

# A Review on the Pharmacological Properties of *Heritiera fomes*

By

Shawdik Das  
13346045

A thesis submitted to the Department of Pharmacy in partial fulfillment of the requirements for the degree of Bachelor of Pharmacy (Hons.)

Department of Pharmacy  
Brac University  
December 2020

©2020. Brac University  
All rights reserved.

## **Declaration**

It is hereby declared that

1. The project submitted is my own original work while completing degree at Brac University.
2. The project does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The project does not contain material, which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I have acknowledged all main sources of help.

**Student's Full Name & Signature:**

SHAWDIK DAS  
21.12.2020

---

**Shawdik Das**

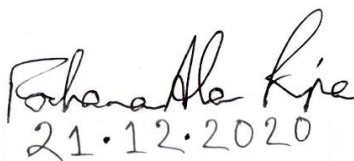
13346045

## Approval

The thesis/project titled “A Review on the Pharmacological Properties of *Heritiera fomes*” submitted by Shawdik Das (ID: 13346045) of summer, 2013 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Pharmacy (Hons.), on 21<sup>st</sup> December, 2020.

### Examining Committee:

Supervisor:  
(Member)



21.12.2020

---

Dr. Farhana Alam Ripa  
Assistant Professor,  
Department of Pharmacy  
Brac University

Program Coordinator:  
(Member)

---

Dr. Hasina Yasmin  
Professor,  
Department of Pharmacy  
Brac University

Departmental Head:  
(Chair)

---

Professor Dr. Eva Rahman Kabir  
Chairperson,  
Department of Pharmacy  
Brac University

## **Abstract**

*Heritiera fomes* is one of the vital plants in the mangrove forest of Bangladesh. It is widely used by the local people in many purposes including domestic and medical uses. The purpose of this project is to highlight the different pharmacological properties of *H. fomes* (Sundori) plant. This plant has a number of medicinal properties such as, anticancer activity, antidiabetic activity, antioxidant activity, anti-nociceptive activity, anti-obesity, antimicrobial activity. Moreover, medicinal properties like, anti-MRSA activity, anti-diarrhea activity, micro-nutrient activity are also found in this plant which makes it an ideal medicinal plant among other plants found in Sundarban mangrove forest. These pharmacological properties helps to discover many medicines and also beneficial for the treatment of many diseases. Scientist believes that *H. fomes* has many more medicinal properties which are yet to be found. The advantageous pharmacological properties and there effect on many diseases have been emphasized in these work.

**Keywords:** *Heritiera fomes*, antidiabetic activity, anticancer activity, anti-MRSA activity, anti-nociceptive activity, anti-obesity activity

## **Dedication**

*Dedicated to my Parents.*

## **Acknowledgement**

All I would like to begin by thanking the Almighty, our creator, the source of our life, knowledge and wisdom. All praises to Him and I am grateful to Him for blessing me with immense strength, patience whenever necessary to complete this project. This research would not have been completed without the assistance of the people who are gratefully recognized here.

First and foremost, I would also like to express my deepest gratitude and honor to my supervisor, Dr. Farhana Alam Ripa, Assistant professor, Department of Pharmacy, Brac University. I would like to thank her for giving me the opportunity to work with her. Her encouragement, continuous assistance, and motivation towards my project helped me to complete it efficiently. Her enthusiasm and dedication towards research and teaching have inspired me to be a part of this novel profession in future.

Then I would like to express my gratitude and appreciation to Dr. Eva Rahman Kabir, Chairperson, Department of Pharmacy, Brac University. She has provided an enormous support and inspired me to complete my research.

Last but not the least, I would like to thank my family, class mates and friends for being with me. Their constant support helped me to work hardly in every stages of my life. Without their prayers and support I would not have come this far.

## Table of Contents

<b>Declaration</b> .....	<b>ii</b>
<b>Approval</b> .....	<b>iii</b>
<b>Abstract</b> .....	<b>iv</b>
<b>Dedication</b> .....	<b>v</b>
<b>Acknowledgement</b> .....	<b>vi</b>
<b>Table of Contents</b> .....	<b>vii</b>
<b>List of Tables</b> .....	<b>xi</b>
<b>List of Figures</b> .....	<b>xii</b>
<b>List of Acronyms</b> .....	<b>xiv</b>
<b>Chapter 1</b> .....	<b>1</b>
<b>Introduction</b> .....	<b>1</b>
1.1 Background .....	1
1.2 Classification of medicinal plants .....	6
1.2.1 Classification according to their usage .....	7
1.2.2 Classification to their active constituents .....	7
1.2.3 Classification according to the period of life .....	7
1.2.4 Botanical classification of medicinal and aromatic plants .....	7
1.2.5 Classification of natural products .....	8
1.3 Some medicinal plants of Bangladesh .....	8
1.4 Phytochemical constituents of medicinal plants .....	9

1.4.1 Alkaloids .....	10
1.4.2 Glycosides .....	11
1.4.3 Polyphenols .....	11
1.4.4 Terpenes .....	13
1.5 Background .....	14
1.6 Description of the plant <i>H. fomes</i> .....	16
1.6.1 Classification of <i>H. fomes</i> .....	17
1.6.2 Location of the plant.....	18
1.6.3 Useful parts of the <i>H. fomes</i> .....	20
1.7 Botanical features of <i>H. fomes</i> .....	24
1.7.1 Salinity.....	24
1.7.2 Limiting water loss .....	25
1.7.3 Conversion to low amount oxygen .....	25
1.7.4 Increased survival of <i>H. fomes</i> offspring.....	25
1.8 Phytochemical constituents of <i>H. fomes</i> .....	26
1.9 Application of chemical constituents derived from <i>H. fomes</i> .....	29
1.9.1 Application of Glycosides .....	29
1.9.2 Application of Alkaloids .....	29
1.9.3 Application of Tannin.....	30
1.10 Importance of <i>H. fomes</i> .....	31
<b>Chapter 2.....</b>	<b>33</b>



<b>Pharmacological properties of <i>H. fomes</i> .....</b>	<b>33</b>
2.1 Anti-cancer property .....	34
2.1.1 Cancer .....	34
2.1.2 Anticancer activity of <i>H. fomes</i> .....	35
2.2 Antidiabetic property .....	35
2.2.2 Antidiabetic activity of <i>H. fomes</i> .....	37
2.2.3 Major bioactive constituents of <i>H. fomes</i> exhibiting hypoglycaemic properties	38
2.3 Antioxidant property .....	39
2.3.1 Antioxidant .....	39
2.3.2 Antioxidant activity of <i>H. fomes</i> .....	40
2.4 Anti-obesity property .....	42
2.4.1 Obesity .....	42
2.4.2 Anti-obesity activity of <i>H. fomes</i> .....	43
2.5 Anti-nociceptive property .....	45
2.5.1 Nociception or pain.....	45
2.5.2 Anti-nociceptive activity of <i>H. fomes</i> .....	46
2.6 Other useful properties of <i>H. fomes</i> .....	47
2.6.1 Anti-diarrhea activity.....	47
2.6.2 Micro-nutrient activity of Sundari .....	48
2.6.3 Antimicrobial activity.....	50
2.6.4 Anti-MRSA activity.....	50

<b>Chapter 3</b> .....	<b>52</b>
<b>Discussion</b> .....	<b>52</b>
<b>Chapter 4</b> .....	<b>59</b>
<b>Conclusion</b> .....	<b>59</b>
<b>References</b> .....	<b>60</b>

## List of Tables

Table 1: Classification of medicinal plants .....	6
Table 2: Classification of medicinal plants according to active constituents .....	7
Table 3: Classification of medicinal plant according to the period of life .....	7
Table 4: Classification of natural products of medicinal plants .....	8
Table 5: List of some medicinal plants of Bangladesh .....	9
Table 6: Different parts name and description of <i>H. fomes</i> .....	21
Table 7: Some phytochemical compound accessed from <i>H. fomes</i> .....	27
Table 8: Micro nutrient content in 100gms of fruit .....	49

## List of Figures

Figure 1: <i>Adhatoda vasica</i> L .....	3
Figure 2: <i>Alocasia indica</i> (Roxb.) Schott .....	3
Figure 3: <i>Annona muricata</i> L.....	4
Figure 4: <i>Bauhinia purpurea</i> L. ....	4
Figure 5: <i>Camellia sinensis</i> (L.) Kuntze .....	5
Figure 6: <i>Clerodendrum viscosum</i> Vent .....	5
Figure 7: <i>Ficus racemose</i> L.....	6
Figure 8: The alkaloid nicotine from tobacco .....	10
Figure 9: Digoxin, used to treat heart failure .....	11
Figure 10: Tannic acid, plant-derived polyphenol.....	12
Figure 11: Monoterpene .....	13
Figure 12: Monoterpenoid.....	14
Figure 13: Mangrove forest, Sundarbans .....	15
Figure 14: <i>H. fomes</i> tree, Sundarbans.....	17
Figure 15: Location of the <i>H. fomes</i> in Bangladesh .....	19
Figure 16: <i>H. fomes</i> in Sundarban .....	19
Figure 17: Roots of <i>H. fomes</i> .....	22
Figure 18: Spike roots of <i>H. fomes</i> .....	22
Figure 19: Flowers of <i>H. fomes</i> .....	22
Figure 20: Leafs of <i>H. fomes</i> .....	23
Figure 21: Fruits of <i>H. fomes</i> .....	23
Figure 22: Trunk with roots of <i>H. fomes</i> .....	24
Figure 23: Stigmastero .....	27
Figure 24: $\beta$ - Sitisterol.....	28

Figure 25: Tannin(Tannic acid) .....	28
Figure 26: Stigmast-4en-3-one .....	28
Figure 27:Cancer cell .....	34
Figure 28: Complications of Diabetes.....	37
Figure 29: Desirable role of mangrove plants in the controlling of diabetes.....	38
Figure 30: Antioxidant, Ascorbic acid .....	40
Figure 31: Procyanidins, identified in <i>H. fomes</i> .....	41
Figure 32: Medical complications of Obesity.....	43
Figure 33: Anatomy of nociceptors .....	46

## List of Acronyms

HFCD	High Fat Cafeteria Diet
MEHF	Methanolic Extract of Leaves of <i>H. fomes</i>
HDL	High Density Lipoprotein
LDL	Low Density Lipoprotein
VLDL	Very Low Density Lipoprotein
HMG-CoA	3-Hydroxy-3-Methyl Glestaryl Coenzyme A
CAT	Catalase
TC	Total Cholesterol
TG	Triglyceride
ROS	Reactive Oxygen Species
GPx	Glutathione Peroxidase
DRG	Dorsal Root Ganglia
MRSA	Methicillin Resistant Staphylococcus Aureus
MDRB	Multi Drug Resistance Bacteria
SOD	Superoxide Dismertase

# Chapter 1

## Introduction

### 1.1 Background

Since the beginning of human medicine history, medicinal plants plays a very important role. The word 'medicinal plant' includes different types of herbal plants (herbology or ayurvedic supplements). Through use of plants and the science related to these applications are known as medicinal reasons The name 'Herb' is borrowed first from Latin word “*Herba*” and from the ancient French word which is called “*Herbe*”. At present, a plant like seeds, fruit, vine, flower, bark, leaf, fringe, or base and a non-woody plant are indicated by herb. Medicinal herbs can also be used as cosmetics, as food, as flavonoids, as well as in various spiritual activities. For several kinds of medicinal purposes, plants were used since before the ancient times. Egyptian manuscript and Chinese works demonstrated the use of herbs in Antiquated Unani compositions. There is evidence that Unani spiritual Hakims, Indian, and European and surrounding of the Mediterranean Sea societies have used herbs for a long time as medicine since over 4000 years. Inherent societies including such Rome, Ethiopia, Iran, Eastern Europe, and United states used herbs throughout their patching up ceremonies, while others developed traditional therapeutic systems in which home-grown remedies were methodically used, such as Unani, Ayurvedic medicine, and Chinese Pharmaceutical. India has been very common among ancient advances and is considered to be a rich reservoir of different medicinal plant species. About 8000 herbal medicines have been summarized in AYUSH systems of indigenous remedies (Firenzuoli & Gori, 2007). Unani Medicine and Ayurveda are the most evolved and widely practiced of these portals in India. The WHO (World Health Organization) recently estimated that about 80% of people worldwide depend

on herbal remedies for so many of their initial medicinal purposes. In addition, about twenty one thousands plant species have immense promise to be used as medicinal herbs, according to the WHO (Bynum & Porter, 2008). More than three-quarters of its global population depends, according to available data, primarily on plants and plant extracts for their health care needs. Over than 30 per cent of all plant species have been used for medicinal purposes at one time or another. It has already been assessed that plant drugs constitute as much as 25 percent of all drugs in developed nations such as joined together Nations, whereas the commitment is as much as 80 percent in fast-growing countries such as China, Sri Lanka, and India. In this way, the economic value of medicinal plants is much greater for nations like India than for the rest of the other countries in the world. These nations offer two-thirds of a species used in the advanced medication system and the nation's population's well-being treatment framework relies on inborn medication frameworks. The use of medicinal herbs as a medicine is known to be very healthy and no side effects are present or negligible. The old researchers agreed that herbs are arrangements to cure a variety of problems and diseases linked to well-being as it were. They thought intensively about almost the same matter, checked to draw specific conclusions about the adequacy of different herbs with therapeutic esteem. Most medicines, described in this way, are completely risk - free or reactions. This may be the explanation why homegrown therapy is rising in popularity around the world. Such herbs with restorative quality offer judicious implications for the treatment of various internal diseases, which are known to be troublesome to remedy. There are numerous forms of medicinal plants that can cure many common ailments, such as Aloe Vera gel, Neem bark and leaf, Tulsi tree, Cayenne pepper, Ginger and so many more. Restorative plants are known to be a rich asset of accouterments that can be used as pharmacopoeial, non-pharmacopoeial, including engineered drugs for sedate improvement. These plants play a fundamental role in the development of human communities across the entire world, a portion of that. In addition,



several plants seeds and fruits are considered a vital source of sustenance and so as a consequence, their restorative qualities are prescribed. Ginger, tea leaf, walnuts, aloe Vera, peppers and turmeric are included in some of these seeds, etc. A few plants and their subordinates are known as vital sources of complex fixtures used in ibuprofen and tooth cleaning products, etc. Some medicinal plants which are found in Bangladesh is given below:



*Figure 1: Adhatoda vasica L. (Claeson, Malmfors, Wikman, & Bruhn, 2000)*



*Figure 2: Alocasia indica (Roxb.) Schott (Rahman, Solaiman, Haque, & Das, 2011)*



*Figure 3: Annona muricata L. (Wahab, Jantan, Haque, & Arshad, 2018)*



*Figure 4: Bauhinia purpurea L. (Chandrashekar & Kumar, 2011)*



*Figure 5: Camellia sinensis(L.) Kuntze (Sharangi, 2009)*



*Figure 6: Clerodendrum viscosum Vent (Nandi & Lyndem, 2016)*



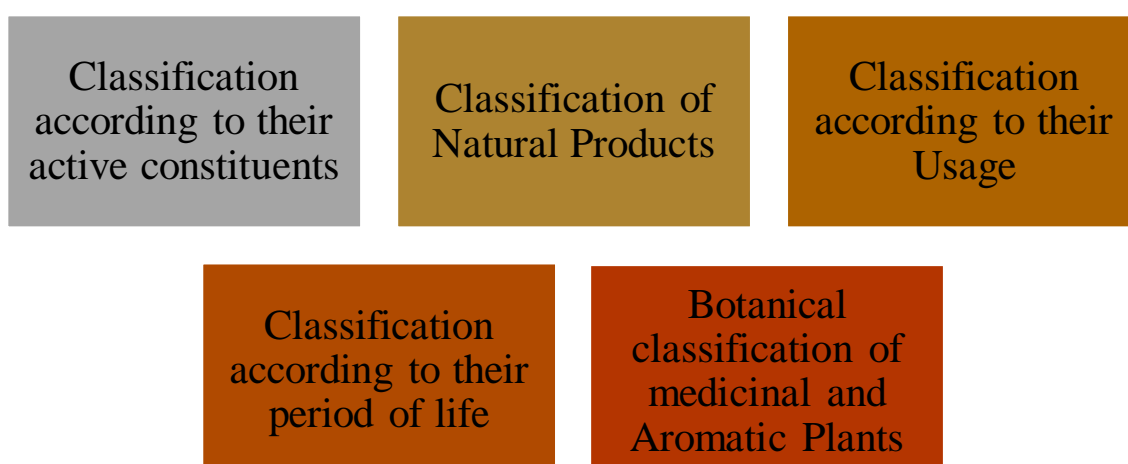


*Figure 7: Ficus racemosa L. (Ahmed & Urooj, 2010)*

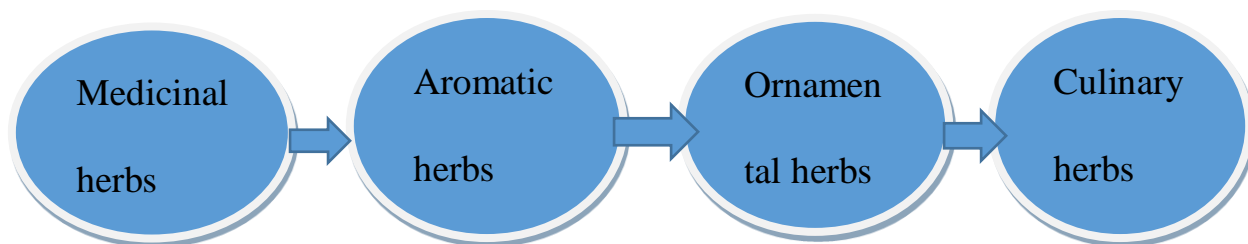
## 1.2 Classification of medicinal plants

Sufficiently Medicinal plants can be classified based on different aspects. There are different variety can be seen among the medicinal plants. They can be classified based on according to their usage, according to their period of life, according to their active constituents, botanical classification of Medicinal and Aromatic plants, and according to their natural products.

*Table 1: Classification of medicinal plants*



### 1.2.1 Classification according to their usage



### 1.2.2 Classification to their active constituents

Table 2: Classification of medicinal plants according to active constituents

No.	Classification	Examples
1.	Aromatic	Lemon, ginger, garlic
2.	Astringents	Peppermint
3.	Bitter	Saponin containing Herbs, Laxative Herbs
4.	Mucilaginous	Aleo vera
5.	Nutritive Herbs	Orange, papaya, onion

### 1.2.3 Classification according to the period of life

Table 3: Classification of medicinal plant according to the period of life

Annuals	They complete their life cycle in one year.
Biennials	They are plants which live two season
Perennials	They grow for more than one season

### 1.2.4 Botanical classification of medicinal and aromatic plants

1. Compositae family

2. Labiatae family
3. Umbelliferae family
4. Leguminosae family
5. Rosaceae family
6. Rutaceae family
7. Cruciferae family
8. Caryophyllaceae family
9. Malvaceae family

### 1.2.5 Classification of natural products

*Table 4: Classification of natural products of medicinal plants*

1. Classification based on their chemical structure	Aliphatic, Acyclic, Aromatic, Heterocyclic
2. Classification based on their biogenesis	Mevalonic acid route, Acetate route, Shikimic acid route
3. Classification based on their physiologic activity	Hormones, antibiotics, vitamins, mycotoxins
4. Classification based on their taxonomy	Morphological studies of plants

### 1.3 Some medicinal plants of Bangladesh

Bangladesh is very rich in medicinal plants. The geographical location is also a great advantage for its abundant amount of medicinal plants. There are many species here which are only found in Bangladesh. Most of the plants are found in coastal areas and some are in Southern part of the country. More than 300 plant species are found useful for the making of

great medicine (Mominul Islam et al., 2018). Among them some plants names are listed below:

*Table 5: List of some medicinal plants of Bangladesh*

Plant name	Family name	Plant category
<i>Bauhinia purpurea L.</i>	Fabaceae	Tree
<i>Cassia fistula L.</i>	Fabaceae	Tree
<i>H. fomes</i>	Malvaceae	Tree
<i>Coriandrum sativum L.</i>	Umbelifers	Herb
<i>Azadirachta indica A. Juss.</i>	Meliaceae	Tree
<i>Ficus racemose L.</i>	Moraceae	Tree
<i>Curcuma longa L.</i>	Zingiberaceae	Tree
<i>Morus alba L.</i>	Moraceae	Tree

#### **1.4 Phytochemical constituents of medicinal plants**

Chemical compounds that provide them a metamorphic advantage may be developed by all forms of medicinal plants, such as defending against different herbivores or maybe in the instance of salicylic acid, mostly as hormone in plant protections. These phytochemicals do have potentiality to be used as different types of drugs, and if scientifically verified, the substance and known pharmacological movement of these substances in therapeutic plants is the rational premise for their use in today's modern pharmaceuticals. Daffodils, for instance,

include nine classes of alkaloids that are approved for use against Alzheimer's disease, including galantamine. Different types of medicinal elements can be found in different medicinal plants. Some of them are listed and discussed below:

### 1.4.1 Alkaloids

At the beginning of the 19th century, it was discovered that active ingredients were responsible for the healing ability of medicinal plants. Some exudates and plant extracts have been found to have anti-bacterial and anti-fungal properties, such as those of neem. Medicinal plant cells are highly advanced chemical factories that manufacture secondary metabolites that have important biological properties, including metabolites, antioxidants, triterpenes and oxygen (Kurhekar, 2017). Alkaloids include sour tasting chemicals present in many medicinal plants that are very common in nature and sometimes harmful. There are various types of medications, both prescription and recreational, with different mechanisms. Such as, scopolamine, atropine, berberine, morphine, quinidine, vincamine, reserpine etc. It has been claimed that several medicinal herbs contribute their alkaloid content to their molecular interactions, physiological activities between alkaloid molecules, and chemical characterization of the components of affected species. It is well known that alkaloids, which are herb secondary metabolites, have anti-microbial function (Kurhekar, 2017).

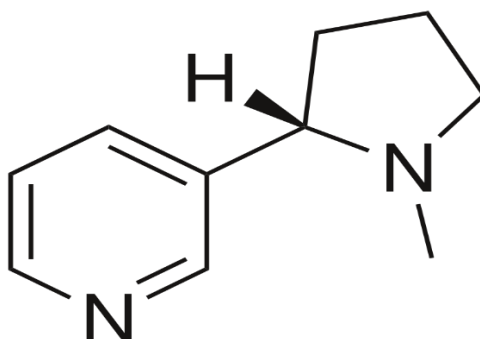


Figure 8: The alkaloid nicotine from tobacco (Peng et al., 2019)



## 1.4.2 Glycosides

Glycoside is one of a broad range of naturally occurring compounds in which a hydroxyl compound is mixed with a part consisting of a glucose, one or more sugars or uranic acid (sucrose). Here a hydroxyl compound, typically a non-sugar product, such as a phenol or alcohol by-product, may also be another carbohydrate, such as cellulose, starch or glycogen, consisting of several glucose units. In medicinal plants, ordinarily glycosides are found in convincing quantities. A number of them have anticancer activity. Glycosides derived from different medicinal herbs have been detected and used to treat various cancers as alternative drugs (H. Khan, Saeedi, Nabavi, Mubarak, & Bishayee, 2018). Popular glycosides, both alone and conversely in conjunction with other chemotherapeutic medications, provide a broad variety of preventive and restorative alternatives toward distinctive forms of cancer. These phytochemical therapies may also be a new pharmaceutical solution to cancer care (H. Khan et al., 2018).

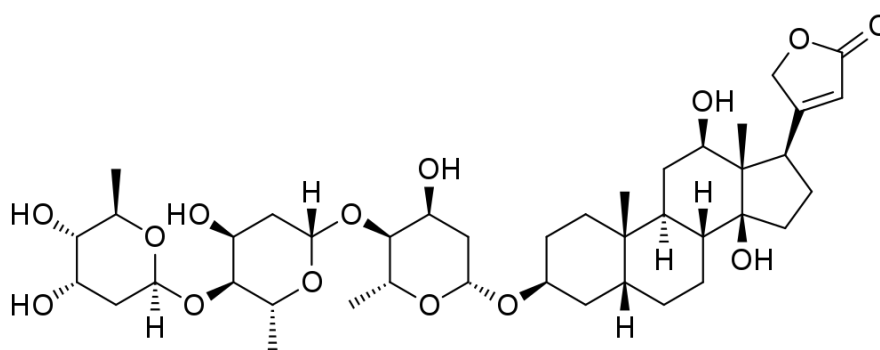
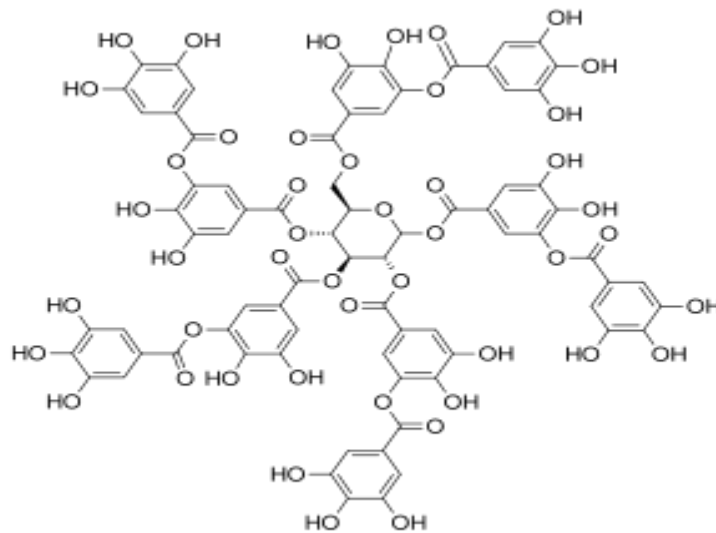


Figure 9: Digoxin, used to treat heart failure (Bartnik & Facey, 2017)

## 1.4.3 Polyphenols

Polyphenols are primarily a natural structural group, but also semisynthetic, synthetic, organic compound described by the existence of broad collective of phenol structural groups.

The rare physical, organic (toxic, metabolic, therapeutic), and chemical properties of specific members of the class is determined by the figure and components of these types phenol structures. For examples, ellagitannin and tannic acid. The verifiably critical chemical course of tannins could be a subset of the polyphenols. Polyphenols of a few classes are far reaching in plants, having assorted parts in guards against plant infections and predators. They include astringent tannins and hormone-mimicking phytoestrogens. Plants incorporating phytoestrogen, gynecological condition such as maturity, menstrual and menopause, has been controlled for decades.

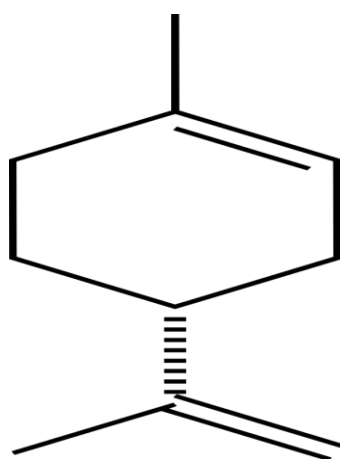


*Figure 10: Tannic acid, plant-derived polyphenol (Rasouli, Farzaei, & Khodarahmi, 2017)*

Medicinal and aromatic herbs and plants are very rich sources of polyphenols. Marjoram (*Majorana syriaca*), winter savory (*Satureja thymbra*), Rosemary (*Rosmarinus officinalis*), and sage (*Salvia officinalis*) are the most auspicious sources for the recovery of polyphenols (Oreopoulou, Tsimogiannis, & Oreopoulou, 2019).

### 1.4.4 Terpenes

Terpenes are a varied and extensive class, developed by conifers, plant variants and certain insect's chemical substances. They frequently have a solid odor and may ensure the plants that deliver them by discouraging herbivores and by drawing in predators and parasites of herbivores. Although "terpenes" are used conversely, terpenoids are modified terpenes as they accommodate additional functional groups, most of the time it is oxygen containing. Terpenes are mainly hydrocarbons. Terpenes and also the terpenoids are essential compositions of the basic natural oils of numerous sorts of medicinal trees and flowers. Fundamental oils are utilized broadly as scents in perfumery and conventional medication, such as fragrance based treatment. Engineered varieties and subordinates of characteristic terpenes and terpenoids too significantly extend the assortment of smells utilized in perfumery and flavors utilized in nourishment added substances. Owing to inadequate composition analysis of their terpenes, tropical medicinal plants remained neutralized by wholesale foods. With much more than 30,000 aggregates with different plants, Terpenes are the most important class of natural products (Obiloma et al., 2019).



*Figure 11: Monoterpene (Booth & Bohlmann, 2019)*

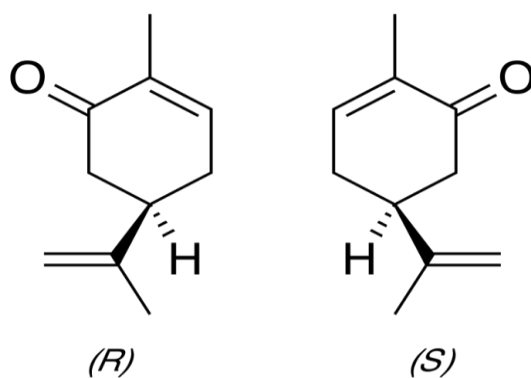


Figure 12: Monoterpenoid (Booth & Bohlmann, 2019)

## 1.5 Background

Bangladesh is one of the countries which has different kinds of plants in different areas. There is much diversity among the plants in the ecosystem. Over 5000 plant species can be found in Bangladesh and is the secondary center of origin of many plant species, including large cultivated plants. As different plants are found in Bangladesh, they are divided into four variety sectors of vegetation. Firstly, there are several low hills covered with bamboo and special wood called rattan in the eastern side that consists of the Sylhet and Chittagong zones (A species of clamber palm). These types of plants form the base of the state's paper business. The core zone, separating areas of the country to the north zone of Dhaka, which embraced by large numbers of ponds and other water resources and supports swampy plants. Madhupur jungles are one of the vast parts of this area. This area is situated northwest of the Jamuna region and southwest of the Padma region which mostly harvests cultivated plants and orchards. With its distinctive mangrove vegetation, the southern region all along with the Bay of Bengal encloses the vast wetlands of the Sundarbans. A few of the tropical plants, like the Sundori (*H. fomes*) for which the Sundarbans forest is called, are commercially important. Besides these, Kalo Baine (*Avicennia alba*), Hargoja (*Acanthus ilicifolius*), Khalsi (*Aegiceras corniculatum*), Peara Baine (*Avicennia marina*), etc. (Vanden Berghe, 2014), are also valuable plants and have different industrial properties. Sundarbans have also different kinds

of flowers which are lilies (locally they are called ‘shapla’, which is the national flower), Chinese hibiscus, tuberose, marigolds, etc.(Vanden Berghe, 2014). There are three institutions are dedicated to maintaining the gene banks of the plants of Bangladesh; the Bangladesh Jute Research Institute (BJRI); the Bangladesh Rice Research Institute (BRRI); and the Bangladesh Agriculture Research Institute (BARI). The influence peddler of these gene banks are circumscribed to crop plants, these institutes are mandated to deal with. There is a broad number of plant species that are not taken care are subject to annihilation due to rapid population increase, deforestation, civilization, and various “scientific development” projects. Already 45 plant species of the country are on the verge of extinction. There is only 5% of forest cover left (Vanden Berghe, 2014). Researchers already warrant more plant extinction. Moreover, Bangladesh is among the riskiest prostate areas in the world. During the rainy season, different natural calamities like flood, cyclone, tidal surge, and tornado often attack this country and occurs boundless damage to animal life and plant recourses. This waterway bank disintegration causes add up to misfortune of not as it were crops but moreover other plant hereditary assets in influenced regions. Every year a large area of forest vanished due to this problem.



*Figure 13: Mangrove forest, Sundarbans (Vanden Berghe, 2014)*

## 1.6 Description of the plant *H. fomes*

The local name of *H. fomes* is ‘Sundari’ which is the dominant plant species of the family Sterculiaceae, in the Sundarbans. Sundarban, the mangrove forests of the southern districts, is named by this plant. The plant is distributed up to about 70 percent of the forest. It is adapted to burgeoning high tide once dictated in the forest and to the low salty and freshwater zone. There is another species of Sundari, *H. littoralis*, is mostly raised in the western part of the Sundarbans. *H. fomes* is not that much bigger tree found in Sundarban. It is a medium-sized hedge plant that can grow to a height of 15 to 30 meters (49 to 83 ft.). The shape of the plant is trunk straight, leaves elliptic and roots are trivial and widely distributed which is form up pneumatophores and blind root sucked. Its bell-shaped flowers are small in nature, almost 5mm, unisexual, color can be orange pinkish and fruits are formed in clusters. The fruits can be up to 5cm (2.0 in) length and up to 3.8 cm (1.5 in) width (Vanden Berghe, 2014). *H. fomes* has a rigid stalk and gray bark and cracked longitudinally. The dark green sheets have correct petioles, clustered at the end of the branch tips. Earlier pneumatophores are mentioned which is produced by the plant at 3 to 4 years of age. This medicinal tree can breed in areas with a heated fair climate of 7.24 °C to 37.79 °C and in addition heavy yearly raindrops of 1650 mm to 5334mm (Siddiqi, 2020). The plant flourishes on clayey land and in some areas like at intervals sides of the rivers and also the below salty areas. In the Sundarbans, the terminal species is sweet, salty and brackish on the young plant colonies. It is highly produced at low salty areas but it cannot spread in the high salt mixed water zone (Vanden Berghe, 2014). The fruits grow up between June and August and seeds sprout readily.



Figure 14: *H. fomes* tree, Sundarbans (M. N. I. Khan, Khatun, Azad, & Mollick, 2020a)

### 1.6.1 Classification of *H. fomes*

Binomial name: *H. fomes* (Vanden Berghe, 2014)

Scientific classification	
Domain:	Eukaryota
Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Malvales

Family:	Malvaceae
Genus:	<i>Heritiera</i>
Species:	<i>H. fomes</i>

### 1.6.2 Location of the plant

In nearly every coastal forest area of the world, *H. fomes* can be found. The field ranges from the Eastern coast of India, Bangladesh and Malaysia to Myanmar and Thailand. It is native to marshy regions in The Indo-Pacific. The tree grows in the forests of the Sundarbans in Bangladesh and West Bengal, in the Ganges-Brahmaputra Delta, on the coasts of Bangladesh's Chittagong and in Arakan (an area noticed in Myanmar) (M. N. I. Khan et al., 2020a). This plant can also be widely found in the Sundarbans fresh water area and spread in a forest area with lower or heavy salt water. In the top plantation that has a high direct sunlight and even in full shade under the forest, *H. fomes* grows properly. The plasticity of leaf anatomical features in *H. fomes* differs in ambient light at different canopy levels as a result of this property. . Comparison to other mangrove plants, in saline conditions, *Heritiera fomes* grows in less quantity and blot soil is rarely deluged by the tide. In addition, it thrives on artificial soils and is the preeminent species in these ecosystems, usually distributed on the low banks that form around the corners of newly emerged saucer-shaped islands (M. N. I. Khan et al., 2020a). Far away from the high strips all along canal, this species grow best. This species does not increase the recurrent flooding (Siddiqi, 2020) and it is restricted as a restrictive moderate to heavy submersion (Roxb, 2009). *H. fomes* should never be located in tropical where water hibernates or on high soils that never overflow (Roxb, 2009). The undergrowth is primarily absent from the thick forests of *H. fomes*. Under mild cover, natural



restoration seems more successful than when the shade seems to be too accessible (M. N. I. Khan et al., 2020).

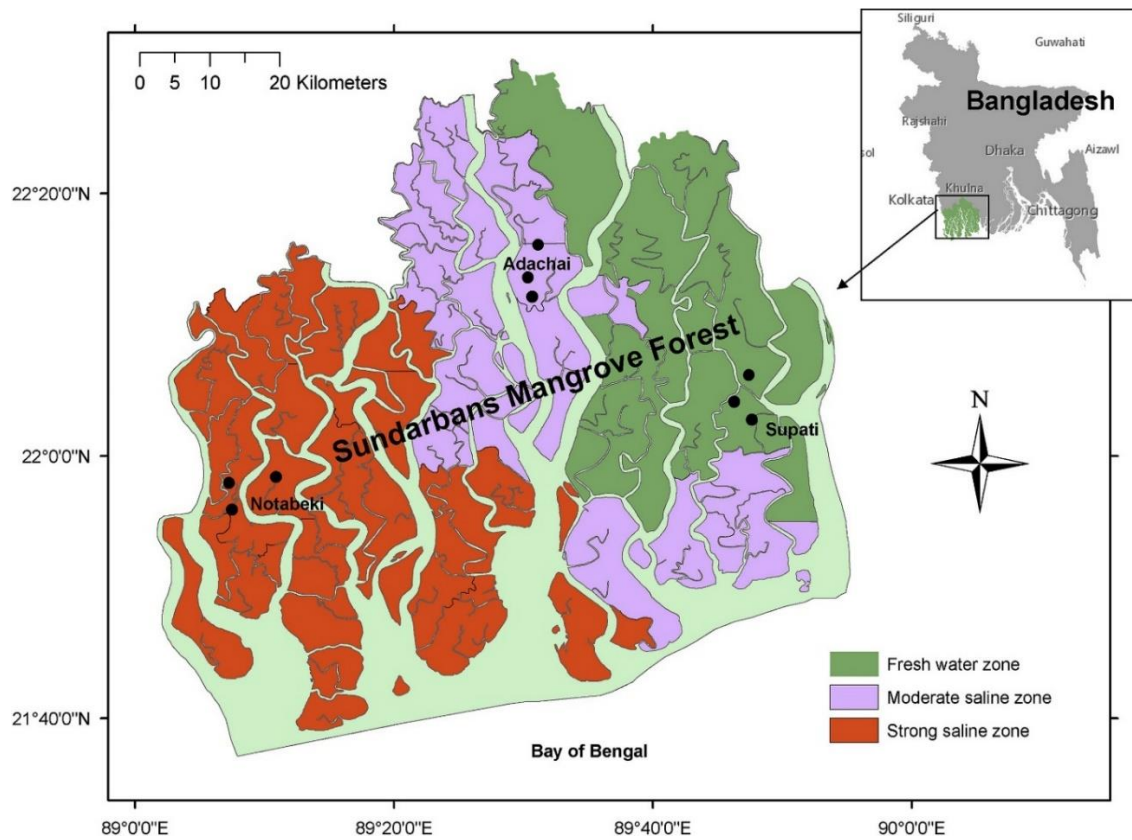


Figure 15: Location of the *H. fomes* in Bangladesh (Roxb, 2009)



Figure 16: *H. fomes* in Sundarban (Mominul Islam et al., 2018)

### **1.6.3 Useful parts of the *H. fomes***

The plant *H. fomes* (Sundari) have different chemical compositions. It accommodates 0.26% and 0.09 percent of chl-a, and chl-b, jointly. It also contains the carbon molecule, polyphenol substances, tannin, and protein derivate elements are 0.11%, 39.44%, 21.11%, and 29.23% of dry mass (Plan, 2012). The tree is mainly harvested in Asia from the forest for its wood. The channel wood species is Sundari and is the main source base in the area for 221 tiny steel mills and 350 pitsaw devices (Taeb, 1996). Its seed is also used because it has an abundant amount of starch and it can be eaten in times of food shortage. The seeds contain tannins and are very acrid if these are not removed first with the help of cold water. The heartwood is a dark red to brownish which is very hard, durable, elastic, and heavy. It is used for construction. Also, wood is a good source of quality charcoal and a good source of fuel. The leaf is sometimes eaten by different kinds of animals like monkeys, insects, etc. fallen leafs are a significant source of complements both for coral reefs and also in reach the habitat for mangroves. The leaves are torn up by the crabs and many other tiny individuals which results in useful minerals. Moreover, pneumatophores are also used for others, small creatures. Some tiny moth larvae used them as their food source (Chowdhury, Kitin, De Ridder, Delvaux, & Beeckman, 2016). The bark of the plant is used for extracting different chemical elements for treating different diseases and other further research. It also helps to give a proper source of fuel. Also. Bark and roots are used for other reasons, for example, fish poison Roots have a huge proportion of filter feeders protected against the tangle of ingrain: shellfish, wet wipes, barnacles. Such filter feeders will purify the water from the silt and nutrients. The roots that cause the coral reef to grow in this process come from clear salt-free water. Also, the roots of ‘Sundari’ are used for the prevention of sand and mud from being washed away with the tide and river current. The parts of *H. fomes* and their details is given below in the list:

Table 6: Different parts name and description of *H. fomes*

<i>H. fomes</i>	
Parts names	Description
Trunk	Straight, Rough, dry, Brown in color
Leaves	Elliptic, broad, green in color
Roots	It has pneumataphores and blind root sucker, hard in nature
Flower	Bell-shaped, small in size, unisexual, orange to pinkish
Fruits	Formed in clusters, normally radish in color, small in size
Spike roots	Very hard in nature, dark brown in color, Spikes like shape.

Some pictures of useful parts of *H. fomes* is given below:



*Figure 17: Roots of H. fomes (Chowdhury et al., 2016)*



*Figure 18: Spike roots of H. fomes (Mominul Islam et al., 2018)*



*Figure 19: Flowers of H. fomes (Mominul Islam et al., 2018)*



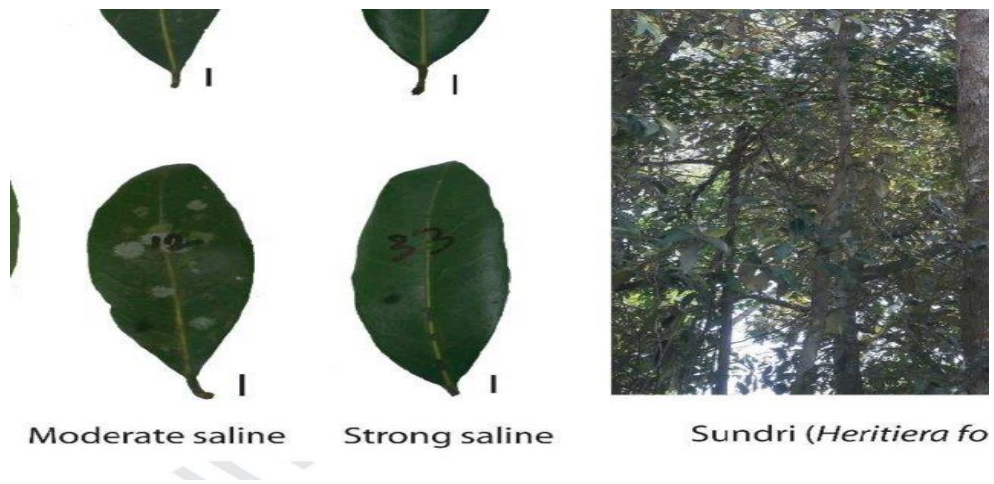


Figure 20: Leaves of *H. fomes* (M. N. I. Khan, Khatun, Azad, & Mollick, 2020b)



Figure 21: Fruits of *H. fomes* (Mominul Islam et al., 2018)



*Figure 22: Trunk with roots of H. fomes (Chowdhury et al., 2016)*

## **1.7 Botanical features of *H. fomes***

The natural vegetation of the Sundarbans forest is mainly full of shrubs, climbers, halophytic herbs, and other tree species. The floristic mixer of the Sundarbans is very upper crust compared to many mangroves of the world. Among them, the Sundarban mangrove forest is influenced by *H. fomes* (Sundari). Salinity is the key factor in controlling the growth and distribution of mangroves. Besides these features, other features are visible in this plant. They are:

### **1.7.1 Salinity**

*H. fomes* have salinity features for its growth and distribution in the forest. This feature contains an appropriate variability. Because it grows in a region of transition between the saline water of the Bay of Bengal and the freshwater of the rivers induced from the Ganges. So, the different saline concentration level is present between the western and eastern zones of the Sundarbans and *H.fomes* have the capability of surviving by adapting both the

saltwater and freshwater environment. Salt tolerance for continued survival in this dwelling which does not avert other plants (Basak, Das, & Das, 1996).

### **1.7.2 Limiting water loss**

In the mangrove forests in the salty soils of the antipodal region, there is a limitation of freshwater available. *H. fomes* have evolved a method of limiting the amount of fresh water lost in their leaves. It can restrict the exposure of the stomata and it can also alter their leaf formation. By orientating leaf this medicinal plant can bypass midday sun heat and by this process, it can reduce evaporation of water from their leaf surface area (Basak et al., 1996).

### **1.7.3 Conversion to low amount oxygen**

In some of the most engulfed areas, a lot of mangroves like red mangroves will expand by raising the water level using stilt roots. They can take air through their body via slits. Also, there is some kind of mangrove like dark mangroves, live on much higher ground, and make pneumatophores. ‘Sundari’ plants have both the properties to survive even in extreme conditions. The pneumatophores can be different types. It can change based on the water condition and environment around it (Basak et al., 1996).

### **1.7.4 Increased survival of *H. fomes* offspring**

All the mangroves have a special kind of seeds. It’s called buoyant seeds. Sundari plants also have this kind of seeds. They are suitable for dispersal in water. Apart from other plant species, *H. fomes* seeds germinate in the soil while attached to the parent tree. When it germinates, it grows within the fruit which is called propagule. These propagules may withstand dehydration and stay dormant for days or even weeks or in some cases for several months and perhaps a year before they enter an acceptable setting. This botanical feature helps Sundari to survive the harsh condition of the forest (Hossain et al., 2013).

## 1.8 Phytochemical constituents of *H. fomes*

*H. fomes* is a very unique mangrove species. It has many chemical compounds which opens several doors for the discovery of many drugs. Though this plant has enormous potential, only a few report and research work can be found on this species about its active principles liable for such activities and its biological properties. *H. fomes* preserves 0.26 percent of chlorophyll, 0.12 percent of carotenoids, also 0.09 percent of chlorophyll b, 21.13 percent of tannins, 39.44 percent of polyphenols, and titratable acid number (TAN) is 34.51 (Basak et al., 1996). The existence of saponins, alkaloids, condensing sugars, tannins, glycosides, steroids, some kind of gums and flavonoids has been exposed by phytochemical analysis of leaves extract (Hossain et al., 2013). Leaf consist of 29.22 percent of protein compound (Basak et al., 1996). The extract bark of *H. fomes* consists of 7-36% tannin ("Dwindling Indian Sundarban Mangrove: The Way Out," n.d.), and a great amount of proanthocyanidins. Also, based on their formation, tannins are dispersed into two associations like as proanthocyanidins (condensed tannins) along with another one is water soluble tannins (hydrolysable). Stem bark which can be collected from truck contains large supply of pentameric, trimeric, hexameric and also procyanidins has been determined from the medicinal plant. In addition, stigmast-4-en-3-one,  $\beta$ -Sitosterol, and stigmasterol were likewise constructed from the Nuclear Magnetic Resonance spectroscopy of trichloromethane extract of the *Heritiera fomes* (Wangensteen, Dang, Uddin, Alamgir, & Malterud, 2009). All the elements which are found from *H. fomes* is listed below:



Table 7: Some phytochemical compound accessed from *H. fomes*

Names of the parts of the plant	Phytochemical compound noted	References
Leafs	0.26% of chlorophyll a 0.09% of chlorophyll b 0.12% of carotenoids 39.44% of polyphenols 21.13% of tannins 29.23% of proteins	(Basak et al., 1996)
Phytoconstituents of leaf sample extract	Condensing sugars, alkaloids, terpenoids, gum like substance Glycosides, tannins, and flavonoids	(Hossain et al., 2013)
Bark	7 to 36 percent of tannin, Great quality of proanthocyanidins	(Chowdhury et al., 2016)
Stem bark	Trimeric, pentameric and hexameric procyanidins	(Wangensteen et al., 2009)
NMR spectroscopy obtained from CHCl <sub>3</sub> derive	B-Sitosterol, also some of Stigmast-4en-3-one, and stigmasterol	(Wangensteen et al., 2009)

Chemical structures of some phytochemical compounds derived by *H. fomes* is demonstrated below:

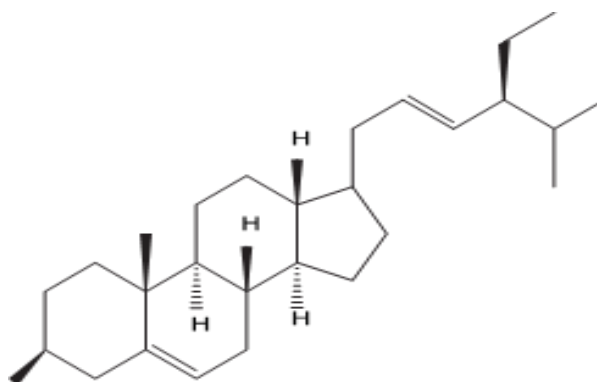


Figure 23: Stigmasterol (Mahmud et al., 2014)

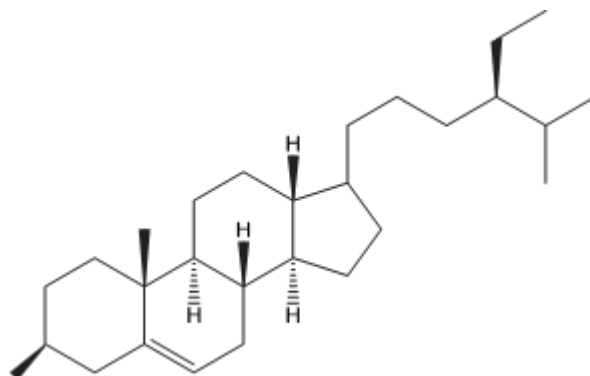


Figure 24:  $\beta$ - Sitisterol (Mahmud et al., 2014)

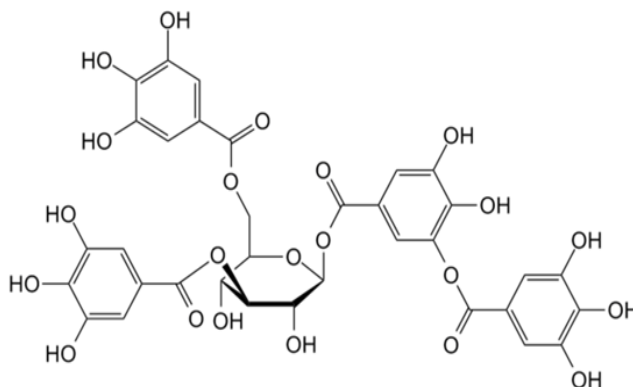


Figure 25: Tannin(Tannic acid) (Drabble & Nierenstein, 1907)

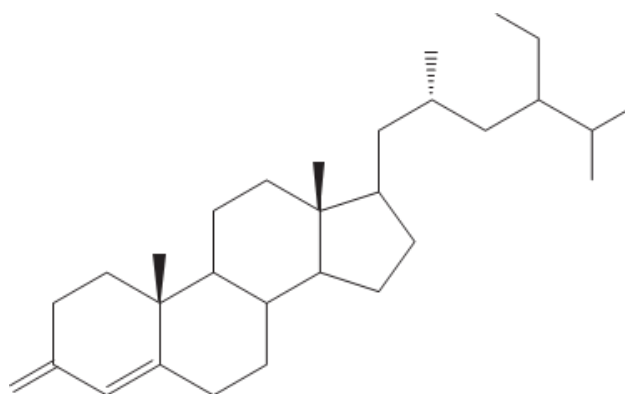


Figure 26: Stigmast-4en-3-one (Mahmud et al., 2014)

## **1.9 Application of chemical constituents derived from *H. fomes***

There are different kind of chemical constituents are found in *H. fomes*. Every element is important as they helps to make drugs and others research purposes to discover many more remedies. They have different application in different sectors. Important applications are given below:

### **1.9.1 Application of Glycosides**

- Hydrophobic metabolites, which increase the metabolism and bio-distribution of plants after glycosylation, becomes much more soluble in water (Kytidou, Artola, Overkleeft, & Aerts, 2020).
- Glycosides acts as anti-bacterial, chologoge, anti-inflammatory, anti-fungal, demulcent, vulnerary.
- Many anti-cancer drugs are discovered with the help of glycosides (Prassas & Diamandis, 2008).
- It can also use as antipyretics
- It is also use as laxatives.
- Used to treat Rheumatoid Arthritis.
- Its active constituents have anticonvulsant, antidepressant and antitumor properties.
- In the hospitals, cardiac glycosides are used to reduce the risk of stroke and atrial arrhythmia (Prassas & Diamandis, 2008).

### **1.9.2 Application of Alkaloids**

- Most of the alkaloids has local anesthetic properties (Kurek, 2019).

- Morphine is now one of the recognized alkaloids, a potent narcotic which is used to relieve pain.
- Atropine which is also an alkaloids is administrated to diagnosis of bradycardia (a condition of depressed heart rate) (Kurek, 2019). It is also used as muscle relaxant for surgery (Kurek, 2019).
- Blood vessel contraction.
- Ephedrine is widely used in bronchial asthma. In addition, it also helps to diminish discomfort from height fever and common colds (Kurek, 2019).
- Alkaloids are also used as antimalarial agent. Example: Quinine.
- Treatment of rapid pulse or cardiac arrhythmia rhythms.
- Treatment of acute gout attacks.(Kurek, 2019)
- Numerous alkaloids, both in beverages and foods, are significant element of human nutrition.
- Alkaloids are also used as central nervous system stimulants. Example: Nicotine (Kurek, 2019)

### **1.9.3 Application of Tannin**

- Tannins are an integral component in the development of leather tanning.
- Inorganic tanning substance still are used currently and account for 90% of leather production in the world (Fraga-Corral et al., 2020).
- Tannins can be used as a mordant and is especially useful in cellulose fibers such as cotton.

- Tannin can produce different types of colors with ferric chloride.
- Tannins are used as coagulant in the treatment of waste waters. (Fraga-Corral et al., 2020)
- Tannins works as adhesives in wood, tires, concrete.
- Tannins also used as Ore Flotation Agents which means, it can separate materials.(Fraga-Corral et al., 2020)
- Tannins or tannic acid can also be used for anti-corrosive primer manufacturing.

Incapacitated tannins that were recently tested to extract uranium via sea water (Sakaguchi & Nakajima, 1987).

### **1.10 Importance of *H. fomes***

- *H. fomes* fruit contains assorted micro-nutrients. This fruit is very helpful for those types of patient who are suffering from kidney disease and syndrome of edema (Halder Ria, Suniti Ghosh Chatterji, 2014).
- The fruit contains abundant amount of magnesium (Mg) which plays as important catalyst in many metabolic reaction.
- The fruit contains manganese, a crucial nutrient for all living organisms (Halder Ria, Suniti Ghosh Chatterji, 2014).
- Its seeds are rich in starch, which can be eaten in times of food storage.
- The wood is very hard, heavy and durable which can be used for construction.
- The wood is also a very good source of fuel and produce a good quality full charcoal.
- *H. fomes* bark is very helpful for control diabetes and in relief of pain.

- It can be a great remedies for the treatment of gastrointestinal tract disease including dysentery, stomachache, and diarrhea.
- The plants bark can also be applied on body to diagnose eczema, abscesses, scabies, and boils.
- The plant is used in hepatitis and jaundice.
- It has anticancer, anti-inflammatory, anti-nociceptive, anti-diabetic, antioxidant activity in its phytochemical constituents.
- *H. fomes* has anti-obesity potential properties which can fight against obesity (Mirza, Ali, & Sanghvi, 2017).
- Antimicrobial activity is another important medicinal use of *H. fomes* (Wangensteen et al., 2009).

## Chapter 2

### Pharmacological properties of *H. fomes*

Pharmaceutical studies or in other word pharmacology are a pharmaceutical and medical field exercised by researching drug or drug action where medicine can be narrowly or widely described as any molecule that exercises physiological or biochemical impact on the person, organ, tissues or cell that has natural or man-made or endogenous (body-made) properties. In particular, the research is carried out on the interactions between a chemical and a living organism, which influence the abnormal or regular role of biochemistry. When the compounds have particular therapeutic properties, they are considered drugs. So, pharmacological properties means the ability to act as chemical substance which can be used as drug and works as medicine. *H. fomes* have several different pharmacological properties which makes it an ideal medicinal plant. Through extraction, several different chemicals can be found from this plant. Such as, alkaloids, tannins, glycosides, protein, flavonoids etc. This chemicals then work as different drugs when modified. This chemicals have unique properties by which various kinds of diseases can be cured. Among the various pharmacological properties some are listed below:

- Anti-cancer
- Antidiabetic
- Anti-nociceptive
- Antioxidant
- Anti-obesity
- Antimicrobial

- Anti-diarrhea
- Anti-MRSA

Pharmacological properties of *H. fomes* are discussed below:

## 2.1 Anti-cancer property

### 2.1.1 Cancer

Cancer can indeed be characterized as an uncontrolled growth of abnormal cells that seem to breed unregulated and proliferate in many cases. Cells may become cancerous due to the accretion of defects or may be due to mutation in their DNA. Most of the time, cells has the capabilities to detect and reconstruct DNA damage. If a cell is severely injured or damaged and cannot repair by its own, then it normally undergoes programmed cell death or in other words apoptosis. Cancer occurred mainly when damaged cell divide, grow and spread abnormally instead of apoptosis as they should. In one region, cancer cells emerge and then spread across lymph nodes. These are immune cell colonies found all over the body (Kok, Sung, Kao, Lin, & Tseng, 2016). There are several different forms of cancer. Sex may depend on the occurrence of a certain cancer. For both males and females, skin cancer seems to be the most widespread of all.



Figure 27: Cancer cell (Kok et al., 2016)



### **2.1.2 Anticancer activity of *H. fomes***

Anticancer describes the natural therapeutic approaches that help prevent or promote the expansion of cancer. They are intended to achieve traditional methods (like chemotherapy, medications, radiation and surgery). Many natural plants are used as a treatment process or development of drugs for cancer. Medicinal plants conserve an important position for being a paramount source of drug discovery irrespective of its categories groups- shrubs, herbs, or tree. In past years, generous developments have been made in the study for and healthy and potent provision of new medicines and bioactive compounds by herbs. Almost 60% of cancer medicines are a natural source and the interest in future chemical medicinal ages natural resources grows gradually over time. Mangrove plants possess symbolic anticancer compounds that fight effectively against lung, stomach, breast, colon, and prostate cancer. Natural products with these characteristics have been classified with 12 distinct chemical groups (Binns & Low, 2016). Chemical components such as alkaloids, phenolic substances, steroids and tannins are secondary bio active metabolic products of pharmacological toxicological as well as other ecological value that may theoretically be used in medicines. *H. fomes* is a promising mangrove plant. *H. fomes* contains several anti-cancer elements. The chemical constituents are found in different parts of the plant. Every part of the plant is very important for anticancer drug development. The phytochemical evaluation of the *H. fomes* extract of the leaves suggests saponins, alkaloids, sugar agents, some glycosides and tannins as well as other chemical compounds. (Binns & Low, 2016). Both stem extract and *H. fomes* leaves display B16 in vitro system anticancer properties with 40 percent inhibition and Ehrlich Ascites in Swiss albino mouse carcinoma (in vivo system) (Binns & Low, 2016).

### **2.2 Antidiabetic property**

Diabetes mellitus is a disease arising when our body pancreas can no more manufacture insulin or the body can no longer handle the insulin it produces in a beneficial way. Insulin is

identified as a pancreatic hormone which functions like as a key to transferring blood sugar or glucose from the food we ingest to energy from the blood vessels into the functioning cells of the body. The blood vessel separates all carbohydrate forms of food into glucose. Insulin helps to join cells with this glucose. So, whenever insulin production stops or its use is not done effectively leads to higher levels of glucose in the blood which is known as hyperglycemia (Binns & Low, 2016). When the glucose levels remain higher for a long period then it can damage the body and also it can be a major reason for the failure of various organs and tissues. In 2012 diabetes has been especially attentive to 1.5 million deaths and 89 million long life adapted for disabilities, over 4 percent of all of which passed prematurely. A summary of the disease on World Health Day was collected by the World Health Organization this year and the number of people who are effected by diabetes increased from 108 million people in 1980 to 422 million in 2014 (Binns & Low, 2016). The increase throughout diabetes was associated with an increase in body mass, as well as the makers showed the possible decrease which can be accomplished by weight management. Diabetes prevalence in the Western Pacific region was reported to be 8.6 percent in 2013 and 138 million adults in the 2013 issue of the IDF (International Diabetes Federation) Atlas and is projected to rise to 11.1 per cent or 201 million adults in 2035 (Binns & Low, 2016).

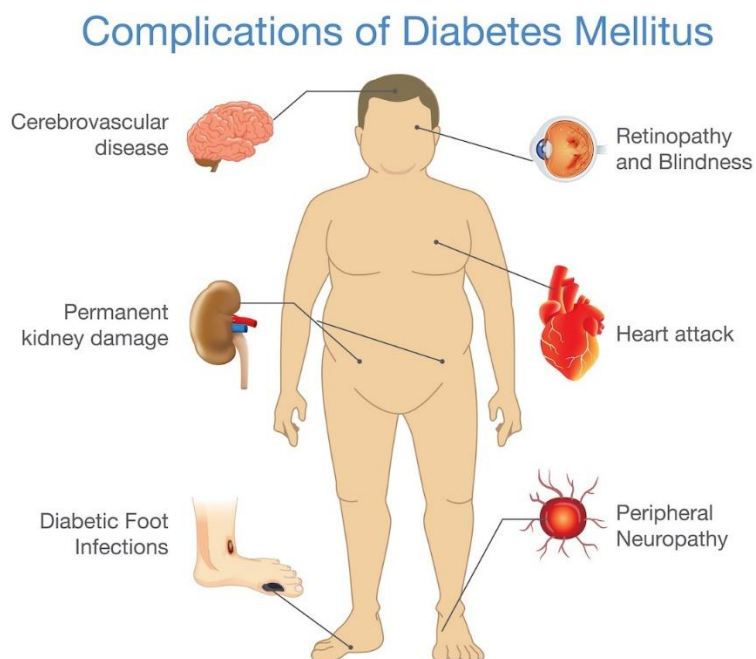


Figure 28: *Complications of Diabetes* (Skyler et al., 2017)

### 2.2.2 Antidiabetic activity of *H. fomes*

Antidiabetic activity refers to as anti-hyperglycemic effect. When the raw methanol extract of *H. fomes* steam bark is administrated in mice they showed dose-reliant reduction in concentration of serum antigen glucose both at 60 as well as 120 minutes (Ali et al., 2011). Without a question, raw bark extract decreased blood glucose levels 49.2% in a dose of 250mg extract/kg body weight by 60 minutes after glucose ingestion. Also it is suggested that, at the higher dose like 500mg/kg in body weight, it showed no compelling change at reduction of serum glucose level, which showed us that 250mg/kg in body weight is the peak antihyperglycemic activity in mice. It's further investigated and confirmed that bark raw methanol extract has a long-term effect on its glucose-reduction function and is stronger than glibenclamide (S. K. Das, Samantaray, Patra, Samanta, & Thatoi, 2016).

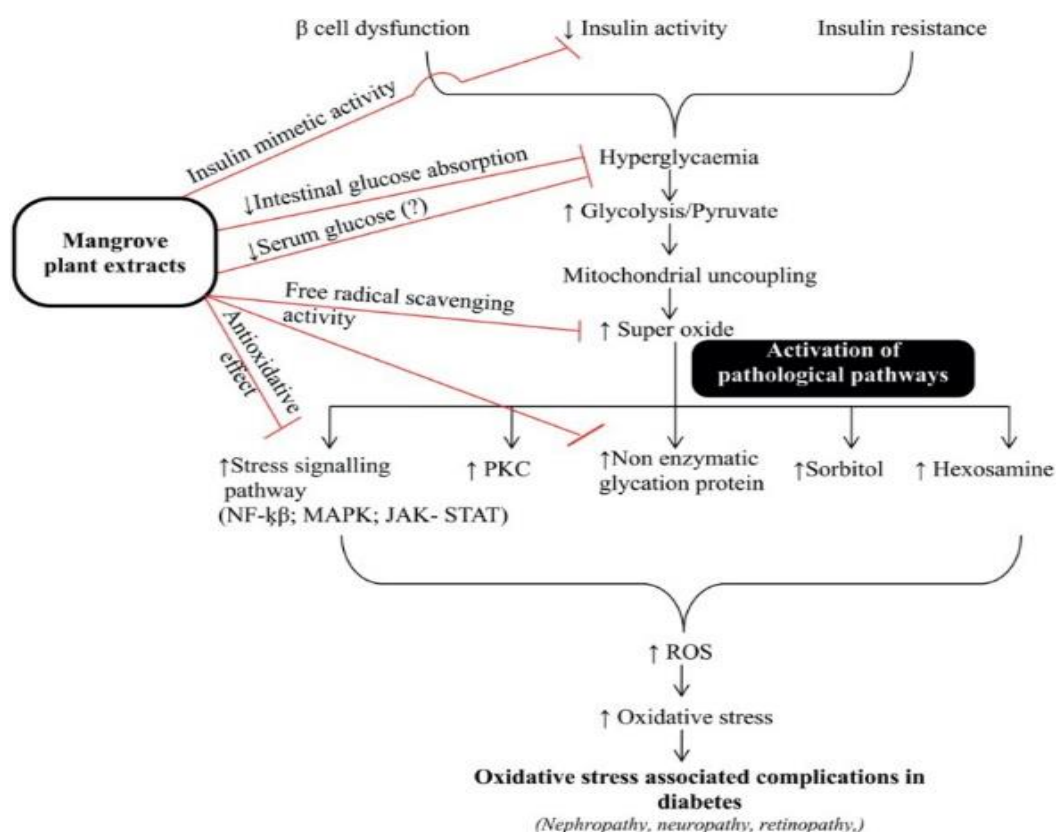


Figure 29: Desirable role of mangrove plants in the controlling of diabetes (S. K. Das et al., 2016)

### 2.2.3 Major bioactive constituents of *H. fomes* exhibiting hypoglycaemic properties

#### Alkaloids:

Alkaloids is one of the major chemical constituents of *H. fomes*. The pancreatic production of insulin by  $\beta$ -cell cells in islets or increased distribution of blood sugar to peripheral tissue may produce antihyperglycaemic activity (S. K. Das et al., 2016). Alkaloids for example, granatoin, trigonellin, and xylogranatinin are proclaimed in *H. fomes* (Mollik et al., 2010) and also in *Acanthus sp.* and *Xylocarpus franatum* (S. K. Das et al., 2016).

**Flavonoids:**

Flavonoids also found to be a chemical component of *H.fomes* could prove essential for traditional diabetic medication as they help to stop apoptosis of  $\beta$  cells to produce  $\beta$ -cells and insulin discharge, and to enhance the action of insulin. They are very useful against hyperglycemic patients (S. K. Das et al., 2016).

**Saponins:**

Steroidal and triterpenoid glycosides are classified mainly as saponins. These chemicals have high hypoglycemic activity, which are well established. Antidiabetic activity of *H. fomes* and arina is responsible for the existence of stigmasterol-3-O- $\beta$ -d-galectopyranoside and also the presence of  $\alpha$ -amyrin in the mangrove forest tree (S. K. Das et al., 2016).

**Tannins:**

Tannins also play a crucial role in reducing complications of diabetes by reducing the stress of oxidation and development of AGEs groups. Members of Malvaceae, Avicenniaceae are rich source of tannins. These tannins can be a great alternative for diabetic control (S. K. Das et al., 2016).

**2.3 Antioxidant property****2.3.1 Antioxidant**

Antioxidants are such item or compounds that can avoid or delay cell damage from unstable molecules, free radicals that are created by the body to respond to surrounding conditions as well as other pressures. Artificial or natural sources of antioxidants may be identified. Food dependent on plants is mainly considered to be high in antioxidants. This herbal antioxidant is a form of phytonutrient or just called an herbal nutrient. There are two type of antioxidants. One is endogenous antioxidants which produces within the body and the other is exogenous

which come from outside the body. Antioxidant activity of various natural compounds is becoming increasingly important. Proanthocyanidins have a strong antioxidant potential and are one of the most popular phenolics in the nature (Wangensteen et al., 2009). A large number of mangrove plants, including *H. fomes*, are expected to play a part in protecting plants against insects, bigger herbivores and microorganisms by using the proanthocyanidins found in fruit, wood, grains and leaves.

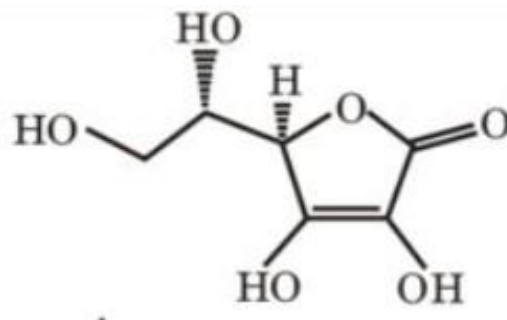


Figure 30: Antioxidant, Ascorbic acid (G. Das, Gouda, Mohanta, & Patra, 2015)

### 2.3.2 Antioxidant activity of *H. fomes*

Antioxidant protection mechanisms for all forms of airborne species avoid harmful damage occurred by free radicals. Antioxidants can be found from different natural resources and foods. A large number of antioxidants in phenolic compounds and flavonoid compounds are found in food. In order to avoid degradation in odor, color, and flavor, antioxidants are applied to supplements. Owing to the tremendous expense of natural antioxidants, numerous dietary supplements have been used. But few studies show the different harmful effects of synthetic antioxidants and their use has been limited. Researchers have therefore focused on natural antioxidants obtained from plants which are found naturally. A lot of medicinal plants consist of the antioxidant compound like radicals, superoxide, peroxy, singlet oxygen, hydroxyl radicals, etc. (Islam, 2017). *H. fomes* is one of the mangrove plants which have antioxidant properties. For both qualitative and quantitative antioxidant properties, leaf

extract from this plant was impregnated. Extract leaves showed a strong activity of antioxidants with a IC50 value of 26.30  $\mu\text{g/ml}$  (50% inhibitive) (Mahmud et al., 2014). With a 50 percent inhibitory concentration value of 22 $\mu\text{g/ml}$  and an efficient concentration rate of 19.4 $\mu\text{g/ml}$ , the bark extract of the plant clearly showed potent antioxidant activity. The protective effect was correlated with the extract's antioxidant properties, as the extract's administration triggered substantial increases in the activity of glutathione peroxidase and superoxide dismutase, as well as the interdiction of lipid peroxidation. Dark bark anti-ulcer activity of *H. fomes* was also controlled in the model of acetic acid-induced gastric ulcer in rodents. With the administration of methanoic extract of *H. fomes*, antioxidant activities such as restoring the levels of reduced catalase (CAT), glutathione (GSH), glutathione peroxidase (GPX) and the antioxidant enzymes super oxidase have been seen (Mahmud et al., 2014).

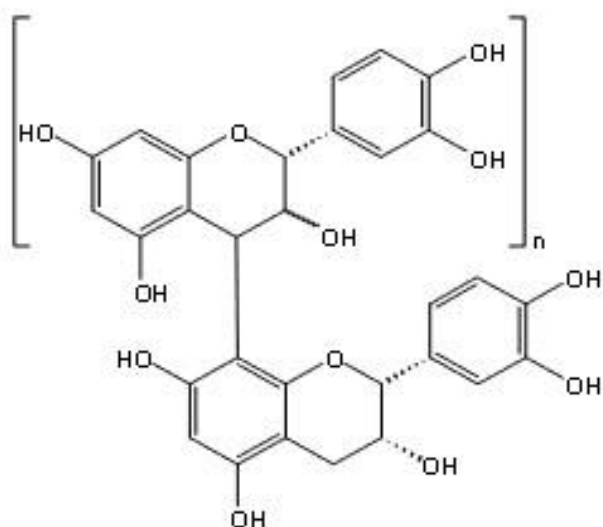


Figure 31: Procyanidins, identified in *H. fomes* (Wangensteen et al., 2009)

## **2.4 Anti-obesity property**

### **2.4.1 Obesity**

Overweight or obesity is indeed a curable condition that has an abundance of body fat as a global health epidemic. Environmental or genetic factors can occur and can be difficult to regulate through healthy eating and exercise. The overweight appearance of a BMI (Body mass index) is a significant health issue. The exuberant weight of anybody's body is difficult. This can also correspond to other health issues, including cardiac disease, obesity, high blood pressure etc. According to an American based organization named Disease Control and Prevention (CDC), obesity in an adult is defined as having a BMI of 30.0. Obesity not only affects our health, but can also create new diseases in our bodies. For instance obesity may be a risk factor for diabetes of type 2, cardiac arrest, stroke, bowel disease, liver fatty disease, sleep autonomic dysfunction, heavy cholesterol, infertility, arthritis, etc. (Moores, 2020). So, it can be easily said that obesity should be seriously taken. Overweight and weight are presently venturing in to the borders of creating nations. Significant diet changes include a significant rise in dietary sugar, an additional consumption of fat, often and a rise in animal products and a reduction in cereal and fiber consumption (Hailemariam, Alamo, & Hailu, 2020). Obesity and overweight in Ethiopia have not been an alarming problem for several years. However, obesity and overweight within adult population are currently expanding from 3% in 2000 to 8% in 2016 (Hailemariam et al., 2020). This data clearly shows us that, Obesity is getting a major issue day by day and extra plan and steps should be taken immediately to have control over this newly arisen problem.



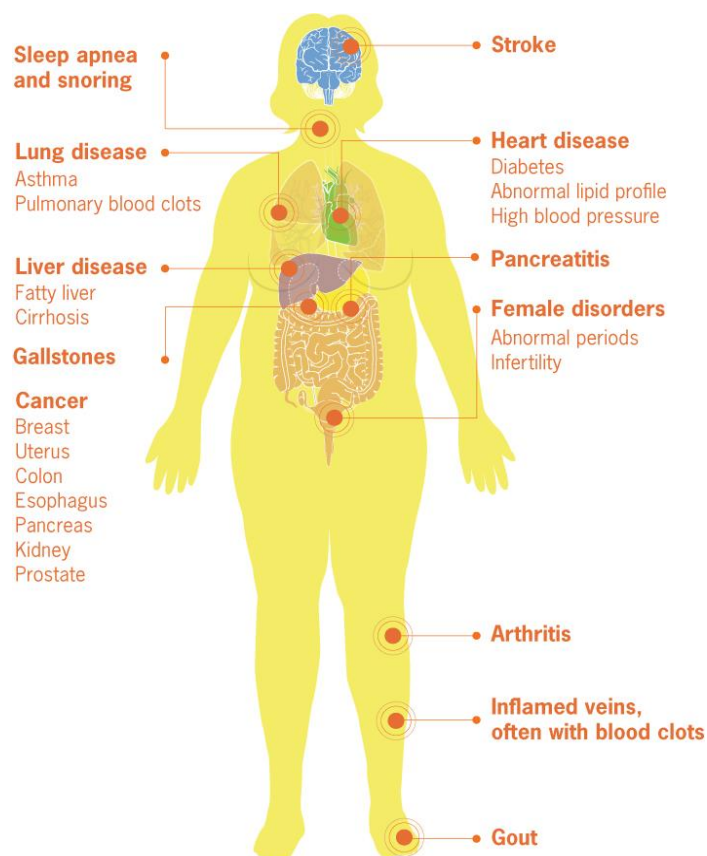


Figure 32: Medical complications of Obesity (Hruby & Hu, 2015)

#### 2.4.2 Anti-obesity activity of *H. fomes*

Administration of high fat cafeteria diet (HFCD) can increase body weight, fat pad, organs weight, LDL cholesterol, triglycerides, VLDL cholesterol and glucose levels. It also decrease HDL cholesterol level as compared to normal control level. But, when treatment with MEHF is given then it showed a significant reduction in the body weight gain, kidney weight, spleen, organ weight of the liver, weight of fat pads, and the levels of LDL cholesterol, VLDL cholesterol, glucose levels, the levels of serum triglycerides and increase the level of HDL cholesterol in a dose dependent way (Mirza et al., 2017). Current pharmacotherapy for the solution of obesity problem remains very limited both in the safety/tolerability of the drugs and in the degree of achievable weight loss. A huge segment of the world's population depends on conventional cures to treat different maladies. The medicinal herb is an crucial

portion of conventional pharmaceutical practiced all over the world due to its adequacy, low costs, simple get to, genealogical involvement, and lack of side impacts. *H. fomes* having a place to the family Sterculiaceae could be a well-known plant in Indian conventional old stories pharmaceutical, *Heritiera fomes* are used for treating gastrointestinal disorders, skin diseases and hepatic messes by country people. For diabetes and pituitary adenoma or in other word goiter, the trunk is extracted in rustic ranges. This medicinal plant is additionally utilized as home grown pharmaceutical to fix torment and disease conditions like, fever locally. It has been assessed for Antidiabetic, antioxidant potential, antibacterial movement, anti-nociceptive, antioxidant and pain relieving movement, and anticancer activity (Mirza et al., 2017). In present work the anti-obesity potential of *H.fomes* has been discovered. The noticeable increase in TG and TC level in cafeteria diet fed animals increase in *de novo* synthesis and intestinal absorption of cholesterol. Moreover, enlarged oxidative stress makes reactive oxygen species (ROS) which can react with lipoproteins to assemble oxidation states, this decreasing the cellular uptake of lipids from the body. This happens because the diminished retention of cholesterol from the slim down or by the antioxidants show within the plant sedate might have contributed to lifted cellular lipid take-up. Also, considerable devaluation of total cholesterol in serum in the plant drug treated groups could be associated to a reduction in the activities of the liver enzyme 3-hydroxy-3-methyl glutaryl coenzyme A (HMG-CoA) reductase, which is a threshold enzyme in the biosynthetic pathway of cholesterol (Mirza et al., 2017). The operations of enzymatic antioxidants (GPx, SOD and CAT) were certainly exalted in the liver during treatment with MEHF and this increased antioxidant ability may have been arbitrated by natural antioxidants present in the plant drug (Mirza et al., 2017).

## **2.5 Anti-nociceptive property**

### **2.5.1 Nociception or pain**

Pain is characterized by the Universal Affiliation for the Consider of Pain as an “unpleasant tactile and emotional encounter related to genuine or potential tissue damage. Nociception is the location of excruciating stimuli. Specialized neurons within the dorsal root ganglia (DRG) or the trigeminal ganglia extend into the skin and delicate tissue to distinguish extremes of warm, cold, mechanical, and chemical signals and caution the body of potential dangers. The arrangement of these neuron is usually pseudo-unipolar, which would be unique since their axons spread simultaneously anteriorly to the skin and posteriorly to the spinal cord. This framework licenses harmful boosts to be identified along the length of the fiber and is clinically vital since it permits torment medications to be focused on either topically to the skin surface or specifically to the epidural or intrathecal space (Renthal, 2014). Nociception also occurs at the nerve terminals by membrane-bound neural terminals (nociceptors) that are activated by particular inflammatory response. This can be taken after by the change of that flag into an activity potential and its engendering to the dorsal horn of the spinal cord. The detection of noxious temperature is approximately 43°C (Renthal, 2014).

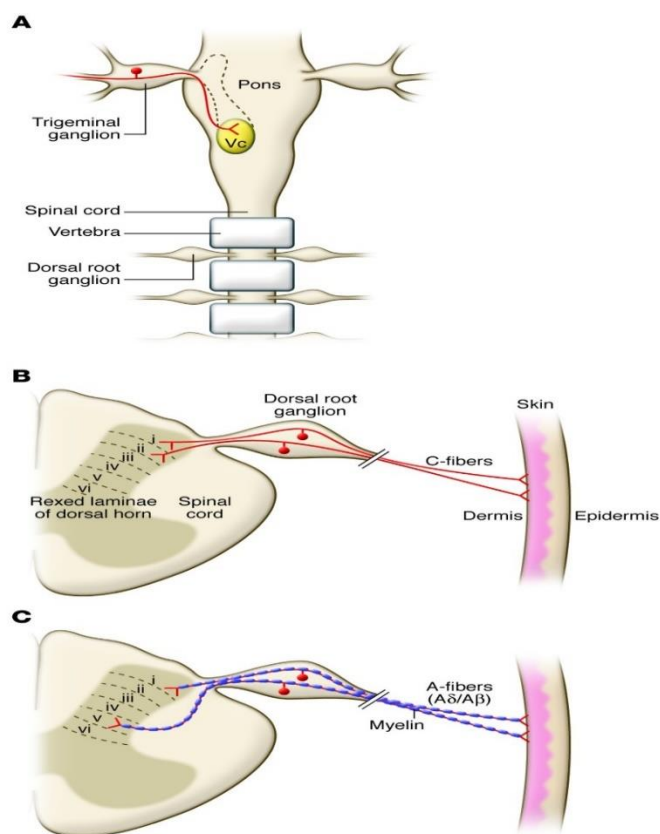


Figure 33: Anatomy of nociceptors (Dubin & Patapoutian, 2010)

### 2.5.2 Anti-nociceptive activity of *H. fomes*

*H. fomes* can show antinociceptive activity as it has chemical compound which certainly shows activity against nociception. Standard antinociceptive drugs, like aspirin shows 20.9% inhibition in writhing's but on the other hand *H. fomes* shows 26.4 % inhibition (Ali et al., 2011). The development of prostaglandins and prostacyclines has been shown to be accountable for nerve fibers that contribute to pain. The anti-nociceptive activity of raw methanolic bark extricate may therefore be attributed to the ability of the extract to squarely unite prostaglandins that can be affected by carbonic anhydrase and/or lipooxygenase retention exercises (Ali et al., 2011) Acidic Acid-induced writhing test, showing chemical-nociceptive initiation of torments, which incidentally increase PGE<sub>2</sub> and PGE<sub>2</sub> $\alpha$ , is demonstrated by the act of anti-nociceptive action of the take-off extracts. Acidic acid usually causes pain through discharges of several endogenous substances, such as serotonin,

bradykinine, histamine, prostaglandins (PGs) and P that threaten quickening nerve cells to produce torment. Peritoneal receptors locally sensitive are able to activate a tightening of the stomach. Increasing the PGE<sub>2</sub> and PGE<sub>2</sub> $\alpha$  in peritoneal fluids, as well as lipoxygenase products have also been correlated with prostanoids. The restriction of PG synthesis and discharge by *H. fomes* is perhaps the most likely route of the peripheral analgesics (Hossain et al., 2013).

## **2.6 Other useful properties of *H. fomes***

*H. fomes* which is called ‘Sundari’ locally is one of few plants which has multiple properties. Besides having antioxidant, anticancer, antidiabetic, anti-obesity properties there are many more advantages we can get from this plant. Local people sometimes call it a magical plant and uses it for many different remedies for over many decades. Additional pharmacological properties of *H. fomes* is discussed below:

### **2.6.1 Anti-diarrhea activity**

Diarrhea is an increment within the recurrence of bowel movements, an increase within the detachment of stool, or both. Diarrhea is caused by the expanded discharge of liquid into the digestive system, diminished absorption of liquid from the digestive tract, or quick section of stool through the digestive tract. Side effects related to diarrhea incorporate stomach torment, particularly cramping. Other indications depend on the cause of diarrhea (Lo Vecchio, Buccigrossi, Fedele, & Guarino, 2019). *H. fomes* have different chemical compounds in their body parts. Most of them are alkaloids and organic substances. *H. fomes* also contains procyanidins in it. Based both in vitro and in vivo models on the biological activities of the procyanidins *H. fomes* has a capacity for medicine. Several studies have demonstrated the absence of diarrheal diseases from plants enriched in proanthocyanidins. Therefore, the procyanidine-rich wood of two *Xylocarpus* trees has been shown in recent trials to have

antidiarrheal effects on the mouse. However the absorption of proanthocyanidins from GI tract is poor. The goal is therefore to exercise local activity in the gastrointestinal tract that may have been necessary if the intestine is opened to oxidants. The antibacterial and antioxidant effects of *H. fomes* have shown that if taken orally, they can have a constructive local impact (Wangensteen et al., 2009). Both plant sections of *H. fomes* are also commonly used in various ailments; for gastrointestinal conditions, seeds and leaves are helped (Dysentery, diarrhea, stomach ache, acidity and constipation).

### **2.6.2 Micro-nutrient activity of Sundari**

Fruits of *H. fomes* are well known for making pickles & nuts and it got to be more prevalent amid unpleasant times in Sundarban. Micronutrient action of *H. fomes* has been embraced in arrange to decide the appropriateness for humans utilize as nourishment fabric. *H. fomes* natural product contains different micro-nutrients. So at a look, it uncovers that this fruit is advantageous for those who are enduring from a kidney infection, a disorder of edema, etc. Both are segregated in individuals, sodium is an essential nutrient that reduces pressure in the blood and sodium in the kidney creates renin that generates aldosterone and large amount of angiotensin, and retains sodium in the pee. As the sodium level increases, the output of renin decreases and a normal sodium level returns (Halder Ria, Suniti Ghosh Chatterji, 2014). In addition, the dissemination of sodium into all creatures via  $\text{Na}^+/\text{K}^+-\text{Atpase}$  is essential for neuronal function and osmo control among cells and the interstitial matrix (Halder Ria, Suniti Ghosh Chatterji, 2014). In extracellular fluid, sodium is by far the most prevalent cation. Potassium is the major electrolytes interior cells (intracellular) the Osmotic impact holds water inside cells & counter adjust the osmotic impact of Sodium (Na). It makes a difference conversion of Blood glucose put away glycogen, Synthesis of muscle protein & vitality generation. Potassium particles moreover play a part in nerve impulse transmission to stimulate muscle activity. Rise to the sum of Na & K offer assistance to anticipate the

advancement of hypertension (L. Kothleen Mahan et.al., 2008). In addition, this fruit contains a tall sum of magnesium (Mg) which plays a catalyst in numerous metabolic responses. Mg is required to actuate the protein within the oxidative phosphorylation of ADP to ATP & moreover for the return of ATP to cyclic AMP which in turn directs parath-hormone secretion (Helen A Guthric, 1983).

Table 8: Micro nutrient content in 100gms of fruit (Halder Ria, Suniti Ghosh Chatterji, 2014)

Name of the fruit	Calcium (mg)	Boron (mg)	Zinc (mg)	Cobalt (mg)	Sodium (mg)	Manganese (mg)
<i>H. fomes</i>	0.93	41.42	0.15	0.0696	0.54	6.54

Table 8: Micro nutrient content in 100gms of fruit (cont.)

Name of the fruit	Iron (mg)	Chromium (mg)	Magnesium (mg)	Potassium (mg)	Copper (mg)
<i>H. fomes</i>	0.16	0.035	1789.19	13.10	11.91

Zn plays a critical auxiliary part as a component of a few proteins and work as an intracellular flag in brain cells (Halder Ria, Suniti Ghosh Chatterji, 2014) and Cu plays a portion in avoiding iron deficiency by fortifying the Synthesis of the haem or globin capacities of the hemoglobin particles. Manganese is used in the reverse transcriptase of various retroviruses (e.g. HIV but not lentiviruses). Arginase, diphtheria poison and Mn-

containing acid phosphatase may be the most common polypeptides containing one of the important element called manganese (Mn-SOD) (Larsson SC et.al.,2008). Boron (Br) content is acceptable in per 100gm of the organic product. Boron has a few significant capacities in our body. Its insufficiency adjusts cerebrum work and diminishes bone creation, structure and quality.

### **2.6.3 Antimicrobial activity**

Many widely known medicinal herbs are well recognized to have antimicrobial properties. While approximately to 50% of the pharmaceutical products presently in use are borrowed from or rely on, plants are not used as anti-microbials (Leach, 2011). Ethanol leaves extricated from *H. fomes* by antimicrobial movement were analyzed using a technique to measure disc dissemination towards all tested and proven grams-positive as well as grams-negative strains of bacteria depending on their folkloric use in skin diseases. Phytochemical compounds, including such carotenoids, tannins, naturally occurring substances, terpenoides, flavonoids and some other phytochemical screened fragrance compounds provide protection components against microbial pathogens, herbivores and shrimp crawling. The imaginary part of flavonoid antifungal activity is because of its ability to compose with dissolve and extra cells through bacterial cell dividers (Hossain et al., 2013).

### **2.6.4 Anti-MRSA activity**

The expanding rise of multidrug-resistant contamination causing microorganisms has ended up a critical burden globally. Disease Control and Prevention (CDC) who assessed that over 2 million ailments and 23,000 passing per year are attributable to antibiotic resistant pathogens within the Joined together States (Okwu, Olley, Akpoka, & Izevbuwa, 2019).They includes Methicillin-resistant *Staphylococcus aureus* (MRSA) along with others. Multidrug-resistant bacteria (MDRB) are microorganisms that are safe to one or more antimicrobial specialists.



They are ordinarily safe to all but one or two commercially accessible antimicrobial agents. This definition incorporates organisms that have obtained resistance to at slightest one operator in three or more antimicrobial categories. The MDRB of clinical intrigued incorporate: Methicillin- safe Staphylococcus aureus (MRSA). About 18–33% of MRSA colonized patients in this way created MRSA contaminations. Community-acquired methicillin-resistant Staphylococcus aureus (CA-MRSA) strains moreover constitute an expanding extent of hospital-onset MRSA diseases (Okwu et al., 2019). Staphylococcus aureus may be a Gram-positive coccoid bacterium. The cells are orchestrated in irregular grape-like appearance and they are more often than not found as ordinary greenery in humans and animals. It is omnipresent within the human populace and 30–40% of grown-ups are asymptomatic carriers. It is additionally a major pathogen of humans and can cause an extend of contaminations from gentle skin contaminations and nourishment harming, to life-debilitating diseases (Okwu et al., 2019).

*H. fomes* is the Sundarbans coral reef plants, have adjusted to a very special region, sloppy salt water, alkaline soils, saltwater tidal training and a highly competitive microbial climate. This plant is covered by endophytic contagious conditions from unfavorable natural conditions (Nurunnabi et al., 2018). Many phytochemical components with various bioactivities have also been described as the elements of the endophytic organism, not fundamental elements of plant biosynthetic pathway. The prime example is taxol that also is really a compound of a Pestalotiopsis microspora endophytic organism, which is not fundamentally formed by the herb itself. Since biotic push resistance is linked to the infectious common endophytic elements, *H. fomes* probably will be a rich source for endophytic parasites that provide chemical and organically dynamic metabolites that enhance allopathic impacts and defend against phytopathic species (Wangenstein et al. 2009; Patra and Thatoi, 2013).

## Chapter 3

### Discussion

*H. fomes* is serving mankind from the beginning of time through different pharmacological properties. Every part of this plant is used for different purposes. From leaves to roots every part has different chemical compounds that have various medicinal and pharmacological properties. Unlike any other mangrove plant, *H. fomes* contains the highest number of pharmacological properties. Such as antioxidant activity, anti-Obesity potential, anticancer activity, antimicrobial properties, antibacterial, anti-inflammatory, antidiabetic activity, and many more. Different kinds of crude drugs are manufactured based on these properties. Antibiotic activeness of extracts obtained from *H. fomes*. is detected counter to many gram positive microorganisms such as, *B. subtilis*, *S.aureus*, *K. rhizophilia* (Wangenstein et al., 2009). The extracts have bacteriostatic effect. The outcomes about are comparable to the antibacterial impacts already watched over procyanidin wealthy plants *X. granatum* and also *X. moluccensis*. The procyanidins which is picked up from *H. fomes* illustrate sensible antibacterial properties (Wangenstein et al., 2009). In addition, the stem bark of *H. fomes* has high procyanidin content. Depending on the underlying activity of including both vivo and in vitro procyanidins, the data showed that *H. fomes* has the potential to be therapeutic. It has been proposed that plants rich in proanthocyanidins have the ability to combat diarrheal diseases (Wangenstein et al., 2009) In addition, proanthocyanidins also have flat absorption rate from the gastrointestinal tract. Proanthocyanidins are hypothesized in this way to apply nearby action inside the GI tract that may be particularly relevant when oxidizing agents are discovered by the digestive system. The antibacterial and antioxidant properties of *H. fomes* showed respectively. Therefore, *H. fomes* may have a constructive local impact if administered orally (Wangenstein et al., 2009). Several consider was accomplished to

evaluate about anti-nociceptive result of Sundari (*H. fomes*), a therapeutic material alleged in conventional medication to include anti-inflammatory and antioxidant activities. Ethanol leaf extract of *H. fomes* set up pivotal against- nociceptive action at two distinctive measurement levels in different creature models of discomfort. Hindrance of PG as well as other synthetic substances amalgamation and release by *H. fomes* may be the most likely route for bypass analgesics (Hossain et al., 2013). The nearness of phyto-components such as alkaloids, molecular substances, including tannins can be capable for its anti-nociceptive movement. Torment obstruction is due to the occurrence of alkaloids and androgenic steroids elements. Anti-nociceptive and anti-inflammatory exercises include tannins in adjusting reactive oxygen species (COX-1 and COX2) as well as lipoxygenase generation. Ethanol is extracted from *H. fomes*, in addition was subjected to a radical rummaging action as conceived, an established instrument used to restrain lipid oxidation by cancer control agents (Hossain et al., 2013). Flavonoids specified through the phytochemical analysis could be appreciable for this impressive antioxidant properties. The ethanol extract of the plant *Heritiera fomes* was moreover hazarded to decide since its conceivable profound rummaging action, a familiar instrument through which cancer prevention agents restrain lipid oxidation. Antimicrobial movement of the ethanol leaves concentrate of *H. fomes* was investigated utilizing circle dispersion examine technique counter to all of the tried Gram-positive as well as Gram-negative bacterial aches dependent on its allegorical utilizes over the skin infections. Phytochemical compositions, for example, flavonoids, alkaloids, including saponins, terpenoid as well as a few more sweet-smelling mixes explored by phytochemical screening give assurance systems against numerous microorganisms, herbivores and creepy crawlies. The conceivable antibacterial action mechanism of flavonoids is due to its ability to compose microbial cells separators with solvent and cellular membranes proteins (Hossain et al., 2013).

Sundari (*H. fomes*), is one of the miniature supplement rich mangrove organic product accessible in a large portion of beach front mangrove woods in India. It contains Mn, Mg, Cu, K, Br and little measure of Fe, Zn, Ca, Cr is found in this organic product which can be the substitute wellspring of supplement for individuals live at seaside part of India like angler and other beneath neediness level since they can't buy costly nutrient rich food and item from market, however this organic product is accessible and least expensive wellspring of miniature supplement for this individuals on the off chance that it remembered for our day by day food propensity (Halder Ria, Suniti Ghosh Chatterji, 2014). The mixes recognized by the GC-MS investigation of ethonolic concentrate of *H. fomes* natural product relates their applications in old stories medication and these dynamic segments may prompt ease drug advancement against oxidative pressure just as other executioner sicknesses. It can end up being a promising nutraceutical later on (Halder Ria, Suniti Ghosh Chatterji, 2014).

Furthermore, there is an extraordinary interest in more secure and long haul viable medications to treat anti-obesity problems which is a worldwide pandemic issue. Therapeutic spices are essential pieces of customary prescriptions and there is a major renaissance of natural meds all around the world as these medications are powerful and safe with no results. Subsequently, in the current work, the counter heftiness capability of MEHF in rodents took care of a high fat cafeteria diet (HFCD) was explored by investigating the body weight, organ and fat cushion weight, and blood and tissue biochemical profiles. The put on in body weight, organ, and fat cushion loads were essentially expanded in HFCD took care of rats when contrasted and the ordinary eating regimen took care of fed rats. This expansion in weight may be because of expanded energy consumption prompting expanded fat statements in tissue and organs. While HFCD took care of rats when treated with MEHF, the put on in body weight, organ, and fat cushion loads fundamentally diminished. It was likewise seen that organization of MEHF didn't modify food admission in treated rodents, demonstrating

that the counteraction of weight increase prompted by this concentrate was not because of a decrease in energy consumption. MEHF may have expanded the catabolism of lipids in fat (Mirza et al., 2017). The huge increment in glucose in cafeteria diet took care of creature can be because of imperfect insulin union furthermore, diminished insulin productivity. Treatment with MEHF nearly standardized the glucose levels in portion subordinate way. The insulin release from  $\beta$ -cells including its pancreatic islets may have been improved or the efficacy of insulin that facilitates the transfer of glucose from the blood into tissues. Administration of a methanolic concentrate of leaves of *H. fomes* controls serum lipid profiles, lessens the oxidative pressure and diminishes fat tissue mass and body weight gain. The instrument instigated by methanolic concentrate of *H. fomes* to be additionally explored.

Concentrates of medicinal plants are wealthy in phytochemicals. Phytochemicals or optional metabolites are characteristic defensive specialist biosynthesized by plants against outside pressure and pathogenic assault. They are vital for plant safeguards and endurance. They have been separated into a few classes: phenolics, alkaloids, steroids, terpenes, saponins, and so on They show different bioactivities, for example, antimutagenic, anticarcinogenic, cell reinforcement, antimicrobial, and calming properties and are accordingly liable for the restorative capability of plants. Thus against MRSA plants have an antibacterial impact on MRSA strains and other restorative/helpful employments (Okwu et al., 2019). The antibacterial (anti-MRSA) action of these plants is ascribed to their phytochemical substance. For occasion, flavonoids complex with bacterial cell divider, extracellular and solvent protein whereas tannins inactivate microbial grips, chemicals and cell encompass proteins. Although *H. fomes* which has shown a good source of anti-MRSA plant and likely promising source for drug developments for MRSA infections. Many exploration examines have announced that some therapeutic plants in various nations have hostile to MRSA exercises because of their phytochemical substance. These plants can be utilized as elective possibility for drug

advancement to stop or/and control the diseases of multi-drug safe *S. aureus*. In any case, there is a requirement for additional examinations to satisfactorily decide the security and clinical viability of hostile to MRSA plants to man (Okwu et al., 2019). Polysaccharides, antioxidants, tannins, glycosides, polyphenols and decreasing carbohydrates in *H. fomes* were shown to be present in an in-vitro study. Any of these formulations can be done with cell reinforcement and as rummage off rebels such as flavonoids, polyphenols and also with present of phenols (Mahmud et al., 2014). Agency for cancer prevention offers oxidative cell insurance. High-cell reinforcement action is taken by proanthocyanidins, their derivatives and hydrolyzed phenolic compounds. A study found that ROS or RNS has supportive searching impact for proanthocyanidine-rich products and also prosthocyanidins. The medicinal plant (*H. fomes*) may serve as both a severe scrounger and 15-LO blocker due to the existence of a high measure of procyanidins. A procyanidin B2 subordinate allegedly worked against human leukemia (HL-60) cell promyelocytic and also melanoma cell lines (Mahmud et al., 2014) Cytotoxic activity in human basal cell cancer has evidently started a mixture of procyanidins. The above discussion shows that the plant will fill in phytomedicines as a decent well. Although the plant has essential organic and pharmacological operation, different existing logical techniques should be used to research its restauration opportunity at the subatomic stage. The plant also has huge number of different and pharmacologic options and a large number of the separated mixtures and generated analogues of *H. fomes* deserve more study (Mahmud et al., 2014).

Also, the methanolic concentrates of leaves (LE) and aeronautical roots (AR) of *H. fomes* demonstrated a critical portion subordinate decrease in the complete cholesterol, fatty substances, LDL, and VLDL levels other than expanding the HDL level. The outcomes showed that the methanolic concentrates of the LE and AR were stronger than metformin hydrochloride in giving a gainful impact on the lipid profile of the diabetic rodents. Leaves

(LE) and elevated roots (AR) concentrates of *H. fomes* have strong antihyperlipidemic, antiatherosclerotic, and cardio-defensive movement. Bangladesh has effectively countless hyperlipidemic patients, yet our medical care framework does not have a viable model for dealing with the sickness including distinguishing proof and therapy (AP et al., 2018). The vast majority don't know about this infection. Additionally, various powerful allopathic meds that are accessible in Bangladesh for the therapy of hyperlipidemia, can cause genuine results after persistent use. In this manner, *H. fomes* plant can be an incredible option for the treatment of hyperlipidemia, atherosclerosis, and can be utilized as a cardio-defensive method and needs further examinations (AP et al., 2018). The capability of bioactive plants or their concentrates to give new and novel items to illness treatment and avoidance is as yet gigantic. Therapeutic plants of various starting points have been utilized since the Ayurveda period to treat wounds, consumes, and furthermore different genuine wellbeing issues. The phytochemical assessment has been gaining fast ground and natural items are getting well known as wellsprings of conceivable anticancer mixes (G. Das et al., 2015). In spite of the fact that the synthetic constituents of a large portion of the mangrove plants are as yet not been concentrated widely, examinations identified with the revelation of a few novel mixes with planned therapeutic qualities for the disclosure of new chemotherapeutic specialists have been attempted all through the world. Be that as it may, an appropriate comprehension of the complex synergistic collaboration of different constituents against malignancy spices in planning the plan to assault the carcinogenic cells without making any mischief or harm the ordinary cells is as yet required. There is additionally a tremendous prerequisite for the advancement of new anticancer medications and chemotherapy procedures, by the logical and orderly investigation of a pool of engineered, organic, and normal items from mangrove plants (G. Das et al., 2015). The ancestral and rustic individuals are altogether subject to mangrove plants for their necessities. The occupants broadly misuse the mangrove plants for

significant wood and different prerequisites. Then again, the plant species are lessening step by step because of brutal deforestation by brokers for business intrigue. Over-abuse of the woods isn't just causing consumption of the plant assets yet in addition disfavoring the regular excellence of the district (Myat Myat Moe, 2009).

Furthermore, mangroves uphold extraordinary biological systems, particularly on their multifaceted root frameworks. In zones where roots are for all time lowered, mangroves might be host to a wide assortment of life forms, including green growth, barnacles, shellfish, and wipes. Mangroves are incredible cradles between the vicious sea and the delicate coast, particularly during typhoons, which can bring amazing tempest floods onto shores. The gigantic mangrove root framework is very effective at disseminating wave energy. This root framework additionally forestalls beach front disintegration. In this manner, there is a critical requirement for the preservation of *H. fomes* plant abundance (Myat Myat Moe, 2009).



## Chapter 4

### Conclusion

*H. fomes* is one of the useful and important plants for Bangladesh. It provides so much value and advantages. Together, the plant and 'Sundarbans' mangrove forest provides great protection for our natural resources and supports unique ecosystems, especially on their convoluted root system. In different regions, where roots are permanently submerged, *H. fomes* may be host to a wide variety of organisms including algae, sponges, and oysters. Besides, mangrove forests are the best buffers and defense systems between fragile coast and violent ocean. They protect mankind from different natural calamities like hurricanes or tornado. Despite these values, mangrove forests including *H. fomes* are going to extinct day by day due to excessive flooding, sedimentation, increased soil saline, deforestation, nutrient imbalances, and cyclone induced stress. The government should take necessary steps immediately to save this plant from further extinction. More research and experiment should be done over *Heritiera fomes* to find out new possibilities and new hope for the fight against new diseases and the betterment of mankind.

## References

- Ahmed, F., & Urooj, A. (2010, June 6). Traditional uses, medicinal properties, and phytopharmacology of *Ficus racemosa*: A review. *Pharmaceutical Biology*, Vol. 48, pp. 672–681. Informa Healthcare. <https://doi.org/10.3109/13880200903241861>
- Ali, M., Nahar, K., Sintaha, M., Khaleque, H. N., Jahan, F. I., Biswas, K. R., ... Rahmatullah, M. (2011). An evaluation of antihyperglycemic and antinociceptive effects of methanol extract of *Heritiera fomes* Buch- Ham. (Sterculiaceae) barks in Swiss albino mice. *Advances in Natural and Applied Sciences*, 5(2), 116–121.
- AP, S., A, S., Md, S., M, M., KMK, A., TB, W., ... SK, K. (2018). Antihyperlipidemic, Antiatherosclerotic and Cardio-protective Activity of Leaves and Aerial Roots of *Heritiera fomes* (Sundari) Extract on Alloxan-induced Diabetic Sprague Dawley Rats. *American Journal of Ethnomedicine*, 05(01), 1–7. <https://doi.org/10.21767/2348-9502.100001>
- Bartnik, M., & Facey, P. C. (2017). Glycosides. In *Pharmacognosy: Fundamentals, Applications and Strategy* (pp. 101–161). Elsevier Inc. <https://doi.org/10.1016/B978-0-12-802104-0.00008-1>
- Basak, U. C., Das, A. B., & Das, P. (1996). Chlorophylls, carotenoids, proteins and secondary metabolites in leaves of 14 species of mangrove. *Bulletin of Marine Science*, 58(3), 654–659.
- Binns, C., & Low, W. Y. (2016). Diabetes in the Asia Pacific Region. *Asia-Pacific Journal of Public Health*, 28(6), 472–474. <https://doi.org/10.1177/1010539516663938>

- Booth, J. K., & Bohlmann, J. (2019, July 1). Terpenes in *Cannabis sativa* – From plant genome to humans. *Plant Science*, Vol. 284, pp. 67–72. Elsevier Ireland Ltd. <https://doi.org/10.1016/j.plantsci.2019.03.022>
- Bynum, W. F., & Porter, R. (2008). The World Health Organization and its work. 1993. *American Journal of Public Health*, 98(9), 1594–1597. <https://doi.org/10.2105/AJPH.98.9.1594>
- Chandrashekar, K., & Kumar, T. (2011). *Bauhinia purpurea* Linn. A Review of its Ethnobotany, Phytochemical and Pharmacological Profile. *Research Journal of Medicinal Plant*, Vol. 5, pp. 420–431.
- Chowdhury, M. Q., Kitin, P., De Ridder, M., Delvaux, C., & Beeckman, H. (2016). Cambial dormancy induced growth rings in *Heritiera fomes* Buch.- Ham.: a proxy for exploring the dynamics of Sundarbans, Bangladesh. *Trees - Structure and Function*, 30(1), 227–239. <https://doi.org/10.1007/s00468-015-1292-2>
- Claeson, U. P., Malmfors, T., Wikman, G., & Bruhn, J. G. (2000, September 1). *Adhatoda vasica*: A critical review of ethnopharmacological and toxicological data. *Journal of Ethnopharmacology*, Vol. 72, pp. 1–20. Elsevier. [https://doi.org/10.1016/S0378-8741\(00\)00225-7](https://doi.org/10.1016/S0378-8741(00)00225-7)
- Das, G., Gouda, S., Mohanta, Y. K., & Patra, J. K. (2015). Mangrove plants: A potential source for anticancer drugs. *Indian Journal of Geo-Marine Sciences*, 44(5), 666–672.
- Das, S. K., Samantaray, D., Patra, J. K., Samanta, L., & Thatoi, H. (2016). Antidiabetic potential of mangrove plants: a review. *Frontiers in Life Science*, 9(1), 75–88.

<https://doi.org/10.1080/21553769.2015.1091386>

Drabble, E., & Nierenstein, M. (1907). On the Rôle of Phenols, Tannic Acids, and Oxybenzoic Acids in Cork Formation. *Biochemical Journal*, 2(3), 96-102.1.  
<https://doi.org/10.1042/bj0020096>

Dubin, A. E., & Patapoutian, A. (2010). Nociceptors: The sensors of the pain pathway. *Journal of Clinical Investigation*, 120(11), 3760–3772. <https://doi.org/10.1172/JCI42843>

Firenzuoli, F., & Gori, L. (2007). Herbal medicine today: Clinical and research issues. *Evidence-Based Complementary and Alternative Medicine*, 4(SUPPL. 1), 37–40. Hindawi Limited. <https://doi.org/10.1093/ecam/nem096>

Fraga-Corral, M., García-Oliveira, P., Pereira, A. G., Lourenço-Lopes, C., Jimenez-Lopez, C., Prieto, M. A., & Simal-Gandara, J. (2020). Technological application of tannin-based extracts. *Molecules*, 25(3), 614. <https://doi.org/10.3390/molecules25030614>

Hailemariam, T. W., Alamdo, A. G., & Hailu, H. E. (2020). *Emerging Nutritional Problem of Adult Population : Overweight / Obesity and Associated Factors in Addis Ababa City Communities , Ethiopia — A Community-Based Cross- Sectional Study. 2020.*

Halder Ria, Suniti Ghosh Chatterji, P. S. (2014). *Micro nutrient acitivity of Sundari ( Heritiera fomes ),The Mangrove plant.* 4(2), 11–18.

Hossain, M., Panthi, S., Asadujjaman, M., Khan, S., Sadhu, S., & Ferdous, F. (2013). Phytochemical and Pharmacological Assessment of the Ethanol Leaves Extract of *Heritiera fomes* Buch. Ham. (Family-Sterculiaceae). *Journal of Pharmacognosy and*

*Phytochemistry*, 2(3), 95–101.

Hruby, A., & Hu, F. B. (2015, December 4). The Epidemiology of Obesity: A Big Picture. *Pharmacoeconomics*, Vol. 33, pp. 673–689. Springer International Publishing. <https://doi.org/10.1007/s40273-014-0243-x>

Islam, M. A. (2017). *Evaluation of Antioxidant Activity and Determination of Total Phenolic Content of leaves extract of Heritiera littoralis (Sundari tree)*. Retrieved from <http://dspace.daffodilvarsity.edu.bd:8080/handle/20.500.11948/2255>

Khan, H., Saeedi, M., Nabavi, S. M., Mubarak, M. S., & Bishayee, A. (2018). Glycosides from Medicinal Plants as Potential Anticancer Agents: Emerging Trends Towards Future Drugs. *Current Medicinal Chemistry*, 26(13), 2389–2406. <https://doi.org/10.2174/0929867325666180403145137>

Khan, M. N. I., Khatun, S., Azad, M. S., & Mollick, A. S. (2020a). Leaf morphological and anatomical plasticity in Sundri (*Heritiera fomes* Buch.-Ham.) along different canopy light and salinity zones in the Sundarbans mangrove forest, Bangladesh. *Global Ecology and Conservation*, 23, e01127. <https://doi.org/10.1016/j.gecco.2020.e01127>

Khan, M. N. I., Khatun, S., Azad, M. S., & Mollick, A. S. (2020b). Leaf morphological and anatomical plasticity in Sundri (*Heritiera fomes* Buch.-Ham.) along different canopy light and salinity zones in the Sundarbans mangrove forest, Bangladesh. *Global Ecology and Conservation*, 23, e01127. <https://doi.org/10.1016/j.gecco.2020.e01127>

Kok, V. C., Sung, F. C., Kao, C. H., Lin, C. C., & Tseng, C. H. (2016). Cancer risk in East Asian patients associated with acquired haemolytic anaemia: A nationwide population-

- based cohort study. *BMC Cancer*, 16(1), 57. <https://doi.org/10.1186/s12885-016-2098-3>
- Kurek, J. (2019). Introductory Chapter: Alkaloids - Their Importance in Nature and for Human Life. In *Alkaloids - Their Importance in Nature and Human Life*. IntechOpen. <https://doi.org/10.5772/intechopen.85400>
- Kurhekar, J. V. (2017). Alkaloids - the healers in medicinal plants. *International Journal of Research in BioSciences*, 6(4), 33–39.
- Kytidou, K., Artola, M., Overkleeft, H. S., & Aerts, J. M. F. G. (2020, April 7). Plant Glycosides and Glycosidases: A Treasure-Trove for Therapeutics. *Frontiers in Plant Science*, Vol. 11. Frontiers Media S.A. <https://doi.org/10.3389/fpls.2020.00357>
- Leach, F. S. (2011). Anti-microbial properties of *Scutellaria baicalensis* and *Coptis chinensis*, two traditional Chinese medicines. *Bioscience Horizons*, 4(2), 119–127. <https://doi.org/10.1093/biohorizons/hzr014>
- Lo Vecchio, A., Buccigrossi, V., Fedele, M. C., & Guarino, A. (2019). Acute Infectious Diarrhea. *Advances in Experimental Medicine and Biology*, 1125(8), 109–120. [https://doi.org/10.1007/5584\\_2018\\_320](https://doi.org/10.1007/5584_2018_320)
- Mahmud, I., Islam, M. K., Saha, S., Barman, A. K., Rahman, M. M., Anisuzzman, M., ... Rahmatullah, M. (2014). Pharmacological and Ethnomedicinal Overview of *Heritiera fomes*: Future Prospects. *International Scholarly Research Notices*, 2014(July), 1–12. <https://doi.org/10.1155/2014/938543>
- Mirza, M. S., Ali, S. A., & Sanghvi, I. (2017). Anti-Obesity Potential of *Heritiera Fomes*

Leaves Methanolic Extract in a Preclinical Model. *IOSR Journal of Pharmacy and Biological Sciences*, 12(04), 01–05. <https://doi.org/10.9790/3008-1204010105>

Mollik, M. A. H., Hossan, M. S. H., Paul, A. K., Taufiq-Ur-Rahman, M., Jahan, R., & Rahmatullah, M. (2010). A comparative analysis of medicinal plants used by folk medicinal healers in three districts of Bangladesh and inquiry as to mode of selection of medicinal plants. *Ethnobotany Research and Applications*, 8, 195–218. <https://doi.org/10.17348/era.8.0.195-218>

Mominul Islam, A. K. M., Hasan, M., Musha, M. M. H., Uddin, M. K., Juraimi, A. S., & Anwar, M. P. (2018). Exploring 55 tropical medicinal plant species available in Bangladesh for their possible allelopathic potentiality. *Annals of Agricultural Sciences*, 63(1), 99–107. <https://doi.org/10.1016/j.aoas.2018.05.005>

Moore, D. (2020). Obesity: Definition, Causes, Diagnosis, Treatment & More. Retrieved August 24, 2020, from Healthline website: <https://www.healthline.com/health/obesity#complications>

Myat Myat Moe. (2009). *Botanical study on importance of mangrove ecosystem for conservation and management purposes*. 4(20), 4419–4422.

Nandi, S., & Lyndem, L. M. (2016, March 3). Clerodendrum viscosum: Traditional uses, pharmacological activities and phytochemical constituents. *Natural Product Research*, Vol. 30, pp. 497–506. Taylor and Francis Ltd. <https://doi.org/10.1080/14786419.2015.1025229>

Nurunnabi, T. R., Nahar, L., Al-Majmaie, S., Rahman, S. M. M., Sohrab, M. H., Billah, M.

- M., ... Sarker, S. D. (2018). Anti-MRSA activity of oxysporone and xylitol from the endophytic fungus *Pestalotia* sp. growing on the Sundarbans mangrove plant *Heritiera fomes*. *Phytotherapy Research*, 32(2), 348–354. <https://doi.org/10.1002/ptr.5983>
- Obiloma, A. A., Madu, W. C., Osuji, G. O., Ampim, P. A., Weerasooriya, A. D., & Carson, L. E. (2019). Terpene-Rich Medicinal Plant Spices for Flavoring of Processed Tropical Food. *American Journal of Plant Sciences*, 10(04), 572–577. <https://doi.org/10.4236/ajps.2019.104041>
- Okwu, M. U., Olley, M., Akpoka, A. O., & Izevbuwa, O. E. (2019). Methicillin-resistant staphylococcus aureus (MRSA) and anti-MRSA activities of extracts of some medicinal plants: A brief review. *AIMS Microbiology*, Vol. 5, pp. 117–137. AIMS Press. <https://doi.org/10.3934/microbiol.2019.2.117>
- Oreopoulou, A., Tsimogiannis, D., & Oreopoulou, V. (2019). Extraction of Polyphenols From Aromatic and Medicinal Plants: An Overview of the Methods and the Effect of Extraction Parameters. *Polyphenols in Plants*, (January), 243–259. <https://doi.org/10.1016/b978-0-12-813768-0.00025-6>
- Peng, J., Zheng, T. T., Li, X., Liang, Y., Wang, L. J., Huang, Y. C., & Xiao, H. T. (2019, April 12). Plant-derived alkaloids: The promising disease-modifying agents for inflammatory bowel disease. *Frontiers in Pharmacology*, Vol. 10, p. 351. Frontiers Media S.A. <https://doi.org/10.3389/fphar.2019.00351>
- Prassas, I., & Diamandis, E. P. (2008). Novel therapeutic applications of cardiac glycosides. *Nature Reviews Drug Discovery*, 7(11), 926–935. <https://doi.org/10.1038/nrd2682>



- Rahman, M. A., Solaiman, M., Haque, M. E., & Das, A. K. (2011). Analgesic and anti-inflammatory activities of *Alocasia indica* (Roxb.) Schott. *Oriental Pharmacy and Experimental Medicine*, *11*(3), 143–146. <https://doi.org/10.1007/s13596-011-0027-1>
- Rasouli, H., Farzaei, M. H., & Khodarahmi, R. (2017, December 29). Polyphenols and their benefits: A review. *International Journal of Food Properties*, Vol. 20, pp. 1700–1741. Taylor and Francis Inc. <https://doi.org/10.1080/10942912.2017.1354017>
- Renthal, W. (2014). Pain Genetics. In *Rosenberg's Molecular and Genetic Basis of Neurological and Psychiatric Disease: Fifth Edition* (pp. 1089–1100). Elsevier Inc. <https://doi.org/10.1016/B978-0-12-410529-4.00090-5>
- Roxb, H. (2009). 禁伐後のHeritiera fomes林における主要樹種の個体群動態 -ミャンマー・エーヤワディーデルタにおける追跡調査から(In Chinese) *Eco-Habitat : JISE Research*, *16*(1), 1–11. [https://doi.org/10.24600/ecohabitat.16.1\\_1](https://doi.org/10.24600/ecohabitat.16.1_1)
- Sakaguchi, T., & Nakajima, A. (1987). Recovery of Uranium from Seawater by Immobilized Tannin. *Separation Science and Technology*, *22*(6), 1609–1623. <https://doi.org/10.1080/01496398708058421>
- Sharangi, A. B. (2009, June 1). Medicinal and therapeutic potentialities of tea (*Camellia sinensis* L.) - A review. *Food Research International*, Vol. 42, pp. 529–535. Elsevier. <https://doi.org/10.1016/j.foodres.2009.01.007>
- Siddiqi, N. A. (2020). *Effects of Abiotic and Biotic factors on the seedling recruitment of Heritiera fomes in the mangroves of the Sundarbans, Bangladesh. Author ( s ): Neaz Ahmad Siddiqi Source : Journal of Tropical Forest Science , Vol . 11 , No . 4 ( October*

1999 ), pp . 69. 11(4), 690–703.

Skyler, J. S., Bakris, G. L., Bonifacio, E., Darsow, T., Eckel, R. H., Groop, L., ... Ratner, R. E. (2017, February 1). Differentiation of diabetes by pathophysiology, natural history, and prognosis. *Diabetes*, Vol. 66, pp. 241–255. American Diabetes Association Inc. <https://doi.org/10.2337/db16-0806>

Taeb, M. (1996). *Islamic Republic of Iran : Country Report To the Fao International Technical Conference on Plant*. (April 1995), 1–61.

Vanden Berghe, E. (2014). *Heritiera fomes* Buch.-Ham. *WoRMS*. Retrieved from <http://www.marinespecies.org/aphia.php?p=taxdetails&id=235117>

Wahab, S. M. A., Jantan, I., Haque, M. A., & Arshad, L. (2018, June 20). Exploring the leaves of *Annona muricata* L. as a source of potential anti-inflammatory and anticancer agents. *Frontiers in Pharmacology*, Vol. 9, p. 661. Frontiers Media S.A. <https://doi.org/10.3389/fphar.2018.00661>

Wangensteen, H., Dang, H. C. T., Uddin, S. J., Alamgir, M., & Malterud, K. E. (2009). Antioxidant and antimicrobial effects of the mangrove tree *Heritiera fomes*. *Natural Product Communications*, 4(3), 371–376. <https://doi.org/10.1177/1934578x0900400311>