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REVIEW ARTICLE **OPEN ACCESS**

Exploring The Exquisite Averrhoa Carambola: A Comprehensive Review

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ABSTRACT

Traditionally, medicines obtained from medicinal plants are used by 75-80 percent of people worldwide. This review focuses on an herbal drug named Averrhoa carambola (AC), one of the evergreentrees grown mostly in tropical and sub-tropic regions. Averrhoa carambola contains mainly flavonoids, tannins, saponins, and alkaloids. It can be eaten raw or used to make juices, salads, pickles, clean utensils, construction, and furniture. The whole tree has manymedicinal values like anti-inflammatory, analgesic, antioxidant, anti-ulcer, anti-tumor, hypotensive, antimicrobial, anti-obesity, Alzheimer's, and hepatoprotective activities.

Keywords: *Star fruit, kamrakh, anti- oxidant, anti-microbial, anti-inflammatory.*

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INTRODUCTION

About 75–80 percent of people worldwide still heavily rely on herbal remedies. Herbal medicines have consistently maintained popularity because of their historical and cultural components, wider social acceptance, improved applicability for use with humans, and fewer side effects. Traditional medicine and the traditional healthcare system have a long history in India. Due to the recent rise in the utilization of herbal drugs, India has an excellent chance to look for therapeutic chemical entities from a traditional healing system [1]. Due to its unusual shape, the Averrhoa species (Oxalidaceae), historically known as "kamrakh"is called star fruit. The starfruit plant is a member of the genus Averrhoa, which involves the species Averrhoa carambola, Averrhoa bilimbi, Averrhoa dolichocarpa, Averrhoa leucopetala, and Averrhoa microphylla [2]. The most notable species is Averrhoa carambola, which is widely grown for commercial purposes. Carambola is derived from the Sanskrit term Karmaranga, which means "meal appetizer". It is a fruit broadly consumed in South-East Asian countries, both tropical and sub-tropical. Star fruits are also widely grown in Australia, Brazil, China, Florida, Queensland, Malaysia, Taiwan, Thailand, Israel, several South Pacific Islands, Philippines. It is frequently observed in India's warmer regions, mainly in the southern states and west coast, which stretches from West Bengal to Kerala. Tropical fruit with a star-like form and a sweet and sour flavor is called starfruit [3]. It can consume the star fruit raw or used to make juices, salads, or pickles. It can be used to clean utensils because it aids in the removal of rust caused by iron oxidation. Starfruit wood is used in construction and furniture [4]. Averrhoa carambola has numerous medicinal applications and contains secondary metaboliteswith a broad spectrum of biological roles. The fruit was used in traditional medical practice to treat cough, food-borne, mouth sores, splenomegaly, arthralgia, severe headache, nose bleed, spermatorrhoea, heats, flus, stomach flu, decreased urination, postpartum edema, ulcers,severe injury, fever, malaria, sub-calorism, among other conditions. Major peripheral and central analgesic action was present in the AC fruits [5,6 &7].

Fig 1: Morphology of Averrhoa carambola [8]

ORIGIN AND DISTRIBUTION

Ceylon and the Moluccas are thought to be the origins of the AC. It can tolerate growing in sub-tropical regions like Israel and Egypt, hot, humid tropics, and also short times of extremely cold temperatures as less as 3°C. It can also withstand growing in latitudes varyingfrom 32°N to 30°S and withhold pH ranges between 5 and 8.5. It needs well soil conditions with a pH between 5.5 & 6.5. It has recently become widely available and grown in most of the world's nations, including in Asia like India and China, Africa like Tanzania, North America like Mexico, Oceania like Australia, French and South America like Brazil [9&10].

BOTANICAL DESCRIPTION

AC is a slow-growing, pretty, small, appealing, multi-stemmed evergreen tree, seldom reaching a height of 10 meters, spreading 20 to 25 feet in circumference, and having a bushy appearance with several branches that create a broad, rounded crown. The trunk's diameter at the base is 15 cm. The AC shrub produces small clusters of five-petalled red, lilac, or purple blooms.

Leaves: They are organized in 15 to 25 cm long, alternative spiral, imparipinnate, ovate obtrullate, deciduous leaves that include 5 to 11 green pedant leaflets that are 2 to 9 cm long and 1 to 4.5 cm wide. The compound leaves are smooth on the upper surface, medium-green, pubescent, soft, and white on the dorsal surface. The leaves are sensitive to sudden shocks and react to light. They also tend to fold together at night. About 15 cm long, pinnate leaves are present. Smooth, oblong to oval-lanceolate, and commonly found in pairs, the upper leaflets are around 5 cm long, and the lower ones are shorter [11].

Flowers: Red and white flowers will bloom on bare branches or at the bases of leaves. The flower is tiny and has a purple hue. It has five petals, five sepals, and five stamens. Under the style is wherethe ovary is located. Twigs and branches are formed along with their trunk [12].

Fruits: They are oblong-shaped, fleshy, have longitudinal angles of 5 to 6 degrees, are 5 to 15 cm long, and can be broad up to 9 cm. They have a crisp, crunchy texture and are shaped like stars when cut crosswise. The smell of the fruits is similar to that of oxalic acid, and they can taste very sour, mildly sweet, or sweet. Smooth, juicy, crispy, and sweet but sourish-tasting describethe flesh. The fruit is green when young and unripe, and when grown and ripened, it starts turning yellowish-orange [13].

Bark: The bark is smooth or finely fissured, and it is light brown.

Seeds: There are approximately 12 cm flat, 5 cm in length seeds, thin, or there could be none at all. After being removed from the fruit, the brown-coloured seeds lose viability within a few days due to the gelatinous aril surrounding them. Starfruit seeds that are fully developed can be easily multiplied [14].

Microscopic analysis: The transverse section's outline resembles a star. The pericarp exhibits the two distinct regions such as the exocarp is the fruit's protective covering and comprises up to four layers of sub-epidermal collenchyma and thin rectangular cells with trichomes in fresh-faced and mature fruits. When the fruit is young, the endocarp is made with several layers of thin, closely packed parenchymatous cells; when the fruit is mature, the endocarp has massive, lysogenously formed cavities and a poorly developed vascular system. Simple trichomes, tannin-filled cells, parenchymatous cells, sclerenchymatous fibres, and collenchymatous cells were all visible in the powdered fruit of AC [15].

CULTIVATION [16,17&18]

AC should be classified as a tropical and subtropical plant that can endure 2.78°C in temperature for a short time. In Israel's interior valley, all trees gave in to the typically hot, dry winds. AC requires moisture to performat peak levels, and rain is ideal for their growth. Old trees are much more resistant to cold because their growth ceases at between 55 and 60 degrees, and extended exposure to temperatures. At 27°F (-

2.78°C), mature trees could endure freezing conditions for a short period with little damage.AC grows most successfully to 4,000 feet in altitude (1,200 m). Starfruit doesn't require any specific soil types to grow well. Rich loam, heavy clay, limestone, and sand are all effective. It prefers a pH between 5.5 and 6.5 soil and delicate to waterlogging. The most crucial techniques for AC propagation are:

- Air layering/marcotting/gotee
- Grafting-bud grafting/wedge grafting.

To perform at its best, the AC needs irrigation. This calls for consistent watering throughout the summer and even during dry spells in the winter. Depending on the blooming cycle, AC is harvested from June till February. No tree bears fruit during this time, but different trees will reach maturity at differentpoints. The busiest harvesting months are August to October and December to February. It is time to manually harvest star fruit if the fruit turns yellow in star shape grooves. Only two to five days at room temperature are recommended for starfruit. Additionally, you can keep them in the fridge for up to two weeks.

CHEMICAL CONSTITUENTS

AC mainly consists of flavonoids, tannins, saponins, alkaloids, epicatechin, gallo tannin, pro-anthocyanidins, and L-ascorbic Acid were also discovered in the fruit. According to reports, sitosterol, camp sterol, lupeol, and isofucosterol are the main sterols in AC fruits. The fruits also contain important plant fatty acidssuch as palmitic, oleic, linoleic, and linolenic acids. O-glycosyl flavonoid components like quercetin-3-o-d glycoside and rutin have been discovered in AC. The portions of AC are a good source of dietary fibre, minerals, volatile flavours, tannins, reducing and nonreducing sugars, pectin, cellulose, hemicelluloses, iron, calcium, phosphorus,and carotenoid compounds [19].

PHARMACOLOGICAL ACTIVITIES

Anti-oxidant: The anti-oxidant action of star fruit leaves sourced from Depok, Sukabumi, and Subang in three Indonesian provinces was examined. It was examined to see if there is any relation between the highest anti-oxidant activity fraction and the content of phenols and flavonoids. According to the FRAP and DPPH assays of 70% ethanolic extracts, AC leaves of the Subang region had better anti-oxidant activity in ethyl acetate fraction (FeEAC value is 1405 mol/g and IC_{50} is 96.077 g/ml). This fraction contains 61.3 mg of gallic acid equivalent/g of total flavonoid content and 2491.1 g ofthe rutin equivalent/g of the total phenolic content. In the ethyl acetate fraction, there is no association between antioxidant activity and the total phenols or flavonoid content[20].

Anti-alzheimer: Based on the research, DMDD could help Alzheimer's patients with their memory problems, and neuronal apoptosis is assessed. DMDD inverted the deficiencies in spatial memory and learning, cell death, and nerve cell loss in the hippocampal region in the APP/PS_1 of transgenic mice. A1-42 apoptosis in PC12 cells as well as loss of the mitochondrial membrane potential, the induction of the pro-apoptotic protein (Bax) and the reduction of the anti-apoptotic protein Bcl-2, as well as the activation of Caspase-3 and -9. DMDD offered a defense against these outcomes. The Bcl-2/Bax ratio was elevated in PC12 in-vitro cells and APP/PS1 mouse model in-vivo with DMDD pre-treatment. The study's conclusions suggest that DMDD may aid in treating the memory and learning deficits observed in the APP/PS_1 transgenic Alzheimer's mice [21].

Anti-obesity: AC effectively inhibited adipocyte differentiation in 3T3-L1 preadipocytes and was investigated as a possible treatment for obesity and diseases associated with AC. It was found that this suppression is likelycaused by the bioactive compound (-)-epicatechin. The mode of (-)-epicatechin binding to thetarget receptor was determined through the computational molecular docking studies, whichalso took into account the most likely mechanism resulting in the overall inhibition of adipocyte differentiation. Genetic expression studies had demonstrated previously that the instantaneousdecreased expression of a C/EBP and PPAR and the increased expression of PPAR receptor genes gave rise to an adipogenic activity of AC extract [22].

Anti-tumor: Swiss albino mice that have either been given CCl_4 (1.6 g/kg body weight in corn oil 3 times/week for 24 weeks), diethyl nitrosamine (DENA)-induced liver cancer (15mg/kg body wt.; single I.P. injection), or liver cancer that has been previously caused by diethyl nitrosamine (DENA) and given the fruit of AC extract (also ACE wasgiven orally five days in a row at a dose of 25 mg/kg body weight each day, and it was then stopped 48 hours before the initial DENA administration (preinitiation stage). CCl_4 was administered after DENA for two weeks. While no tumor occurrence was seen in animals subjected to carcinogens, ACE administration significantly reduced tumor occurrence, cancer cell yield, and tumor burden. In a carcinogen-treated control, the ACE treatment caused a significant reduction in the

peroxidation (P< 0.001) as well as an increase in the activity of catalase, reduced glutathione, and nonenzymatic antioxidants like superoxide dismutase and total proteins (P< 0.001). These results showed that AC extract prevented the harmful physical and bio-chemical modifications of DENA/CCl4-induced hepato-carcinogenesis in mouse models [23].

Anti-microbial: AC ethanolic extracts phytochemical profile, total phenol content, antioxidant (AAO%) content, and antimicrobial potential. The qualitative evaluation of the chemical constituents and a quantitative evaluation of the phenol content were conducted, and the Folin-Ciocalteu test was used. Qualitative and quantitative antioxidanttests were performed using DPPH (2,2 diphenyl-1-picrylhydrazila) and iron reduction(FRAP). The minimal inhibitory concentration (MIC) was established within 96-well plates using micro-dilution. Steroids, saponins, and pyrogallic tannins have all been discovered occur. Fruit and stem bark samples had the highest total phenol levels (0.0734 mg EAG/g and 0.0866 mg EAG/g, respectively). The antioxidant assessment used an extract of AC (AAO%) was found to be 71.9%. For leaf extracts, MICs of 100 g/mL have been demonstrated [24].

Hepato-protective: AC root extract (EACR) in mice with acute hepatic injury by carbon tetrachloride (CCl_4). For seven days, Normal Saline and the recommended course of treatment were given intra-gastrically (i. g.). Except for thenormal group, all mouse groups received intraperitoneal injections of 0.15% CCl_4 to create an acute liver injury model as well as measure the levels of the liver tissue superoxide dismutase(SOD), glutathione (GSH), malondialdehyde (MDA) and glutathione peroxidase (GSH-Px), the serum concentrations of the enzymes alanine aminotransferase (AST), aspartate transaminase (ALT) and interleukins (IL-1, IL-6) were measured. The expression of proteins like caspase-3, nuclear factor-kappa B(NF-kB), and TNF-α were evaluated using Western blot analysis. The histopathological changes were discovered using HE staining. Following EACR treatment, the levels of ALT, AST, IL-1, IL-6, and MDA within the liver reduced significantly while the activities of GSH, SOD, and GSH-Px increased, and the protein expressions of the TNF-alpha, NF-kB, and caspase-3 were all significantly decreased in the EACR groups. Additionally, HE staining showed that liver damage was reduced after taking EACR. The conclusion was given as EACR can be hepatoprotective [25].

Anti-ulcer: The alcohol-water (1:1) extract of the leaves of AC was found to possess significant, dose-dependent anti-ulcer activity against damage to the gastric mucosa brought on by the ethanol-acid method. The protective effect was produced at the higher dose of the extract but not at the lowest. AC extract contains flavonoids, triterpenoids, and mucilage, all linked to some degree of anti-ulcer activity [26].

Analgesic: In the Swiss-Albino mice acetic acid-induced writhing model, the AC fruit showed significant peripheral and central analgesic activities and inhibitedwrithing by 37.1% and 42.75%, respectively. Upon oral dosages of 200 and 400 mg/kg body weight, the crude extract prolonged the tail flicking time of 1 hour by 33.65% & 40.88%, respectively, in the thermal radiation flick test [27].

Anti -inflammatory: The anti-inflammatory effects on skin inflammation of twoisolated flavonoids, their ethyl acetate, hexane, and butanol fraction, and also in the ethanolic extract of AC. Ear edema in a mouse model of Croton oil-induced Inflammation was used to gauge the anti-inflammatory activity. Applying ethanolic extract topically reduced edema in a dose-dependent manner, with a higher inhibition of 73% and an ID_{50} value of 0.05 (0.03-0.1mg/ear). A maximum of 60% (0.6mg/ear) inhibition of myeloperoxidase (MPO) activity had also inhibited by the AC extract. Everyfraction tested inhibited the MPO action and the development of edema. Following treatment with ethyl acetate fraction, the MPO action and edema formation was reported to inhibit at 75.5 and 54.8 %, respectively. Apigenin-6-C-(2′′-O rhamnopyranosyl)-l- fucopyranoside had slightly reduced the edema formation rate (28.1%). Collectively, these preliminary results provide evidence for the broadly used anti-inflammatory activity of AC, and there were new possibilities for its use in treating skin conditions[28].

Anti-hyperglycemic: This investigation looks into the mechanisms underlying the potential influence of EACR on diabetic mice given streptozotocin (STZ). And through the tail vein, male mice were administered 120 mg/kg of STZ. The mice were categorized as hyper-glycemic mouse models once their blood glucose levels reached or fell below 11 mmol/L.The mice were given metformin (320 mg/kg /day) and EACR (150, 300, 600, and 1200 mg/kg/day) intra-gastrically for 3 weeks. The results demonstrated that EACR significantlyincreased serum insulin levels while decreasing serum levels of glucose, triglycerides, free fatty acids, and total cholesterol[29].

CONCLUSION

Traditional herbal remedies and holistic health practices are beginning to play a significant complementary role in preventing and treating modern civilization's passive illnesses.The World Health Organization (WHO) has advised that traditional health and folk medicine systems be incorporated with modern medical

therapies to address health issues worldwide more effectively, realizing the importance of broadening the Western medical perspective. In India, AC fruit is easily obtainable. The plant appears to possess a wide range of therapeutic effects on many diseases. The primary phytoconstituents found in the plant, which are said to be responsible for the effects, are flavonoids, alkaloids, tannins, and saponins. Various plant parts possess antioxidant, analgesic, anti-inflammatory, hypoglycemic, hepatoprotective, antimicrobial, and anti-ulcer activity.

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CONFLICT OF INTEREST

This article entitled Exploring the Exquisite Averrhoa Carambola: A Comprehensive Review is herewith submitted for publication. It has not been published before, and it is not under consideration for publication in any other journal(s).

REFERENCES

1. Dasgupta P, Chakraborty P, Bala. N.N. (2013). Averrhoa Carambola: An Updated Review. International Journal of Pharma Research & Review; 2(7):54-63.
2. Hansraj Manda, Kapil Vyas, Ankur Pandya, Gaurav Singhal. (2012). A complete review on: Averrhoa carambola. World journal of pharmacy and pharmaceutical sciences; 1:17-33.
3. Luan F, Peng L. (2021). Traditional Uses, Phytochemical Constituents and Pharmacological Properties of Averrhoa carambola L: A Review. Frontiers of Pharmacology;12.
4. Hansraj Manda, Kapil Vyas, Ankur Pandya, Gaurav Singhal. (2012). A complete review on: Averrhoa carambola. World journal of pharmacy and pharmaceutical sciences; 1:17-33.
5. Hilu, Khidir & Borsch, Thomas & Müller, Kai & Soltis, Douglas & Soltis, Pamela & Savolainen, Vincent & Chase, Mark & Powell, M. & Alice, Lawrence & Evans, R. & Sauquet, Hervé & Neinhuis, C. & Slotta, T. & Rohwer, Jens & Campbell, Christopher & Chatrou, Lars. (2003). Angiosperm phylogeny base on matK sequence information. American Journal of Botany; 90:1758-1776.
6. Manali Chakraborty & Savita Budhwar. (2018). Comparative investigation of Star Fruit: A healthy underutilized medicinal component. International Journal of Multidisciplinary;3.
7. Dr. NL Gowrishankar, Shantha Sheela N, Farsena A, Raheesul Mubashireen, Rameesa K, Shahna Sharin VP and Sinara NS. (2018). A complete review on: Averrhoa carambola. Journal of Pharmacognosy and Phytochemistry; 7(3): 595-599.
8. P. Dasgupta, P. Chakraborty, N. N. Bala. Averrhoa Carambola: An Updated Review. (2013). International Journal of Pharma Research & Review; 2(7):54-63.
9. Hansraj Manda, Kapil Vyas, Ankur Pandya, Gaurav Singhal. (2012). A complete review on: Averrhoa carambola. World journal of pharmacy and pharmaceutical sciences; 1:17-33.
10. Luan F, Peng L, Lei Z, Jia X, Zou J, Yang Y, He X and Zeng N. (2021). Traditional Uses, Phytochemical Constituents and Pharmacological Properties of Averrhoa carambola L: A Review. Frontiers of Pharmacology;12.
11. Hansraj Manda, Kapil Vyas, Ankur Pandya, Gaurav Singhal. (2012). A complete review on: Averrhoa carambola. World journal of pharmacy and pharmaceutical sciences; 1:17-33.
12. Hilu, Khidir & Borsch, Thomas & Müller, Kai & Soltis, Douglas & Soltis, Pamela & Savolainen, Vincent & Chase. (2003). Angiosperm phylogeny base on matK sequence information. American Journal of Botany;90:1758-1776.
13. Manali Chakraborty & Savita Budhwar. (2018). Comparative investigation of Star Fruit: A healthy underutilized medicinal component. International Journal of Multidisciplinary;3.
14. Dr. NL Gowrishankar, Shantha Sheela N, Farsena A, Raheesul Mubashireen, Rameesa K, Shahna Sharin VP and Sinara NS. (2018). A complete review on: Averrhoa carambola. Journal of Pharmacognosy and Phytochemistry; 7(3): 595-599.
15. Gheewala payal, Kalaria pankti, Chakraborty manodeep, Kamath jagadish v. (2013). Phytochemical and pharmacological profile of Averrhoa carambola linn: an overview. International research journal of pharmacy;3(1).
16. Mortan JF. (1987). Fruits of warm climates. FL: Flair books;125-128.
17. Kapoor LD. (1998). CRC handbook of ayurvedic medicinal plants. Boca Raton Fla. CRC Press; 58.
18. Warrier PK, Nair RV. (2002). Indian Medicinal plants: A compendium of 500 species. Madras: Orient Longman; 224.
19. Thomas S, Patil DA, Gand Narseh Chandra. (2008). Pharmacognostic evalution & physiochemical analysis of A.C L. fruit. Journal of Herbal medicine & Toxicology; 2(2): 51-54.
20. Kumar Hitesh and Arora Tejpal. (2016). Starfruit: A fruit for healthy life. Journal of pharmacognosy and phytochemistry;5(3):132-137.

21. Hou CY, Lin YS, Wang YT, Jiang CM, Wu MC. (2008). Effect of storage conditions on methanol content of fruit and vegetables juice. Journal of Food Complementary Analysis; (21):410-415.
22. Avinash, Patil & Koli, Swapneel & Patil, Darshana & Anita, Phata. (2012). A Comprehensive Review of An Important Medicinal Plant – Averrhoa carambola L. Pharmacognosy Communications; 2:13-17.
23. Annisa dhanira, berna elya, katrin basah. (2020). Antioxidant activity test of fractions from star fruit leaves (Averrhoa carambola l.) From three regions in west java. International journal of applied pharmaceutics;12.
24. Luan F & Peng L. (2021). Traditional Uses, Phytochemical Constituents and Pharmacological Properties of Averrhoa carambola L.: A Review. Frontiers Pharmacology; 12:699899.
25. Xiaojie Wei , Xiaohui Xu ,Zhenfeng Chen, Tao Lianga, Qingwei Wen, Ni Qin, Wansu Huanga,Xiang Huang, Yuchun Li, Juman Li, Junhui He, Jinbin Wei, Renbin Huang. (2018). Protective Effects of 2-Dodecyl-6- Methoxycyclohexa-2,5 -Diene-1,4-Dione Isolated from Averrhoa Carambola L. (Oxalidaceae) Roots on Neuron Apoptosis and Memory Deficits in Alzheimer's Disease. Cellular Physiology and Biochemistry; 49:1105-1114.
26. Rashid AM, Yip YM, Zhang D. (2018). Averrhoa carambola L. peel extract suppresses adipocyte differentiation in 3T3-L, Food Function;7(2):881-892.
27. Singh R, Sharma J, Goyal PK. (2014). Prophylactic Role of Averrhoa carambola (Star Fruit) Extract against Chemically Induced Hepatocellular Carcinoma in Swiss Albino Mice. Advanced Pharmacology Sciences.
28. Silva K, Pinheiro C, Soares C, Souza M. (2021). Phytochemical characterization, antioxidant potential and antimicrobial activity of Averrhoa carambola L. (Oxalidaceae) against multi resistant pathogens. Brazilian Journal of Biology;81.
29. Huang X & Zhang S. (2019). Protective effect of extract of Averrhoa carambola l. root on CC14-induced acute liver injury in mice. Chinese Pharmacological Bulletin;106-110.

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