WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
SJIF Impact Factor 8.453
Volume 13, Issue 22, 577-598. Review Article ISSN 2277–7105

FROM FARM TO PHARMACY – A COMPREHENSIVE STUDY OF EGGPLANT (SOLANUM MELONGENA)

Tejasvee Sujit Ubale*[1], Dhanshri Vikas Shinde[2], Payal Krishna Mhaskar[3], Naresh Devaram Choudhary[4], Yogita Sanjay Chaudhari[5] and Shrutika Dipesh Patil[6]

[1]Assistant Professor at Lokmanya TMV's Lokmanya Tilak Institute of Pharmacy, Kharghar Navi Mumbai.

[2,3,4,5]Student at Lokmanya TMV's Lokmanya Tilak Institute of Pharmacy, Kharghar Navi Mumbai.

[6]Principal at Lokmanya TMV's Lokmanya Tilak Institute of Pharmacy, Kharghar Navi Mumbai.

Article Received on
01 October 2024,

Revised on 22 October 2024,
Accepted on 11 Nov. 2024

DOI: 10.20959/wjpr202422-34645

***Corresponding Author**
Tejasvee Sujit Ubale
Assistant Professor at Lokmanya TMV's Lokmanya Tilak Institute of Pharmacy, Kharghar Navi Mumbai.

ABSTRACT

Solanum melongena L., or aubergine, is an herbaceous vegetable crop that is cultivated worldwide for food purposes. It has coarsely lobed leaves, white to purple flowers, and berries as its fruit. It is one of the best dietary sources of biologically active polyphenolic compounds, vitamins, antioxidants, and medicinal requirements. The genus Solanum comprises over 1,400 species, some of which, like S. dulcamara L., are toxic to humans. Eggplant is considered an Old-World crop, cultivated primarily in Africa, Asia, and Europe. Apart from its nutritional and agronomic benefits, aubergine has numerous other health benefits. Aubergine extracts have been shown in numerous trials to have excellent therapeutic qualities for a wide range of illnesses, including inflammatory infections, burns, gastritis, stomatitis, arthritis, and warts. Apart from generating a diverse array of secondary metabolites, aubergine is also rich in vitamins, glycol-alkaloids, and antioxidant compounds, all of which are critical for preserving overall health. Analgesic, antipyretic, antioxidant, anti-inflammatory, anti-asthmatic, hypolipidemic, hypotensive, antiplatelet, CNS depressive, and anaphylactic reaction inhibitory effects are all attributed to the plant. To determine Solanum melongena's real potential and determine whether it can be used clinically and profitably, more research must be done. An overview of the historical

context, Classification, phytochemistry, Nutritional benefits and pharmacology are discussed in this review.

KEYWORDS: Aubergine, Health benefits, Nutritional benefits, Solanum melongena.

I. INTRODUCTION

Brinjal, also known as eggplant (Solanum melongena L.), is a significant solanaceous crop found in subtropical and tropical regions. The term "brinjal" is commonly used in the Indian subcontinent, originating from Arabic and Sanskrit. In contrast, the name "eggplant" comes from the appearance of certain varieties, which are white and shaped like chicken eggs. Eggplant (Solanum melongena) is a commercial flowering plant belonging to the family Solanaceae. The family contains 75 genera and over 2000 species. Members are mostly herbaceous plants, and the fruit is berry and seeds have large endosperm and are grown mainly for food and medicinal purposes. It is a vegetable crop grown on over 1.7 million worldwide.[2] Eggplant is a crucial crop in subtropical and tropical regions, with extensive cultivation in countries like India, Bangladesh, Pakistan, China, Nepal, the Philippines, and Sri Lanka, which together account for about 75% of global eggplant production. Eggplant is widely consumed as vegetable for its various health benefits. It is highly fibrous, contains antioxidants, potassium, Vitamin B-6 and Phyto-nutrients like flavonoids which help in preventing cancer and heart disease. It also Promotes weight loss with its low calories. It is good booster for brain and also helps in maintaining good health by lowering cholesterol in our body. Raw eggplant is 92% water, 6% carbohydrates, 1% protein, and has negligible fat. It provides low amounts of essential nutrients, with only manganese having a moderate percentage (11%) of the Daily Value. Minor changes in nutrient composition occur with season, environment of cultivation (open field or greenhouse), and genotype.[1],[2],[3],[11] The plant's parts can be used to cure a variety of illnesses, including cholera, bronchitis, neuralgias, inflammatory disorders, cardiac debility, and asthma. Root decoction consumed internally to treat asthma and as a stimulant in general. For heaps, leaves are utilised. The cooked root of the wild plant is traditionally used to treat syphilis, together with sour milk and grain porridge. In addition, the juice that is taken from its leaves is used to treat stomach and throat problems. Fruit juice, occasionally combined with crushed leaves, applied topically to hands suspected of having Syphilitic outbreaks. Stops Heart Disease: Rich in antioxidants, eggplants can help lower the risk of heart disease. According to studies, consuming brinjal juice has a preventive impact and lowers triglyceride and LDL cholesterol

levels. Phytochemical studies have yielded flavonoids, alkaloids, tannins and steroids. The medicinal properties of the plant are derived from its chemical constituents. The plant's antioxidant property is due to the flavonoids. The terpenes (steroids) make it useful for bronchitis. Analgesic property is because of the alkaloids. In addition to its numerous traditional uses, Solanum melongena has been shown to possess several significant pharmacological properties. Solanum melongena (eggplant) is chosen for the project due to its: Nutritional value, Relevance to pest and disease resistance studies, Genetic diversity, Economic importance as a major crop, Potential medicine. A variety of activities were investigated, including antimicrobial properties using the leaves and fruit, antiulcer effects from the fruit peels, antifungal activity of the fruit peels, and anticancer potential also derived from the fruit peels. The methodologies employed for these assessments included minimum inhibitory concentration and the disc diffusion method. A variety of activities were investigated, including antimicrobial properties using the leaves and fruit, antiulcer effects from the fruit peels, antifungal activity of the fruit peels, and anticancer potential also derived from the fruit peels.[3],[4] The methodologies employed for these assessments included minimum inhibitory concentration and the disc diffusion method. Solanum melongena (eggplant) is chosen for the project due to its: Nutritional value, Relevance to pest and disease resistance studies, Genetic diversity, Economic importance as a major crop, Potential medicinal properties. These factors make it a valuable subject for agricultural, genetic, and health-related research.

II. CLASSIFICATION

Eggplant (Solanum melongena L.) is an important crop of subtropics and tropics and is a berry-producing vegetable that belongs to the large Solanaceae family (nightshade family).[1],[6] It contains about approx. 3000 species distributed in 90 genera.[6] The genus Solanum is subdivided into 13 major clades, where eggplant is the member of the large and taxonomical Leptostemonum clade, comprising nearly 450 species. Ethnobotanical importance of brinjal in India It is also commonly known as “spiny Solanum” due to the presence of sharp epidermal prickles on the stem and leaves. The subgenus Leptostemonum contains about 450 currently recognized species.[6]

Table No. 1: Brief description of Eggplant.[7][6][1]

Category	Details
Common Names	Eggplant, Brinjal, Aubergine
Scientific Classification	Family: Solanaceae Genus: Solanum Species: S. melongena
Chromosome Number	2n = 24 (Diploid)
Main Varieties	S. melongena (brinjal), S. aethiopicum (scarlet brinjal), S. macrocarpon (gboma brinjal)
Cultivar Groups (S. aethiopicum)	Gilo, Shum, Kumba, Aculeatum

Fig. 1: Various species of Eggplant.[8]

III. GENETIC DIVERSITY

Solanum melongena L., commonly referred to as aubergine in France and Britain and brinjal in Southern Asia, is the fifth most important vegetable in terms of economic value in the Solanaceae family, after tobacco (Nicotiana tabacum L.), tomato (Solanum lycopersicum L.), potato (Solanum tuberosum L.), and chili (Capsicum annuum L.). In many local populations, especially in Africa, the Middle East, Southeast Asia, and the subtropics (India, Bangladesh, and Central America), the fruit is a staple in many cuisines.[1] Additionally, it is grown in a number of warm-temperate locations, including the Mediterranean and Southern USA.[2]

Approximately 1400 species make up the huge genus Solanum, some of which are toxic to humans, including S. dulcamara L. (the nightshades). Domesticated in Africa, Asia, and Europe, eggplant is regarded as an Old-World crop. On the other hand, New World crops like potatoes and tomatoes, which have South American origins, are related to it.[1]

This review focuses on the Asian eggplant (S. melongena) and two related species, Ethiopian/scarlet eggplant (S. aethiopicum L.) and Gboma/African eggplant (S. macrocarpon L.). These small crops are used for food and medicine. Despite historical similarities, they are relatively distantly related within the genus. The most reliable hypothesis is that the Middle Eastern/African species was deliberately carried into the Indo-China region.[3]

The earliest domesticated eggplant species are landraces and small-fruited S. ovigerum. Recent molecular data suggests multiple domestications, but disagreements persist. Academics use contemporary technologies to study eggplant evolution using Solanaceae family members and fruit characteristics like size, shape, flavor, and color.[5] The genetic basis of traits in crops can be applied to other crops if the same genes are involved in domestication processes. For example, eggplant and tomato domestication syndromes share similarities with potatoes and peppers. However, lack of genome sequence data hinders using wild animals in breeding efforts.[7]

Moreover, the lack of a genome sequence for wild relatives hinders the creation of genome-anchored markers, which are necessary for successful trait transfer through marker-assisted selection. In reality, it can be difficult to introduce a desired gene from more distant relatives of eggplants. Collonier and associates[8][9] revealed that just four of the 19 natural species that were crossed with S. melongena, S. aethiopicum, S. macrocarpon, S. linnaeanum, and S. incanum produced fruitful offspring. However, there have been many achievements in introducing Fusarium willow resistance from S. aethiopicum and Verticillium wilt resistance from S. linnaeanum into the grown eggplant.[10][11] Recently, a significant number of mapping populations have been produced from crosses between cultivated eggplant and wild relatives.[12]

The breeding program for eggplants aims to understand the genetic composition of adaptive traits in their wild cousins. High-throughput sequencing has enabled molecular markers for genetic mapping, diversity analysis, and candidate gene analysis. This research reviews the genetic variety and resources of farmed eggplant and its wild cousins, focusing on their relationship with wild relatives, domestication, taxonomy, and economic significance.[12]

The Solanaceae family ranks eggplant third in terms of harvested area and production, behind potatoes and tomatoes. Globally, the harvested area for potatoes and tomatoes in 2019 was more than that of eggplant by a factor of ten and nearly triple, respectively (Figure 1). China

(35.5 million) and India (12.6 million) are the two countries with the highest production, followed by Egypt (1.2 million) and Turkey (0.8 million). Other significant producers of eggplant in Southeast Asia are the Philippines (0.2 million), Sri Lanka (0.1 million), and Indonesia (0.5 million) (Table 1)

Table No. 2: Production and area of Eggplant in the World.[13]

Area	Area Harvested	Production	Area	Area Harvested	Production
China	782,998	35,590,700	Spain	3470	245,150
India	727,000	12,680,000	Mexico	2333	185,234
Egypt	43,818	1,180,240	Algeria	6047	184,145
Turkey	23,337	822,659	Syrian Arab Republic	8342	154,807
Iran	21,350	670,158	Iraq	8660	136,749
Indonesia	43,954	575,392	Sri Lanka	9877	134,863
Japan	8650	301,700	Kazakhstan	4812	108,065
Italy	9550	300,620	United States of America	2614	105,302
Philippines	21,819	249,890	Rest of the world	119,173	1,572,468
			Total	1,847,804	55,198,142

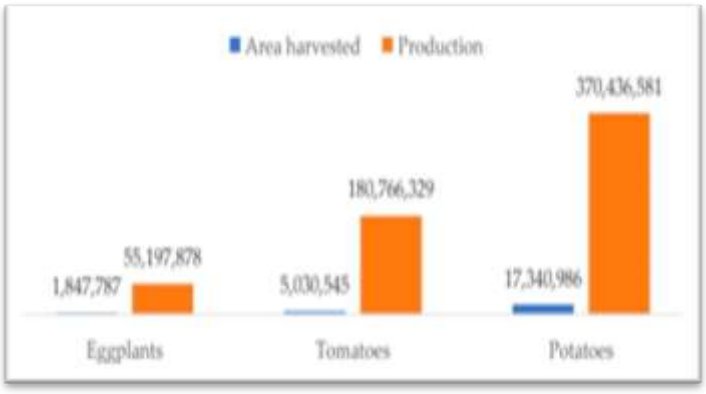

Fig. 2: Harvested areas (hectares) and production of Eggplant, Tomatoes and Potatoes.[13]

- Antioxidant capacity of eggplant

Hazardous substances known as reactive oxygen species (ROS) are created by a variety of biological processes and have the potential to overproduce in response to various stimuli. Completely processed electrons or oxygen produced by the electron transport chain (ETC) in the mitochondria is the primary source of ROS. (19) Numerous antioxidant mechanisms that regulate ROS generation through signaling and metabolic pathway modifications allow normal cells to maintain oxidative equilibrium. The chemical bonds of surrounding molecules are reactive and highly disrupted by the free radical groups of ROS. Because of this, ROS are

recycled or neutralized as soon as they are created; antioxidants primarily carry out this function.[21]

- Root Traits

The study identified eggplant genotypes with the highest total root length and surface area, with significant genetic variation in root traits such as number of tips, width, diameter, perimeter, orientation, and root angles. Accessions with the most root tips were found in Iran, while accessions with the most roots, orientation, and size were found in India and Malaysia.

Fig. 3: Different fruit shapes, colours, and sizes of Solanum melongena accessions in the World Vegetable Center germplasm collection.[1]

Fig. 4: Wild (S. incanum; A-D) and semi- domesticated (S. melongena; E-H) eggplant relatives usually have small, round, yellow fruits and the plants are abundantly prickly.[1]

IV. MORPHOLOGY

Brinjal is an annual to perennial herb, and it grows up to 1.5 m (150–200 cm) tall, often much branched, with long taproot, stems, and leaves with or without prickles, and is densely covered with stellate hairs having 8–10 arms.[1] The fruit of the eggplant is classified as a berry, and it contains numerous edible soft seeds that are bitter because they contain nicotinoid alkaloids. Wild species of eggplant produce large, spiny leaves and small, green, hard, egg-shaped fruits. Solanum melongena differs in terms of fruit colour and shape. Colour ranging from dark purple to black, with some green and white varieties, the fruit of cultivated eggplant also differs with the wild type and is larger and variable in shape. Some eggplant varieties have rounder (S. melongena var. esculentum) fruits, while others have elongated (S. melongena var. serpentinum) fruits. Unlike S. melongena, the species Solanum aethiopicum and Solanum macrocarpon are grown for their nutritious leaves. S. aethiopicum resembles a

shrub and has glabrous or hairy leaves. With its large, spherical, edible fruits, the Gilo group is the most significant group in the S. aethiopicum complex. The only reason S. macrocarpon is grown is for its big, glossy leaves. Small, inedible yellow-orange fruits are produced by it.[7]

Leaves: The leaf pattern is opposite, large, single lobed, and covered with dense wool-like hair. The leaves may be with or without spines at the middle portion of the leaf.[1]

Flower: It is complete, actinomorphic, and hermaphrodite. Calyx is five-lobed; Corolla is five-lobed gamopetalous with margins of lobes incurved. The basic flower is 5-merous (5 sepals, 5 petals, 5 stamens), but 6, 7, and 8-merous flowers are commonly found in globose and round fruited plant types. If in open fields and warm conditions, the insects are visiting on flowers, and the rate of allogamy can reach 70% or more.[1]

Fruit: The fruit are fleshy berries borne singly or in clusters. The shape of the fruit has many varieties, from ovoid, oblong, obovoid, or long cylindrical. The colour of the flower is purple, purple black, yellowish, white, green variegated type of purple with white stripes, green with light green/white stripes, or even combination of three colours. Eggplant fruits all year around.[1]

Stem: The plant is woody, and it develops several branches as per the roughly dichotomic ramification pattern. Eggplant is a diploid species, which has a basic chromosome number of 12 and a genome size of approximately 956 Mbp.[11]

Fig. 5: Botanical Description.[1]

V. BIOACTIVE COMPOUNDS AND CHEMICAL COMPOSITION

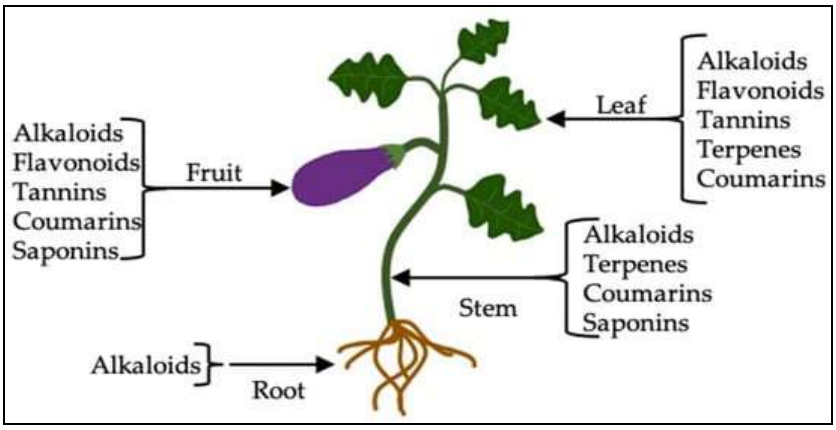

Fig. 6: Bioactive compounds present in various plant part.

The metabolic by-products of plants that are not primary in nature are however utilized by older and more contemporary types of medicine which, because of their bioactive properties, especially the free radical scavenging mechanism, are very essential in the presentation of drugs and drug compositions. Among these phytochemicals, phenolics and carotenoids serve a very important role for human health. Besides other edible plants and fruits, egg plant too possesses its distinct list of bioactive compounds such as phenolics.[7]

- Alkaloids

Alkaloids are natural compounds defined by the presence of one or more nitrogen atoms in their structures. Moreover, they may be differentiated based on the source, chemical structure, or pathway by synthesis. Nevertheless, we can mostly find them classified as true alkaloids, protoalkaloids, and pseudoalkaloids (41). The Italian term Solanum onoratum, for instance, belongs to the Solanaceae family and is particularly known for producing numerous alkaloids, most of which have some anti-cancer effect. They are also reported to be neuroprotective agents considering the many types of neurodegenerative disorders such as Huntington's disease, Parkinson's disease, epilepsy, and schizophrenia and Alzheimer's diseases that they can be used to treat as potential conduits for drug formulation.[1]

- Ascorbic acid

The Role of Vitamin C in Fruits and Vegetables and Its Alleged Free Radical Scavenging Action in Disease Prevention In addition to its vitamin roles, ascorbic acid is a disease-preventing agent due to its ability to scavenge free radicals. However, ascorbic acid is a known antioxidant that helps in the synthesis of collagen and aids iron absorption in the body.[22]

- Flavonoid

Flavonoids exist in the garden eggplant as more glycoside forms-based free hydroxyl aglycones. Free radical scavengers, super antioxidants, and highly efficient water-soluble, non-toxic compounds are capable of preventing damage to cells caused by oxidative stress and are also characterised with high anticancer activities.[22]

- Saponin

Saponins are glycosides that contain an aglycone (sapogenin) connected to one or more sugar groups later on. Saponins are further divided into the steroidal or triterpenoid 1,2 classification based on their composition and structure. Most saponins pass through the intestinal barriers and are thus poorly absorbed in the blood. They exhibit foaming action in solution form, exert a haemolytic power, are bitter, and also cause astringency. However, these compounds have been proven to enhance health, particularly through anti-insulin resistance and anti-obesogenic activities. Saponins obtained from the Solanum genus have demonstrated antitumor, anti-inflammatory, antiviral, antimycotic, antioxidant, hypoglycaemic, and hypolipidemic activities. Diosgenin has been found in dietary Solanum species and was extracted to examine its potential biological effects, such as modulating oxidative stress, improving the lipid profile, and targeting pathways associated with mitochondrial dysfunction.[12]

- Phenolic

Eggplant tissue, or painful substances containing antioxidants, especially phenolic compounds, are the biological components most accessed from etlingera elatior. Such compounds include a class of natural products known as secondary metabolites that are produced as plants undergo growth and reproduction for different reasons, such as stress response, disease resistance, and protection from the sun's rays. Antioxidant activities of different crops towards the edible portion of the eggplant are among the highest due to the high levels of phenolic compounds found in the crop. More than half of these phenolics, about 30 to 60 percent, are contained in the wastes of this crop, particularly in the peel. Therefore, despite agricultural wastes having a small quantity of phenolic compounds, most eggplant tissues are great contributors of phenolic compounds. The levels and structure of phenolics present in the eggplant as well as the proportion of concentrated phenolics found in EB are also influenced by plant crop management (types or varieties, age, growing size of plants, etc.), cultivation, and climatic variables (season, temperature, moisture, acidity levels,

etc.). The number of phenolic compounds, however, was mainly dependent on the variation in eggplant cultivars as opposed to the cultivation environment.[13]

- Pectin

Pectin is a complex homopolysaccharide common in the cell walls of higher terrestrial plants with a wide range of uses and healthful effects. This active agent has been studied in detail, and as a result, over the recent years, its demand in the world market has grown by 4-5% every year. The chemical structure of pectin can be divided into three main components: homogalacturonan, rhamnogalacturonan I (RG-I), and rhamnogalacturonan II (RG-II). Additionally, other components like xylogalacturonan and apiogalacturonan may also be present.[13]

- Anthocyanin

Foods that are abundant in anthocyanins have been proven to be of great help for various health issues such as diabetes, neuronal disorders, cardio-vascular disorders, and cancer. In addition, animal studies with anthocyanin-containing supplements have cancer preventive and therapeutic potential and may also be beneficial for heart health. A high level of the compound nasunin found in purple eggplant has been known to protect cells from lipid peroxidation and reactive oxygen species. Moreover, the anthocyanin available from the peel of eggplant is reported to be very effective in the prevention of excessive weight gain due to its action of lowering serum triglyceride and cholesterol levels and increasing HDL. Consumption of eggplant due to anthocyanins' beneficial activities such as anti-allergic, antioxidant, anti-inflammatory, anti-mutagenic, anti-microbial and anti-viral, and eyesight improvement are valued.evaluated the anthrocyanin content of different varieties of Indian eggplant descending varieties, "long green" to "purple colour small size," which was 0.048 mg/100 g and 0.756 mg/100 g, respectively, as Cya-3-glu quivalents.[4]

VI. NUTRITIONAL BENEFITS OF EGGPLANT

Every 100g of a raw brinjal fruit contains 92% water, 6% carbohydrates, 1% protein, and has negligible fat. Minor changes in nutrient composition may occur because of changes in climate or environment of cultivation and genotype. Although it provides low amounts of essential nutrients with only manganese having a moderate percentage (11%) of the daily value, fruits are rich source of dietary fibres, vitamin B1, B3, B6, C, K, pantothenic acid, beta-carotene equivalents and folate.

Fruits also contain arginine, aspartic acid, histidine, delphinidine−3 bioside (nasunin), oxalic acid, solasodine, ascorbic acid, tryptophan, etc. Leaves consist of rich amounts of chlorogenic, hydrocaffeic and protocatechuric acids. Various alkaloids present are tropane, pyrrolidine, quinazolizidine, steroid alkaloids and glycoalkaloids. two namely steroidal saponins melongoside-L and melongoside-M, and three new saponins melongoside-N, -o and P, have been isolated from Brinjal seeds. Catechol oxidase has been isolated and Identified from S. melongena. The Another bioflavonoid glycoside, solanoflavone present in the leaves and fruits of S. melongena has also been isolated. In addition, Eggplant also consists of the antioxidant's lutein and zeaxanthin. Lutein appears to play a role Trusted Source in eye health, and it may help prevent age-related macular degeneration, which can lead to vision loss in older people.[2][7]

Nutritional Value of Eggplant

Table No. 3: Nutritional Value of Eggplant.[7]

NUTRIENT	UNIT	VALUE PER 100g
Water	G	92.3
Energy	kcal	25.0
Protein	g	0.98
Total lipid	g	0.18
Carbohydrates	g	5.88
Fibre, total dietary	g	3.00
Sugars, total	g	
Minerals		
Calcium	mg	9.00
Iron	mg	0.23
Magnesium	mg	14.0
Potassium	mg	229.0
Sodium	mg	200
Zinc	mg	0.16
Vitamins		
Vitamin C	mg	2.20
Vitamin B6	mg	0.084
Thiamine	mg	0.39
Vitamin B12	mg	0.49
Lipids		
Fatty acids	mg	0.034
Cholesterol	mg	0.000

VII. HEALTH BENEFITS

In addition to its nutritional and agricultural value, aubergine offers a wide range of medical advantages. Numerous studies demonstrate the excellent therapeutic properties of aubergine extracts for a variety of conditions, including arthritis, gastritis, stomatitis, burns, warts, and inflammatory infections. In addition to producing a wide range of different secondary metabolites, aubergine also contains vitamins, glycol-alkaloids, and antioxidant chemicals, all of which are important for maintaining good health. For instance, fruit skin contains a significant amount of the phenolic molecule chlorogenic acid, which has been shown to have anti-obesity, anti-inflammatory, anti-diabetic, and cardio-protective properties. The chlorogenic acid also has anticarcinogenic properties by inducing apoptosis in a variety of human cancer cells, including leukaemia and lung cancer cells. Additionally, studies on eggplant have demonstrated its ability to effectively combat a variety of bacteria, including B. cereus, Pseudomonas sp., Vibrio cholerae, Bacillus subtilis, Staphylococcus aureus, and Escherichia coli. Apart from their ability to add colour, eggplants are a rich source of anthocyanin molecules. Anthocyanins are recognised to have a major protective effect against diabetes, neurological issues, cardiovascular diseases, inflammation and cancer. Consuming purple eggplant can help prevent lipid peroxidation and ROS formation, which are brought on by high levels of iron in cells. Anthocyanins found in aubergine skin reduce the oxidation of low-density lipoprotein (LDL), which raises serum antioxidant volume and protects against heart disease and hyperlipidaemia. Brinjal peels contain anthocyanin, which appears to have a crucial role in preventing obesity by lowering blood triglyceride and cholesterol levels, raising high-density lipoprotein (HDL) cholesterol, and lowering serum triglyceride levels. Additionally, they aid in the treatment of ulcers and improve vision. Carotenoids should be consumed through food because our bodies are unable to synthesise them. Consuming foods high in carotenoids is highly associated with a lower risk of developing some cancers. One of the main issues facing school-age children, particularly in underdeveloped nations, is a vitamin A shortage. A diet high in carotenoid-rich eggplant can reduce this problem in such countries. The anti-cancer properties of aubergine are attributed to its glycoalkaloids. In vitro, human lung cancer cells are reduced by solasodine, a naturally occurring aglycone molecule. Additionally, they can reduce blood cholesterol and have anti-inflammatory properties. The fibre found in eggplant aids in digestion by clearing our stomachs of toxins and other dangerous substances, which lowers the risk of stomach and colon cancer. Additionally, aubergine contains phytonutrients that strengthen brain memory and shield cell membranes. It preserves the health of the brain by shielding its cells from the destruction caused by free

radicals. Certain compounds found in eggplant can also prevent brain tumours. Rich in minerals including magnesium, manganese, potassium, and copper, eggplants are beneficial for health bones as well. Eggplants are rich in minerals, vitamins, and minerals, and are beneficial for bone health. They are also an effective Fe chelator, beneficial for pregnant and lactating women. They can treat various disorders like asthma, dysuria, high blood pressure, osteoporosis, arthritis, diabetes, bronchitis, heart diseases, and strokes. Juice from brinjal roots and leaves is used to treat skin diseases, cough, otitis, anorexia, tooth aches, burns, piles, inflammation, intestinal foot pain, and stomach issues. Patients with Fe deficiency should include eggplant, especially Turkey berry, Thai eggplant, and cherry eggplant. Dry eggplants treat stomach bloating, gas, piles, and strengthen bones.[8] [15]

VIII. CLINICAL EFICACY

I. Activity of antioxidants

Because of the fruit's phenolic components, eggplant is one of the top ten vegetables for scavenging free radicals. The flavonoids are responsible for the plant's antioxidant properties. Antioxidant Activity conducted research on the fruit of S. melongena's water-soluble component's protective effect on rat liver microsomes. The protective activity (PA%) of antioxidants against rat liver microsomes and lipid peroxidation generated by CCl4 were assessed, as well as the release of malondialdehyde. It was discovered that S. melongena juice exhibited an 80% protective effect against lipid peroxidation. In 1999, Sudheesh and colleagues investigated the antioxidant properties of S. melongena flavonoids in rats given normal and cholesterol-fed diets at doses of 1 mg flavonoid from jalapeño.[18][7]

II. The Analgesic Effect

Alkaloids are responsible for their analgesic properties. The impact of a crude alkaloidal fraction extracted from S. melongena leaves on the central nervous system was investigated by Vohora et al. in 1984. It demonstrated a notable analgesic effect. Using doses of Sohani B. Solanke, Mutalik et al. (2003) assessed the analgesic efficacy of S. melongena leaves in albino mice.In the acetic acid-induced writhing test, 100 mg, 250 mg, and 500 mg/kg body weight demonstrated considerable dose-dependent analgesic efficacy.[11] [2]

III. Anti – asthmatic activity

It helps with asthma and bronchitis because of the terpenes (steroids) in it. Internally administered root decoction used as an asthma remedy and general stimulant. In 2004 Bello et al. conducted a clinical experiment using S. melongena fruit at a dose of 89 ± 0.6 g of

fruit/day in moderate-to-severe asthmatics. The trial was randomized, double-blind, placebo controlled. The fruit of S. melongena was found to considerably reduce asthma symptoms and indications as well as the illness severity score following two weeks of daily consumption. A salbutamol sparing effect was discovered.[2]

IV. Antidiabetic

In addition to its numerous traditional uses, S. melongena has been shown to have antidiabetic properties.

The American Diabetes Association, Mayo Clinic, and the National Diabetes Education Program of the NIH advise type-2 diabetes patients to follow an eggplant-based diet. This idea is supported by the low soluble carbohydrate concentration and high fibre content of eggplant. The phenolic-linked antioxidant activity and beta-glucosidase inhibitory ability of eggplant provide a more physiologically relevant explanation, since they may lessen the pathogenesis caused by hyperglycaemia. High α-glucosidase inhibitory activity and, in certain cases, moderate to high angiotensin I-converting enzyme (ACE) inhibitory activity were found in phenol-enriched eggplant extracts with moderate free radical scavenging-linked antioxidant activity. By limiting glucose absorption and lowering glucose levels, inhibition of these enzymes offers a solid biochemical foundation for the management of type 2 diabetes.[7][11][14]

V. Antihypertensive

The plant's various parts can be used to treat cardiac debility and inflammatory disorders. Both the in-vivo and in-vitro preparations are studied for the cardiovascular effects of S. melongena extract (SME). SME produced dosage - dependent hypotensive responses in normotensive albino rats. Additionally, there was a dose-dependent response duration. In rats who are already hypertensive, giving eggplants orally can make them hypertensive. These rats are utilized as a model of essential hypertension in humans because they contain hereditary characteristics that cause hypertension with age, suggesting that eggplant may have hypotensive effects on individuals with comparable genetic variables. As a functional food, eggplant may help avoid hypertension and its consequences in day-to-day life.[2][14]

VI. Nervous system

Various parts of the plant are useful in the treatment of neuralgias. The effect of crude alkaloid fraction of S. melongena leaves on the central nervous system (CNS) was studied. The result showed that it has some CNS depressant activity.[11][7]

VII. Antiglaucoma

In order to ascertain the potential for ocular problems, investigated the effects of bolus ingestion of 10 gm of S. melongena on visually active male volunteers. Miosis and a 25% reduction in intraocular pressure were observed in the results. Patients with elevated intraocular pressure may benefit from using S. melongena, according to some research. (glaucoma).[11]

VIII. Miscellaneous

Eggplant has demonstrated efficacy in treating otitis, toothaches, cholera, dysuria, and nasal ulcers. For heaps, leaves are utilized. Syphilis has traditionally been treated with cooked wild plant roots combined with sour milk and grain porridge. the leaf juice used to treat stomach and throat issues. Fruit juice, occasionally combined with crushed leaves, applied topically to suspected syphilitic hand lesions. Fruit was crushed with vinegar and was thought to be cooling. The roots were utilized by Chinese and Annamite people to treat skin conditions. Chlorogenic acid and similar chemicals found in trace amounts in eggplant have a variety of positive health effects, including strong antioxidant activity, free radical scavenging, and antitumoral activities.[8] [15]

IX. BIOLOGICAL ACTIVITY

1. Antimicrobial activity of the leaf extracts of Solanum melongena L.

For the antimicrobial study, the researchers used the leaves of an eggplant and hand-picked them, washed, dried and powdered them. The extracts were obtained using ethanol and acetone solvents, and filtered by Whatman filter paper. The extracts were further assayed for antibacterial activity against Escherichia coli NCIM 2832 and Micrococcus aureus NCIM 5021, growth patterns on acetone and ethanol extracts, and their minimum inhibitory concentrations in vitro. The incubations are carried out at 30 °C on a rotary shaker rotating at 120 r.p.m., and the cell count was taken for every half-hour interval.[17]

2. In vitro Antimicrobial Activity of Ethanolic Extract Using Fruit Extract

The eggplant fruit is washed, crushed, and air-dried, then powdered and extracted with ethanol. The extract is concentrated and stored in a sample bottle. The bacterial and fungal strains Pseudomonas aeruginosa, Candida albican, and Staphylococcus aureus were obtained from New Era specialists, Hyon Foods Laboratory provided other strains of Escherichia coli, Shigella dysenteries, Salmonella typhi, Rhizopus stolonifera and Aspergillus flavus. Inoculation was done on nutrient agar and potato dextrose agar. The antimicrobial activity of the ethanolic extract was studied by the disc diffusion methods. Extracts of different concentrations are impregnated on discs and plates incubated for 20-24 hours for bacterial study and 48-72 hours for fungal study. Ciprofloxacin (25 µg/disc) and Fluconazole (10 µg/disc) were used as controls. Antibacterial and antifungal activities were expressed as mean diameter of inhibition zones.[18]

3. Solanum melongena Peels against Ethanol Induced Gastric Ulcer

Fresh eggplant peel was manually removed, air dried, and then powdered. The dried powdered peel was used for extraction using 70% ethyl alcohol in water (v/v) that was acidified with 3% v/v acetic acid. There were 30 male rats, divided into five groups: those who received either the peel extract or famotidine as a reference anti-ulcer drug. The experiment used various rat groups, the control group, ulcerative and reference group, which were administered extracts, ethanol doses, peel extracts, or famotidine for seven consecutive days utilized in the experiment. The rats were anesthetized, and then the stomach content of each rat was centrifuged. Based on results, it was seen that the peel extract reduced the volume of gastric secretion by 76.00% and 78.00%, respectively, in ulcerative rats to an improvement of 950% and 975% as compared to untreated ulcerative rats. The research also proved that the peel extract has been useful in treating stomach ulcers.[21]

4. Antifungal Effects of Solanum Melongena L Peel Extract Against Candida Albicans: In Vitro Study

The ethanol extract of eggplant peel was found to have antifungal activities against Candida albicans. The peel was dried and crushed before diluting in 25%, 50%, and 75% concentrations. Then, it was inoculated in the sabouroud dextrose agar medium with incubation at 37°C for a day. The disc diffusion method was used to analyse the activity of the extract. Sterile paper discs and nystatin discs were put on the disc paper. The zone of inhibition was observed in the growth medium. Statistical Analysis Data on diameter

inhibition zone were presented as a mean accompanied by a standard deviation. On performing the Shapiro-Wilk test, data were not normally distributed. The Kruskal-Wallis H test was applied for the determination of mean differences in diameter inhibition zone between groups.[20]

5. In Vitro and In Vivo Anticancer Activity of the Fruit Peels of Solanum melongena L. against Hepatocellular Carcinoma

The Methanol Extract of the Peel (MEP) is a solution of a compound that was extracted from fruit peels which were then chromatographed to produce compounds. Compounds isolated are from different fractions through purification steps. Compound S1 is derived from Fraction A, while S2 is derived from Fraction B; on the other hand, Compound S3 was isolated from Fraction C and S4 from Fraction D. The study was of 40 white female albino rats divided into four groups. Hepatocarcinogenesis was induced chemically in rats by intraperitoneal route and CCl4 injection. Liver tissues are then subjected to histopathological examination. In vitro anticancer activity of MEP against five lines of human cancer cells was studied.[19]

- **OUTCOMES OF LABORATORY PROCEDURES**

1. According to the experiment, it was noted that gram-positive micrococci were more susceptible to the leaf extract as compared to gram-negative Escherichia coli. The e. coli could not withstand the concentration because a lipid solvent like ethanol is able to dissolve the lipid layer on the outer layer of gram-negative organisms, making the organism more susceptible to the action of the leaf extract. It is due to the presence of a large class of siloxanes that have been detected significantly in the extracts.[17]

2. The inhibitory effect of ethanol extract of Solanum melongena linn fruit with minimum inhibition concentration, the standard antibacterial drug (Ciprofloxacin), and the antifungal standard drug (Fluconazole) against some selected microorganisms When compared to the usual medication (ciprofloxacin), Pseudomonas aeroginesa and Shigella dystenteriae had MICs of 70.00 µg/ml with inhibition zones of 13.67 mm and 12.83 mm, respectively, while Staphylococcus aureus had the highest MIC at 50.00 µg/ml and a 15.33 mm inhibition zone. However, Salmonella typhi and Escherichia coli were not inhibited at the tested concentration. Furthermore, Candida albican and Aspergillus flavus both showed a MIC of 50.00µg/ml and inhibition zones of 1.00 mm and 0.67 mm, respectively, against fluconazole, which showed inhibition zones of 20.00 mm and 24.00 mm, respectively. The fruit extract from Solanum melongena Linn did not suppress Rhizopus stolonifera.[18]

3. The study found that rats with stomach ulcers treated with peel extract showed a significant improvement in gastric secretion volume, with a decrease of 76.00% and 78.00% compared to the control group.[21]

4. The eggplant peel extract test results against C. albicans showed antifungal activity. This is evidenced by the formation of an inhibition zone around the disc paper that has been given the extract.[20]

5. Among the cell lines tested, the most active was S1 solasodine and S4 solamargine, but the highest activity comes from HEPG- a liver cancer cell line. In vivo studies by MEP demonstrated dosage-dependent anticancer efficacy against CCl4-induced hepatocellular carcinoma at two dose levels of 100 and 200 mg/kg body weight. Histopathology of liver tissues confirmed the anticancer efficacy of MEP treatment.[19]

CONCLUSION

A thorough overview of S. melongena L. has been provided in this review. Together with a number of alkaloids, saponin, flavonoids, ascorbic acid, phenolics, and pectin it consists mostly of Nasunin an anthocyanin colour. The physical characteristics and phytochemical composition of aubergine fruits. are extremely varied. Additionally, it is a great crop for enhancing its biochemical makeup, which will have a significant impact on the human population, because of its short growing season, widespread popularity, and adaptability to a variety of climates and environments. To understand the likely mechanisms of action of the bioactive chemicals extracted from aubergine, more investigation and an analysis are necessary. As a result, strong methods must to be used to evaluate the nutritional and biochemical makeup of aubergine. It is important to note that many of the bioactive substances are still unidentified or inadequately described. The plant has a wide range of medicinal and pharmacological properties, including anti-diabetic, bronchitis, analgesic, antioxidant, and asthma, hepatic problems, cardiac problems, neuralgias, CNS depression, antipyretic action, Hypolipidemic Action, Anaphylactic Reactions, Glaucoma, antiplatelet, spasmogenic activity, and Activities Inhibiting Calcium Channels, toothaches, otitis dysuria, cholera, nasal ulcers, etc. Additionally, Research is necessary to identify the active component of the extract and to validate the action's mechanism. The Clarification of these plants' harmful effects is also necessary.

REFERENCE

1. Swamy, K.R.M., "ORIGIN, DISTRIBUTION, TAXONOMY, BOTANICAL DESCRIPTION, GENETIC DIVERSITY AND BREEDING OF BRINJAL (Solanum melongena L.)," INTERNATIONAL JOURNAL OF CURRENT RESEARCH, Mar. 2023; 15(3). doi: https://doi.org/10.24941/ijcr.44826.03.2023.
2. S. K. Tiwari, P. Mishra, and K. K. Rai, "Ethnobotanical importance of brinjal in India," Indian Horticulture, Sep. 2020; 65(3).
3. G. S. Saleh, "Chemical Detection of some Active Compounds in Egg Plant (Solanum melongena) Callus as Compared with Fruit and Root Contents," INTERNATIONAL JOURNAL OF CURRENT MICROBIOLOGY AND APPLIED SCIENCES, Jan. 2015; 4.
4. M. Sharma and P. Kaushik, "Biochemical Composition of Eggplant Fruits: A Review," Applied Sciences, Jul. 2021; 11(15): 7078. doi: https://doi.org/10.3390/app11157078.
5. D. Kumar, Narendra Singh Gujjar, P. Singh, A. Kumar, P. Kumar, and B. Tiwari, "To Study Correlation Between Yield and Its Components in Eggplant (Solanum melongena L.)," Journal of Experimental Agriculture International, Jun. 2024; 46(7): 739–753. doi: https://doi.org/10.9734/jeai/2024/v46i72627.
6. D. Taher, S. Solberg, J. Prohens, Y. Chou, M. Rakha, and T. Wu, "World Vegetable Center Eggplant Collection: Origin, Composition, Seed Dissemination and Utilization in Breeding," Frontiers in Plant Science, Aug. 2017; 8. doi: https://doi.org/10.3389/fpls.2017.01484.
7. N. Gürbüz, S. Uluişik, A. Frary, A. Frary, and S. Doganlar, "Health benefits and bioactive compounds of eggplant," Food Chemistry, Dec. 2018; 268: 602–610. doi: https://doi.org/10.1016/j.foodchem.2018.06.093.
8. M. Y. Naeem and S. Ugur, "Nutritional Content and Health Benefits of Eggplant," Turkish Journal of Agriculture - Food Science and Technology, Dec. 2019; 7(3): 31–36. doi: https://doi.org/10.24925/turjaf.v7isp3.31-36.3146.
9. N. N. Mat Sulaiman et al., "Genetic Variability of Eggplant Germplasm Evaluated under Open Field and Glasshouse Cropping Conditions," Agronomy, Mar. 2020; 10(3): 436. doi: https://doi.org/10.3390/agronomy10030436.
10. Y. Oladosu et al., "Genetic Diversity and Utilization of Cultivated Eggplant Germplasm in Varietal Improvement," Plants, Aug. 2021; 10(8): 1714. Doi: https://doi.org/10.3390/plants10081714.
11. Ms. Sohani B. Solanke and Dr. M.G. Tawar, "Phytochemical Information and

Pharmacological Activities of Eggplant (Solanum Melongena L.): A Comprehensive Review," http://www.easpublisher.com/easjpp/, Oct. 05, 2019. doi: 10.36349/EASJPP. 2019.v01i05.001

12. C. A. Elizalde-Romero, L. A. Montoya-Inzunza, L. A. Contreras-Angulo, J. B. Heredia, and E. P. Gutiérrez-Grijalva, "Solanum Fruits: Phytochemicals, Bio accessibility and Bioavailability, and Their Relationship With Their Health-Promoting Effects," Frontiers in Nutrition, Nov. 2021; 8. doi: https://doi.org/10.3389/fnut.2021.790582.
13. A. Karimi, M. Kazemi, S. A. Samani, and J. Simal-Gandara, "Bioactive compounds from by-products of eggplant: Functional properties, potential applications and advances in valorization methods," Trends in Food Science & Technology, Jun. 2021; 112: 518–531. doi: https://doi.org/10.1016/j.tifs.2021.04.027.
14. F. Yarmohammadi, M. Ghasemzadeh Rahbardar, and H. Hosseinzadeh, "Effect of eggplant (Solanum melongena) on the metabolic syndrome: A review," Iranian journal of basic medical sciences, 2021; 24(4): 420–427, doi: https://doi.org/10.22038/ijbms.2021.50276.11452.
15. M. PLAZAS et al., "Breeding for Chlorogenic Acid Content in Eggplant: Interest and Prospects," Notulae Botanicae Horti Agrobotanici Cluj-Napoca, May 2013; 41(1): 26. doi: https://doi.org/10.15835/nbha4119036.
16. G. H. Narayanan et al., "An Ethnobotanical Survey of the Medicinal Plants Used by the People of Sekkarakudi Village, Thoothukudi District, Tamil Nadu, India," East African Scholars Journal of Agriculture and Life Sciences, Aug. 2024; 7(08): 101–109. doi: https://doi.org/10.36349/easjals.2024.v07i08.001.
17. M. A. Sitap, S. R. Tilawale, N. H. Nadaf, and J. S. Ghosh, "Antimicrobial activity of the leaf extracts of Solanum melongena L. (the green variety)," International journal of pharma research and review, Jan. 2015.
18. U. O. Mbah, A. C. C. Egbuonu, O. D. Omodamiro, O. Jeremiah, and I. D. Nwanne, "In vitro Antioxidant and Antimicrobial Activity of Ethanolic Extract of Egg Plant (Solanum melongena Linn) Fruit," Asian Journal of Research in Medical and Pharmaceutical Sciences, Jan. 2019; 5(4): 1–10. doi: https://doi.org/10.9734/ajrimps/2018/45933.
19. M. M. S. Maha M Salama, "In Vitro and In Vivo Anticancer Activity of the Fruit Peels of Solanum melongena L. against Hepatocellular Carcinoma," Journal of Carcinogenesis & Mutagenesis, 2013; 04(03). doi: https://doi.org/10.4172/2157-2518.1000149.
20. Ami Febriza, Shelli Faradiana, Yusqadriani Yusbar, and Vivien Novarina Kasim, "Antifungal Effects of Solanum Melongena L Peel Extract Against Candida Albicans: In

Vitro Study," www.iasnetedu.com.

21. A. M. El-Feky, A. Naser, and M. Hamed, "Solanum melongena peels against ethanol-induced gastric ulcer in rats via regulating mucosal enzymes, oxidative stress and inflammatory mediators' pathways," Egyptian Journal of Chemistry, Apr. 2024; 0(0). doi: https://doi.org/10.21608/ejchem.2024.271316.9354.
22. A. I. Mansurat, M.A Dandago, and H.B Diya'udeen, "Phytochemical Contents and Antioxidant potentials of Eggplants from Kano State, Nigeria: A Review," Dutse Journal of Pure and Applied Sciences, Mar. 2023; 9(1): 160–167. doi: https://doi.org/10.4314/dujopas.v9i1a.16.