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A COMPLETE REVIEW ON: *AVERRHOA CARAMBOLA*

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ABSTRACT

Averrhoa carambola, a multipurpose, drought resistant evergreen tree commonly known as “kamrakh” belonging to family Oxalidaceae, is gaining lot of importance for its therapeutic potentials. Various part of tree has been used in traditional folkloric medicine. *Averrhoa carambola* is a also a good source of potassium, copper, as well as folate and panthothenic acid. The Ascorbic acid levels of the star fruit is believed to be responsible for its sweet or sour taste. For a sweet fruit, the ascorbic acid level is around 10.40 mg per 100ml of juice. For a sour fruit, the ascorbic acid lever is about 15.4 mg per 100ml of juice.. Before exploiting any plant for medicinal purpose it is imperative to have complete information about its biology, chemistry, and all other applications so that the potential of plant could be utilized maximally. The taxonomy, botanical description of the plant, its distribution and ecological requirement are discussed in this paper. The possibilities of potential of plant for various pharmacological activities have been summarized. Overall, this paper gives an overview on covering the biology, chemistry, and various commercial and therapeutic applications.

Keywords: *Averrhoa carambola* ,Ecological requirement, Pharmacological, Therapeutic applications,Reproduction.

INTRODUCTION

The word carambola is derived from the Sanskrit word karmaranga meaning "food appetizer". Star fruit was called carambola in the Malayalam language, and when the Portuguese took it to Africa and South America they kept the original name[1-5].

Averrhoa carambola **Star Fruit**

Classification of *Averrhoa carambola*

Scientific Name: *Averrhoa carambola*

Kingdom	*Plantae* – Plants
Subkingdom	*Tracheobionta* – Vascular plants
Superdivision	*Spermatophyta* – Seed plants
Division	*Magnoliophyta* – Flowering plants
Class	*Magnoliopsida* – Dicotyledons
Subclass	*Rosidae*
Order	*Geraniales*
Family	*Oxalidaceae* – Wood-Sorrel family
Genus	*Averrhoa* Adans. – averrhoa
Species	*Averrhoa carambola* L. – carambola

Nomenclature[6,7]

The carambola is known under different names in different countries. It should not be confused with the closely related bilimbi, with which it shares some common names.

- Bengali – *kamranga*
- Assamese - *kordoi (কৰ্দৈ) / rohdoi (ৰহদৈ)*
- Marathi – *karambal*

- Telugu - *ambanamkaya (అంబాణంకాయ)*
- English - *carambola, starfruit*
- Filipino - *balimbing, saranate*
- Hindi - *kamrakh*
- Gujarati - *kamrakh*
- Tamil - *thambaratham (தம்பரத்தம்)*
- Indonesian - *belimbing*
- Malay - *belimbing*
- Sylheti - *khafrenga*
- Sinhala - *Kamaranga*
- Vietnamese - *khế*

Botany/Description[8-10]

Balimbing is a small tree growing to a height of 6 meters or less.Flowers are Red and white appear on bare branches or at leaf bases. Leaves are pinnate, about 15 centimeters long. Leaflets are smooth, usually in 5 pairs, ovate to ovate-lanceolate, the upper ones about 5 centimeters long and the lower ones smaller. Pannicles are small, axillary and bell-shaped, 5 to 6 millimeters long. Calyx is reddish purple. Petals are purple to bright purple, often margined with white. Fruit is fleshy, green to greenish yellow, about 6 centimeters long, with 5 longitudinal, sharp and angular lobes. Seeds are arillate, Seedlings have been known to bear in 3 years.Season: August - March.

Category

EdibleFruitsandNutsTropicals and Tender Perennials

Height:

30-40 ft. (9-12 m)

Spacing:

15-20 ft. (4.7-6 m)

SunExposure:

Full Sun

Danger:

N/A

BloomColor:

Pink

BloomTime:

Blooms repeatedly

Foliage:

Evergreen

Otherdetails:

Requires consistently moist soil; do not let dry out between waterings

SoilpHrequirements:

6.1 to 6.5 (mildly acidic)

6.6 to 7.5 (neutral)

7.6 to 7.8 (mildly alkaline)

Patent Information:

Non-patented

Propagation Methods:

From seed; direct sow outdoors in fall

By grafting

Seed Collecting:

Seed does not store well; sow as soon as possible

Constituents

Studies indicate the presence of saponins, alkaloids, flavonoids and tannins. Seeds yield an alkaloid, harmaline, $C_{13}H_{14}N_{20}$.

Origin and Distribution[11,12]

The carambola is believed to have originated in Ceylon and the Moluccas but it has been cultivated in southeast Asia and Malaysia for many centuries. It is commonly grown in the provinces of Fukien, Kuangtung and Kuangsi in southern China, in Taiwan and India. It is rather popular in the Philippines and Queensland, Australia, and moderately so in some of the South Pacific islands, particularly Tahiti, New Caledonia and Netherlands New Guinea, and in Guam and Hawaii.

There are some specimens of the tree in special collections in the Caribbean islands, Central America, tropical South America, and also in West Tropical Africa and Zanzibar. Several trees have been growing since 1935 at the Rehovoth Research Station in Israel. In many areas, it is grown more as an ornamental than for its fruits.

It was introduced into southern Florida before 1887 and was viewed mainly as a curiosity until recent years when some small groves have been established and the fruits have been used as "conversation pieces" to decorate gift shipments of citrus fruits, and also, in clear-plastic-wrapped trays, have been appearing in the produce sections of some supermarkets. One fruit-grower and shipper now has 50 acres (20 ha) planted but suggests that other prospective growers be cautious as the market may remain limited. Shipments go mainly to Vancouver, Quebec, Cleveland, and Disneyworld. Small amounts are sold locally.

Varieties

There are 2 distinct classes of carambola–the smaller, very sour type, richly flavored, with more oxalic acid; the larger, so-called "sweet" type, mild-flavored, rather bland, with less oxalic acid.

In 1935, seeds from Hawaii were planted at the University of Florida's Agricultural Research and Education Center in Homestead. A selection from the resulting seedlings was vegetatively propagated during the 1940's and 1950's and, in late 1965, was officially released under the name **'Golden Star'** and distributed to growers. The fruit is large, deeply winged, decorative, and mildly subacid to sweet. Furthermore, this cultivar shows the least minor-element deficiency in alkaline soil, and even isolated trees bear well and regularly without cross-pollination.

Several cultivars from Taiwan are being grown at the United States Department of Agriculture's Subtropical Horticulture Research Unit in Miami, including 'Mih Tao' (P. I. No. 272065) introduced in 1963, also 'Dah Pon' and 'Tean Ma' and others identified only by numbers, and Fwang Tung' brought from Thailand by Dr. R J. Knight in 1973. There are certain "lines" of carambola, such as 'Newcomb', 'Thayer' and 'Arkin' being grown commercially in southern Florida. Some cultivars and seedlings bear flowers with short styles, others only flowers with long styles, a factor which affects self- and cross-pollination.

Climate

The carambola should be classed as tropical and sub-tropical because mature trees can tolerate freezing temperatures for short periods and sustain little damage at 27º F (-2.78º C). In Florida, the tree survives in sheltered sites as far north as St. Petersburg on the west coast and Daytona Beach on the east. It thrives up to an elevation of 4,000 ft (1,200 m) in India. In an interior valley of Israel, all trees succumbed to the prevailing hot, dry winds. The

carambola needs moisture for best performance and ideally rainfall should be fairly evenly distributed all year. In Australia, it is claimed that fruit quality and flavor are best where annual rainfall is 70 in (180 cm) or somewhat more.

Soil

Not too particular as to soil, the carambola does well on sand, heavy clay or limestone, but will grow faster and bear more heavily in rich loam. It is often chlorotic on limestone. It needs good drainage; cannot stand flooding.

Propagation and management

Propagationmethods

Propagation is by seed, budding and grafting onto seedling rootstocks, or air-layering. Theseedlings are transplanted into polythene bags, and after 6-12 months in the nursery are plantedoutataspacingof4x6m.

TreeManagement

When young, A. carambola is delicate and requires careful attention. Because it is a fast-growing tree, it requires pruning and thinning of excess fruit at an early stage. Good crops are harvested from grafted varieties when they are 2-3 years old. Yields of up to 900 kg/year are common for 10-year-oldtrees.

GermplasmManagement

Seed storage behaviour is intermediate. The lowest safe mc is 12.3%; further desiccation reduces viability. Cool temperatures damage the seeds. Viability can be maintained for 6 months with partially dried seeds at 5 deg. C. There are approximately 15 000 seeds/kg.ut. Mature trees can be top-worked by bark-grafting.

Reproduction [13-16]

Averrhoa carambola is an angiosperm, which undergo reproduction via alteration of generations. Star fruit tree's are dioecious, meaning that a male and female star fruit tree is needed to create a new tree. *Averrhoa carambola's* pollination is not air born, but instead it is pollinated by insects. The two main insects that are responsible for the pollination of *Averrhoa carambola* are honey bees and sting-less bees.

Honey bee

Sting-less bees

These bees are attracted to the star fruit trees because of its sweet nectar and the color of the flowers, as shown below.

Adaptation

Averrhoa carambola live in tropical climates, but they have adapted to sub-tropical environments as well. Mature *Averrhoa carambola* can tolerate temperatures as low as -2.78ºC for a short period of time.

Averrhoa carambola optimal soil medium is a think layer of rich loam, but it also has also adapted to several other soil mediums. Star Fruit tree's have been able to grow on think layers of limestone, sand, and even clay.

Star fruit trees originated at relatively low elevations, but have adapted to thrive in elevations of up to 1,200m, as seen in Asia.

Interactions with species

Overall, *Averrhoa carambola* is relatively free of disease and insect problems. However, it does still have interactions with several different species.

In Malaya, *Dacus dorsalis* are so densely populated that growers have to wrap the fruits on the trees with paper to keep the flies from destroying them.

Like most fruit trees, *Averrhoa carambola* also interacts with the common fruit fly

Acrosternum hilare has also been found to feed on the stems of the Star fruit trees. This "green stink bug" is a common pest of plants that have a wide range of diversity.

The nematode, *Rotylenchulus reniformis*, uses the roots of the *Averrhoa carambola* as one of its host. This parasitic relationship causes the destruction of the roots, which leads to death of the Star fruit tree.

Blooming

In the greenhouse, these plants start flowering in late spring and will have up to 4 flushes of flowers throughout the year. Flowers form in the leaf axils. The variegated white and purple flowers are followed by yellow to golden brown fruits that are up to 5 inches (12.7 cm) long.

Culture

The tree needs full sun. A spacing of 20 ft (6 m) has been advocated but if the trees are on good soil no less than 30 ft (9 m) should be considered. At the Research Center in Homestead, trees 8 to 10 ft (2.4-3 m) high respond well to 1 lb (0.5 kg) applications of N, P, K, Mg in the ratio of 6-6-6-3 given 3 to 4 times per year. If chlorosis occurs, it can be corrected by added iron, zinc and manganese. Some advisers recommend minor-element spraying 4 times during the year if the trees are on limestone soils. Moderate irrigation is highly desirable during dry seasons. Heavy rains during blooming season interfere with pollination and fruit production. Interplanting of different strains is usually necessary to provide cross-pollination and obtain the highest yields.

Harvesting and Yield

In India, carambolas are available in September and October and again in December and January. In Malaya, they are produced all the year. In Florida, scattered fruits are found through the year but the main crop usually matures from late summer to early winter. Some trees have fruited heavily in November and December, and again in March and April. There may even be three crops. Weather conditions account for much of the seasonal variability.

The fruits naturally fall to the ground when fully ripe. For marketing and shipping they should be hand-picked while pale-green with just a touch of yellow.

Trees that receive adequate horticultural attention have yielded 100 to 250 or even 300 lbs (45-113-136 kg) of fruit.

Keeping Quality[17-19]

Carambolas have been shipped successfully without refrigeration from Florida to northern cities in avocado lugs lined and topped with excelsior. The fruits are packed solidly, stem-end down, at a 45º angle, the flanges of one fruit fitting into the "V" grooves of another. Of course, they cannot endure rough handling.

In storage trials at Winter Haven, Florida, carambolas picked when showing the first signs of yellowing kept in good condition for 4 weeks at 50º F (10º C); 3 weeks at 60º F (15.56º C); 2 weeks at 70º F (21.1º C). Waxing extends storage life and preserves the vitamin value.

Pests and Diseases

The carambola is relatively pest-free except for fruit flies. In Malaya, fruit flies (especially *Dacus dorsalis*) are so troublesome on carambolas that growers have to wrap the fruits on the tree with paper. Experimental trapping, with methyl eugenol as an attractant, has reduced

fruit damage by 20%. In Florida, a small stinkbug causes superficial blemishes and a black beetle attacks overripe fruits. Reniform nematodes may cause tree decline.

Anthracnose caused by *Colletotrichum gloeosporioides* may be a problem in Florida, and leaf spot may arise from attack by *Phomopsis* sp., *Phyllosticta* sp. or *Cercospora averrhoae. Cercospora* leaf spot is reported also from Malaya, Ceylon, China and may occur in the Philippines as well. A substance resembling sooty mold makes many fruits unmarketable in summer.

Food Value

Nutritional Value of Star Fruit[20]

The First thing that you need to know about *Averrhoa carambola* is how to prepare it properly. There are several ways of doing so, but the one I use and enjoy the most is simple but yet effective. Follow this link, Star Fruit Preparation, to view a video on how to prepare a Star Fruit for consumption.

Averrhoa carambola is packed full of nutrients. In consuming 100g of this amazing fruit, you will have taken in .38g of protein and only .08g of fat. You also will have consumed 9.38g of carbohydrates, and .9g of fiber.

Averrhoa carambola is a also a good source of potassium, copper, as well as folate and panthothenic acid. The Ascorbic acid levels of the star fruit is believed to be responsible for its sweet or sour taste. For a sweet fruit, the ascorbic acid level is around 10.40 mg per 100ml of juice. For a sour fruit, the ascorbic acid lever is about 15.4 mg per 100ml of juice. If your not sure if the fruit you are eating is sweet or sour, here is a video of what a baby looks like

eating a sour star fruit.Ripening and storage studies were conducted at the Florida Citrus Experiment Station at Lake Alfred in 1966. They found quite a difference in the acid make-up of mature green and mature yellow carambolas. Fresh mature green fruits of 'Golden Star' were found to have a total acid content of 12.51 mg/g consisting of 5 mg oxalic, 4.37 tartaric, 1.32 citric, 1.21 malic, 0.39 ketoglutaric, 0.22 succinic, and a trace of fumaric. Mature yellow fruits had a total acid content of 13 mg/g, made up of 9.58 mg oxalic, 0.91 tartaric, 2.20 - ketoglutaric, 0.31 fumaric.

In 1975, 16 carambola selections and 2 named cultivars were assayed at the United States Citrus and Subtropical Products Laboratory, Winter Haven, Florida. Preliminary taste tests ranked 'No. 17, 'No. 37', 'No. 42' and 'Tean Ma' as preferred. In a later test, 'Dah Pon' was ranked above 'Tean Ma'. 'No. 17' (º Brix 9.9) was described as "sweet, good and apple-like". 'No. 37' (º Brix 6.7), as "sour and sweet". 'No. 42' (º Brix 8.3), as "sour, tart and apple-like". 'Dah Pon' (º Brix 8.0), as "good and mild". 'Tean Ma (º Brix 7.2), as "sweet, good and mild". Analyses showed that these 5 were among those with relatively high ascorbic acid content– 'No. 17, 30 mg; 'Dah Pon', 30 mg; 'No. 37', 37 mg; 'No. 42', 37 mg; and 'Tean Ma', 41 mg. 'No. 40' had 43 mg and 'No. 11', 50 mg, whereas 'M-23007' had only 14 mg and 'No. 10' only 17 mg.

Oxalic acid content of the 18 selections and cultivars ranged from 0.039 mg to 0.679 mg and 4 of the preferred carambolas were in the lower range as follows: 'No. 17', 0.167; 'Dah Pon', 0.184; 'Tean Ma', 0.202; 'No. 42', 0.276 mg, but 'No. 37', with 0.461 was 3rd from the highest of all.

Puerto Rican technologists found the oxalic acid content of ripe carambolas to average 0.5 g per 100 ml of juice, the acid being mostly in the free state. They likened the juice to rhubarb juice and advised that physicians be informed of this because there are individuals who may be adversely affected by ingestion of even small amounts of oxalic acid or oxalates. Other investigators have presumed the oxalic acid in fully ripe carambolas to be precipitated as calcium oxalate or in solution as neutral salts. The health risk needs further study.

Food Value Per 100 g of Edible Portion*	
Calories	35.7
Moisture	89.0-91.0 g
Protein	0.38 g
Fat	0.08 g
Carbohydrates	9.38 g
Fiber	0.80-0.90 g
Ash	0.26-0.40 g
Calcium	4.4-6.O mg
Phosphorus	15.5-21.0 mg
Iron	0.32-1.65 mg
Carotene	0.003-0.552 mg
Thiamine	0.03-0.038 mg
Riboflavin	0.019-0.03 mg
Niacin	0.294-0.38 mg
Ascorbic Acid*	26.0-53.1 mg

* According to analyses made in Cuba and Honduras.

Amino Acids: (shown in Cuban analyses)

Tryptophan	3.0 mg
Methionine	2 mg
Lysine	26 mg

Other amino acids reported by the Florida Citrus Experiment Station at Lake Alfred and expressed in micromoles per g in mature green fruits (higher) and mature yellow fruits (lower), respectively, are:

Asparagine	0.82-0.64
Threonine	0.92-0.79
Serine	3.88-2.00
Glutamic Acid	2.41-1.80
Proline	0.23-0.09
Glycine	0.20-0.10
Alanine	5.40-1.26
Valine	0.17-0.11
Isoleucine	0.03-trace
Leucine	trace
Phenylalanine	trace
Gamma Amino Bytyric Acid	0.77-0.55
Ornithine	0.11-0.13
Histidine	trace

**Analyses in India showed 10.40 mg ascorbic acid in the juice of a "sweet" variety; 15.4 mg in juice of a sour variety. Ascorbic acid content of both waxed and unwaxed fruits stored at 50º F (10º C) has been reported as 20 mg/100 ml of juice. Waxed fruits stored for 17 days at 60º F (15.56º C) had 11 mg/100 ml of juice. Unwaxed fruits had lost ascorbic acid.

Food Uses[21,22]

Ripe carambolas are eaten out-of-hand, sliced and served in salads, or used as garnish on avocado or seafood. They are also cooked in puddings, tarts, stews and curries. In Malaya, they are often stewed with sugar and cloves, alone or combined with apples. The Chinese cook carambolas with fish. Thais boil the sliced green fruit with shrimp. Slightly underripe fruits are salted, pickled or made into jam or other preserves. In mainland China and in Taiwan, carambolas are sliced lengthwise and canned in sirup for export. In Queensland, the sweeter type is cooked green as a vegetable. Cross-sections may be covered with honey, allowed to stand overnight, and then cooked briefly and, put into sterilized jars. Some cooks add raisins to give the product more character. A relish may be made of chopped unripe fruits combined with horseradish, celery, vinegar, seasonings and spices. Indian experimenters

boiled horizontal slices with 3/4 of their weight in sugar until very thick, with a Brix of 68º. They found that the skin became very tough, the flavor was not distinctive, and the jam was rated as only fair. Sour fruits, pricked to permit absorption of sugar and cooked in sirup, at first 33º Brix, later 72º, made an acceptable candied product though the skin was still tough. The ripe fruits are sometimes dried in Jamaica.

Carambola juice is served as a cooling beverage. In Hawaii, the juice of sour fruits is mixed with gelatin, sugar, lemon juice and boiling water to make sherbet. Filipinos often use the juice as a seasoning. The juice is bottled in India, either with added citric acid (1% by weight) and 0.05 % potassium metabisulphite, or merely sterilizing the filled bottles for 1/2 hr in boiling water.

To make jelly, it is necessary to use unripe "sweet" types or ripe sour types and to add commercial pectin or some other fruit rich in pectin such as green papaya, together with lemon or lime juice.

The flowers are acid and are added to salads in Java; also, they are made into preserves in India. The leaves have been eaten as a substitute for sorrel.

Other Uses

The acid types of carambola have been used to clean and polish metal, especially brass, as they dissolve tarnish and rust. The juice will also bleach rust stains from white cloth. Unripe fruits are used in place of a conventional mordant in dyeing.

Wood: Carambola wood is white, becoming reddish with age; close-grained, medium-hard. It has been utilized for construction and furniture.

Medicinal Uses: In India, the ripe fruit is administered to halt hemorrhages and to relieve bleeding hemorrhoids; and the dried fruit or the juice may be taken to counteract fevers. A conserve of the fruit is said to allay biliousness and diarrhea and to relieve a "hangover" from excessive indulgence in alcohol. A salve made of the fruit is employed to relieve eye afflictions. In Brazil, the carambola is recommended as a diuretic in kidney and bladder complaints, and is believed to have a beneficial effect in the treatment of eczema. In *Chinese Materia Medica* it is stated, "Its action is to quench thirst, to increase the salivary secretion, and hence to allay fever."

A decoction of combined fruit and leaves is drunk to overcome vomiting. Leaves are bound on the temples to soothe headache. Crushed leaves and shoots are poulticed on the eruptions of chicken-pox, also on ringworm.

The flowers are given as a vermifuge. In southeast Asia, the flowers are rubbed on the dermatitis caused by lacquer derived from *Rhus verniciflua* Stokes.

Burkill says that a preparation of the inner bark, with sandalwood and *Alyxia sp., is* applied on prickly heat. The roots, with sugar, are considered an antidote for poison. Hydrocyanic acid has been detected in the leaves, stems and roots.

A decoction of the crushed seeds acts as a galactagogue and ernmenagogue and is mildly intoxicating. The powdered seeds serve as a sedative in cases of asthma and colic.

Risks

Carambola contains oxalic acid, which can be harmful to individuals suffering from kidney failure, kidney stones, or those under kidney dialysis treatment. Consumption by those with kidney failure can produce hiccups, vomiting, nausea, and mental confusion. Fatal outcomes have been documented in some patients.

Drug interactions

Like the grapefruit, carambola is considered to be a potent inhibitor of seven cytochrome P450 isoforms. These enzymes are significant in the first-pass elimination of many medicines, and, thus, the consumption of carambola or its juice in combination with certain medications can significantly increase their effective dosage within the body. Research into grapefruit juice has identified a number of common medications affected, including statins, which are commonly used to treat cardiovascular illness, and benzodiazepines (a tranquilizer family including diazepam).

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