

## Review

# Origin, distribution and systematics of culinary cucumber (*Cucumis melo* subsp. *agrestis* var. *conomon*)

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## ABSTRACT

The non-dessert or culinary forms of *C. melo* are a distinct group distributed and adapted well essentially under humid tropics of Southern India. Culinary cucumber or vegetable cucumber (*Cucumis melo* subsp. *agrestis* var. *conomon*) belongs to the family Cucurbitaceae, genus *Cucumis*, species *melo*, subspecies *agrestis* and variety *conomon*. In English, it is popularly called as Mangaluru cucumber, Oriental pickling melon, Japanese pickling melon, golden melon, culinary melon, Indian yellow cucumber, yellow cucumber, lemon cucumber, and so on. Although much of the information about culinary cucumber calls them cucumbers they are not cucumbers! They are actually a part of the so called “*conomon*” group of melons (*Cucumis melo*). Traditionally the *conomon* melons have been used in the Far East for pickling. Culinary cucumbers have a special feature that the fruits can be stored up to 8-10 months without losing their freshness. They can be stored for many weeks by hanging them from the ceiling, firmly bound by thin coconut fibre ropes. This ethnic vegetable is used for preparation of various culinary items. Even seeds are used for preparation of juice against dyspepsia. In this review article, the aspects about the family to which culinary cucumber belongs, genus *Cucumis*, origin and distribution of the genus *Cucumis*, domestication of melons (*Cucumis melo*), intraspecific classification of *Cucumis melo*, genetic diversity in melons, crossability among *Cucumis* species, and among *Cucumis melo* subspecies, origin and distribution of culinary cucumber, uses, nutritional value, medicinal properties, evaluation of germplasm, high yielding varieties, cultivation aspects, have been discussed. Understanding the evolutionary history and domestication process, increases the possibility for better exploiting the genetic diversity for cultivar development. Its storage trait can be transferred to muskmelon by adopting a suitable breeding method. The local landraces or varieties which are highly tolerant to high temperature, drought, pests and diseases in summer, can also be employed as a useful breeding material.

**Key words:** Crossability, culinary melon, domestication, genetic diversity, pickling melon, intraspecific classification.

## INTRODUCTION

Culinary cucumber or nondessert cucumber (*Cucumis melo* subsp. *agrestis* var. *conomon*) belongs to the family Cucurbitaceae. In English, it is popularly called as Mangaluru cucumber, Oriental

pickling melon, Japanese pickling melon, golden melon, Indian yellow cucumber, yellow cucumber, lemon cucumber. In South Indian states of Karnataka, Kerala, Tamil Nadu, Telangana and Andhra Pradesh, it is

Known by a variety of local names such as Mangaluru cucumber, Mangaluru southkayi, sambar cucumber, sambar southe, thouthe, mage-kaayi, moge-kaayi, mogem, dosakaya, budamekaya, bollari, Malabar cucumber, Madras cucumber, kani vellari, vellarikka and so on (Munshi and Alvarez, 2005; Eflora, 2007; Shruti Prakash et al., 2016; Suzanne, 2016).

It is an all time favorite vegetable crop grown in Malnad and coastal Karnataka especially Mangalore,

Udupi, Uttara Kannada, Chikkamagaluru, Shivamogga, Hassan and Coorg districts; Kerala, Tamil Nadu, Telangana, and Andhra Pradesh. Although much of the information about vegetable cucumber calls them cucumbers they are not cucumbers! They are actually a part of the so called “*conomon*” group of melons (*Cucumis melo*). Traditionally the *conomon* melons have been used in the Far East for pickling. The fruit of culinary cucumber looks like a cucumber and feels and tastes just like a gourd when cooked. It is a common and popular vegetable found in almost every home in Southern India (Suzanne, 2016). The fruit grows up to 25cm x 20 cm in size, and will be sweet (rather not bitter) always. The pulp texture has a range of variation. This is a common vegetable in the backyard garden (Eflora, 2007). This vegetable is not quite easily available in the Northern parts of India. Now we can see it on the shelves of the supermarkets, Malls, Vegetable shops in cities like Bengaluru, Mysore and Chennai. It is also popularly known as the *dosakaya* in Telugu and it is a popular vegetable in Andhra Pradesh. *Dosakaya* or yellow cucumber is a small, round or oval shaped, light green to bright yellow colored vegetable, with a crisp crunchy skin and a mild sweetish and tart taste (a pleasant sour taste). Few people from Andhra region also call it as *budamkaya* (Vahrehvah. 2017). It is commonly cooked as curry, added in *sambar* or soup, *daal* and also in making *dosa-aavakaaya* (Indian pickle) and chutney; it is also grown and available through farms in Central California (WIKI, 2017). It is popularly called as ‘*Vellari*’ or ‘*kanivellari*’ in Malayalam and it is the common vegetable in Kerala, and the golden yellow fruits are normally used (Agri. Correspondent, 2001).

This crop has a special feature that the fruits can be stored up to 8-10 months without losing their freshness. Fruits can be stored for many weeks by hanging them from the ceiling, firmly bound by thin coconut fibre ropes (Vidya, 2012). The fruits which contain moderate amount of vitamins and minerals are used in the preparations of an array of traditional vegetarian dishes like *dosa*, chutney, curry, *sambar* and pickles and so on. The fruits possess cooling properties and are used as a skin moisturizer and as a digestive agent. Even seeds are used for preparation of juice against dyspepsia (indigestion). They are as easy to grow as any other melons and are very productive (Mukunda Lakshmi *et al.*, 2017). It is used to make tangy (a sharp taste or smell) curries and is

also simply stir-fried, sometimes with a coconut and raw mango paste, to make a palya or vegetable side dish (Vidya, 2012).

The objective of this review article is to discuss the about the family to which culinary cucumber or Mangaluru cucumber belongs, the genus *Cucumis*, origin and distribution of melons (*Cucumis melo*), domestication of melons, intraspecific classification of melons, genetic diversity in melons, crossability among *Cucumis* species, and among *Cucumis melo* subspecies; origin and distribution of culinary cucumber, uses, nutritional value, medicinal properties, evaluation of germplasm, high yielding varieties, and cultivation aspects. Understanding the evolutionary history and domestication process, increases the possibility for better exploiting the genetic diversity for cultivar development. The discussion of the breeding history indicates how artificial selection could speed up changes in fruit characteristics to attend specific uses and increase adaptation to a variety of environmental conditions.

## GENUS CUCUMIS

Culinary cucumber or nondessert cucumber (*Cucumis melo* subsp. *agrestis* var. *conomon*) belongs to the family Cucurbitaceae and the genus *Cucumis*. The family Cucurbitaceae is represented by some 118 genera and 825 species (Jeffrey, 1980). The family includes pumpkins, squashes, gourds, watermelon, cucumber, melons, loofah and several weeds. *Cucumis* is a genus of twining, tendril-bearing plants in the Cucurbitaceae family which includes the cucumber (*Cucumis sativus*), melons (*Cucumis melo*, including cantaloupe and honeydew), the horned melon (*Cucumis metuliferus*), and the West Indian gherkin (*Cucumis anguria*). Melon (*C. melo*) is considered the most diverse species within the genus *Cucumis*, showing wildly diverse fruit morphologies (WIKI, 2017).

## MELONS (CUCUMIS MELO)

*Cucumis melo* L. is an important horticultural crop across wide areas of the world. Within the genus *Cucumis*, it belongs to the species *melo*, having  $2n=24$  chromosomes. Great morphological variation exists in fruit characteristics such as size, shape, colour and texture, taste and composition, and *C. melo* is therefore considered the most diverse species of the genus *Cucumis*. The species comprises feral, wild and

cultivated varieties, the latter including sweet “dessert” melons, as well as non-sweet forms that are consumed raw, pickled or cooked. The extensive variation found in *C. melo* has led botanists to propose intraspecific classification schemes. It is emphasised that such “horticultural types” should be treated under the rules of cultivated plant nomenclature, and not as true botanical taxa. The subdivision of *C. melo* into two subspecies, viz., *ssp. melo* and *ssp. agrestis* is botanically meaningful. Melon is divided into two subspecies, *C. melo ssp. agrestis* and *C. melo ssp. melo*, differentiated by the pubescence on the female hypanthium (a cup-like or tubular enlargement of the receptacle of a female flower); *ssp. melo* has pilose or lanate ovaries (*i.e.*, spreading, usually long, hairs), while *ssp. agrestis* has sericeous ovaries (appressed, usually very short hairs) (Kirkbride, 1993; Asya Stepansky *et al.*, 1999). *Cucumis melo* includes a wide range of cultivars. Although crosses outside the species are sterile, intraspecific crosses are generally fertile, resulting in a confusing range of variation (Purseglove, 1968).

Purseglove (1968) described *Cucumis melo* as follows: “A variable, trailing, softly hairy annual. Vines are monoecious or andro-monoecious. Root system large and superficial. Stems ridged or striate. Leaves orbicular or ovate to reniform, angled or shallowly 5-7 lobed, 8-5 cm in diameter, dentate, base cordate; petiole 4-10 cm long; tendrils simple. Flowers staminate and clustered, pistillate and solitary, or hermaphrodite, 1.2-3.0 cm in diameter, yellow, on short stout pedicles; calyx 5-lobed, 6-8 mm long; corolla deeply 5-partite, petals round, 2 cm long; stamens 3, free, connectives of anthers prolonged; pistil with 3-5 placentas and stigmas. Fruit very variable in size, shape and rind, globular or oblong, smooth or yellow-brown, or green, flesh yellow, pink or green, many seeded. Seeds whitish or buff, flat, smooth, 5-15 mm long. About 30 seeds per g.”

### Origin and distribution of melons (*Cucumis melo*)

The centre of origin for melon (*Cucumis melo*) is still not clear although the evidence points to Africa where wild species of *Cucumis* with the same basic chromosome number  $n=12$  ( $2n=24$ , 48 or 72) frequently occur. However, domestication may have occurred independently in Southeast Asia, India and East Asia. Today the primary centre of diversity for this extremely polymorphic species is in Southwest and Central Asia,

mainly Turkey, Syria, Iran, Afghanistan, North and Central India and Transcaucasia, Turkmenistan, Tadjikistan, and Uzbekistan. There are also secondary centres of diversity in China and Republic of Korea and in the Iberian peninsula (Esquinas-Alcazar, and Gulick, 1983). Based on the theory of continental drift, the occurrence of feral and semi-feral melons in certain parts of the world, and the Mosaic, Biblic and Koranic theories, the watermelon is supposed to have originated in Central Africa and the muskmelon originated in south-eastern Africa and peninsular India. The present day occurrence of these plants in different parts of the world may be the result of dispersal by birds, animals and man. The present-day muskmelon, *Cucumis melo*, evolved from the African horned melon, *C. metuliferus*. The cucumber, *C. sativus* ( $2n=2x=14$  chromosomes), is an off-shoot in the evolution of muskmelon. In its various forms and designations, *C. melo* has undergone numerous genetic, morphological and biochemical changes before it acquired its current form (Mallick, and Masui, 1986).

Melon was introduced in Central America in 1516, in Virginia in 1609, and in New York in 1629 (Ware & McCollum, 1980). Melon can be considered as the most highly developed types of ancient cultivated species and, through many changes, melon could get into those elite forms that exist today (Mallick & Masui, 1986). Archeological remains indicated that melon was cultivated in Iran 3000 BC. India, Iran, Afghanistan and China remain as areas of melon diversification. Ancient melon that was distributed throughout the Middle East and Asia originated the genetic diversity that exists in the area (Robinson & Decker-Walters, 1997).

The African group (melon group) has 30 species divided into six subgroups (Kirkbride, 1993). Melon and other  $2n = 24$  species were originally distributed across a large part of Africa and Middle East up to Pakistan and South Arabia. However, some species also occurred in the Asiatic group range (Kroon *et al.*, 1979; Ramachandran & Narayan, 1985). This is the case of *C. hystrix* Chakr., which is the only  $2n = 14$  and native to Asia. This species is of particular interest because of morphological and biochemical characteristics similar to *C. sativus* and chromosome number equal to *C. melo*, indicating a possible bridge between the two species (Chen & Adelberg, 2000). Africa has been generally regarded as the centre of

origin of *C. melo*, while India has been considered as an important centre of diversification. Strong viewpoints and arguments on African versus Indian origin are moot in the light of continental drift, South Eastern Africa and peninsular India were likely continuous or contiguous (Pitrat, 2008).

According to Patrizia *et al.* (2010) among the fundamental questions regarding cultivated plants is their geographic origin and region of domestication. The genus *Cucumis*, which includes cucumber (*Cucumis sativus*) and melon (*Cucumis melo*), has numerous wild African species, and it has therefore been assumed that melon originated in Africa. For cucumber, this seemed less likely because wild cucumbers exist in India and a closely related species lives in the Eastern Himalayas. Using DNA sequences from plastid and nuclear markers for some 100 *Cucumis* accessions from Africa, Australia, and Asia, it is reported that melon and cucumber are of Asian origin and have numerous previously overlooked species-level relatives in Australia and around the Indian Ocean. The wild progenitor of *C. melo* occurs in India, and the data confirm that the Southeast Asian *Cucumis hystrix* is the closest relative of cucumber. Most surprisingly, the closest relative of melon is *Cucumis picrocarpus* from Australia. *C. melo* diverged from this Australian sister species approximately 3 Ma (3 Megaannum or 3 million years) and both diverged from the remaining Asian/Australian species approximately 10 Ma (10 Megaannum or 10 million years). The Asian/Australian *Cucumis* clade (group) comprises at least 25 species, nine of them new to science, and diverged from its African relatives in the Miocene, approximately 12 Ma (12 Megaannum or 12 million years). (Miocene is pertaining to an epoch of the Tertiary Period, occurring from 25 to 10 million years ago, when grazing mammals became widespread). Range reconstruction under maximum likelihood suggests Asia as the ancestral area for the most recent common ancestor of melon and cucumber, fitting with both having progenitor populations in the Himalayan region and high genetic diversity of *C. melo* landraces in India and China.

### **Domestication of melons (*Cucumis melo*)**

Melons moved from India to central Asia, China, the Middle East, and Europe. The timeline for movement of melons to these areas is unknown, but a recent study of ancient manuscripts, the Hebrew Bible,

and images from antiquity document, the culture and uses of non-sweet melons in the *chate* and *flexuosus* groups was as early as 1350 B.C. (Janick *et al.*, 2007). Domestication of melon may have occurred independently in Southeast Asia, India, and East Asia. Today, the primary center of melon diversity is in Southwest and Central Asia (Turkey, Syria, Iran, Afghanistan, north and central India and Transcaucasia, Turkmenistan, Tajikistan, and Uzbekistan) with secondary centers of diversity in China, Korea, and the Iberian Peninsula (James *et al.*, 2013). The breeding history of melon in America dated back to the selection of the green flesh type cultivar 'Rocky Ford'. Selection for orange flesh cultivars began in the early 1900s. Disease resistant cultivars were developed in the 1930s and the first F1 hybrid was introduced in 1955, becoming the predominant type of melon cultivars (Robinson and Decker-Walters, 1997). Breeding for yield, disease resistance and fruit high density have been the most important goals in a melon breeding programme (Whitaker and Davis, 1962).

The most ancient records on cultivated *Cucumis melo* appear in Egyptian mural paintings. Among the vegetables listed in the bible as being eaten by the Hebrews in Egypt are the *qishu'im* (snake melon), likely identified as non-sweet *C. melo* varieties, similar to var. *flexuosus* or *adzhur*. Extensive records are also found in ancient Chinese writings from about 2000 B.C. and Greek and Roman documents from the first century B.C. The sweet melon forms were not known in the Roman period, and were imported from Persia or Caucasus by travellers, making their appearance in Europe only around the 13th century (Asaya Stepansky *et al.*, 1999).

### **Intraspecific classification of melons (*Cucumis melo*)**

Based on fruit and plant characteristics, Naudin (1859) classified *Cucumis melo* into seven groups viz., *Cucumis melo* var. *cantaloupensis* Naud.; *Cucumis melo* var. *reticulatus* Naud.; *Cucumis melo* var. *indorus* Naud.; *Cucumis melo* var. *flexuosus* Naud.; *Cucumis melo* var. *conomon* Mak.; *Cucumis melo* var. *chito* Naud.; and *Cucumis melo* var. *dudaim* Naud. However, Jeffrey (1980) proposed a division of *C. melo* into two subspecies according to the hairiness of the ovary: subsp. *agrestis* with short hairs found

throughout India and eastern Asia and subsp. *melo* with long hairs found throughout India and central and western Asia, Europe, and the New World. According to Akashi *et al.* (2002), seed length is highly variable among melon varieties, and melon groups can be classified into large-seed types (seed length  $\geq$  9.0 mm) and small-seed types (seed length < 9.0 mm). The former includes the groups *cantalupensis* and *inodorus* with sweet flesh, which are of commercial importance in the United States and Europe as well as in Mediterranean and Asian countries. The latter includes the groups *conomon* and *agrestis* with low sugar content and smooth skin, which are cultivated mainly in South and East Asia (Robinson and Decker-Walters 1997).

Great morphological variation exists in fruit characteristics such as size, shape, colour and texture, taste and composition, and *C. melo* is therefore considered the most diverse species of the genus *Cucumis* (Kirkbride 1993, Whitaker and Davis 1962, Jeffrey 1980, Bates and Robinson 1995). The species comprises feral, wild and cultivated varieties; the cultivated varieties includes sweet “dessert” melons, as well as non-sweet forms that are consumed raw, pickled or cooked (Asaya Stepansky *et al.*, 1999). Munger and Robinson (1991) proposed a further-simplified version of Naudin’s taxonomy, dividing *C. melo* into (1) a single wild variety, *C. melo* var. *agrestis*, and (2) six cultivated ones, viz., *cantalupensis*, *inodorus*, *conomon*, *dudaim*, *flexuosus* and *momordica*. Following is a description of the seven melon (*C. melo*) varietal groups:

### 1) *C. melo* var. *agrestis*

Wild melon, native gooseberry, ulcardo melon, *Cucumis melo* subsp. *agrestis* var. *agrestis*, a wild vine known in India as Kachri or Selni, skin green with dark green patches, flesh small and large seed cavity. Mostly made into chutney. Thin-stemmed, monoecious plants growing as weeds in African and Asian countries. Very small (<5 cm), inedible fruits with very thin mesocarp and tiny seeds.

### 2) *C. melo* var. *cantalupensis*

Medium-large size fruits, smooth, scaly or netted rind of variable colour. Fruits are aromatic with sweet, juicy flesh, and abscise at maturity. *Cucumis melo*

subsp. *melo* var. *cantalupensis*, cultivar with yellow netted skin with longitudinal green grooves, yellow to salmon coloured scented flesh. Includes also former var. *reticulatus*. Andromonoecious flowering in most genotypes, hairy ovary. Includes dessert melon types.

### 3) *C. melo* var. *inodorus*

Large-sized winter melons, with non-aromatic, non-climacteric and long-storing fruits, with thick, smooth or warty rind and white flesh, without flavor. . Includes sweet dessert melons from Asia and Spain, such as Honeydew and Casaba type-cultivars. Usually andromonoecious, hairy ovary.

### 4) *C. melo* var. *flexuosus*

Fruits are very elongated, non-sweet, eaten immature as cucumbers. Found in the Middle East and Asia, where similar, less elongated types, have also been reported as ancient vegetable crops. Usually monoecious. This isn’t a cucumber (though it is believed to be native of Armenia. Or somewhere close by, like Iran.). Armenian cucumber is actually a variety of muskmelon. It is also known as *Kakdi* or snake melon, or yard-long cucumber. The latter is especially apt because these things can grow to 36 inches long, and they do taste remarkably like cucumbers.

### 5) *C. melo* var. *conomon*

The *Conomon* group includes the oriental pickling melon. The fruits are smooth, cylindrical, and may be green, white, or striped. The flesh is white and can taste either sweet or bland. Andromonoecious, vines bear dark, spiny leaves, sericeous ovaries. Corresponds to Naudin’s var. *acidulous*. Dosakaya, *Cucumis melo* subsp. *agrestis* var. *conomon*, resembling golden cucumber but with green patches turning darker on ripening, flesh white, used in *sambar* and *pachadi* preparations.

### 6) *C. melo* var. *chito* and *dudaim*

These were described by Naudin, but grouped together by Munger and Robinson. *C. melo* var. *chito* was reportedly of American feral origin, with small plum-size, aromatic fruits used as pickles, monoecious vines and sericeous ovaries. The fruits are the size of a peach, with a yellow rind and bland white flesh. This variety was very popular in Victorian times for making sweet pickles, pies and preserves. They were developed in China and introduced into America in the 1880’s. In the Orient this type of melon is pickled. This

is known as mango melon (vine peach). *C. melo* var. *dudaim* is of Persian origin, andromonoecious, sericeous ovaries, bears small, aromatic, red or brown-striped fruits, grown as ornamentals in Oriental gardens. Example is, 'Queen Anne's Pocket Melon'

7) *C. melo* var. *momordica*

Snap melon, phut, phoot, *Cucumis melo* subsp *agrestis* var *momordica*, native of India, young fruits with thick cucumber like skin and taste, turning pinkish with light pinkish flesh when ripe Eaten fresh,



*C. melo* var . *agrestis*



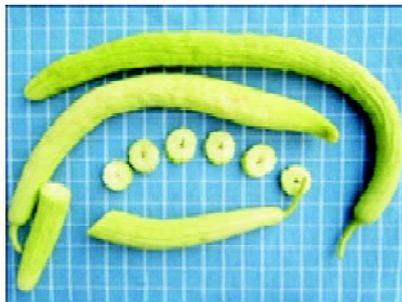
*C. melo* var. *cantalupensis*



*C. melo* var. *reticulatus*



*C. melo* var. *inodorus*



*C. melo* var. *flexuosus*



*C. melo* var. *conomon*



*C. melo* var. *makuwa*



*C. melo* var. *chito*



*C. melo* var. *dudaim*



*C. melo* var. *momordica*

**Plate 1:** Subspecies & varieties of *C. melo*

but somewhat bland. A group added to include Indian accessions with monoecious vines, sericeous ovaries and large, non-sweet fruits with thin rind that splits at maturity.

According to USA's National Research Council (NRC, 2008) even with the limited germplasm on hand, taxonomists have divided the species *Cucumis melo* into at least eight groups, which are also considered as subspecies. These are as follows:

- 1) Cantaloupe- the cantaloupes (as defined in Europe);
- 2) Reticulatus- the netted or nutmeg muskmelons; cantaloupes (as defined in the United States);
- 3) Inodorus- winter, honeydew, casaba, or Persian melon;
- 4) Flexuosus- snake or serpent melon;
- 5) Conomon- Oriental pickling melon;
- 6) Chito- mango melon, garden melon;
- 7) Dudaim- pomegranate melon, Queen Anne's pocket melon;
- 8) Agrestis- a form grown for its seeds

However, National Research Council reported that the intraspecific classification of this highly polymorphic species (*Cucumis melo*) is confused. A number of species and varieties have also been erected from time to time, but this may not be justified as all the forms hybridize readily and there are many intermediate types. The most commonly cultivated types or horticultural varieties of *Cucumis melo* are as follows (NRC, 2008):

**1) Muskmelon** (*reticulatus*; called cantaloupes in the trade) grown mainly in the United States. This has smaller fruits and rinds that are finely netted to nearly smooth, with very shallow ribs.

## **2) Casaba, Persian or Winter melon**

It produces large fruits that mature late with good storage quality. The rind is usually smooth, yellow, and often striped or splashed in green and white. The flesh is firm with little musky odor or flavor. The

Honeydew cultivar group, America's best known Winter melons, with ivory skin and green flesh, is of the *inodorus* type.

## **3) Vegetable types**

A number of forms, often with elongate fruits resembling cucumbers, are grown in India, and the Far East and used as vegetables. These are mostly domesticates of subspecies *agrestis*, and were used in Egypt, Palestine, and throughout the Fertile Crescent from ancient times until about 50 years ago. The Fertile Crescent, also known as the cradle of civilization, is a crescent-shaped region containing the comparatively moist and fertile areas of what is an otherwise arid and semi-arid Western Asia, the Nile Valley and Nile Delta. In recent times they have attracted research attention in Israel and the United States.

The species *C. melo* is a polymorphic taxon encompassing a large number of botanical and horticultural varieties or groups. Melon is divided into two subspecies, *C. melo* ssp. *agrestis* and *C. melo* ssp. *melo*, differentiated by the pubescence on the hypanthium (a cup-like or tubular enlargement of the receptacle of a flower, loosely surrounding the gynoeceum or united with it) (Jeffrey 1980). Furthermore, the *C. melo* ssp. *agrestis* has been subdivided into *conomon*, *makuwa*, *chinensis*, *acidulous* and *momordica* groups, and the *C. melo* ssp. *melo* into ten groups: Cantaloupe, reticulates, adana, chandalak, ameri, inodorus, flexuosus, chate, tibish, dudaim and morren. The *conomon* group is divided into var. *conomon* and var. *makuwa* which are cultivated in India, China, Korea, Japan, and Southeast Asia. The fruit of var. *conomon* is neither sweet nor aromatic and is eaten raw as salad or pickled like cucumber. In contrast, the fruit of var. *makuwa* is sweet and fragrant when fully ripened and is eaten raw as a dessert (Pitrat 2008). The *conomon* group is an important genetic resource for disease resistance and is often utilized in melon breeding, as reviewed by Akashi *et al.* (2002).

The Korean melon (*Cucumis melo* L. var. *makuwa*) or *chamoe*), following its Korean name, is a type of melon primarily grown in Korea. This is also known as Chameh melon, Golden melon, Oriental melon, Japanese cantaloupe and Sun Jewel. The fruit is typically about 15 cm long and weighs slightly over

0.5 kg. It has smooth, oblong with white stripes that run the length of the fruit. It has white flesh that is juicy and sweet, and the seed cavity is filled with small white seeds. Phylogenetic studies tracing the genetic lineage of the plant suggest that the Korean melon may have originated in East India. They were then thought to have been introduced to China from the west via the Silk Road. (Phylogenetics is the study of the evolutionary history and relationships among individuals or groups of organisms. *e.g.* species, or populations). The plant is an annual herbaceous plant that branches and trails. The stem is angular and hirsute (hairy) and 7 mm in diameter. The leaves are reniform (kidney-shaped) with 5-7 lobes. It is andromonoecious (both bisexual and male flowers on same plant) with yellow flowers. The Korean melon has also been used as cattle feed. In Korean folk medicine, the fruit has been used for acute gastritis, fever, mental disorders, dysuria, jaundice, alcoholism, and hyperesthesia/paralysis. The apex has been used as an emetic and for hepatitis, constipation, syphilis, jaundice, and edema. The leaves have been used for blisters and alopecia, and the seeds for indigestion and cough. Research suggests that the hexane extract of the seeds could be used as a way to control type 2 diabetes. When hexane was used to extract fatty acids, it was found to contain linoleic acid, oleic acid, and palmitic acid. The hexane extract was found to inhibit the enzymes alpha-glucosidase and alpha-amylase. Theoretically, this could decrease the levels of blood sugars for patients with type 2 diabetes. The seeds of the melon are also edible and contains some nutrients (WIKI, 2017a).

### Genetic diversity in melons (*Cucumis melo*)

*Cucumis melo* L. is an important horticultural crop across wide areas of the world. Within the genus *Cucumis*, it belongs to the subgenus *melo*, having  $2n=24$  chromes. *C. melo* (melon) genotypes differ widely in morphological and biochemical traits. Intraspecific classification of such variability has been difficult, and most taxonomists still rely on the work of Naudin (1859) (Asaya Stepansky *et al.*, 1999; Akashi *et al.*, 2002).

A collection of 54 accessions representing diverse genotypes from 23 countries was surveyed. Morphological traits related to the vegetative and flowering stages and mature fruit morphology and quality parameters, *e.g.*, taste, aroma, sugar

composition and pH, were scored. These were used to construct a “botanical-morphological” dendrogram that generally reflected the classification of *Cucumis melo* into several horticultural varieties. DNA polymorphism among the accessions was assessed using the Inter-SSR-PCR and RAPD techniques that detected abundant DNA polymorphism among melon genotypes. Cluster analysis indicated that the largest divergence was between North American and European *cantalupensis* and *inodorus* cultivars as one group, and the more “exotic” varieties: *conomon*, *chito*, *dudaim*, *agrestis* and *momordica*, as a second group. The molecular phylogeny agreed, broadly, with the classification of melon into two subspecies, and did not contradict the division into “horticultural varieties”. It was apparent, however, that the infra-specific (within a species) division is rather loose, molecular variation being distributed continuously between and within cultivar groups. It is suggested that despite the morphological diversity, separation between varietal-groups may be based on a too small number of genes to enable unambiguous intra-specific classification based on DNA diversity (Asaya Stepansky *et al.*, 1999).

Tanaka *et al.* (2007) conducted RAPD analysis of melon landraces from Asian countries and showed that the Japanese melon varieties *makuwa* and *conomon* are closely related with the small-seed type (< 9.0 mm) melon in East India. They suggested that the *conomon* group vars. *makuwa* and *conomon* might be differentiated from the small-seed type melon in East India by its further Eastward transmission. An analysis of melon landraces from Myanmar, sharing the border with India in the west and China in the east, revealed a genetic similarity among small-seed type accessions from India and Myanmar (Yi *et al.* 2009). These results highlight the importance of a germplasm diversity analysis of melon from Southeast Asia.

A crop’s name often reflects its history. In the case of melon, the *conomon* group var. *conomon* is called “Yue Gua” in Chinese. The Chinese character “Yue” represents Vietnam, and it is believed that “Yue Gua” was introduced to China from Vietnam. Vietnam shares a border with China in the north and with Laos and Cambodia in the west. Northern Vietnam is characterized by high and rugged mountains that are

last parts of the Himalayan range. In this area, reflecting the geographical complexity, many kinds of indigenous crops, such as rice, maize, and cucumber are grown by ethnic minorities. Cucurbitaceae crops are considered to be one of the most important horticultural crops in Vietnam. Different types of landrace melons are also cultivated and are called “Dua thom” (melon with aroma), “Dua bo” (melon with powdery flesh), “Dua vang” (melon with yellow skin), “Dua le” (round shape, white epicarp color generally), and “Dua gang” (elongated fruit) depending on their fruit characteristics. The former four types are used as a dessert. In contrast, “Dua gang” is mainly used as a vegetable and looks quite similar to the Japanese “Shirouri”, which is classified in the *conomon* group var. *conomon*. Besides these, weedy melon also grows in Vietnam and is called “Dua dai”. However, irrespective of their importance as genetic resources for disease resistance (Darvono *et al.* 2003) and wet tolerance (Akashi *et al.* 2002), less attention has been paid to the Vietnamese melon and little is known about their genetic diversity and their relationship with melon landraces of the surrounding countries.

Phan Thi Phuong Nhi *et al.* (2010) have studied the genetic diversity among 59 melon landraces collected in Vietnam by analyzing the morphological traits of the fruit and molecular markers. The melon landraces were also analyzed with RAPD and SSR markers to uncover genetic diversity in the nuclear genome. For the cytoplasm genome analysis, a single nucleotide polymorphism (SNP) in the plastid subtype ID sequence (PS-ID), the linker sequence between the genes *rpl16* and *rpl14*, and the consensus chloroplast SSR marker (ccSSR7) were employed. The morphological characters of the melon landrace fruits were highly diversified. Among the five types of cultivated melon, “Dua le” and “Dua vang” were classified as *conomon* var. *makuwa*, whereas “Dua gang” was classified as *conomon* var. *conomon*, and “Dua bo” was classified as *momordica*. However, “Dua thom” could not be classified into a proper group or variety. The gene diversity based on random amplified polymorphic DNA (RAPD) and single sequence repeat analyses was small and equivalent to that of Chinese *conomon*. A cluster analysis revealed that “Dua bo”, “Dua le”, “Dua vang”, and “Dua gang” were grouped in cluster II. Clusters III and IV consisted mainly of *conomon* accessions from China

and Japan. “Dua thom” was classified into cluster V with landraces from Yunnan Province, China. The comparison of a RAPD profile with 291 melon accessions from Africa and Asia clearly showed that “Dua thom” and Yunnanese landraces were closely related with the small-seed type melons from Myanmar, Bangladesh, and northeastern India. The other four types were related closely with *conomon* and *agrestis* accessions from China, Korea, and Japan, indicating their involvement in the differentiation and establishment of the *conomon* group in East Asia.

The increasing number of varieties and morphological similarities among melons has necessitated the use of precise system for their identification and characterization. There are several local varieties of melon grown in different regions of India. of India have large variability for fruit shape, size, skin characters, flesh colour, keeping quality and reaction towards insect pest and disease incidence. The non-dessert or culinary forms of *C. melo* is a distinct group distributed and adapted well essentially under humid tropics of Southern India. Great morphological variation exists in fruit characteristics such as size, shape, colour and texture, taste and composition, and *C. melo* is therefore considered the most diverse species of the genus *Cucumis* (Kirkbride 1993; Whitekar and Davis 1962; Jeffrey 1980; Bates and Robinson 1995) (Koli, 2013).

#### **Crossability among *Cucumis* species and among *Cucumis melo* subspecies**

Seeds of ten *dosakaya* types (*C. melo* subsp. *agrestis* var. *conomon*) were used in the study. Counts of somatic chromosomes were made from root tip cells using propiono-orcein stain. To ascertain the compatibility with other *Cucumis* species, reciprocal crosses were made with *Cucumis metuliferus*, *C. anguria*, *C. longipes*, *C. zeyheri*, *C. myriocarpus*, *C. dipsaceus*, and *C. melo*. The success of the cross was determined by the per cent of fruit set in crosses, number of developed seeds in crossed fruits, per cent of pollen fertility and viability in  $F_1$ . Meiotic studies were carried out in the pollen mother cells of  $F_1$  plants to study the behavior of chromosomes during diakinesis. Examination of many metaphase plates of root tip cells revealed the chromosome number of  $2n=24$  in all *dosakaya* types studied. The crosses revealed that each *dosakaya* type studied was crossable with only

*C. melo*. Fruit set was nil in crosses with other species. The results clearly show that the fruit set, mean seed number, seed germination, and  $F_1$  pollen fertility and viability of crosses between *dosakaya* types and *C. melo* were well comparable to that of selfing, thus indicating the free crossability of *dosakaya* types with *C. melo*. The presence of 24 somatic chromosomes and free compatibility with *C. melo* as revealed by normal bivalent formation in all the  $F_1$ s indicate that *dosakaya* is *C. melo* ( $2n=24$ ) and not *C. sativus* ( $2n = 14$ ) (Parthasarathy, and Sambandam, 1980).

Pangelo (1951) reported that all the seven varieties of *Cucumis melo* viz., *Cucumis melo* var. *cantaloupensis* Naud.; *Cucumis melo* var. *reticulatus* Naud.; *Cucumis melo* var. *indorus* Naud.; *Cucumis melo* var. *flexuosus* Naud.; *Cucumis melo* var. *conomon* Mak.; *Cucumis melo* var. *chito* Naud.; and *Cucumis melo* var. *dudaim* Naud., hybridized readily with one another and there was apparently very little sterility even among progenies from crosses involving variant types.

According to Subha *et al.* (1986) the lines CS26 (*Cucumis melo* var. *cocomon*; Oriental pickling melon) and CS52 (*Cucumis melo* var. *momordica*; snap melon) collected indigenously differed from other melon varieties for their plant habit and fruit characteristics. CS26 is grown in the midlands of Kerala (India) for ripened fruits. These fruits are stored in the open for up to one year for year around use. CS52 is grown on the coasts of Kerala (India) during summer months for their ripened and cracked fruits which yield delicious flesh. The present study was carried out to determine compatibility of these two varieties with *Cucumis melo* var. *indorus* Naud.; *Cucumis melo* var. *flexuosus* Naud.; and *Cucumis melo* var. *utilissimus* Duth and Full. The varieties were grown at a spacing of 1.5 m between plants and 3 m between rows with ten pits for each, having 2 plants per pit. Bagging of the male and female matured flower buds with butterpaper bags was done in the evening. Pollination was performed the next morning between 6:30-8:30 A.M., when the stigmas were receptive. The pollinated flowers were covered and labeled. Along with selfs, 20 cross combinations (including reciprocals) among the five selected melons were made by hand pollination. The crossability index was then calculated. The genetic distances among the five botanical varieties were

calculated as per Mahalanobis. The genetic distance was based on nodes to first female flower, fruit weight, seeds/fruit and fruits/plant. All the five botanical varieties of *Cucumis melo* were found to be crossable with each other. No significant reciprocal effect was observed indicating that the maternal parent did not have any influence on crossability index. The crossability index was highest for oriental pickling melon x long melon (79.19) and the lowest for muskmelon x snake melon (47.15%) It was lesser than 50% in muskmelon x snake melon, long melon x muskmelon, long melon x snap melon and snap melon x muskmelon. Crossability index was more than 70% in oriental pickling melon x long melon and snake melon x oriental pickling melon. In other crosses, crossability index varied from 50 to 70%. Genetic divergence could also be considered as a measure of affinity. Muskmelon and snake melon were the most divergent ( $D^2 = 0.38$ ). In the order of affinity, the five melon varieties could be arranged as oriental pickling melon, long melon, snap melon, snake melon, and muskmelon.

## CULINARY CUCUMBER

### *(Cucumis melo* subsp. *agrestis* var. *conomon*)

#### Origin and distribution of culinary cucumber

The botanical name of culinary cucumber or Mangaluru cucumber is *Cucumis melo* subsp. *agrestis* var. *conomon*. It has many forms in cultivation, differing from cucumber (with which they often been confused in past but have white flesh as against greenish white in cucumber). Not much is known about how the Madras cucumber came to acquire its name. Its botanical name, *Cucumis Maderaspatensis*, implies that the vegetable originated in the Madras region. According to botanist Avinash Khaire, this refers to the erstwhile Madras province as defined under British law, which extended to present-day Tamil Nadu, Andhra Pradesh, parts of Karnataka and Kerala (Vidya, 2012; Yogesh Pawar, 2016). Going by name alone, the Madras cucumber may seem like a close relative of *Cucumis Maderaspatanus*, also known as the Madras pea pumpkin, a creeper yielding small, scarlet berries. However, the two plants belong to completely different species. In fact, the Madras cucumber shares more similarities with the musk melon (Vidya, 2012). Many like Swami Virendra Bhatt, in charge of the community kitchen at the Dharmasthala shrine in Karnataka's Malnad region brush this off as "ethnophobic propaganda". According to this chef-

Culinary cucumber



**Mangalore cucumber**



**Mangalore cucumber**



**Mangalore cucumber**



**Dosakai**



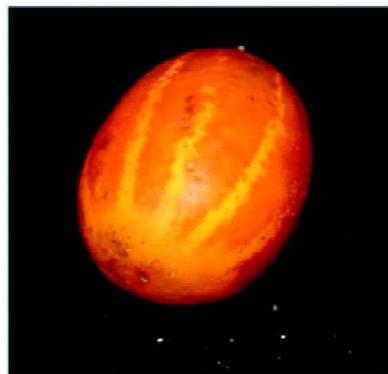
**Mangalore cucumber**



**Dosakai**



**Vellarikka**



**Dosakai**



**Dosakai**

**Plate 2:** Landraces of culinary cucumber grown in South Indian States

priest, “References to this *soutekai* (cucumber in Kannada) in our literature predate the arrival of the British to India” (Yogesh Pawar, 2016).

According to *Hortus Kewensis, or, A Catalogue of the Plants Cultivated in the Royal Botanic Garden at Kew*, a seminal book on English horticulture, by William Aiton (1789), Scottish botanist and father of Indian botany William Roxburgh is credited with introducing the Madras cucumber to India’s East coast in 1805 (Vidya, 2012; Yogesh Pawar, 2016). It is reported that *dosakai* or *dosakai melon* is prevalent in Southeastern India in Andhra Pradesh, both in gardens and in the kitchen. *Dosakai* is a small, round yellow cucumber with green overlay and intermittent stripes creating the appearance of sections. As the cucumber matures, the skin becomes a darker yellow and the green patches become smaller. It has a pale yellow to white flesh with small, yellowish edible seeds. *Dosakai* has a tangy taste, unlike most members of the Cucurbit family where bitterness is the norm; it is sweet and flavorful. It doesn’t contain the chemical compound that gives most fruit in this family a bitter taste (Anon., 2017b).

The Oriental pickling melon (*C. melo* ssp. *melo* var. *conomon*) is considered to be the most ancient form of melon domesticated in China (Jeffrey 1980; Walters 1989) and is cited several times in a book written between 1,000 and 500 years B.C.E. It is also held that it had originated from wild melon (var. *agrestis*) in China (Walters 1989). Oriental pickling melon is cultivated in Asia – India, China, Japan, Korea and Southeast Asia (Lim, 2012). According to Munger and Robinson (1991) it includes two types of fruits, one used as a vegetable (non-sweet and eaten raw or pickled) and one that can have high sugar content. Only the first one (oriental pickling melon) has survived in the *conomon* group (Robinson and Decker-Walters 1997). This variety is characterised by dark green foliage, andromonoecious, elongated fruit, smooth thin white or light green skin, white firm flesh, not sweet, not aromatic, not climacteric, small yellow seeds (Koli, 2013).

The common *Cucumis melo* subsp. *agrestis* will not exceed 10 cm in length, and will be bitter in taste before maturity. Whereas, vegetable cucumber or Mangalore cucumber (*Cucumis melo* subsp. *agrestis* var. *conomon*) grows up to 25 cm x 20 cm in size, and will be sweet (rather not bitter) always. The pulp texture

has a range of variation. Some of these were earlier also separated under var. *mukuwa* Makino, and var. *conomon* (Thunb.) Makino under *C. melo* directly. These include,

### 1) Malabar cucumber

This is also known as Mangaluru cucumber (Mangaluru sauthekai in kannada). Very common in Dakshina Kannada area. Available in super markets, malls and vegetable shops in cities like, Chennai, Bangalore. It is also known as Madras cucumber. Fruits are golden yellow.

### 2) Kani Vellari/ Vellarikka (Malayalam):

Fruits are golden yellow with green patches as above case. Not bitter.

### 3) Chinese Dua gang/Chinese Yellow Cucumber:

Similar with smaller fruits.

### 4) Dosakai or Dosakaya (Telugu):

Larger fruits with green patches turning brown when mature. The mature fruit rind becomes yellow in colour, which means it is ready for harvesting. Flesh is white, used in *sambar* and *pachadi* preparations.

All above are used as vegetable (1-4). The landraces of Oriental pickling melon/culinary cucumber grown in Southern States of India are furnished in Plate 2.

### 5) Korean melon

It is easily recognized by its bright yellow skin with white to pale yellow ridges. Due to its thin skin, the Korean melon is notoriously susceptible to bruising, cuts and a short shelf life, often less than a week. Traditionally, the entire fruit is eaten, including the skin and seeds, but this may not be desirable for all tastes. Korean melons can be prepared much in the same way as other small melons. The Korean melon is also known as Chameh melon, Golden melon, Oriental melon, Japanese cantaloupe and Sun Jewel. Fruits are golden yellow with white sutures, and used as table fruit (Eflora, 2007; SLP, 2017).

### Uses of culinary cucumber

When cut open, the off-white flesh is turgid and crunchy, a characteristic that it holds on to even after cooking. While most parts of south India discard the slightly bitter seeds, these are hugely in demand by

both the beauty and nutrition industries. Mangaluru based nutritionist Sharavati Rao points out that it can be found in lentil preparations like *sambar* in Kerala and Tamil Nadu; in Andhra Pradesh, it is combined with *dal*, tamarind extract and fiery Andhra chillies to make the *dosakayapappu*. “Despite its name, this personal favourite is a staple in Mangalurean cuisine” (Yogesh Pawar, 2016).

Coastal Karnataka not only combines it with *dal* to make the deliciously yummy *koddilu*, but also several non-*dal* tangy gravies that are much in demand. Depending on where you are—whether Karwar or Kasargod or anywhere in between—the style of cooking these varies every few kilometres. It is sometimes sliced thin and dry stir fried with coconut, raw mango paste and chillies to make a tasty and nutritious side dish to go with rice. It’s also perfect to combat the summer heat. Its cream-coloured flesh (much like a musk melon’s) has the crunchy, watery texture of a cucumber yet holds its form when cooked. The seeds are edible yet mildly bitter, which is why the vegetable is often deseeded before it is used (Vidya, 2012; (Yogesh Pawar, 2016).

Yellow cucumber or lemon cucumber, also known as *dosakai* (in Telugu) is a vegetable with yellow rind color, available in parts of India. This versatile cucumber is sweet and flavorful, and doesn’t have much of the chemical that makes other cucumbers bitter and hard to digest (Anon., 2017a). *Dosakai* is commonly used in Indian *sambar* (soup) or *dal* referred to as *dosakaya pappu*. It is also the key ingredient in *dosakaya pachadi*, a chutney made with the yellow cucumber. *Dosakai* is used to make a delicacy from the state of Andhra Pradesh in southeastern India called *dosa avakai*, which is a pickled dish. The pickling process is quick, and the dish is ready in 24 hours, unlike the traditional mango pickle of the same region of India which takes a week. *Dosakai* stores very well after pickling (Anon., 2017b).

*Dosakai* is generally used or added in *sambar*, soup, *dal* and also prepare *dosa-aavakaaya* pickle and chutney. The tender yellow cucumbers are nice lemony yellow color and turn a golden yellow as it ripens. The mild, pleasant taste is complemented by a cool, crisp texture. Resembling a lemon in appearance, the flavor is more delicately sweet and less acidic than the common green cucumber. Yellow cucumbers (tender ones) could also be eaten fresh and can be

pickled when they get ripen. Some varieties of yellow cucumbers are grown in greenhouses that are seedless, have thinner skins and are longer in length, usually between 30-50 cm (Anon., 2017b). In Andhra Pradesh, it is used to add heft and nutritive value to tuvar dal in a dish known as *dosakayapappu*. It is also made into a spicy pickle called *dosvakaya* (Vidya, 2012).

The Madras cucumber is usually cooked and not eaten raw. Its flesh also has a slight sourness, which lends itself well to pickling. True to its name, the Madras cucumber continues to be cultivated mainly in south India. It also finds the maximum number of uses in the cuisines of Tamil Nadu, Andhra Pradesh and coastal Karnataka. Its mild flavour lends itself well to strong, fragrant preparations such as *sambar*. But it seems to find particular favour in traditional Mangalurean vegetarian recipes (Vidya, 2012).

### Nutritional value of culinary cucumber

Madras cucumbers are an excellent source of fibre, especially when they are unpeeled. Rich in vitamins A, C, E and K, they also contain antioxidants that help to delay the ageing process. But most importantly, they have an easy, agreeable flavour (Vidya, 2012). At about 3.6 per cent protein, 4 percent fat, and 2.5 percent carbohydrate, they are what the doctor ordered for those who can’t have meat, says Mangalore based nutritionist Sharavati Rao. “They are extremely rich in antioxidants and vitamins A, C, and E. They can help prevent macular degeneration in the eyes. The antioxidants in these seeds can keep blood cholesterol under check and decrease the risk of cancer. In fact, the vitamin C fights cold and flu by boosting immunity. Apart from being a great source of minerals like magnesium, phosphorous and potassium that regulate blood pressure.” (Yogesh Pawar, 2016).

Yellow cucumber is low in fat and cholesterol. The flesh of cucumbers is primarily composed of water but also contains ascorbic acid (vitamin C) and caffeic acid, both of which help soothe skin irritations and reduce swelling. Cucumbers’ hard skin is rich in fiber and contains a variety of beneficial minerals including silica, potassium and magnesium. The silica in cucumber is an essential component of healthy connective tissue, which includes muscles, tendons, ligaments, cartilage, and bone. cucumber juice is often recommended as a source of silica to improve the

complexion and health of the skin, plus cucumber's high water content makes it naturally hydrating—a must for glowing skin. Most of the cucumbers varieties have around 95 % of water content which is a great way to increase the fiber and water intake. There is a high content of vitamins A, B6 and C present in the flesh of the cucumber. In addition to that these fruits are known to have a high concentration of minerals such as calcium, potassium, magnesium and silica. 100 g of flesh of yellow cucumber without peel contain, carbohydrates: 3.63 g; sugars: 1.67 g; dietary fiber: 0.5 g; fat: 0.11 g; protein: 0.65 g; thiamin (vitamin B1): 0.027 mg; riboflavin (vitamin B2): 0.033 mg; niacin (vitamin B3): 0.098 mg; vitamin B6: 0.040 mg; calcium: 16 mg; iron: 0.28 mg; magnesium: 13 mg; phosphorus: 24 mg; potassium: 24 mg; zinc: 0.20 mg (Anon., 2017).

### Medicinal properties of culinary cucumber

The fully ripened fruit of Japanese pickling melon has rarely been used for food because the mid-ripened fruit is utilized for making pickles, but the fully ripened fruit is no longer valuable for pickles due to the fruit body being too soft. The fully ripened fruit that may be used for non-pickling products, particularly if the fully ripened fruit demonstrated health benefits such as anticarcinogenic properties. The phytochemical extract from the fully ripened fruit of Japanese pickling melon was purified via a bioassay-guided fractionation scheme, which was based on the induction of differentiation in a RCM-1 human colon cancer cell line. On the criteria of two differentiation markers (duct formation and alkaline phosphatase activity), the most potent fraction contained a compound identified as 3-methylthiopropionic acid ethyl ester, based on GC retention time. Previously, the role of 3-methylthiopropionic acid ethyl ester was considered as an odor producing compound in many fruits, but this study indicates potential medical benefits of this compound (Nakamura *et al.*, 2008).

Katsura-uri (*Cucumis melo* var. *conomon*), an heirloom (a traditional variety of plant) vegetable cultivated in Kyoto, Japan is at the risk of extinction. Japanese food culture has traditionally used immature and mid-ripened fruit in the preparation of pickles, the consumer demand of which has markedly decreased. A new strategy was adopted for Katsura-uri, aimed at increasing its inclusion in the present diet habit (*e.g.*, Katsura-uri juice as a functional drink to prevent obesity and diabetes). Chemical analysis was

performed to determine sugar profiles of fully ripened Katsura-uri fruits that uniquely possess muskmelon-like fragrance. In the questionnaire-based sensory evaluation, palatability was compared among the fruit juices without sweeteners and those with sugar or zero-calorie sweetener. Chemical analysis results showed that the fully ripened Katsura-uri fruit had significantly lower levels of fructose, glucose, and sucrose (low-calories and lack of sweetness) than muskmelon fruits. In the questionnaire-based sensory evaluation, zero-calorie sweetener dramatically improved the palatability of the unprocessed fruit juice without altering its low-calorie properties and muskmelon-like fragrance. This demonstrated a new strategy to protect this heirloom vegetable from extinction by adding a new function that could increase its demand as a low-calorie fruit in the present diet habit for human health (Azusa Sasaki *et al.*, 2017).

### Evaluation of culinary cucumber landraces

Seven varieties of oriental pickling melon, *Cucumis melo* L. var. *conomon* Makino, were evaluated in Okinawa (Japan). During the summer season in Okinawa, vegetable production is used to be reduced to a low level, due to typhoons, high temperature, pests, and diseases. A large quantity of vegetables are imported from the highlands in mainland Japan, and consumed at considerably high expense. On the other hand, however, some local vegetables can be grown well in this area. As these vegetables and their varieties seem to have tolerance and adaptability to the severe conditions, characteristics of local varieties of oriental pickling melon was compared with cucumber. Growth of oriental pickling melon was more vigorous and rapid. The plants were characterized by more lateral shoots and smaller leaves as compared to cucumber, compact plant-type, high creeping vines, earliness of harvest and high yield ability. The quality and taste of fruit were also good. These characteristics are better than those of several cucurbits introduced from mainland Japan or continental China. The fruit can be harvested earliest among the cucurbits examined. Especially, "ohama", collected in Ishigaki Island, was found to be the best variety as for yield and quality, and can be used as a better vegetable than cucumber. This result indicates the importance of re-evaluation of local varieties. It seems that these local varieties which are highly tolerant to high temperature, drought, pests and diseases in summer

can also be employed as a useful breeding material (Hiroshi Nakamura and Denji Ishiuchi, 1986).

Among the 24 oriental pickling melon genotypes tested for their performance for fruit fly incidence under northern dry zone of Karnataka, the genotypes *viz.*, Sirsi Local followed by BCMCO-01 BCMCO-02 and BCMSO-03 were found with least infestation of cucurbit fruit fly. However, the powdery mildew incidence was less in genotypes like Mysore Local, Sirsi Local and Thirthalli Local. Among the genotypes BCMCO-02, Sirsi Local and BCMSO-03 had shown moderately resistant to the downy mildew disease. These genotypes were found better as compared to the released (Kerala varieties) varieties which could be used as source for further crop improvement programme (Shruti Prakash *et al.*, 2016).

During the year 2010-2011 evaluation of 25 Oriental pickling melon F1 hybrids for yield, quality and pest and diseases was done at UAS, Bengaluru. The F1 hybrid CMC GKVK 1 X CMC GKVK 2 have shown better performance for characters such as fruit length and fruit diameter, while the F1 hybrid CMC GKVK 2 X CMC GKVK 4 performed well for other characters such as per cent fruit set, number of fruits, total fruit yield per vine and also it was moderately resistant to powdery mildew. However, the fruit flesh thickness and total soluble solids were high with the F1 hybrid CMC GKVK 1 X CMC GKVK 12 (Thyagaraj *et al.*, 2014).

### **High Yielding Varieties of culinary cucumber**

#### **Mudicode**

This is a Oriental pickling melon variety released by Kerala Agricultural University (KAU), Trichur. This variety gives an average yield of 30.4 tonnes per hectare. Selected through systematic evaluation of the germplasm collection, this variety can be grown in home gardens and in commercial farms as well. The variety yields fruits which weighs 1.8-2.5 kg each, according to the scientists. The attractive oval- shaped fruits can be harvested from 55-50 days after sowing, and the crop will last until 79 or 88 days. The early- maturing variety 'Mudicode is ideally suited for growing in Thrissur, Palakkad and Ernakulam districts. It is recommended that the variety should follow a spacing of 2 m x 1.5 m. About 500-750 g seeds will be required to cover a hectare (Agri.Correspondent, 2001).

#### **Arunima**

This is a Oriental pickling melon variety released by Kerala Agricultural University (KAU), Trichur. This improved variety developed from a local type collected from Kasaragode district, is also an early- maturing type, and it is ideally suited for rice fallows during summer. It has a spreading growth habit with branched stem. The leaves are broad with hairy veins and petioles. Male flowers are produced in clusters, while female flowers are solitary. Fruits are large and attractive with uniform cylindrical shape. The fruits are bright green with creamy spots when tender and they turn orange yellow upon ripening. The average length of the fruit is 33.14 cm and the girth 40.72 cm. The flesh thickness of the fruit is 3.6 cm, and each fruit will contain about 645 seeds. The average fruit weight is 2.3 kg at full maturity. The total duration of the crop is 60 days. 'Arunima is relatively tolerant to downey mildew, but is susceptible to mosaic disease under field conditions. The average yield under normal field practices is 27 tonnes per hectare. The fruits are of good quality with a long shelf life. Under normal storage conditions, the fruits can be kept without spoilage for upto 90 days. Hence, this is an ideal variety for off-season marketing. The variety should ideally be sown in the second week of January, and the harvest can be had in the first week of April enabling the farmers to get premium price in the market (Agri.Correspondent, 2001).

#### **Saubhagya**

This is a Oriental pickling melon variety released by Kerala Agricultural University (KAU), Trichur. It is a short duration, less vigorous high yielding variety, maturing in 65-70 days and is suitable for high density planting. Other good qualities of Saubhagya, like concentrated fruiting and small attractive fruits, led to its wide acceptance among the vegetable growers of Kerala state. High density planting needs more nutrients than the crop planted at the normal recommended spacing. This variety has been released by KAU (Ningaraju, and Joseph, 2014).

#### **RNSM-1 (striped)**

A high yielding varieties of sambar cucumber variety grown in Telangana conditions. The fruits are not bitter and in general, they are good looking. Essential character for this variety is sourness and sweetish combination. Each fruit weighs between 250g - 500g (Rao, 2017).

#### **Naveen (plain yellow)**



Mudicode



Saubhagya



Naveen (plain yellow)



RNSM-1 (striped)



Dosakai Melon Cucumber



Cucumber Yellow Round

**Plate 3:** High yield varieties of culinary melon

A high yielding varieties of sambar cucumber variety grown in Telangana conditions. The fruits are not bitter and in general, they are good looking. Essential character for this variety is sourness and sweetish combination. Each fruit weighs between 250g - 500g (Rao, 2017).

### **Dosaki Melon Cucumber**

Developed by Caribbean

Garden Seeds.

### **Cucumber Yellow Round**

Indo UK Agree Seeds, Hyderabad

### **(Plate. 3)**

In addition to these high yielding varieties, farmers are also growing many local types or landraces of culinary cucumber or Mangaluru cucumber or oriental pickling melon in Southern India.

### **Cultivation of culinary cucumber**

Culinary cucumber or oriental pickling melon is a highly cross pollinated and usually andromonoecious in nature, preferring warm weather and bright sunlight for its better growth and development (Mukunda

Lakshmi *et al.*, 2017). Plants are very easy to grow and do well in areas that have short summers and the fruits/ vegetable mature faster and need less heat to ripen than most cucumbers.

Krishnamurthy Ballal, Udipi, has used one year old seeds for sowing. Since 60 years he is using the seeds multiplied by him. He grows two types of Mangaluru cucumber; yellow and black (like watermelon) rind coloured mature fruits. Sowing is done in February, when the temperature becomes warm. In coastal sands, the sowing is done in October. Seeds are soaked for 12 hours before sowing. 3.5 m long and 75 cm wide trench is opened; 6 baskets of cowdung, 6 baskets of burnt soil or *sudumannu*, and 1 spoonful of Furadon are added; Then seeds are sown in the trench. Before earthing up, only 10-12 plants per 3.5 m long row are retained (30 cm distance from plant to plant in the row). After 3 weeks of sowing earthing up of plants is done. Then mulching is done with dry leaves. After 3 weeks of sowing, male flowers appear and after 4 weeks of sowing, hermaphrodite/ female flowers appear. Once in 2 days plants are irrigated. After 8 weeks of sowing, fruits are ready for harvest. Harvesting continues for another 2 weeks. About 250 fruits are harvested; the fruit weight ranged from 5 kg/fruit (50 out of 250) to 500 g/fruit. Immature

fruits are bitter. The mature fruits are not bitter and not sweet; fruits are used for cooking purpose. The fruits are stored for 6-7 months (April to October) using coconut fronds rope. Fruits are not sold, but used for home consumption. In the market the fruits were sold during 2017 for Rs 20/kg (in April) to Rs 50-60/kg (in other months). To control *Gantu hula*, Furadon is applied (1 tea spoon/3.5 m long row). Wild pigs, porcupine, peacock, and ants are damaging the crop. To control wild pigs and porcupine, *choorimullu* is put along the fence. It is grown on commercial scale in Bajpe area, Puttur area, Byndooru (Mangaluru sauthekai) and Uttara Kannada (mogeikai). The ideal seasons for sowing are January –March and September –December. Rainy season is not suitable for this crop (Personal Communication from Krishnamurthy Ballal, Udupi).

Thimmappa Gowda, Panambu, Shantigodu, Puttur, Dakshina Kannada, has been growing Mangaluru sauthekai in the paddy fallow land. The farmer has utilized 5 cents (2000 m<sup>2</sup>) of paddy fallow land. The land is prepared in the month of January and seeds are sown in January. 15 deep trench is prepared; spacing between rows will be 1.2 m and between plants in a row the spacing will be 60 cm. Burnt soil or *sudumannu* is added along with farm yard manure; 5 kg suphala is also added. Sowing is done in the trench. 3-4 days after sowing the seeds will germinate. Plants start vining 10-12 days after germination. Earthing up is done 3 weeks after sowing; Thinning of extra plants is also done. At the time of earthing up operation, 5 kg Suphala® is added. Then the inter-space is mulched with dry coconut fronds and the vines are allowed to trail on the dry coconut fronds. 6 weeks after sowing flowering takes place. For eating the fruits, the immature fruits can be harvested 10 days after fruit set; for cooking purpose, the mature fruits (yellow and black colour fruits) can be harvested 4 weeks after fruit set. Regular irrigation, weeding and manuring should be done for getting good yield. The main pest of this crop is a kind beetle named *Epilachna* beetle. This beetle destroys plants eating entire leaves, if not control. Remove and destroy eggs and adult beetle. Avoid chemical pesticides as far as possible. The fruits are used for home consumption and stored for one year. If sold, each kg of fruit fetches Rs 20-30 (Personal Communication from Thimmappa Gowda, Panambu, Shantigodu, Puttur, DK).

Culinary cucumber can also be grown in large pots and you need to provide support for the growing vines. The maturity of the fruits is approx about 60 – 75 days (Anon., 2017a). *Dosakai* prefers a growing climate with short summers. It is available year-round with a peak season in the late fall and through the winter months in Andhra Pradesh (Anon., 2017b). Plants require a long warm growing season. They grow best in temperature between of 16<sup>o</sup> C to 25<sup>o</sup> C.; need moist but well-drained, nutrient-rich soil. Amend soil with compost or other organic matter prior to planting. Soil pH should be 6.0 to 6.8. Seed should be sown at 1 cm depth and covered with soil. Sow 3-4 seeds per pit and thin the seedlings to 2 per pit after 10 days. The recommended spacing is 1.25-1.50 m distance between two plants. Water the field as per need of crop. Keep seedlings moist but not wet. Use a watering can with fine spray. Cucumber ready to harvest in about 8-10 weeks, depending on the growing conditions (Anon., 2017).

Among the cucurbits cultivated in Kerala, Oriental pickling melon occupies an important place. It is mainly cultivated in the summer rice fallows as an irrigated crop. The average yield of oriental pickling melon in the state is about 25-30 tonnes per hectare under the recommended spacing of 2m x 1.5m (Anoop, 2009). A field experiment was conducted at the Kerala Agricultural University during December 2012 to March 2013 to standardize drip fertigation under high density planting in summer grown oriental pickling melon. The experiment was laid out in Randomised Block Design (RBD) with three replications. The treatments consisted of combinations of four irrigation levels (50, 75 and 100 % Ep through drip irrigation and farmers practice of pot irrigation) and three fertilizer levels (100, 150 and 200 % Recommended dose of fertilizer). Irrigation levels significantly influenced the growth characters *viz* ., length of vine, number of leaves per vine, number of branches per vine, LAI and shoot dry matter production. The highest values of vegetative characters were observed under drip fertigation with 100 per cent Ep combined with 200 per cent of recommended dose of fertilizers. The number of fruits and fruit characters like weight of fruit and volume of fruit were significantly influenced by the levels of irrigation. Maximum number of fruits as well as the weight and volume of fruits were observed at 100 per cent Ep given through drip irrigation

and was significantly superior to all other irrigation levels. Fertilizer levels also significantly influenced both vegetative parameters and yield attributes. The highest growth parameters and yield attributes were observed with 200 per cent RDF. Highest fruit yield of 72.4 tonnes per hectare was obtained by drip fertigation with the 100 percent Ep combined with 200 per cent of recommended dose of fertilizer (Ningaraju, and Joseph, 2014).

The main constraint for production of oriental pickling melon in the summer rice fallows is the scarcity of water for irrigation. Therefore a study was undertaken in summer grown oriental pickling melon under high density planting to estimate the water and nutrient requirement through drip fertigation. Saubhagya variety of op melon maturing in about 65 days was planted at a spacing of 1.00 m x 0.30 m in channels accommodating 33,333 plants per hectare (Ningaraju, and Joseph, 2014).

The ideal seasons for growing are January-March and September-December. The seed rate is 0.5 - 0.75 kg/ ha. And the spacing to be provided is 2.0 m x 1.5 m. Pits of 60 cm diameter and 30-45 cm depth are taken. Well rotten FYM and fertilizers are mixed with topsoil in the pit and four or five seeds are sown in a pit. Remove unhealthy plants after two weeks and retain three plants per pit. Apply FYM @ 20-25 t/ha as basal dose along with half dose of N (35 kg) and full dose of P<sub>2</sub>O<sub>5</sub> (25 kg) and K<sub>2</sub>O (25 kg/ha. The remaining dose of N (35 kg) can be applied in two equal split doses at the time of vining and at the time of full blooming. A fertilizer dose of 70:25:25 kg N:P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O/ ha in several splits is recommended in Onattukara region. The fertilizer dose per pit would be 28:10:10 g N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O. During the initial stages of growth, irrigate at an interval of 3-4 days. Irrigate in alternate days, during flowering and fruiting. For trailing cucumber and melon, spread dried twigs on the ground. Conduct weeding and raking of the soil at the time of fertilizer application. Earthing up may be done during rainy season. The important pests are *Epilachna* beetle and red pumpkin beetle. They can be controlled by adopting the measures recommended for bitter gourd. The important diseases are downy mildew, powdery mildew and mosaic. The control measures as recommended for bitter gourd can be adopted. Harvesting can be done

only after 10 days (at least) of insecticide / fungicide application. The fruits should be washed thoroughly in water before cooking (KAU, 2011).

To optimize the spacing and planting geometry requirements of short duration and less spreading Oriental pickling melon cv. 'Saubhagya', a field trial involving seven spacing treatments was undertaken at Mannuthy in the summer rice fallows for two consecutive seasons. The closest spacing of 1.0 x 0.30 m (trench method), accommodating 33,333 plants/ ha, yielded 28.4 t/ha, which was 184% greater than the yield obtained for in the conventional pit planting method (2.0 x 1.5 m). Furthermore, average weight of fruits and productivity increased significantly when the trench-to-trench spacing was reduced from 2 to 1 m, implying a general favourable impact of closer trench/row spacing on the performance of less spreading oriental pickling melon cultivars, which are particularly suitable for the summer rice fallows of Kerala (Jamuna Devi *et al.*, 2004).

The potential for high yields over short intervals (three months) and the low input requirements make this crop an ideal choice for the vegetable growers of the state. Moreover, the short duration and less spreading varieties (*e.g.*, 'Saubhagya') occupy a special niche for summer rice fallow cultivation. The recommended crop husbandry practices for oriental pickling melon are, however, based on trials with the vigorously growing and spreading variety, 'Mudicode'; which may not perhaps be relevant for the short duration and less spreading varieties. Additionally, in 'Saubhagya', the fruits are borne on the lower nodes that make the conventional pit sowing method (45 cm<sup>3</sup>) particularly unsuitable—as it would lead to fruit production in the pits that, in turn, may result in fruit decay—as fertilizers and irrigation water are applied to these pits. This necessitated an investigation to optimize the spacing and planting geometry requirements of the short duration and low spreading variety 'Saubhagya'. The field experiment was conducted in the summer rice fallows of the Agricultural Research Station, Kerala Agricultural University, Mannuthy. The site (10o32' N and 76o10' E at an altitude of 22.5 m) experiences a warm humid tropical climate. The soil of the experimental area was Ultisol (red clay soils) with medium organic C

(0.43 %) and available K levels (55 kg ha<sup>-1</sup>), beside high contents of available P (15 kg ha<sup>-1</sup>). Seeds were sown in shallow 30 cm wide trenches in six spacing treatments (2.0 x 0.30 m, 2.0 x 0.45 m, 1.5 x 0.30 m, 1.5 x 0.45 m, 1.0 x 0.30 m and 1.0 x 0.45 m) along with the recommended pit sowing practice (at 2.0 x 1.5 m with three plants per pit). The corresponding population densities were 16666, 11111, 22222, 14814, 33333, 22222 and 9999 ha<sup>-1</sup> respectively. The experiment was conducted for two seasons *viz.*, December 2002 to February 2003 and February to April 2003 in a randomised block design with four replications (plot size 12 m<sup>2</sup>), and following the general crop husbandry recommendations of KAU. Observations on economic characters were compared using ANOVA followed by the Duncan's Multiple Range Test (Jamuna Devi *et al.*, 2004).

Golden cucumber, is an intercrop that is cultivated along with sugarcane; both the seeds are planted in November-December; golden cucumber yield was obtained in 60-70 days; around 4.5 tonnes of golden cucumber were produced. Golden cucumber was sold at Rs. 14-18 a kg. A major portion of expenses on sugarcane cultivation is recovered from this crop. The main reason for good price this year is the increase in the prices of vegetables, he said (Vinayak, 2017.).

Cucurbit fruit fly (*Bactrocera cucurbitae*) is one of the most important pests of cucurbits, which damage the crop to large extent. Because of the difficulties associated for the control of this pest by chemical insecticides, farmers experienced great losses in cucurbits. Powdery mildew is a widespread and often production limiting disease of Oriental pickling melon (Shruti Prakash *et al.*, 2016).

Depending on individual tastes, generally culinary melon or Mangaluru cucumber fruits are harvested when they change their color from dark green to light green or brown and in some cases orange. For long distance transporting green fruits are harvested. The orange color of fruit indicates that the fruit is over ripe and is excellent for extracting the seeds (D'Souza, 2010). Fruit yield of 10-15 t/ha can be obtained.

## CONCLUSIONS

Melons of India have large variability for fruit shape, size, skin characters, flesh colour, keeping quality and reaction towards insect pest and disease incidence. The non-dessert or culinary forms of *C. melo* is a distinct group distributed and adapted well essentially under humid tropics of Southern India. Great morphological variation exists in fruit characteristics such as size, shape, colour and texture, taste and composition, and *C. melo* is therefore considered the most diverse species of the genus *Cucumis*.

The culinary cucumber or Mangaluru cucumber has a special feature that the fruits can be stored up to 8-10 months without losing their freshness. They can be stored for many weeks by hanging them from the ceiling, firmly bound by thin coconut fibre ropes. The fruits which contain moderate amount of vitamins and minerals are used in the preparations of an array of traditional vegetarian dishes like dosa, chutney, curry, *sambar* and pickles. Even seeds are used for preparation of juice against dyspepsia. The fruits possess cooling properties and are used as a skin moisturizer and as a digestive agent.

It is a common and popular vegetable found in almost every home in Southern India. Vegetable cucumber/ Madras cucumber/ Managlore cucumber is not quite easily available in the Northern parts of the country. Now-a-days it is available in supermarkets, malls and vegetable shops in cities and this ethnic, poor man's vegetable is becoming popular.

Understanding the evolutionary history and domestication process, increases the possibility for better exploiting the genetic diversity for cultivar development. Its storage trait can be transferred to muskmelon by adopting a suitable breeding method. As reported by Hiroshi Nakamura and Denji Ishiuchi (1986) of the seven varieties of oriental pickling melon, *Cucumis melo* L. var. *conomon* Makino, evaluated in Okinawa (Japan), during the summer season was found to be the best variety as for yield and quality. And it can be used as a better vegetable. It seems that the local varieties which are highly tolerant to high temperature, drought, pests and diseases in summer, can also be employed as a useful breeding material.

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