okra is cultivated for its fibrous fruits or pods containing round, white seeds. The fruits are harvested when immature and eaten as a vegetable. The young fruits produced by this species are used as a vegetable. They are picked when still immature (3-6 cm long), before the differentiation of fibers and before the seeds are fully developed. After cooking, these young fruits have a mucous consistency; the water in which they are boiled becomes thick and ropy. They are

consumed alone or in salad, after cooking in salty water, and are used in the preparation of certain African sauces. For year-round consumption, the fruits are conserved either in the form of slices dried naturally in the sun (Africa and India) or frozen or sterilized (USA) (Rao *et al*., 2019). The leaves are also eaten as spinach by Africans. The fibers extracted from the stems are sometimes used, as on the banks of the Niger in Mali, to make strings and nets (Chevalier, 1940). The roots and stems of okra are used for cleaning the cane juice from which gur or brown sugar is prepared (Chauhan, 1972). Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries. Mature fruits and stems containing crude fiber are used in the paper industry. Extracts from the seeds of the okra is viewed as alternative source for edible oil. The greenish yellow edible oil has a pleasant taste and odour, and is Okra- an important vegetable crop of India high in unsaturated fats such as oleic acid and linoleic acid. The oil content of the seed is quite high at about 40% (Rao *et a*l., 2019).

Consumption of young immature okra pods is important as fresh fruits, and it can be consumed in different forms. Okra fruit is principally consumed fresh or cooked (Ogunbor , 2020). In Iran, Egypt, Lebanon, Israel, Jordan, Iraq, Greece, Turkey and other parts of the eastern Mediterranean, okra is widely used in a thick stew made with vegetables and meat. In Indian cooking, it is sautéedor added to gravy-based preparations and is very popular in South India. It became a popular vegetable in Japanese cuisine towards the end of the 20th century, served with soy sauce and katsuobushi or as tempura. It is used as a thickening agent in Charleston gumbo. Breaded, deep fried okra is served in the southern United States. The immature pods may also be pickled. Okra leaves may be cooked in a similar manner as the greens of beets or dandelions. The leaves are also eaten raw in salads. Okra leaves may be cooked in a similar way to the greens of beets or dandelions. Since the entire plant is edible, the leaves are also eaten raw in salads. Okra seeds may be roasted and ground to form a caffeine-free substitute for coffee. When importation of coffee was disrupted by the American Civil War in 1861, the Austin State Gazette said "An acre of okra will produce seed enough to furnish a plantation of fifty negroes with coffee in every way equal to that imported from Rio (Ogunbor, 2020).

It's medicinal value has also been reported in curing ulcers and relief from hemorrhoids. Unspecified parts of the plant were reported in 1898 to possess diuretic properties this is referenced in numerous sources associated with herbal and traditional medicine. Okra has found medical application as a plasma replacement or blood volume expander. It is also good source of iodine which is useful in the treatment of simple goiter and source of other medically useful compound. It is very useful genitourinary disorders, spermatorrhoea and chronic dysentery. Tests conducted in China suggest that an alcohol extract of okra leaves can eliminate oxygen free radicals, alleviate renal tubular-interstitial diseases, reduce protein urea, and improve renal function. Unspecified parts of the plant were reported in 1898 to possess diuretic properties this is referenced in numerous sources associated with herbal and traditional medicine. Some studies are being developed targeting okra extract as remedy to manage diabetes.Okra (*Abelmoschus esculentus* (L.) Moench) is a medicinal plant of immense importance with large pharmacological applications. Besides having the above mentioned nutritional and medical, industrial properties, it has been used as an ingredient of many herbal formulations, which are used for the cure of various ailments, in particular the regulation of blood pressure, fat, diabetes, chronic dysentery genito-urinary disorders, simple goiter and ulcer (Ogunbor, 2020).

As a vegetable, okra may be prepared like asparagus, sauteed, or pickled, and it is also an ingredient in various stews and in the gumbos of the southern United States; the large amount of mucilage (gelatinous substance) it contains makes it useful as a thickener for broths and soups. In some countries the seeds are used as a substitute for coffee. The leaves and immature fruit long have been popular in the East for use in poultices to relieve pain (Ogunbor, 2020). Okra can be boiled, fried, steamed, grilled, battered or eaten raw. The fruits of the okra plant are preserved by pickling or drying and grinding into powder. They're used to make things like soups, sauces and salads. The principal use of okra is in soups like gumbos and various culinary preparations in which meats form an important factor. Okra is also sometimes cooked similarly to the way green peas are cooked — the very young and tender pods are often boiled and served as a salad with French dressing. For those growing up in the Southern U.S., okra is a staple and most often served fried with a generous cornmeal coating. However, there are lots of other healthy ways to add it to your diet (Axe, 2021).

The crop is cultivated for its young tender fruits, used in curry and soups after cooking (Eagri, 2023). Several species are edible, with both the young seed pods and the young leaves being eaten as a vegetable. The most important commercially-grown species is okra. *Abelmoschus manihot* (aibika) furnishes cordage like jute, and *Abelmoschus moschatus* (abelmosk) is grown for musk seeds (musk ambrette, a musk substitute, which can cause phytophotodermatitis (Wikipedia, 2023). The pods of the plant are mucilaginous, resulting in the characteristic "goo" or slime when the seed pods are cooked; the mucilage contains soluble fiber. One possible way to de-slime okra is to cook it with an acidic food, such as tomatoes, to minimize the mucilage. Pods are cooked, pickled, eaten raw, or included in salads. Okra may be used in developing countries to mitigate malnutrition and alleviate food insecurity. Okra is one of three thickeners that may be used in gumbo soup from Louisiana. In Cuba and Puerto Rico, the vegetable is referred to as *quimbombó*, and is used in dishes such as *quimbombó guisado* (stewed okra), a dish very similar to gumbo. It is also used in traditional dishes in the Dominican Republic, where it is called *molondrón*. In the Brazilian state of Bahia, okra is known as *quiabo* and is used to prepare *caruru*, a dish of cultural and religious importance - in addition to being a symbol of Afro-Brazilian cuisine. In South Asia, the pods are used in many spicy vegetable preparations as well as cooked with beef, mutton, lamb and chicken (WIKI, 2023a). Bast fibre from the stem of the plant has industrial uses such as the reinforcement of polymer composites. The mucilage produced by the okra plant can be used for the removal of turbidity from wastewater by virtue of its flocculant properties. Having composition similar to a thick polysaccharide film, okra mucilage is under development as a biodegradable food packaging (WIKI, 2023a).

NUTRITIONAL VALUE

Okra provides an important source of vitamins, calcium, potassium and other mineral matters which are often lacking in the diet in developing countries. The composition of edible portion of okra is given in Table 4 (Gopalan *et al*., 2007).

Table 4. Composition per 100 g of edible portion of okra

Calories	35.0	Calcium (mg)	66.0
Moisture (g)	89.6	Iron (mg)	0.35
Carbohydrates (g)	6.4	Potassium (mg)	103.0
Protein (g)	1.9	Magnesium (mg)	53.0
Fat (g)	0.2	Copper (mg)	0.19
Fibre (g)	1.2	Riboflavin (mg)	0.01
Minerals (g)	0.7	Thiamine (mg)	0.07
Phosphorus (mg)	56.0	Nictonic acid (mg)	0.06
Sodium (mg)	6.9	Vitamin C (mg)	13.10
Sulphur (mg)	30.0	Oxalic acid (mg)	8.0

The composition of okra pods per 100 g edible portion is water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 µg, riboflavin 0.08mg, thiamin 0.04 mg, niacin 0.60 mg, ascorbic acid 47.00 mg. Protein, carbohydrate and vitamin C contains of okra (Singh et al., 2014). Okra is a popular health food due to its high fiber, vitamin C, and folate content. Okra is also known for being high in antioxidants. Okra is also a good source of calcium and potassium (Ravindrakumar and Shanthakumar, 2019). Okra raw nutrition value per 100g is given in Table 5 (Ravindrakumar and Shanthakumar, 2019). The composition of okra pods per 100 g

edible portion is water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 µg, riboflavin 0.08mg, thiamin 0.04mg, niacin 0.60 mg, ascorbic acid 47.00 mg. Protein, carbohydrate and vitamin C contains of okra and plays a vital role in human diet (Ogunbor, 2020).

Table 5. Okra Raw Nutrition Value per 100g 33kcal

Carbohydrates 7.45 G (140 Kj)	
Sugars 1.48	G -Dietary Fibers 3.2 G
Fat 0.19g	Protein 2g
Water 90.19g	Vitamin A 36µg (7%)
Thiamine (B1) 0.2 Mg (17%)	Riboflavin (B2) 0.06mg (5%)
Niacin (B3) 1mg (7%0	Vitamin C 23mg (28%)
Vitamin E 0.27 Mg (2%)	Vitamin K 31.3 Mg (30%)
Calcium 82mg (8%)	Iron 0.62 Mg (5%)
Magnesium 57 Mg (16%)	Potassium 299mg (6%)
Zinc 0.58 Mg (6%)	

It is a major source of vitamins A, B, C, minerals, Iron and Iodine and important vegetable source of viscous fiber but it is reportedly low in sodium saturated fat and cholesterol. Presence of Fe, Zn, Mn and Ni also has been reported. Okra provides an important source of vitamins, calcium, potassium and other mineral matter which are often lacking in the diet in developing countries. Seven days old fresh okra pods have the highest concentration of nutrients. (Ogunbor, 2020). The composition of okra leaves per 100 g edible portion is: water 81.50 g, energy 235.00 kJ (56.00kcal), protein 4.40 g, fat 0.60 g, carbohydrate 11.30 g, fibre 2.10 g, Ca 532.00 mg, P 70.00 mg, Fe 0.70 mg, ascorbic acid 59.00 mg, β- carotene 385.00 µg, thiamin 0.25 mg, riboflavin 2.80 mg, niacin 0.20 mg. Carbohydrates are mainly present in the form of mucilage. The leaf buds and flowers are also edible (Ogunbor, 2020). Okra seeds contain about 20% proteins and 20% oil. Okra seed oil has potential hypo-cholesterolemic effect. The potential for wide cultivation of okra for edible oil as well as for cake is very high. Okra seed flour could also be used to fortify cereal flour. . Its ripe seeds are roasted, ground and used as a substitute for coffee in some countries. Maturefruits and stems containing crude fibre are used in the paper industry. (Ogunbor, 2020). Greenish-yellow edible okra oil is pressed from okra seeds; it has a pleasant taste and odor, and is high in unsaturated fats such as oleic acid and linoleic acid. The oil content of some varieties of the seed can be quite high, about 40%. Oil yields from okra crops are also high. A 2009 study found okra oil suitable for use as a biofuel. The roots and stems of okra are used for clarification of sugarcane juice from which gur or brown sugar is prepared (Ogunbor, 2020).

While it might not be as nutrient-dense as veggies such as spinach and kale, it's packed with some valuable nutrients. It's a high-fiber food, for starters: Nearly half of its nutrition is a soluble fiber in the form of gums and pectins. Nearly 10 percent of the recommended levels of vitamin B6 and folic acid are also present in a half cup of cooked okra. Known as a high-antioxidant food, it can fight free radical damage and support improvements in cardiovascular and coronary heart disease, type 2 diabetes, digestive diseases, and even some cancers. Additionally, it's abundant in several other vitamins and minerals, including thiamine, riboflavin/vitamin B2 and zinc (Axe, 2021).

A half cup (about 80 g) of cooked okra nutrition contains approximately (Axe, 2021): 17.6 calories, 3.9 grams carbohydrates, 1.5 grams protein, 0.2 grams fat, 2 grams fiber, 32 micrograms vitamin K (40 percent DV), 13 milligrams vitamin C (22 percent DV), 0.2 milligrams manganese (12 percent DV), 26.8 micrograms folate (9 percent DV), 0.1 milligrams thiamine (7 percent DV), 0.1 milligrams vitamin B6 (7 percent DV), 28.8 milligrams magnesium (7 percent DV), 61.6 milligrams calcium (6 percent DV), 225 international units vitamin A (5 percent DV). In addition, okra nutrition contains some vitamin E, riboflavin, niacin, pantothenic acid, choline, iron, phosphorus, potassium, zinc and copper. It is a good source of vitamins A and B, protein and minerals. It is also an excellent source of iodine and is useful for the treatment of goiter. (Eagri, 2023). Raw okra contains 90% water, 2% protein, 7% carbohydrates and negligible fat. In a 100 gram reference amount, raw okra is a rich source (20% or more of the Daily Value, DV) of dietary fiber, vitamin C, and vitamin K, with moderate contents of thiamin, folate and magnesium (Table 6) (WIKI, 2023).

Table 6. Nutritional value of raw okra fruits

Okra, raw	
Nutritional value per 100 g (3.5 oz)	
Energy	138 kJ (33 kcal)
Carbohydrates	7.46 g
Sugars	1.48 g
Dietary fibre	3.3 g
Fat	0.19 g
Protein	1.9 g
Vitamins	Quantity %DV†
Vitamin A equiv.	5% 36 µg
Thiamine (B1)	17% 0.2 mg
Riboflavin (B2)	5% 0.06 mg
Niacin (B3)	7% 1 mg
Folate (B9)	15% 60 µg
Vitamin C	28% 23 mg
Vitamin E	2% 0.27 mg
Vitamin K	30% 31.3 µg
Minerals	Quantity %DV†
Calcium	8% 82 mg
Iron	5% 0.62 mg
Magnesium	16% 57 mg
Phosphorus	9% 61 mg
Potassium	6% 299 mg
Zinc	6% 0.58 mg
Other constituents	Quantity
Water	89.6 g

Link to Full USDA Database entry
Units
µg = micrograms • mg = milligrams
IU = International units
†Percentages are roughly approximated using US recommendations for adults.

HEALTH BENEFITS

Okra is said to be very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Nadkarni, 1927). Its medicinal value has also been reported in curing ulcers and relief from hemorrhoids (Adams, 1975).

Health Benefits of Okra as describd by Abdullah (2015) are as follows:

It keeps you feeling full: Okra's dietary fiber helps you feel full for longer, which will keep you from snacking on those stray potato chips after dinner.

It's great for your digestion: The fiber is the main factor here again. High fiber content is great for the digestive tract and keeps you going more regularly. This not only helps keep your weight down, but makes you healthier over all.

It's a low calorie food: It's always nice when a food can satisfy your hunger and help you stay trim. The low caloric count of okra means you can definitely scoop another spoonful onto your dish and still see the numbers go down on the scale.

It's a diuretic: That means it helps the body detoxify itself and helps you shed excess water weight. A great weapon in your arsenal for de-bloating!

It helps control cholesterol levels: The pectin in okra lowers LDL or bad cholesterol, which improves cardiac function.

It's cancer fighting: Packed with antioxidants, okra can provide much-needed support to cells in fighting off free-radicals that can lead to cancer.

It boosts the immune system: The healthy fiber in okra feeds much-needed good bacteria in our intestines, which builds our immunity against viruses and infection.

It supports fertility and healthy pregnancy: The high amount of folates in okra are especially important in a pre-conception diet as it "decreases the incidence of neural tube defects in offspring". Likewise, eating more folates during the pregnancy helps support a healthy mom and baby.

It stabilizes blood sugar levels: Okra's fiber content is also responsible for slowing down the rate of sugar absorption in the digestive tract.

It helps prevent diabetes: Research has shown that in addition to its stabilizing effects on blood sugar, okra actually reduces blood sugar levels and could be an option for diabetes prevention.

It helps prevent kidney disease: Studies have shown that eating more okra results in the reduction of kidney damage over time.

It may help reduce asthma symptoms: Okra's powerful dose of vitamin C has been linked to easing respiratory issues like asthma.

It can give you shiny, bouncy hair: Okra boiled, cooled, and mixed with lemon juice can be applied to your hair for a nice bouncy finish. Neat, huh?

It's good for your brain: Okra is believed to be a top brain food and is eaten frequently in the Middle and Far East by students who need a mental boost.

It's anti-inflammatory: That means it's good for joints, as well as treating lung inflammation, sore throat, and irritable bowel syndrome.

It's good for eye health: Okra's nutrients like vitamins C and A have been linked to a reduction in the risk of cataracts and macular degeneration.

It supports strong bones: Thanks to its vitamin K and folates, okra has been credited with preventing bone loss and fending off osteoporosis.

It's great for your skin: The high vitamin C content helps the growth and rejuvenation of skin cells and collagen, which keeps skin looking smoother, younger and healthier

It's a great source of vegetable protein: With 2 g of protein per cup, okra is an easily-digestible, vegetarian source of filling, fibrous protein.

It supports ulcer healing: Okra coats the digestive tract when consumed and helps speed the healing of peptic ulcers.

Benefits of Okra as described by CJ (2017) are as follows

Packs A Truckload Of Nutrients: Okra pods are loaded with significant amounts of vital nutrients – protein, fiber, calcium, iron, and zinc. It, thus, qualifies as an effective economical tool capable of treating malnutrition around the world.

Helps Control Hunger: Okra is loaded with soluble fibers. Soluble fiber makes you feel full faster and for longer. This can help keep your calorie intake in check, helping you with your weight loss goals. With a longer-lasting feeling of satiety, your need to binge will be curbed immensely.

Keeps You From Getting Tired: It is unfortunate how common the word "fatigue" has become in today's world. What used to be mostly age and sickness-related, is now an everyday struggle for young, healthy individuals. Okra seeds can delay fatiguing. They contain antioxidant polyphenols and flavonoids that promote glycogen storage in the liver. Glycogen is a body fuel reserve, and more of it means you will take longer to tire. This is why okra is also good for individuals suffering from depression. You will be able to fight the feeling of being inexplicably tired.

Manages Diabetes Mellitus: Turkish people have long been consuming an infusion of roasted okra seeds to manage diabetes mellitus. Okra's peel and seed can lower blood glucose levels, making them useful in managing diabetes mellitus. They do so by inhibiting carb-breaking enzymes, increasing sensitivity to insulin, and ensuring there are sufficient insulin-producing cells in the pancreas. More insulin and less breakdown of carbs to glucose means lower blood sugar. One study proved that okra seeds prevent the intestinal breakdown of carbohydrates to glucose by inhibiting the enzyme alpha-glucosidase.

Stabilizes Cholesterol Levels: The more finely ground okra powder is, the better it can adsorb cholesterol.Okra promotes cholesterol degradation and inhibits the production of fat in the body. It, thus, decreases total cholesterol and triglyceride and enhances excretion of bile acids (made from cholesterol) in the feces. By regulating cholesterol levels in the blood, okra can prevent clogging of arteries – protecting us from heart diseases like atherosclerosis.

Fortifies Bones And Prevents Excessive Bleeding: The most abundant vitamin in okra is vitamin K. This vitamin helps strengthen bones and promotes clotting of blood. Okra, thus, helps prevent osteoporosis, fractures, and excessive bleeding (due to injury or bleeding disorders).

Boosts Immunity And Improves Eyesight: Okra contains moderate levels of vitamin A. Vitamin A encourages the production of white blood cells, key players in your immune system. While infections and diseases do their rounds in the general population, okra will equip your body well enough to resist. Vitamin A also supports eyes health. If you have weak eyesight or if you come from a family with a history of weak eyesight, it makes sense for you to consume okra regularly.

Prevents Gastritis: In Asian medicine, the fruit of the okra plant is used as a mucilaginous food additive to treat gastric irritations. H. pylori bacteria infect the stomach lining and cause inflammation called gastritis. Okra juice contains anti-adhesive compounds that bind to the surface of free-floating bacteria in the gut. This unanticipated binding blocks sites on the bacteria responsible for docking to the stomach lining. In effect, okra juice prevents H. Pylori infections and gastritis. A concern that arises is whether okra's non-specific binding to bacteria can deter normal gut bacteria. Further studies are required to assess whether okra's benefits outweigh its potential side effects. Having said that, we can take refuge in the fact that okra is eaten widely in Asia and Africa for centuries now with no adverse effects on the digestive system. Children between 2 to 5 are more vulnerable to H. Pylori infections, so it makes sense to ensure they eat okra regularly.

Prevents Liver Disease: Your liver is your body's prime detox organ. Okra can help ensure it is protected from disease. In one study, chemically-induced liver disease in rats was efficiently counteracted by okra. Oral pre-administration of okra extracts reduced the effects of damaging free radicals that cause liver disease. Okra may have done so by stabilizing liver cell membranes, making them more defensive against intruding free radicals.

Staves Off Neurodegenerative Disorders: Okra may help reduce the risks of Alzheimer's in individuals who are genetically predisposed to it. It may also help prevent other neurodegenerative diseases related to oxidative stress. Imagining how difficult it can be to live with a nerve disorder, this benefit of okra is of great preventive value.

Kills Breast Cancer Cells: In one study, a lectin isolated from okra was capable of instigating cell suicide in breast cancer cells. The growth of breast tumor cells was inhibited by a significant 63%.

Breast cancer affects 1 in 8 women during their lifetime. Incorporating okra in your diet may help reduce this statistic drastically.

Keeps Asthma Symptoms In Check: Okra seems to be beneficial for asthma patients. How exactly it does so is not yet known. Some postulate that okra's high vitamin C content is responsible for its respiratory benefits, however, no clear correlation between vitamin C and asthma exists.

Benefits of Okra as described by Axe (2021) are as follows:

Good Source of Calcium and Magnesium: Okra provides ample calcium and magnesium, helping prevent both calcium deficiency and magnesium deficiency. In addition to healthy bones, calcium is needed to regulate heart rhythms, blood pressure and cholesterol levels. It also helps with muscle function and nerve-signaling functions. For those who suffer from the symptoms of lactose intolerance or are vegans or vegetarians, calcium provided by vegetables can help make up for a lack of dairy.

Supports Heart Health and Normal Cholesterol Levels*:* The soluble fiber within okra helps naturally reduce cholesterol and, therefore, can help decrease the chance of developing issues such as cardiovascular disease, according to **the** Journal of Food Processing & Technology. Specifically, it's loaded with pectin fiber, which can help reduce high blood cholesterol simply by modifying the creation of bile within the intestines. A scientific review published in 2018 in the International Journal of Nutrition and Food Sciences points out that nearly half of the contents of okra pods are soluble fiber in the form of gums and pectins. In addition, the mucilage of okra binds excess cholesterol and toxins found in the bile acids, making it easier for the liver to eliminate them. The mucilage also has other medicinal applications when used as a plasma replacement or blood volume expander.

Promotes Healthy Eyesight Thanks to Antioxidants*:* Okra pods are a fantastic source of vitamin A and beta-carotene, as well vitamin C, which are important nourishment for sustaining healthy eyesight (along with healthy skin). Additionally, this nourishment may help inhibit eye-associated illnesses, such as macular degeneration.

Good Source of Protein*:* Okra nutrition benefits are so plentiful that it's been called the "perfect villager's vegetable" due to its dietary fiber and distinct seed protein balance of both lysine and tryptophan amino acids. The amino acid composition of this veggie's seeds is actually comparable to that of soybeans, which are a popular plant-based protein source. The seeds provide essential amino acids that you must get from your diet, since your body cannot make them on its own.

Helps Stabilize Blood Sugar*:* Okra helps stabilize blood sugar by regulating the rate at which sugar is absorbed from the intestinal tract. The seeds contain blood glucose normalization qualities and lipid profiles that may help naturally prevent diabetes. In a 2011 study published in the Journal of Pharmacy & BioAllied Sciences, researchers in India found that when rats were fed dried and ground okra peels and seeds, they experienced a reduction in their blood glucose levels, while others showed a gradual decrease in blood glucose following regular feeding of okra extract for about 10 days. In addition to scientific research, many diabetics have reported lowered blood sugar levels after soaking cut-up okra pieces in water overnight and then drinking the juice in the morning. In fact, in countries like Turkey, roasted seeds have been used for generations as a traditional diabetes medicine.

High in Fiber and Supports Gut Health/Digestion: Okra contains insoluble fiber, which helps keep the intestinal tract healthy by decreasing the risk of some forms of cancer, especially colorectal cancer. It also has liver detoxification, antibacterial and chemo-preventive activities that support normal digestion and gut health. One study found that consumption of okra could enhance communication of microbiota-gut-brain axis via regulation of inflammation responses. According to some experts, this veggie can help protect intestinal barrier function and lubricate the intestines. It's capable of adding bulk to stools, and therefore, it helps prevent constipation and works as a natural laxative. Unlike harsh laxatives that can irritate the intestinal tract, the mucilage is soothing and helps encourage easier elimination.

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