



PHYTOCHEMICAL AND PHARMACOLOGICAL PROFILE OF *AVERRHOA CARAMBOLA* LINN: AN OVERVIEW

Gheewala Payal, Kalaria Pankti, Chakraborty Manodeep*, Kamath Jagadish V
Department of Pharmacology; Shree Devi College of Pharmacy, Mangalore-574142 Karnataka, India

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*E-mail: manodep.chakraborty@gmail.com

ABSTRACT

Herbal medicines and their application have always been the basis for man's curiosity from the time immemorial. *Averrhoa carambola* Linn, commonly known as Kamrakh or Golden Star, is undoubtedly one of the most unique creations of nature grown widely in the tropics and the warmer areas of subtropics. *Averrhoa carambola* is reported to contain mainly saponins, flavonoids, tannins and alkaloids. It is used as a well known remedy for the treatment of a number of manifestations in Ayurvedic as well as folklore systems of medicine. In Ayurveda, *Averrhoa carambola* finds use as an anti-helminth, anti-malarial, antipyretic, digestive tonic, febrifuge, antiscorbutic and antidote for poison. It is considered as one of the best Indian cooling medicines. These properties are believed to be mediated by different phytochemicals found in the plant, acting singly or in concert. A relatively large number of scientific publications on *Averrhoa carambola* have been published in recent years, including a number of research articles. The goal of this review is to provide an updated categorization of the phytochemical constituents along with the comprehensive list of known ethno-botanical uses, common names and a brief summary of relevant pharmacological activities of this plant.

Key words: *Averrhoa carambola*, Oxalidaceae, Phytochemical constituents, Pharmacological activities.

INTRODUCTION

Nature always stands as a golden mark to exemplify the outstanding phenomena of symbiosis¹. Herbs are staging a comeback and herbal renaissance is happening all over the world². In the western world, as the people are becoming aware of the potency and side effects of synthetic drugs, there is an increasing interest in the natural product remedies with a basic approach towards the nature. Herbal medicines as the major remedy in traditional system of medicine have been used in medical practices since antiquity. The practices continue today because of its biomedical benefits as well as place in cultural beliefs in many parts of world and thus have made a great contribution towards maintaining human health¹. *Averrhoa carambola* generally called starfruit is an attractive, slow growing evergreen tree that belongs to Oxalidaceae family. It is believed to have originated in Ceylon and Moluccas but has been cultivated in Southeast Asia and Malaysia for many centuries. It is commonly grown in Southern China, Taiwan and India. It is rather popular in the Philippines and Queensland, Australia, and moderately in some of the South Pacific islands³. In the present review, an attempt has been made to congregate the botanical, phytochemical, ethnomedicinal and pharmacological information on *Averrhoa carambola* Linn.

Scientific Possession

The species in the genus *Averrhoa* are the only woody, tree-like plants belonging to the Oxalis family Oxalidaceae. The Oxalis family has nearly 900 species; most are herbaceous perennials or annuals native from tropical and semitropical locations though a number also grow in other parts of the world. *Averrhoa* has sometimes been placed in the family Averrhoaceae. The genus *Averrhoa* contains two species: Bilimbi (*Averrhoa bilimbi* L.) and Carambola (*Averrhoa carambola* L.). *Averrhoa carambola* is considered most important between the two species⁴. The generic name is after Averroes, the widely known Arabian physician, astronomer and Philosopher of 12th century. The specific name 'carambola', is said to have come from Malabar and was adopted early by the Portuguese⁵.

Common Names

Averrhoa carambola L. has travelled sufficiently to have acquired a number of regional names all over the world and in different parts of India which are depicted in table no.2^{6,7}.

Botanical Description

Averrhoa carambola tree is a slow growing, short trunked with a much branched, bushy, broad, rounded crown and reaches upto 6-9m in height. It grows on its best if the climatic condition is wet, humid and distinct dry. It likes a well-drained, clay-loam soil with a pH of 5.5-6.5 and can withstand some water logging. It cannot tolerate drought conditions or salt⁸.

Bark

The bark is light brown, smooth or finely fissured.

Leaves

Its deciduous leaves, spirally arranged, are alternate, imparipinnate, with 5 to 11 nearly opposite leaflets, ovate or ovate-oblong, 1 1/2 to 3 1/2 in (3.8-9 cm) long. The leaves are soft, medium-green, and smooth on the upper surface, finely hairy and whitish on the underside. The leaflets are sensitive to light and more or less inclined to fold together at night or when the tree is shaken or abruptly shocked.

Flowers

Small clusters of red-stalked, lilac, purple-streaked, downy flowers, about 1/4 in (6 mm) wide, are borne on the twigs in the axils of the leaves.

Fruits

The fruit is green when small and turns yellow or orange when ripe. The fruit is fleshy, five lobed, ovate to ellipsoid that ranges from 5-8 cm long and 9 cm wide. The fruits are very fragile and are susceptible to wind scarring while growing on tree. The skin is thin, light to dark yellow and smooth with a waxy cuticle. The fruit is crunchy, and has a slightly tart, acidic, sweet taste, reminiscent of pears and apples. The flesh is light yellow to yellow, translucent, crisp and very juicy without fibre.

Seeds

Each cell of fruit contains no more than 5 seeds and sometimes none. Seeds are edible, 0.6-1 cm long, thin, light

brown and enclosed by a gelatinous aril. Seeds lose viability in a few days after removal from fruit⁹.

Averrhoa carambola is easily propagated from fully developed seeds. In damp peat moss, they will germinate in one week in summer; require 14 to 18 days in winter. The seedlings are transplanted to containers of light sandy loam and held until time to set out. They are very tender and need good care¹⁰.

Microscopic study of the powdered fruit of *Averrhoa carambola* L. revealed the presence of simple trichomes, parenchymatous cells, tannin filled cells, collenchymatous cells, sclerenchymatous fibres¹¹.

Traditional Uses

Fruits

In India, the ripe fruit or its juice may be taken to counteract fever. A slave made of the fruit is employed to relieve eye afflictions. In Brazil, the carambola is recommended as diuretic in kidney and bladder complaints. In Chinese Materia Medica it is used to quench thirst, increase the salivary secretion and hence to allay fever. In Ayurveda, the ripe fruit is considered as digestive, tonic and causes biliousness. The dried fruit is also used in fever; it is cooling and possesses antiscorbutic properties. It is considered as one of the best Indian cooling medicines. Fruits and its fruit juices are used as astringent and antioxidant¹¹. The fruits are also used for the treatment of throat inflammation, mouth ulcers, toothache, cough, asthma, hiccups, tight feeling in chest, nausea, vomiting, indigestion, food poisoning, colic, diarrhoea, jaundice, malarial splenomegaly and ascites.

Leaves

The crushed leaves or shoots are applied externally in the treatment of chickenpox, ringworms, tinea, cold and headache. Tea of boiled leaves is also used to relieve aphthous stomatitis and angina. A mixture of the leaves and the fruits can be used to arrest vomiting and to treat fever. Moreover, leaves also find use in treating chronic conditions like oliguria, boils and pyodermas, postpartum edema, gastroenteritis and traumatic injury^{12, 13}.

Flowers

The boiled flowers are used as an antihelmintic, in fever, subcalorism and malaria. The flowers are added to salads in Java; also, they are made into preserves in India¹³.

Roots

The roots of *Averrhoa carambola* are used to treat arthralgia, chronic headache, epitaxis and spermatorrhea. The roots with sugar are considered to be an antidote for poison¹³.

Seeds

A decoction of the crushed seeds acts as a galactagogue and emmenagogue and is mildly intoxicating. The powdered seeds serve as a sedative in cases of asthma and colic¹².

Edible property

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 Queensland, the sweeter type is cooked green as a vegetable. A relish may be made of chopped unripe fruits combined with horseradish, celery, vinegar, seasonings and spices. 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. Fresh fruits of carambola are also used for the preparation of jellies⁸.

Miscellaneous uses

Acid type carambola dissolves tarnish and rust, occasionally used for cleaning and polishing metals. Fresh juice of the fruit is used to remove stains from clothing and other articles. Unripe fruit of *Averrhoa carambola* contains potassium oxalate, which is used in dyeing⁸.

Phytochemistry

Preliminary phytochemical analysis indicated the presence of saponins, alkaloids, flavonoids and tannins¹¹. Further investigations have shown that the fruit of *A. carambola* is rich in antioxidants, especially polyphenoloxidase, proanthocyanidins, epicatechin and vitamin C¹⁴. Investigations characterizing the secondary metabolites of *A. carambola* have identified two O-glycosyl flavonoid components such as quercetin-3-O- β -d-glucoside and rutin¹⁵. Other compounds indentified included the following: β -sitosterol, lupeol, anthraquinone glucoside¹⁶, cyanidin-3-O- β -d-glucoside, cyanidin-3,5-O- β -d-diglucoside¹⁷, β -amirin¹⁸ and C-glycoside flavones, such as apigenin-6-C- β -l-fucopyranoside and apigenin-6-C-(2-O- α -l-rhamnopyranosyl)- β -l-fucopyranoside. This latter compound is also known a carambolaflavone¹⁹. Edible portion of the fruit is a good source of reducing and non-reducing sugars, minerals, volatile flavours, tannins, dietary fibres, pectin, cellulose, hemicelluloses, iron, calcium, phosphorous and carotenoid compositions⁴. Presence of p-Anisaldehyde, 5-hydroxymethyl-2-furfural, gallic acid and dihydroabscissic alcohol in the stem bark of *A. carambola* has also been noted. Studies also suggest the presence oxalic acid, tartaric acid, α -ketoglutaric acid and amino acids in fruits as well as in fruit extract of *Averrhoa carambola*²⁰.

Pharmacological Activities

Anti-inflammatory activity²¹

Anti-inflammatory activity was measured using a croton oil-induced ear edema model of inflammation in mice. Topically applied ethanolic extract of *Averrhoa carambola* leaves reduced edema in a dose-dependent manner, resulting in a maximum inhibition of $73 \pm 3\%$ and an ID₅₀ value of 0.05 (range: 0.02–0.13) mg/ear. Myeloperoxidase (MPO) activity was also inhibited by the extract, resulting in a maximum inhibition of $60 \pm 6\%$ (0.6 mg/ear). All of the fractions tested caused inhibition of edema formation and of MPO activity. Treatment with the ethyl acetate fraction was the most effective, resulting in inhibition levels of 75 ± 5 and $54 \pm 8\%$ for edema formation and MPO activity, respectively.

Antimicrobial activity²²

Averrhoa carambola fruit was evaluated for its antimicrobial activity. Fruit extracts at various stages of ripening (young, half ripe and full ripe) prepared in different organic solvents, were screened for antimicrobial activity against Gram positive bacteria (*Staphylococcus aureus* ATCC 6538P and *Bacillus cereus* ATCC 11778) and three Gram negative bacteria (*Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 19429 and *Streptococcus typhimurium* ATCC 23564). Young, Half ripe and full ripe stages of fruit showed different degree of activity against Gram positive and Gram negative bacteria. Methanol and acetone extracts were considerably more effective than other solvent extracts in inhibiting the Gram-positive micro-organisms better than Gram negative microorganisms.

Hypoglycaemic activity²³

Several insoluble fiber-rich fractions (insoluble dietary fiber, alcohol-insoluble solid and water-soluble solid) isolated from the pomace of *Averrhoa carambola* possessed potential hypoglycaemic effects as demonstrated by a study on several in vitro methods. The fibers could effectively absorb glucose, retard glucose diffusion, postpone the release of glucose from starch and inhibit α -amylase activity to certain extent. All of these mechanisms might create a concerted function in lowering the rate of glucose absorption and as a result decrease the postprandial serum glucose concentration. Our results revealed that the hypoglycemic effects of these insoluble FRFs were significantly ($P < 0.05$) stronger than that of cellulose. Therefore, it was suggested that they could be incorporated as low-calorie bulk ingredients in high-fiber foods to reduce calorie level and help control blood glucose concentration.

Antioxidant activity²⁴

The analysis of polyphenolic antioxidants in star fruit by liquid chromatography and mass spectrometry was performed on the fruit juice and residue extract. The peaks were mainly antioxidants which were mainly attributed to phenolic compounds. They were characterised as L-ascorbic acid, (-)epicatechin, gallic acid gallotannin forms and proanthocyanidins. The residue of the star fruit, which is normally discarded during juice drink processing, was further found to contain much higher antioxidant activity than the extracted juice. It is also showed strong antioxidant activity in delaying oxidative rancidity of soya bean oil at 110°C. This property of *Averrhoa carambola* residue extract powder would be of health benefit and suggests great commercial potential as nutraceutical resource or functional food ingredient.

Hypocholesterolaemic and hypolipidaemic activities²⁵

Water-insoluble fiber-rich fraction (WIFF) isolated from the pomace of star fruit showed hypocholesterolaemic and hypolipidaemic activities. Investigations in hamsters showed pronounced cholesterol- and lipid-lowering effects of WIFF which might be attributed to its ability to enhance the excretion of cholesterol and bile acids via the faeces. It decreases the serum concentrations of triacylglycerol, total cholesterol, and liver cholesterol and increases the concentration of total lipids, cholesterol and bile acids in faeces.

Metabolic effects on enzyme²⁶

Inhibition of midazolam 1-hydroxylase activity of human CYP3A by filtered extracts of various tropical fruits was examined. The results showed that among the tropical fruit juices tested, starfruit juice showed the strongest inhibition. The addition of star fruit juice (5.0%, v/v) caused the almost complete inhibition of midazolam 1-hydroxylase activity of human CYP3A (0.1%). The reproducibility of the effects of star fruit juice to inhibit CYP3A activity was examined irrespective of the timing of the purchase of the star fruits, the period from purchase of the fruit to preparation of the juice, and the shops from which the star fruits were obtained, the same extents of inhibition of CYP3A activity by the respective star fruit juices were observed. Inhibition depended on the amount of fruit juice added to the reaction mixture (0.2 to 6.0%, v/v)

Anti ulcer effect²⁷

In this study, *Averrhoa carambola* extract prevented acute, gastric mucosa injury induced by ethanol-acid method; at doses of 800 and 1200 mg/Kg, p.o., the protective action was

produced at a highest, but not a lowest dose of the extract. In phytochemical studies of plants with antiulcer properties, activity due to the presence of triterpenes, flavonoids, and mucilage was observed. As *Averrhoa carambola* extract contains these constituents, the partial anti-ulcer activity could be due their effects. On the other hand, the mucilage present in *Averrhoa carambola* extract could act directly to protect the gastric mucosa, avoiding gastric damage induced by necrotizing agents.

CONCLUSION

Averrhoa carambola is a plant with diverse potentials. The wide spectrum of phytochemicals bottled up in various parts of the plant makes it ideal for nutritional and medicinal uses which could help in salvaging the mankind from the present burden of diseases. Numerous phytochemical and pharmacological studies have been conducted on different parts of *Averrhoa carambola*. However most of the work done so far has not been followed up in such a way to clear scientific doubts and determine active principles and mechanism of action. In view of the nature of plant more research can be done to investigate the unexplored and unexploited potential of the plant. Only such research would place *Averrhoa carambola* in its proper place in nutritional and medical sciences.

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Table 1: TAXONOMICAL CLASSIFICATION OF *AVERRHOA CARAMBOLA*¹²:

Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Geraniales
Family	Oxalidaceae
Genus	<i>Averrhoa</i> L.
Species	<i>Averrhoa carambola</i> L.

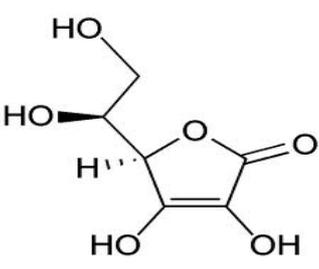
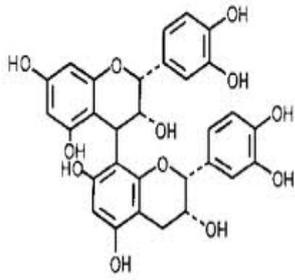
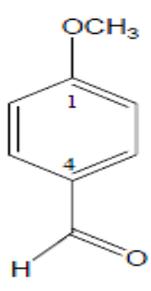
Table 2: DIFFERENT VERNACULAR NAMES OF *AVERRHOA CARAMBOLA*^{6,7}:

Language (India)	Name	Country	Name
Sanskrit	Karmaranga	Indonesia	Belimbing
Hindi	Karmal	Phillipines	Saranate
Gujarati	Kamrakha	France	Carambolier
English	Chinesegooseberry	Florida	Arkin
Tamil	Tamarattai	Thailand	Ma fueang
Bengali	Kamranga	Brazil	Caramboleiro
Malayalam	Caturappuli	Mexico	Carambolera
Assamese	Kordoi/Rohdoi	Vietnam	Khe ta

Table 3: NUTRITIONAL VALUE OF *AVERRHOA CARAMBOLA* (per 100 gram)²⁸:

Sr.no	Component	Per 100g edible portion	Sr. no	Component	Per 100g edible portion
1.	Food energy	24.0 calories	8.	Ash	0.4 g
2.	Phosphorous	15.5-20 mg	9.	Calcium	7.0 mg
3.	Moisture	92.0 g	10.	Iron	0.4 mg
4.	Protein	0.7g	11.	β-carotene	155.0 µg
5.	Fat	0.1g	12.	Vitamin B ₁	0.1 mg
6.	Carbohydrate	5.0 g	13.	Vitamin B ₂	0.1 mg
7.	Fiber	1.8 g	14.	Vitamin C	25.8 mg

Table 4: PHYTOCONSTITUENTS OF *AVERRHOA CARAMBOLA*

		
Ascorbic acid	Proanthocyanidin	p-anisaldehyde



1(a)



1(b)



1(c)



1(d)

Fig: 1(a,b,c,d) representing the fruit, flower, leaves and bark of *Averrhoa carambola*.