[redacted] Review of [redacted] Literature

Chapter 2

Review of Literature

2.1 Introduction

Hemostasis is the normal physiological response preventing significant blood loss after vascular injury. The process depends on an intricate series of events involving platelets, other cells, and the activation of specific blood proteins, known as coagulation factors. When blood vessel injury occurs, physiological hemostasis is triggered, and the coagulation process begins. It serves to maintain the integrity of the circulatory system; however, the process can become imbalanced, leading to significant morbidity and mortality. Knowledge of the hemostasis process is important in understanding the major disease states associated with thrombosis (LaPelusa A, Dave HD 2023).

A thrombus, colloquially called a blood clot, is the final product of the blood coagulation step in hemostasis. There are two components to a thrombus: aggregated platelets and red blood cells that form a plug, and a mesh of cross-linked fibrin protein. The substance making up a thrombus is sometimes called cruor. A thrombus is a healthy response to injury intended to prevent bleeding but can be harmful when clots obstruct blood flow through healthy blood vessels (Gale A. 2011).

Mural thrombi are thrombi that adhere to the wall of a blood vessel. They occur in large vessels such as the heart and aorta and can restrict blood flow but usually do not block it entirely. They appear grey-red with alternating light and dark lines (known as lines of Zahn) which represent bands of fibrin (lighter) with entrapped white blood cells and red blood cells (darker) (Gale A. 2011).

2.2 The Coagulation Cascade

The last enzyme in the coagulation cascade, thrombin, transforms soluble fibrinogen into insoluble fibrin, causing the coagulation process to occur through a series of successive events.1. Additionally, thrombin stimulates factor-XIII, quickens the synthesis of factor-V, and activates platelets, all of which promote thrombin production and platelet aggregation (Tortora, 2000). A complicated interplay of different systems leads to clotting (Rickles & Falanga 2001). One of the fundamental components of a clot is thrombin, which is formed when platelets break and transform prothrombin in the blood. Blood clotting within veins is known as thrombosis (Figure 2.1).

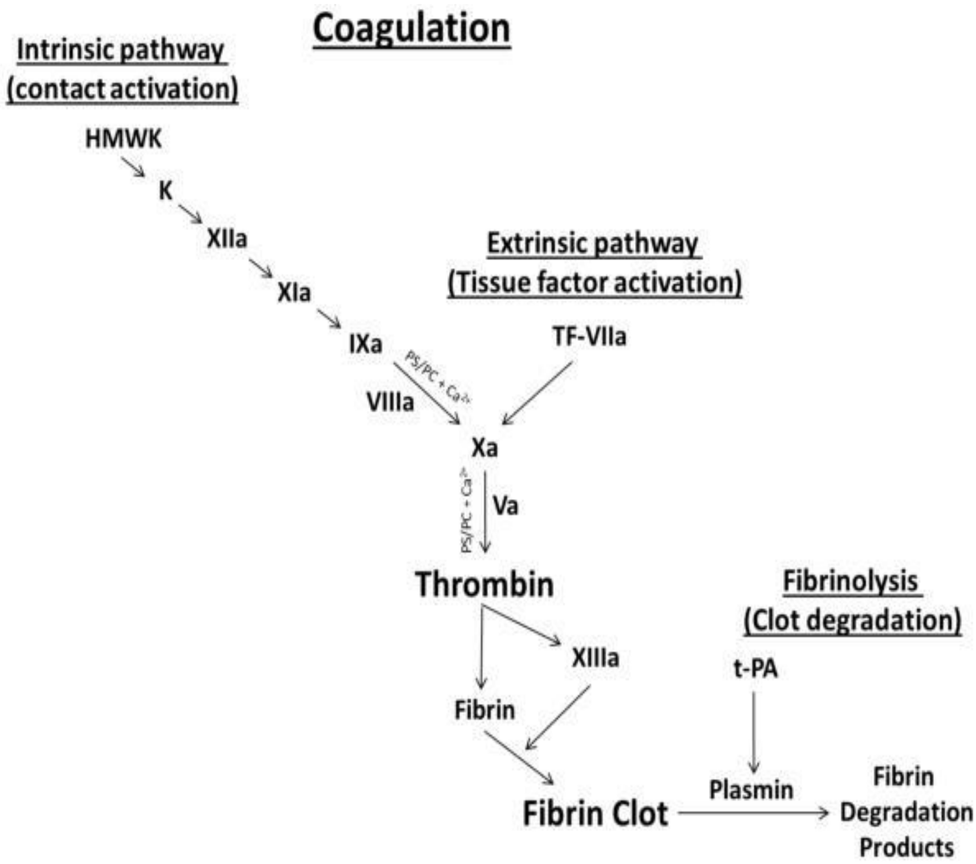

Figure 2.1: Blood clotting cascade

2.3 Thrombus Formation

A thrombus can obstruct an artery or vein's ability to carry blood. It can become a potentially fatal embolus if it separates from the vessel wall and lodges in the lungs or other important organs (Mackman, 2008; Turpie et.al. 2002). The delicate balance that the coagulation system depends on is between:

- Natural coagulant and anticoagulant factors
- The coagulation and fibrinolytic system

When there is an imbalance in the blood coagulation system, a pathological thrombus arises. This imbalance can cause heart attacks, and cardioembolic strokes in individuals with AF, and VTE, among other significant health issues (Turpie et.al. 2002; Turpie & Esmon 2011; Geerts et.al. 2008). Deep vein thrombosis (DVT) and/or pulmonary embolus (PE) are two different but associated manifestations of thrombotic encephalopathy (TE).

2.4 Virchow's Triad

Rudolph Virchow, a German pathologist, proposed more than 150 years ago that anomalies in three main areas led to thrombus formation and propagation:

- Blood flow
- The vessel walls
- Blood components

Virchow's triad refers to these three elements (Wong & Baglin, 2012).

It is currently possible to further refine the elements of Virchow's triad (Heit, 2015; Kahn, 2006).

- Circulatory stasis: anomalies in turbulence and hemoheology at stenotic areas and vascular bifurcations
- Damage to the arterial wall - anomalies in the endothelium, including atherosclerosis and the vascular inflammation it causes.
- Hypercoagulable state: deviations from normal coagulation and fibrinolytic pathways, as well as abnormal platelet function, linked to a higher risk of VTE and other cardiovascular conditions, such as heart failure, coronary artery disease (CAD), and stroke in individuals with atrial fibrillation (Kahn, 2006).

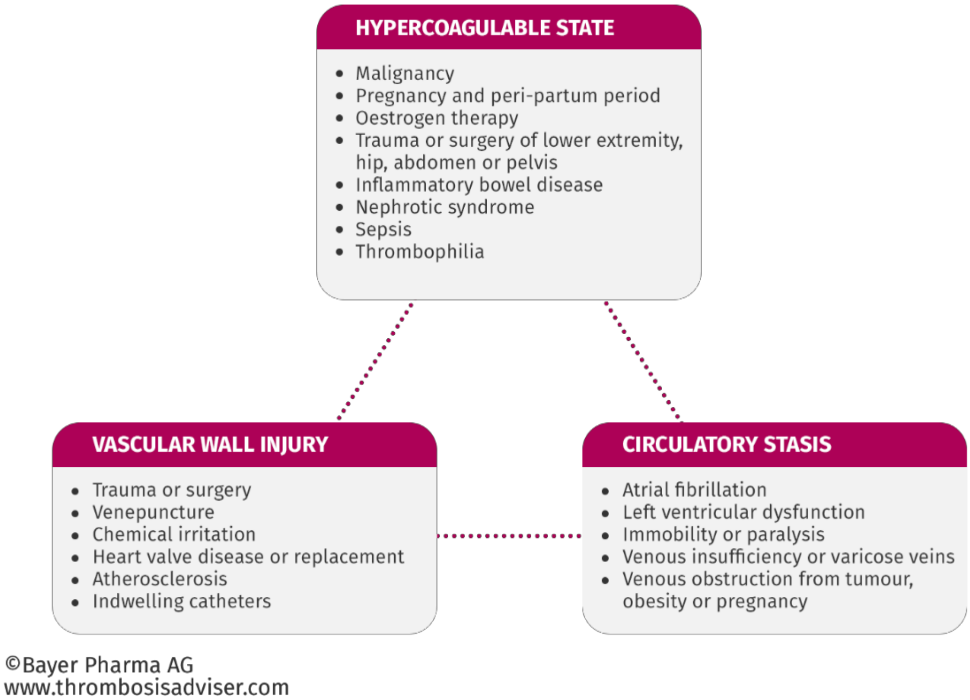

Figure 2.2: Virchow's triad

2.5 TYPES OF THROMBI

There are two possible forms of thrombus, each with a unique makeup and appearance (Tapson, 2008).

- Platelet aggregates make up the majority of arterial thrombus, often known as white thrombus.
- Red blood cells and fibrin make up the majority of venous thrombus (red thrombus).

2.5.1 Arterial thrombi

Arterial thrombosis is the term used to describe a thrombus that develops inside an artery. An atherosclerotic plaque rupture is usually the cause of clot formation since it is a highly thrombogenic event that draws platelets to the area quickly. As the thrombus expands into the artery lumen, the clot's fibrin content gradually rises. Accordingly, an arterial thrombus is usually exposed to rapid blood flow, has a high platelet content, and grows quickly (Mackman, 2008; Turpie et.al. 2002). Thrombi associated with autoimmune factors are classified as arterial clots as well, but they more closely resemble "venous-type" clots, which satisfy Virchow's triad for thrombogenesis. Low-flow, low-pressure settings are the breeding grounds for AF-related thrombi, which result in fibrin-rich, slowly-growing clots (Mackman, 2008).

Risk factors

Important risk factors for arterial thrombosis include (Turpie et.al. 2002):

o Smoking

o Obesity

o High blood pressure

o Increased levels of cholesterol

o Diabetes

o Increasing age

o Family history

o Physical inactivity

o Increased concentrations of blood coagulation factors

o Blood serum lipid abnormalities

2.5.2 Venous thrombi

Venous thrombi:

o Feature enmeshed erythrocytes

o Tend to fragment, creating an embolus

o Typically manifest as DVT and PE

Venous thrombosis is the term used to describe the development of a thrombus inside a vein. An embolus occurs when a thrombus breaks free and moves through the bloodstream (Turpie et.al. 2002).

2.5.2.1 Venous thromboembolism

DVT is the most prevalent form of VTE, primarily affecting the leg's major veins (Mackman, 2008, Turpie et.al. 2002). A thrombus that has broken away from the blood vessel wall partially or completely moves toward the lungs, where it may obstruct a pulmonary artery (a PE). PE, which has the potential to be fatal, is a danger for patients with DVT.

Risk factors

VTE is commonly linked to surgery, trauma, and malignancy. Patients with idiopathic instances lack a discernible environmental risk factor or triggering event (Turpie et.al. 2002).

Predisposing risk factors for VTE include (Geerts et.al. 2008):

o Increasing age (particularly >60 years)

o Pregnancy and postpartum

o Obesity (body mass index >30 kg/m2)

o Immobility (including lower extremity paralysis)

o History of VTE in one's family or personally

o Dehydration

o Use of oestrogen-containing oral contraceptives

o Hormone replacement therapy

VTE risk factors that are revealed include (Geerts et.al. 2008):

o Surgery

o Cancer therapy

o Heart or Respiratory failure

o Acute disease

o Critical care admission

o Venous compression (e.g. by tumor, haematoma, arterial abnormality)

o Recent MI or stroke

o Metabolic, endocrine, or respiratory pathologies

o Central venous catheterization

o Inflammatory bowel disease (e.g. ulcerative colitis or Crohn’s disease)

o Severe infection

o Myeloproliferative diseases

o Varicose veins with associated phlebitis

o Inherited or acquired thrombophilias

o Selective oestrogen receptor modulators

o Erythropoiesis-stimulating agents

o Nephrotic syndrome

o Paroxysmal nocturnal haemoglobinuria

o Long-distance travel

2.6 Treatment

The classification of drugs to treat thrombotic disease is as below (Klabunde, 2011; Golan, 2008).

Table 2.1: Classification of drugs

a. Anti-coagulant agent/blood thinner	**b. Thrombolytic (Fibrinolytic) Drugs**	**c. Anti-platelets agents**
• The most common blood thinners used today are • Heparin, • Low molecular weight heparin, and • Warfarin	• There are three major classes of fibrinolytic drugs: • Tissue plasminogen activator (tPA), • Streptokinase (SK), and • Urokinase (UK)	• Anti-platelet drugs include • Thromboxan A_2 inhibitors, • ADP receptor inhibitors, • Glycoprotein IIb/IIIa

2.7 Review of Literature of *Tecomella undulata*

One of Rajasthan, India's most significant medicinal plants is *Tecomella undulata* (Seem). It is also referred to as Ammora in English, Rohitaka in Sanskrit, and Rohida in Hindi. It is sometimes referred to as Desert Teak since it grows in the arid and semi-arid parts of the Thar desert. It is commonly referred to as Marwar teak or Desert teak in the local trade. Tecomella is well-known for its high-quality lumber, its secondary metabolites' medicinal qualities, and the use of its leaves, flowers, and pods as fodder. Syphilis, urinary issues, splenic enlargement, gonorrhea, leukoderma, jaundice, and liver problems have all been treated with it for a long time (Kirtikar and Basu 2005, Sheth and Mitaliya 2005).

2.7.1 Habitat

Tecomella undulata is a species that is found only in the arid regions of Arabia, southern Pakistan, and northwest India. According to Kirtikar and Basu 2005, it mostly affects Maharashtra, Gujarat, Rajasthan, Punjab, and Haryana in India.

2.7.2 Vernacular Name (Kirtikar and Basu 2005)

Bombay: Lohera, Lohuri, Rakhtreora, Rugtrora, Roira;

Hindi: Rugtrora, Lasbala: Lahira;

Marathi: Rakhtroda,Raktarohida, Marara: Rohira, Roira;

Punjab: Lahura, Luar, Rohira, Roir;

Sanskrit: Chalachhada, Kushalmali, Kutashalmali;

Sind: Khen, Lahero, Lohuri.

2.7.3 Synonyms: *Tecoma undulata* G. Don, *Bignoniaundulata* Sm.

2.7.4 Trade Name: Rohida tree, Desert teak, Marwar teak.

2.7.5 Scientific Classification (Sheth and Mitaliya 2005).

Kingdom: Plantae;

Order: Lamiales;

Family: Bignoniaceae;

Genus: *Tecomella*;

Species: *T. Undulata*;

Binomial Name: *Tecomella Undulata*.

2.7.6 Description

A little tree or shrub with drooping branches.

The leaves have an entire length of 1-3.2 cm, a thin oblong shape, an obtuse tip, and undulated edges.

The flowers are inoffensive, with short lateral branches ending in corymbose few-flowered racemes. The calyx is 9.5-11 mm long, campanulate, and the lobes are 3 mm long, broadly oblong, obtuse, and mucronate. The pedicles are 6-13 mm long.

Corolla: orange-yellow, 3.8–6.3 cm long, campanulate, with 5 subequal, rounded lobes. Lobes spathulate-oblong and spherical, stigma 2-lamellate, filaments glabrous, and stamens exserted.

Capsule: 20 x 1 cm smooth, sharply pointed, linear-oblong, slightly curved capsules with thin valves.

The seeds, including the wing, measure 2.5 by 1 cm. According to Pandey & Dasgupta 1970, the wing is nonexistent at the base of the seed and extremely narrow around its apex.

The wood is close-grained, light-streaked, greyish, or yellowish-brown wood and is robust, resilient, and long-lasting. While the bark of mature trees is hard and dark brown, that of immature plants is delicate and greenish brown.

The bark is found in 6 to 9-mm thick, flat, or slightly curved chunks. The bark's exterior is a deep shade of brown. The exterior has transverse cracks and longitudinal furrows, which give the surface a rough texture. The bark's inside is smooth and has a brownish hue. Although the bark has no smell, it tastes harsh.

2.7.7 Phytochemical Review of *Tecomella undulata*

Table 2.2: Phytochemical Review of *Tecomella undulata*

Part used	Phytochemical Class (solvent used)	Phytochemical constituents (Isolated)	Reference
Flower	Alkaloids (ethanolic)	2-pyrrolidine methanol, 3-amino-4-pyrazolecarbonitrile, 3-(1-methyl-2-pyrrolidinyl) pyridine, 2-methyl-6- propylpiperidine, 1-piperidineethanol, 4-formyl-1,3-dihydro-1,3-dimethyl-2H-imidazole-2thione, 5-acetylpyrimidine-2,4,6(1H,3H,5H)-trione, 1-(1-cyclohexen-1- yl) Pyrrolidine, decahydroquinoline,	Laghari et.al. 2014

		5,7-dimethyl-1,3- diazadamantan-6-one, 2,4-dihydro5-methyl-2- phenyl-3H-Pyrazol-3-one (By GC-MS)	
Heartwood		radermachol, lapachol, cluytyl frulate, β-lapachone, α-lapachone, Dehydro-α-lapachone.	Singh P, 2008
Leaves	Flavonoids	Deterpene, ursolic acid, Aphanamixol, oleanolic acid, triacontanol, betulinic acid, cirsimaritin, cirilineol, pentariacontanol and 4,5-dihydroxy-3,6,8-trimethoxyflavones	Mohibb-E-Azam, 1999, Bhau B.S et.al 2007
Bark	Flavonoid glycoside, Phytosterol	iridoid glucosides, β-sitosterols, rutin, tecomelloside, , quercetin, luteolin-7-glycoside, Tecomin, Lapachol, veratric acid, dehydrotecol, alcohol ferulate, n-tricontanol and tecomelloside, Undulatoside B, Alphanamixinin	Mohibb , 2000, Rohilla and Garg, 2014, Joshi et.al. 1977
Root	Irridoids	6-O-veratryl-catalposide-α-lapachone	Mohibb, 2000
Seed and fruit shell	Fatty acid and Tannins	7.14% tannin and seed oil contains Rohitukin, Palmitic acid, Linoleic acid, Oleic acid, Alimonoid, Stearic acid, linoleic acid (53%), Stearic acid, Palmitic acid along with lauric acid.	Khare 2007

		Fruit shell Aphanamixin lactone, Aphanamixolide,	
All part		Fe, Ca and Zn	Saraf & Sankhla 2013

2.7.8 Pharmacological Review of *Tecomella undulata*

Table 2.3: Pharmacological Review of *Tecomella undulata*

Part used	Solvent	Pharmacological activity	Reference
Leaves	Methanol	Hepatoprotective Activity	Patel et.al. 2011
Leaves	Hexane Chloroform Methanol	Antibacterial activity	Abhishek et.al 2013
Leaves	Methanol	Analgesic activity	Ahmad et.al 1994
Leaves	Methanol	Antibacterial and Antibiofilm effects	Parekh et.al 2005, Valizadeh et.al 2020
Leaves	Methanol	Anti HIV activity	Bhau et.al 2007
Leaves	Ethanolic	Anti-ulcer, Laxative, and Anti-Inflammatory activities	Arsalan et.al. 2023
Stem Bark	Methanol	Hepatoprotective Activity	Khatri et.al 2009
Stem Bark	Methanol	Hepatoprotective Activity	Rana et.al. 2008
Stem Bark	Chloroform	Antiproliferative activity	Ravi et.al. 2011

Stem Bark	Ethanolic	Anti-diabetic and Anti-oxidant	Kumar et.al. 2012
Stem Bark	Ethyl acetate	Anti-obesity	Al-Yahya et.al. 2013
Stem Bark		Antifungal and anti-termite action	Bhau et.al 2007
Stem Bark		Smooth muscle relaxant activity	Khare 2007
Stem Bark	Alcoholic and Chloroform extracts	Cardiotonic and chloretic activity	Khare 2007
Stem Bark	Ethanolic extract	Immunomodulatory activity	Choudhary 2011
Stem Bark	Ethanolic extract	Antioxidant activity	Sharma et.al. 2013
Stem Bark	Ethanolic extract	Anticancer activity	Ravi et al., 2011
Heartwood	Ethanolic	Potent CDK7 inhibitor as an anticancer	Khandelwal et.al. 2022
Root	Ethanolic	Antispermatogenic effect	Goyal & Purohit 2022
Flowers	Petroleum ether	Anti-depressant like activity	Dhingra & Deepak 2019.
Plant	Ethanolic	Non-alcoholic steatohepatitis	Srinivas et.al 2023
Plant	Methanolic	Acaricidal activity	Khan et.al. 2013

2.8 Literature Review of *Citrus medica*

One of the most significant commercial fruit crops produced on every continent is citrus. *Citrus medica*, also called citron or otroj, is a significant medicinal plant belonging to the Rutaceae family. This little tree can reach a height of 2.4–4.5 meters and is evergreen. Its large fruit, which measures 20–22.5 cm and resembles a pineapple, is mostly grown in regions near the Mediterranean, Iran, Central and South America, and India (Anonymous 2001).

Historically, *Citrus medica* has been used as a carminative, stomachic, tonic, expectorant, cardiotonic, antispasmodic, appetizer, and to induce spleen tumors (Hartwell 1982). The peel of *Citrus medica* is consumed raw with rice and used as a dysentery treatment (Fleisher Z, Fleisher A 1991, Bhuiyan et al. 2009). According to Filomena et al. (2007), *Citrus medica* is useful in the treatment of diabetes and Alzheimer's disease.

2.8.1 Habitat:

2.8.2 Vernacular Name:

Arabic: Raranj, Trunj;

Chinese: fo shou gan, xiang yuan;

English: Buddha's-Hand, citron, etrog citron, finger citron flesh-finger citron, small citron

Local Name: Bijoru, Gadhha Limbu

2.8.3 Scientific classification:

Kingdom: Plantae;

Subkingdom: Tracheobionta;

Superdivision: Spermatophyta;

Division: Magnoliophyta;

Class: Magnoliopsida;

Subclass: Rosidae;

Order: Sapindales;

Family: Rutaceae;

Genus: *Citrus*

Species: *medica*

2.8.4 Description:

Depending on the species, genetic background, and method of establishment (seed or grafting), trees can have different forms and rates of development. Compared to trees grown by grafting, trees grown from seeds typically have more thorns and upright branch growth.

The flowers are fragrant, axillary, solitary, few, or cymose, with a diameter of 2-4 cm (0.8-1.6 in), and frequently perfect (containing both functional stamens and pistils) or staminate. There are typically five petals with oil glands and a calyx with four to five lobed petals. Between 20 and 40 stamens are present. Petals in Kafr limes range in color from white to pinkish, while those in citrons have pinkish to purplish petals and those in lemon types are crimson. With 8–18 locules (cavities) and 4–8 ovules per locule arranged in two rows, the sub globose ovary is superior.

The leaves are whole, unifoliate, 4-6 cm (1.6-3.2 in) long, moderately thick, and have petioles that are winged. The leaves have sharp to obtuse tips and are ovate, oval, or elliptical in shape. Additionally, they feature glands that, when crushed, release oils. While older twigs and branches have a circular cross-section and no spines, younger twigs are angled, and green, and have one spine on the axilla.

The fruit is a fleshy, indehiscent berry known as a hesperidium, and its size, color, shape, and juice quality vary greatly. The diameter of citrus fruits varies, with limes measuring 4 cm (1.6 in) and pummels surpassing 25 cm (10 in). Fruits range in form from globose to ovoid. The stalked pulp is present in 10–14 portions of the fleshy endocarp, which are separated by thin septa. The pulp (juice vesicles) in each part contains a watery, acidic, or slightly sweet juice.

The seeds are angular, fattened, and pale white to greenish in color. Typically, seeds are polyembryonic, meaning they contain several embryos that have the potential to germinate. The embryos are either nuclear or zygotic. The process of ovarian pollination and sexual reproduction produces zygotic embryos. Completely generated from the mother plant, the nucellar embryos resemble the parent plant in every way (Little 1964, Liogier 1988, Manner 2006,).

2.8.5 Phytochemical Review of *Citrus medica*

Table 2.4: Phytochemical Review of *Citrus medica*

Part used	Phytochemical class (Solvent used)	Phytochemical constituents (Isolated)	Reference

Fruit	Alkaloids, Carbohydrate, Cardiac Glycoside (methanol, hexane and ethanol)	-	Balamurugan et.al 2014
Fruit	phenolic and flavonoid contents (ethanolic extract)	-	Al-Yahya et.al 2013
Fruit	Polyphenolic, flavonoid	Apigenin, Apigenin-6,8-diglucoside, Catechin, Epicatechin, Dihydroquercetin, Eriocitrin (Eriodictyol-7-O rutinoside, Herbacetin, Hesperetin, Hesperidin, Neohesperidin, Kaempferol 3-O-rutinoside, Naringenin 7-O-glucoside, Naringin, Neodiosmin (Diosmetin-7-O Neoheseridoside), Nobiletin, Quercetin, Rutin, Tangeritin, Vitexin, 3,5,6-Trihydroxy 3,4,7 Trimethoxyflavone, 6,8-di-C Glucosyldiosmetin, Caffeic acid, Benzoic acid, Gallic acid, p-Coumaric acid, Salicylic acid, Chlorogenic acid, Methyl benzoate, Methyl paraben, Methyl-4 Hydroxycinnamate, trans-	Chan et.al. 2010, Chu et.al 2012, Fomani et.al 2014, Zhao et.al. 2015, Menichini 2016, Fratianni et. al 2019, Luo et.al 2020, Taghvaeefard, et.al 2021, Mondal et.al 2021, Dadwal et.al. 2022

	Coumarins	Cinnamic Acid, trans-Ferulic acid, Herpetiosol B, Herpetiosol C, Silychristin A, Silychristin B Oxypeucedanin Hydrate, Scoparone, Skimmin, Haploperoside A, Leptodactylone, Herniarin, Isomeranzin, Scopoletin, Isoscopoletin, Umbelliferone, Nordentatin, Bergapten, Citrumedin-B, Xanthyletin, 5,8 dimethoxhypsoralene	Wang et.al 2003, Chan et.al. 2010, Chu et.al 2012, Fomani et.al 2014, Zhao et.al. 2015, Chan et.al. 2017,
fruit peel	phenolics, flavanones, ascorbic acid (vitamin C), and pectin	iso-limonene (39.37%), citral (23.12%), and limonene (21.78%)	Chhikara 2018
fruit peel	essential oils	isolimonene (39.37%), citral (23.12%) and limonene (21.78%) (GC- MS).	Bhuiyan et.al 2009
fruit peel	volatile organic components of monoterpene group	d-limonene(85.93%), sabinene (6.85%), myrcene (3.46%) by Headspace Trap (HS- Trap) sampling technique was characterized by GC-MS	Talekar, 2013
fruit peel	essential oils	Limonene (> 85%).	Tatiana de Sousa Fiuza, 2015

	Minerals	Copper, Calcium, Iron, Manganese, Sodium, Zinc, Potassium, Magnesium,	Mahdi et.al. 2019
	Vitamins	Ascorbic acid (vitamin C), Niacin, Pyridoxine, Riboflavin, Thiamin	Mahdi et.al. 2019, Dadwal et.al. 2022
Seed	Fatty acid and Triterpenoids	Oleic acid, 12-Octadecadienoic acid (Z,Z), ß-Sitosterol,	Patil 2013
Seed	(Petroleum ether extract)	Hexadecanoic acid (GCMS method)	Patil 2013
Leaf	Essential oils	Limonene, Cyclohexanone, 2-methyl-5-(1-methylethenyl), 1,2-Cyclohexanediol, 1-methyl-4-(1-methylethenyl), Geranyl methyl ether, erucylamide (28.43%), limonene (18.36%) and citral (12.95%)(GC- MS), Dihydrokaem pferide	Bhuiyan et.al 2009, Hetta et.al 2013
Pulp	Minerals	Copper, Calcium, Potassium, Manganese, Sodium, Magnesium, Zinc, Iron	Mahdi et.al. 2019
Pulp	Amino acid	Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Valine, Alanine, Arginine, Asparagine,	Mahdi et.al. 2019, Dadwal et.al. 2022, Mucci et. al 2013

		Glycine, Aspartic acid, Glutamic acid, Proline, Serine, Tryptophan, Cystine, Tyrosine	
Bark	Flavonoid	Atalantoflavon	Chan et.al. 2010, Fomani et.al 2014

2.8.6 Pharmacological Review of *Citrus medica*

Table 2.5: Pharmacological Review of *Citrus medica*

Part of Plant	Extract	Model / Pharmacological Activity	References
Fruit	Distilled water Decoction	Analgesic effect	Sood et.al 2009
Fruit	Half-ripe and Ripe fruit juice	Antimutagenicity and Anticancer Effects	Entezari et.al 2009
Fruit	Aqueous extract	Antiulcer activity	Nagaraju et.al 2012
Fruit	Ethanolic extract	Antioxidant activity & Cardio Protective Potential	Al-Yahya et.al 2013, Hanafy et.al 2021
Fruit	Methanol extract (flavonoid isolation)	Antiurolithiatic action	Sood et.al 2009
Fruit	Essential oil	Central nervous system activities	Aliberti et. al 2016
Fruit	Essential oil	Antiviral activity	Nagy et.al 2018

Leaf	Petroleum ether extract	In-vitro anthelmintic activity	Bairagi et.al 2011
Leaf	Petroleum ether extract	Anthelmintic activity	Kabra et.al 2012
Peel	Water-ethanol extract	Antibacterial effect	Kabra et.al 2012
Peel	Chloroform and Ethanol extracts	Antimicrobial activity	Somesh Mehra, 2015
Root	Methanolic extract	Antidiabetic activity	Kanakam et.al 2014
Seed	Petroleum ether extract	Antidiabetic and Hypolipidemic activity	Sah et.al 2011, Peng et.al 2009
Seed	Petroleum ether extract	Anti-ovulatory activity	Patil 2009
Whole plant	Hydroalcoholic extract	PEG induced kidney stones	Baheti et.al 2013
Whole plant	Ethanolic extract	Antioxidant and Free Radical Scavenging Activity	Munwar et.al. 2015
Pulp	Juice	Anticancer activity	Cirmi et.al 2017
Pulp	Juice	Immunosuppressive, Anti-Depressant, Hepatoprotective, Neuroprotective	Huang et al. 2000, Lu et al. 2011, Piao et.al 2020, Ma et al. 2021b,

2.9 Literature Review of *Sesamum indicum*

Sesamum indicum L., or black sesame seed, is one of the most important oil seed crops in the world. It is also referred to as gingelly, beniseed, sesamum, sim-sim, and until (Shyu, Y.S. and Hwang, L.S. 2002). It has been grown for antiquity, notably in Asia and Africa, because of its high protein and edible oil content (Salunkhe, DK et al. 1991). It is also thought to be a nutritious food (Fukuda, Y. and Namiki, M 1988). According to folklore, black sesame is a necessary component in a tea that helps stroke sufferers heal. *S. indicum* contains antioxidant compounds such as sesamol, sesamolin, and sesaminol (Wichitsranoi J et al 2011).

The plant known as "sesame," or "Benne," is an annual, erect plant (Sindicum) with numerous varieties that are a member of the Pedaliaceae family. Since ancient times, it has been cultivated for its seeds, which are extracted to yield valuable oil and are also used as food and flavoring (Encyclopedia Britannica, 2012).

2.9.1 Vernacular name

Bengali: Til

Hindi: Gingli, Til

Sanskrit: Tila

English: Sesame

2.9.2 Scientific Classification

Kingdom: Plantae

Division: Tracheophyta

Class: Magnoliopsida

Order: Lamiales

Family: Pedaliaceae

Genus: *Sesamum*

Species: *indicum*

Bionomial Name: *Sesamum indicum*

2.9.3 Botanical Description (Isha et.al 2012):

Habitat:

An annual plant with opposing leaves that are 4–14 cm long and have a complete margin, it grows 50–100 cm tall on a branching stem.

Flowers:

The blooms have four lobes on their tubular, yellow mouths that are 3–5 cm long. Some flowers are purple, blue, or white, among other colors. The photoperiod and sesame variety have an impact on when flowers begin. Sesame seeds' oil content is also influenced by photoperiod, a longer photoperiod results in a higher oil content. The ratio of the seed's oil content to protein content is inverse.

Fruits:

Sesame fruit is a capsule that is usually pubescent, rectangular in shape and has a small, triangular beak that is grooved. Depending on the varietal cultivar, the fruit naturally splits open to release the seeds either by using two apical pores or by breaking along the septa from top to bottom.

Seeds:

They're not big. There are currently thousands of identified variants that differ in size, shape, and color. The seeds are typically 2 mm in diameter, 1 mm thick, and 3–4 mm long. The seeds have an oval shape, are somewhat thinner at the eye than the other end and have been slightly flattened. The seeds range in weight from 20 to 40 mm. The seed coat could have ribs or be smooth.

The cultivar that is collected affects the color of the sesame seeds. The most traded variety of sesame is the off-white kind. Other common colors are buff, tan, gold, brown, reddish, gray, and black.

2.9.4 Phytochemical Review of *Sesamum indicum*

Table 2.6: Phytochemical Review of *Sesamum indicum*

Part used	Phytochemical class (Solvent used)	Phytochemical constituents (Isolated)	Reference
Seed	Unsaturated Fatty acid	Palmitic acid, Oleic acid, Stearic acid, Arachidic acid, Linoleic acid, Linolenic acid, Lignoceric acid, Palmitoleic acid, Margaric acid, Caproic acid, Behenic acid, myristic acid,	Wu, K.; et. al 2017

Seed	Carbohydrates	D-Glucose, D-galactose, D-Fructose, Raffinose, Stachyose, Planteose, Sesamose	Kapadia GJ et.al 2002, Hegde, D.M. 2012
Seed	Lignan	Sesamin, Sesamolin, Sesamol, (+)-Episesaminone, (+) Episesaminol 6-catecho, pinoresinol, (□)-Pinoresinol-O-glucoside, (+)-Pinoresinol Di-O-*b*-D-glucopyranoside, glucopyranosyl-(1!6)-*b*-Dglucopyranoside, Sesaminol, (+)-Sesaminol 2-O-*b*-D-glucoside (+)-Sesaminol diglucoside, (+)-Sesaminol 2-O-*b*-D-glucosyl (1!2)-O-[*b*-D-glucosyl (1!6)]-*b*-D-glucoside, Sesamolinol, (+)-Sesamolinol 40-O-*b*-D-Glucoside, Sesamolinol 40-O-*b*-D-glucosyl (1!6)-O-*b*-D-glucoside, Matairesinol, Samin, Sesangolin, Disaminyl ether	Wu, K.; et. al 2017, Dar, A.A. et.al 2019
Seed	Phenolic antioxidants	Sesamol and Sesaminol (Cholesterol lowering effect, prevent high BP.),	Ogawa H et.al 1995

		two unique substances, Sesamin and Sesamolin	
Seed	Micronutrients	Phosphorous, Iron, Magnesium, Manganese, Zinc, Potassium, Selenium, Sodium, Copper, Calcium	Hasan AF et.al 2000, ANSES 2022
Seed	Vitamins	Vitamin A, Thiamine, Riboflavin, Niacin, Pantothenic acid, Folic acid, Ascorbic acid, *a*-Tocopherol, *b*-Tocopherol, γ-Tocopherol, _-tocopherol, Tocotrienol	Hegde, D.M. 2012, Fasuan, T.O. et.al 2018, ANSES 2022
Seed	Protein	Albumin, Globulin (*a* and *b*), Prolamin, Glutelin fractions	Hegde, D.M. 2012
Seed	Essential amino acid	Alanine, Arginine, Aspartic acid, Cysteine, Glutamic acid, Glycine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Serine, Threonine, Tyrosine, Valine, Tryptophan, Proline, *g*-Aminobutyric acid	Kapadia GJ et.al 2002, Wang, R. et.al 2020

2.9.5 Pharmacological Review of *Sesamum indicum*

Table 2.7: Pharmacological Review of *Sesamum indicum*

Part of Plant	Extract	Pharmacological Activity	References
Seeds	Ethanolic	Analgesic, Antipyretic, anti-inflammatory activity	Saleem TSM, 2011
Seeds	oil	Hypolipidemic activity	Lim JS, 2007
Seeds	oil	Antineoplastic Activity	Chajraborthy GS, 2008, Majdalawieh, A.F. et.al 2020, Albaqami, J.J. 2024
Seeds	oil	Wound Healing Activity	Kiran K, 2008
Seeds	oil	Hepato protective activity	Gauthaman K, 2009
Seeds	Ethanolic	Antioxidant activity	Joshi et.al 2005, Bopitiya, D., & Madhujith, T. 2015, Askander, N.Z et.al 2023, Albaqami, J.J. 2024
Seeds	Methanolic extract	Anthelmintic activity	Kamal et.al, 2015
Seeds	Methanolic	Antihypertensive effect	Du, T. et.al 2023
Seeds	Oil	Antimicrobial activity	Beg, M.A., & Ali, R. (2023)

Seeds	Methanolic	Anti-peptic and gastroprotective ulcer activity	Sori, R.K. et.al 2018, Mishra, S et.al 2019
Seeds	Methanolic	Antidiabetic, and hypoglycemic potential	Quintero-Soto, M.F. et.al 2022
Seeds	Oil	Ovicidal activity	Akter, S., et.al 2019

2.10 Latest Discoveries of Plants with Anticoagulant Properties

Table 2.8: list of plants with anticoagulant activity

Name of drug	Part	Chemical constituent	Reference
Panax notoginseng	Root	Three Saponins	Cui et.al 2022
Laminaria japonica	-	Polysachharides - LJP0, LJP04, LJP06, and LJP08	Li et.al 2022
Punica granatum		antithrombin-III like protein (ALPP)	Sawetaji et.al 2023
Cupressus sempervirens	Whole plant	phenolic and flavonoid compounds – Hesperetin, pyro catechol, rutin, gallic acid, chlorogenic acid, naringenin, and quercetin	Al-Rajhi et. Al 2023
Pistacia lentiscus	Leaves and fruits	3,5-di-*O*-galloyl quinic acid, gallic acid, and 3,4,5-tri-*O*-galloyl quinic acid	Drioiche et.al 2023
Phyllophorella kohkutiensis	Ball sea cucumbers	Fucosylated chondroitin sulfate	Lan et.al 2023
Polygonum amplexicaule D	-	butyl gallate and β-sitosterol	Huang et.al 2024

Tripleurospermum inodorum	Herb	chlorogenic acid, 5-*O*-p-coumaroylquinic acid, 1-*O*-p-coumaroylquinic acid, luteolin-7-glucoside, quercetin-3-glucoside, luteolin-7-rutinoside, 3,5-*O*-dicaffeoylquinic acid, quercetin-3-*O*-malonylglucoside, apigenin-7-glucoside, luteolin-3-malonylglucoside, cynarin, rhamnetin-3-(*O*-dimethyl rhamnosyl glucosylglucoside), and luteolin	Marakhova et.al 2024
Chaetomorpha linum	Green Sea Weed	sulfated arabinogalactan	Quach et.al 2024