Abstract
Averrhoa bilimbi is a multipurpose, long-lived tropical plant commonly known as “Bilimbi, Cucumber Tree” belonging to family Oxalidaceae. The plant has an enormous fiscal value since most of the parts like leaves, bark, flowers, fruits, seeds, roots or the whole plant are used as alternative medicine to treat a variety of diseases especially diabetes. In the present review, we tried to give the existing information on photochemical constituents, conventional medicinal uses and anti-microbial, anti-inflammatory, cytotoxic activities, anti-oxidant activity, antifertility and antibacterial activities and other biological activities of Averrhoa bilimbi. The extract of various parts of Averrhoa bilimbi is medicinally used as a folk remedy for many symptoms and showed significant pharmacological activities so it is necessary to perform further investigation to isolate such pharmacological active compounds which can be used in production of novel drugs for various diseases. Overall, this paper gives an overview on covering the biology, and various commercial and therapeutic applications.

Keywords: Averrhoa bilimbi, phytochemical constituents, Pharmacological, Therapeutic applications.

INTRODUCTION
From ancient times plants have provided a source of inspiration for novel drug compounds, as plant derived medicines have made large contributions to human health and well being. (1) Many Indian Plants are used therapeutically for their antidiabetic effect and antibacterial activities. (2) Averrhoa bilimbi (Bilimbi) is medicinally used as a folk remedy for many symptoms. It is used for the treatment of fever, mumps, pimples, inflammation of the rectum and diabetes, itches, boils, rheumatism, syphilis, bilious colic, whooping cough, hypertension, stomach ache, ulcer and as a cooling drink.(3).

Classification of Averrhoa bilimbi, L.
Kingdom: Plantae - Plants
Subkingdom: Tracheobionta- Vascular plants
Superdivision: Spermatophyta- Seed plants
Division; Magnoliophyta- Flowering plants
Class: Dicotyledonae
Subclass: Rosidae
Order: Oxalidales
Family: Oxalidaceae
Genus: Averrhoa
Species: blimbi L.
The bilimbi, Averrhoa bilimbi, L., (Oxalidaceae), is closely allied to the carambola but quite different in appearance, manner of fruiting, flavor and uses. The only strictly English names are "cucumber tree“ and "tree sorrel".

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Puerto Rico, Trinidad, the lowlands of Central America, Venezuela, Colombia, Ecuador, Surinam, Guyana and Brazil, and even in northern Argentina, and it is very popular among the Asiatic residents of those countries as it must be in Hawaii. Still it is grown only as an occasional curiosity in southern Florida (5).

**Description**
The tree is attractive, long-lived, reaches 16 to 33 ft (5-10 m) in height; has a short trunk soon dividing into a number of upright branches. The leaves, very similar to those of the Otaheite gooseberry and mainly clustered at the branch tips, are alternate, imparipinnate; 12 to 24 in (30-60 cm) long, with 11 to 37 alternate or subopposite leaflets, ovate or oblong, with rounded base and pointed tip; downy; medium-green on the upper surface, pale on the underside; 3/4 to 4 in (2-10 cm) long, 1/2 to 1 1/8 in (1.2-1.25 cm) wide.

Small, fragrant, 5-petalled flowers, yellowish-green or purplish marked with dark-purple, are borne in small, hairy panicles emerging directly from the trunk and oldest, thickest branches and some twigs, as do the clusters of curious fruits. The bilimbi is ellipsoid, obovoid or nearly cylindrical, faintly 5-sided, 1 1/2 to 4 in (4-10 cm) long; capped by a thin, star-shaped calyx at the stem-end and tipped with 5 hair-like floral remnants at the apex. The fruit is crisp when unripe, turns from bright-green to yellowish-green, ivory or nearly white when ripe and falls to the ground. The outer skin is glossy, very thin, soft and tender, and the flesh green, jelly-like, juicy and extremely acid. There may be a few (perhaps 6 or 7) flattened, disc-like seeds about 1/4 in (6 mm) wide, smooth and brown (6).

**Natural Habitat**
*A. bilimbi* is a tropical tree, more sensitive to cold especially when very young. It prefers direct sunlight and seasonally humid climates, with evenly distributed rainfall throughout most of the year but there should be a 2-3 month dry season (7).

**Varieties:** Bilimbis are all much the same wherever they are grown, but P.J. Wester reported that a form with sweet fruits had been discovered in the Philippines.

**Climate:** The bilimbi is a tropical species, more sensitive to cold. The tree makes slow growth in shady or semi-shady situations. It should be in full sun.

**Soil:** - While the bilimbi does best in rich, moist, but well-drained soil, it grows and fruits quite well on sand or limestone.

**Propagation:**- Most efforts at grafting and budding have not been rewarding. Air-layering has been practiced in Indonesia for many years. However, the tree is more widely grown from seed. Bilimbi trees are vigorous and receive no special horticultural attention. (8)

**Parts used:** Leaves, Flower, Fruits

- **The fruit** conserve is administered as a treatment for coughs, beri-beri and biliousness. Syrup prepared from the fruit is taken as a cure for fever and inflammation and to stop rectal bleeding and alleviate internal hemorrhoids. **The leaves** are applied as a paste or poulticed on itches, swellings of mumps and rheumatism, and on skin eruption. They are applied on bites of poisonous creatures. Malaysians take the leaves fresh or fermented as a treatment for venereal disease. A leaf infusion is a remedy for coughs and is taken after childbirth as a tonic. A leaf decoction is taken to relieve rectal inflammation. **A flower** infusion is said to be effective against coughs and thrush. In Java, the fruits combined with pepper are eaten to cause sweating when people are feeling "under the weather". A paste of pickled bilimbi is smeared all over the body to hasten recovery after a fever. In some villages in India, the fruit of the bilimbi was used in folk medicine to control obesity. This led to further studies on its Antihyperlipidemic properties (9).

**Phytochemical constituents**
The fruit extracts contain flavonoids, saponins and triterpenoid.
The chemical constituents of *A. bilimbi* include:
- Amino acids,
- citric acid,
- cyanidin-3-Ο-h-D-glucoside,
- phenolics, potassium ion, sugars .
● vitamin A.

The Bark extracts contains - Alkoids, saponins, flavonoids.(10)

Nutrition in Bilimbi :-

Bilimbi is a nutrition-packed, starchy fruit that grows mostly on the trunk of tall trees. It is a rich source of VitaminC. Other than the vitamins and minerals, the fruit also consists of fibre, ash, protein and moisture as well as minerals.

Nutritional value for 100 g of edible portion

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B1</td>
<td>0.010 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0.036 mg</td>
</tr>
<tr>
<td>Moisture</td>
<td>94.2-94.7 g</td>
</tr>
<tr>
<td>Protein</td>
<td>-0.61 g</td>
</tr>
<tr>
<td>Fiber</td>
<td>-0.6g</td>
</tr>
<tr>
<td>Ash</td>
<td>-0.31-0.40 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>-3.4g</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>-11.1 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>-1.01mg</td>
</tr>
<tr>
<td>Caroten</td>
<td>-0.035mg</td>
</tr>
<tr>
<td>Thiamine</td>
<td>-0.010mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>-0.302mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>-0.302mg</td>
</tr>
<tr>
<td>Ascorbic Acid</td>
<td>-15.5mg</td>
</tr>
</tbody>
</table>

Pharmacological profile of Averrhoa bilimbi

Various extracts of fruit and leaves of Averrhoa bilimbi have anti-diabetic, anti-microbial, anti-inflammatory, cytotoxic activities, anti-oxidant activity, antifertility, and antibacterial activities. These properties of Averrhoa bilimbi fruit have been accredited to its saponins, tannins and Flavonoids.

Anti-diabetic activity:-

Ethanol leaf extract of Averrhoa bilimbi and its semi-purified fractions possess hypoglycemic and hypolipidemic properties in Type I diabetic rats when administered intraperitoneally as well as orally. The semi-purified fractions of the ethanolic extract of Averrhoa bilimbi leaves such as AF (Aqueous Fraction) and BuF (Butanol Fraction) have potent hypoglycemic and hypotriglyceridemic properties in HFD–STZ–diabetic rats. AF (125 mg/kg BW) caused a significant hypoglycemic effect at 30 min, 60 min, 120–min and 180 min when compared with vehicle control. The body weight food and water intakes of the rats did not differ significantly in AF and BuF–treated diabetic rats. The semi-purified fractions of the ethanolic extract of Averrhoa bilimbi leaves such as AF and BuF ameliorated diabetes in HFD–STZ–diabetic rats. Moreover, AF is more potent than BuF in the amelioration of hyperglycemia and hypertriglyceridemia. However, the chemical nature of potential antihyperglycemic component (s) of AF and BuF remains to be elucidated. (12)

Antimicrobial Activity

Antibacterial activity of aqueous and chloroform extracts of the leaves and fruits of Averrhoa bilimbi L. using the standard disc diffusion test the crude dried extracts, which were prepared in the different concentrations prior to the antibacterial assay. The results obtained demonstrated the potential of A. bilimbi extracts against some of the Gram-positive and-negative bacteria. The 100 mg mL\(^{-1}\) aqueous extract of A. bilimbi’s leaves and fruits showed positive antibacterial activity against the Gram-positive S. aureus, S. epidermis B. cereus, C. diphteriae with the latter also gave positive effect against K. rhizophila. Both extracts also exhibited positive antibacterial activity against the Gram-negative S. typhi, C. fuendii and A. hydrophila. On the other hand, the 100 mg mL\(^{-1}\) chloroform extracts of A. bilimbi’s leaves and fruits demonstrated antibacterial activity against the Gram-positive S. aureus, S. epidermis, B. cereus, K. rhizophila and C. diphteriae and Gram-negative S. typhi, C. fuendii, A. hydrophila and P. vulgaris. In conclusion, the A. bilimbi leaves and fruits possess potential antibacterial activity (13).

Cytotoxic activity

Methanolic extract of Averrhoa bilimbi fruits and its different fractions were assessed for cytotoxic potential using brine shrimp lethality bioassay which is a well-accepted assay for the primary screening of plant extracts. In methanolic extract and its four fractions showed significant cytotoxic potential demonstrating that samples are biologically active, The LC50 values of crude methanolic extract, chloroform, carbon tetrachloride, pet ether and aqueous soluble fractions of Averrhoa bilimbi fruits were found to be 0.005, 5.691, 1.198, 0.781 and 6.123μg/ml, respectively. Therefore, the obtained result tends to suggest that plant extract of Averrhoa bilimbi fruits may be candidate for anticancer therapy. In light of the results of the present study, it can be concluded that the plant extract and its fractions possesses cytotoxic potential. Positive result of methanolic extract and its different organic solvent soluble fractions led us to the inference that the plant extract may contain bioactive compounds (14).

Antitumor& antioxidant activities

Antithrombotic and antioxidant activities of Averrhoa bilimbi Linn in normal and diabetic rats.(15) different methanol/water extracts, and their total phenolic content (TPC) and total antioxidant capacity (TAC) compared. The TAC was evaluated using established in vitro models such as 1, 1-diphenyl-2-picrylhydrazyl radical scavenging activity, 2, 2’-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid) scavenging assay, total reducing power, phosphor molybdenum assay and metal chelating activity. All the extracts of the dried fruit showed lower TPC compared to the fresh bilimbi extracts by 23-88%, TAC of which corresponded accordingly. The investigation revealed that A. bilimbi was a good source of antioxidants (16).

Toxicity studies

The preliminary general toxicity of A. bilimbi fruit in mice it was conducted by Savithri et al has studied Oral administration of the fruit homogenate daily for 15 days did not result in any toxic symptoms up to a dose of 1 g/kg (17).

Thrombolytic activity

Natural sources the extractives of Averrhoa bilimbi were assessed for thrombolytic activity and the resulted ad, Addition of 100μl SK, a positive control (30,000 I.U.), to the clots and subsequent incubation for 90 minutes at 37°C, showed 92.81% lysis of clot. At the same time, distilled water was treated as negative control which exhibited negligible lysis of clot (1.32%). In this study, the
chloroform soluble fraction (CSF) exhibited highest thrombolytic activity (8.13%), these are used for the discovery of cardio-protective drugs (18).

**Antifertility**

Study in mice showed the kamias fruit as a potential source of antifertility drug. A butanol fraction of the ethanol extract exhibited a higher reduction in fertility rate. The activity may be due to either or both of the steroidal glucosides and potassium oxalate constituents.

**Conclusion**

Plants are the major source for bio-active compounds they are meant for several biological activities in human and animals. As the prevalence of obesity and Diabetes mellitus are very common in our society, research on plants with antidiabetic and antibacterial properties as evidenced by the current research on the various plant parts. For optimum effect in patients, the components responsible should be isolated, purified and further clinical trials has to be conducted. By using the fruit of *A. bilimbi* many pharmacological works are done but pharmacological potential of other parts of the plant is required to be worked out and fractions or purified compounds for potential anticancer and antitumor activity, which may aid ongoing anticancer drug discovery. Hence, further studies are recommended to be undertaken to isolate the exact compound(s) and to better recognize the mechanism of such actions scientifically.

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**REFERENCES**


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