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A STUDY ON THE IMPACT OF FINANCIAL LITERACY & FINANCIAL INCLUSION ON ENTREPRENEURSHIP INTENTION AMONG STUDENTS IN BANGALORE

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ABSTRACT
In the present scenario where there is a lack of job opportunities, as we know the demand and supply for the job are never the same, in such a situation imparting entrepreneurial skills to the youngster becomes a prerequisite. The basic requirement to become an entrepreneur is to have finance and having a literacy about the arrangement of it is the basic skill that is required foremost to become an entrepreneur. At the same time, financial inclusion plays a dominant role in persuading the youth to become an entrepreneur. This research is an attempt to study the role of financial literacy and financial inclusion in the willingness of students to become an entrepreneur. A total of 258 responses were collected from autonomous institutions undergraduate students of Bangalore through a structured questionnaire. The analysis is done by using the tools of measure of central tendency, SPSS, and SEM. The study reveals that the independent variable of financial literacy and financial inclusion is highly significant with the dependent variable willingness of entrepreneurship. The analysis support that a higher level of financial literacy and awareness about financial inclusion leads to entrepreneurship development. The suggestion for the same was included in the study.

Keywords: Financial Inclusion, Financial Literacy, Entrepreneurship willingness.

INTRODUCTION
In a developing country like India, more than 50% of its population is below the age of 25 and more than 65% is below the age of 35. In 2022 the average age of Indians is 28.7 years. The growth and upliftment of this young youth will facilitate the development of an economy. In a country like India, the youth unemployment rate is 22.90 % as of 2021(https://tradingecomics.com). There is a need for entrepreneurship development to provide more & more job opportunities and overall upliftment. Financial literacy plays a dominant role in entrepreneurship development. Nowadays the financial product's extensive variety and complexity demand a high level of financial literacy to understand the benefits of these financial products & services offered by financial institutions for better financial planning and personal financial management. The young students must equip themself with the knowledge of investment, saving, insurance, loans, tech finance, and various avenues for investment for retirement planning, which lead to confidence-building in making financial decisions that facilitate financial well-being.

Financial literacy and awareness about finical inclusion will facilitate and give ideas to young minds about the arrangement of funds for their business plan which boosts their morale to come forward and take the initiative to start up their business which promotes and persuade them to become an entrepreneur.

Aim of the Study
The study aims at understanding the present situation and the role of financial literacy and financial inclusion on the willingness of entrepreneurship among undergraduate autonomous students of Bangalore, it also focuses on analysing the impact of demographic factors on the main variables of the study and as well as the steps taken to overcome by suggesting suitable means.

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Aim of the Study
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A STUDY ON THE ROLE OF FINANCIAL LITERACY AND FINANCIAL INCLUSION ON INVESTMENT BEHAVIOUR AMONG WOMEN FACULTY

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Abstract

Financial literacy and financial inclusion play a pivotal role in investment decisions in the present scenario, which is influenced by many demographic variables such as income, age qualification and gender. Financial inclusion provides access to various financial avenues whereas financial literacy creates awareness about these avenues which influence investment behaviour. Women play a very important role in the economic development of a country. But some studies replicate those women are not secure and independent in terms of finance. Still, the financial decision is taken by the male in the family the main reason for this is the lack of financial literacy and accessibility of financial services among women.

Thus, this research is an attempt to study the role of financial literacy and financial inclusion on investment behaviour among women faculty in Bangalore, Karnataka. This research is descriptive in nature, data were obtained by a closed-end questionnaire. A total of 126 responses were collected through a google form. The measure of central tendency, SPSS, and AMOS was used to analyse the data collected through a questionnaire. The analyses of the study clearly show that financial literacy has a greater influence on investment behaviour. The respondents clearly state that the knowledge about the financial avenues and accessibility of the financial services play a role in catalyst planning their investment.

Key Words: Financial Literacy, Financial Inclusion, Investment Behaviour, Financial Services.

Introduction

The financial sector plays an important role in the welfare of society and global economic growth. The role of the financial sector can be observed by the level of consumers' financial literacy, financial inclusion and investment behaviour. Financial literacy means knowledge of managing own

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Original Article

Biochemical and biophysical changes in plasma a erythrocyte membranes of alcohol-consuming type 2 diabetics: a clinical st

Naresh Ellutla [1], Ananda Vardhan Hebbani [2], Vaddi Damodara Reddy [3], Daisy Kunnathuparambil Lonappan [4], Varadacharyulu Nallanchakravarthula [1]*

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Abstract

The effects of alcohol consumption on blood glucose levels are unpredictable , more so for an al Since type 2 diabetes is a chronic condition with impairment of glucose metabolism, the influe tion in such a derailed metabolism ought to be investigated. We aimed to understand the inte the metabolisms of glucose and alcohol by investigating the biochemical and biophysical chan respectively. We performed a clinical study with 20 human non-alcoholic subjects, non-diabet and the test subjects were categorized as alcoholics, people with diabetes and alcoholic dia against the control group. Increased plasma AST, ALT, ALP, and LDH enzyme activity; higher l turic acid reactive species (TBARS) both in plasma and erythrocyte lysate; higher fasting and hemoglobin levels (Hb1Ac); elevated levels of erythrocyte membrane total cholesterol/phospl erythrocyte membrane fluidity in the alcoholic diabetics was noted. Alcohol induced oxidative metabolism and its worsening effects in people with type 2 diabetes leading to a failure in the is evident from the study.

Keywords: alcohol, type 2 Diabetes, erythrocyte membrane; HB1Ac, lipid peroxidat

Introduction

to be inversely associated

Journal of Ethnic Foods

REVIEW ARTICLE Open Access

Vegetarian ethnic foods of South India: review on the influence of traditional knowledge

Srinidhi K. Parthasarathi[1], Ananda Vardhan Hebbani[2*] and Padma Priya Dharmavaram Desai[3]

Abstract

South Indian cultures are diverse and unique amongst Indian traditions. In spite of many changes in Indian traditions over generations, South Indian states seem to have maintained a great extent of similarity with reference to vegetarian ethnic food habits and the reason behind is not convincingly known. Hindu traditional texts have extensive mention of the ethnic origins of many cultural practices prevailing in India and the present review aims to explore the different vegetarian ethnic foods of South India and also look into the influential role of food related ideologies mentioned in the traditional texts. Ethnographic study data about the prevailing vegetarian foods of the states were generated using multiple tools and presented. It is observed that there is a great extent of similarity amongst the varieties of vegetarian foods being prepared in Hindu communities of South India. Our study also highlights the strong influential role of tradition in evolution of vegetarian foods prevailing even today in South India.

Keywords: South India, Hinduism, Vegetarian ethnic foods, Philosophical perspective

Introduction

South India represented by five major Indian states viz., Tamil Nadu (TN), Karnataka (KA), Kerala (KL), Andhra Pradesh (AP) and Telangana (TG); is well known for its rich cultural heritage and food is one of the major contributors to its richness. Traditions and food are highly inter-influential throughout India, more so in South India. Based on the historical evidences, it is clear that the Dravidian civilization of South India is much more primitive (flourished approximately 4500 years ago) in comparison to the rest of Indian civilizations [1] and South Indian cuisines seemingly continue to retain many of the ancient Dravidian food culture elements.

According to India State of Forest Report (IFSR 2021), South Indian states (total geographical area of 6,35,748 km^2) comprises of a high percentage of forest cover viz., 20.31% in TN, 20.19% in KA, 54.7% in KL, 18.28% in AP and 18.93% in TG; which enriches the food heritage of South India [2]. The states are also major contributors of agricultural economy of India and nearly 48% of its population engage in agriculture. Paddy, sorghum, pearl millet, pulses, chilli and ragi are the major crops cultivated in the South India. The South Indian states are also predominant spice-producing Indian states [3] and thus cuisines here are relatively more flavoured and spicy when compared to other Indian cuisines because of the extensive usage of spices such as ginger, paprika, coriander, cinnamon, tamarind, pepper and cumin seeds [4]. With reference to the dietary practices, reports show that approximately 30% of South Indian people are vegetarians [5] and they generally belong to either of the Brahmin, Arya Vysya, Lingayat and Nambudiri communities under Hinduism.

South Indian vegetarian cuisines seem to be unaffected by other cultural influences and people continue

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Original Article

Biochemical and biophysical changes in plasma and erythrocyte membranes of alcohol-consuming type 2 diabetics: a clinical study

Naresh Ellutla [1], Ananda Vardhan Hebbani [2], Vaddi Damodara Reddy [3], Daisy Kunnathuparambil Lonappan [4], Varadacharyulu Nallanchakravarthula [1]*

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Received: 30 December 2021 / Accepted: 28 March 2022

Abstract

The effects of alcohol consumption on blood glucose levels are unpredictable , more so for an alcoholic Type 2 diabetic person. Since type 2 diabetes is a chronic condition with impairment of glucose metabolism, the influence of excess alcohol consumption in such a derailed metabolism ought to be investigated. We aimed to understand the interpolating relationship between the metabolisms of glucose and alcohol by investigating the biochemical and biophysical changes in plasma and erythrocytes, respectively. We performed a clinical study with 20 human non-alcoholic subjects, non-diabetics were considered as controls and the test subjects were categorized as alcoholics, people with diabetes and alcoholic diabetics. Findings were analyzed against the control group. Increased plasma AST, ALT, ALP, and LDH enzyme activity; higher levels of nitric oxide, thiobarbituric acid reactive species (TBARS) both in plasma and erythrocyte lysate; higher fasting and postprandial glucose, glycated hemoglobin levels (Hb1Ac); elevated levels of erythrocyte membrane total cholesterol/phospholipids (C/P) ratio and altered erythrocyte membrane fluidity in the alcoholic diabetics was noted. Alcohol induced oxidative and nitrosative stress during its metabolism and its worsening effects in people with type 2 diabetes leading to a failure in the overall metabolic homeostasis is evident from the study.

Keywords: alcohol, type 2 Diabetes, erythrocyte membrane; HB1Ac, lipid peroxidation, nitric oxide.

Introduction

Complications associated with diabetics consuming alcohol had been a point of concern globally for a very long time [1]. While people rely on alcohol consumption generally for social reasons, being an addictive drug, they generally end up becoming chronic alcoholics. The global diabetes prevalence in 2021 is estimated to be a large number, i.e., nearly 800 million, and alcohol drinking has been known to be associated with incidences of diabetes and hyperglycemic status [2]. According to previous meta-analysis studies, light-to-moderate alcohol consumption was shown to be inversely associated with the incidence of type 2 diabetes [3–5]. Health reports state diabetes and alcoholism as the second and third leading causes of global deaths [6, 7].

It is well known that alcohol affects various physiological and bio-chemical events of the human body leading to a broad spectrum of metabolic disorders [8]. Ingested alcohol readily enters the circulation exposing all the cells and tissues to a continued shock of alcohol and its metabolites for very long durations. Thus it is predictable that red blood cells and the other biochemical constituents in the circulation are significantly influenced by alcohol. Studies on the assessment

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Bulletin of the National Research Centre

REVIEW Open Access

Effects of D-pinitol on diabetes mellitus: an updated review

Anandakumar Pandi[1*], Vanitha Manickam Kalappan[2] and Naveenkumar Chandrashekar[3]

Abstract

Background: The awareness in the consumption of plant-based food has gained attention in the recent years. Phytochemicals are thought to play a critical role in health promotion and in the prevention and management of chronic diseases. These compounds have reported to produce little or no side effects and are thus significantly used in treating various ailments. D-Pinitol is the chief active compound found in soy and soy products. Several studies have shown the health benefits of D-pinitol such as antioxidant, anti-diabetic, anti-inflammatory and anticancer properties. In this review, an attempt has been made to review the effects of D-pinitol against diabetes mellitus in pre-clinical and clinical studies.

Methodology: Journal articles were sourced and filtered with relevant keywords on "D-pinitol and diabetes mellitus". Scientific databases, including PubMed, NCBI, Google Scholar, Science Direct, SciFinder and Web of Science, were accessed to identify the most relevant articles on the effect of D-pinitol in diabetes mellitus. The study duration was from September 2021 to February 2022.

Results: This comprehensive review demonstrates the application of D-pinitol against diabetes mellitus. Most of the animal and clinical studies included in this review reported that D-pinitol treatment effectively regulated hyperglycemia and prevented insulin resistance.

Conclusions: D-Pinitol could serve as an effective anti-hyperglycemic agent for the treatment of diabetes mellitus. Further research to study its safety and mechanism of action is recommended in order to employ this compound for clinical trials.

Keywords: D-Pinitol, Antioxidant, Glucose, Insulin, HbA1C

Background

Diabetes mellitus is one of the most common non-communicable diseases. It is group of metabolic disorders in which hyperglycemia lasts over a longer period leading to several other complications (Toi et al. 2020). It is characterized by supraphysiological glucose due to the deficiency in insulin secretion or insulin receptor or post-receptor events that results in the disturbances in the biochemical pathways of carbohydrates, fats and protein (Ruiz 2012). Moreover, the impaired metabolism leads to the progression and aggravation of oxidative stress through different mechanisms like glucose autoxidation, protein glycation, etc. (Dos Santos et al. 2019). The total number of people with diabetes is predicted to increase from 171 million in 2000 to 366 million in 2030 (Tao et al. 2015). Studies direct that the incidence of diabetes will continue to rise in the future due to growing prevalence of obesity, accelerating aging populations, environmental factors and sedentary lifestyles (Piché et al. 2020). Chronic blood sugar level and insulin resistance may in turn lead to severe impairment and dysfunction of heart, kidney, liver, eye, nerves, etc., which predominantly lead to mortality (Kautzky-Willer et al. 2016). At present, there is no known cure approaches for diabetes mellitus except in some very specific cases. Several efforts are

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Beni-Suef University Journal of Basic and Applied Sciences

REVIEW

Open Access

Cardioprotective effects of Ferulic acid against various drugs and toxic agents

Anandakumar Pandi[1*], Mahto Hemanti Raghu[1], Naveenkumar Chandrashekar[2] and Vanitha Manickam Kalappan[3]

Abstract

Background: Homeostatic regulation of cardiomyocytes is indispensable in maintaining the normal physiological activity of cardiac tissue. Cardiotoxicity induced by drugs may lead to cardiac abnormalities such as arrhythmia, myocardial infarction and myocardial hypertrophy. Moreover, drug-induced cardiotoxicity confines the additional use of the implicated drugs. Several studies have reported that consumption of phytochemicals on regular intervals shall protect humans against numerous diseases such as diabetes, cardiovascular disease, inflammatory diseases and cancer.

Main body: Ferulic acid (FA) is a plant derived polyphenol abundantly found in vegetables, fruits and grains. FA is widely known for its antioxidant, anti-inflammatory, anticancer, nephroprotective and hepatoprotective effects. FA has been well documented for its cardioprotective activity against various drugs and toxic agents as well. However, the cardioprotective action of FA have remained a challenge with regard to understanding its mechanism in health and diseases.

Conclusion: The main purpose of this review is to explore the cardioprotective mechanisms of FA against several drugs and chemicals to recommend further studies to investigate the potential protective effect of FA.

Keywords: Ferulic acid, Antioxidant, Cardioprotective, Preclinical, Cell line, Human health

1 Background

Cardiotoxicity usually denotes toxicity that has a harmful effect on the heart, which may ultimately result in myocardiopathy such as arrhythmia, myocardial infarction and myocardial hypertrophy [1, 2]. In the last few years, more than 20% of clinical drugs were forced out of the market because of cardiovascular side effects, which hampered the drug development and extremely affected the improvement in patient health [3]. Several studies have showed that drug-induced cardiac dysfunction may be a stepwise process accompanied by the increase of cardiac biomarkers and structural myocardial deformation, finally resulting in reduced left ventricular ejection fraction (LVEF) [4, 5]. Recently, the most accepted term for cardiotoxicity is the reduction in LVEF of at least 10% to less than 55% [6]. Studies show that cardiac cell death or damage concurrently occurs with the progression of cardiotoxicity, demonstrating that drug-induced cardiomyocyte death may be the major for cardiotoxicity [7].

In the recent years, extensive research has been undertaken to investigate the action of phytochemical compounds found in the diet [8]. The [illegible] reason commonly found in fruits, vegetables, beverages and herbal remedies [9]. These alkaloid compounds contain numerous active substances like flavonoids, polyphenols, indoles and sulfur containing elements [10]. These phytochemicals have the tendency to safeguard humans against diabetes mellitus, hepatic disorders, cardiovascular disease, cancer, arthritis, and Alzheimer's disease and many more [11, 12]. Findings from numerous studies have demonstrated that

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JOURNAL OF BIOCHEMICAL AND MOLECULAR TOXICOLOGY

RESEARCH ARTICLE

Baicalein inhibits cell proliferation and enhances apoptosis in human A549 cells and benzo(a)pyrene-induced pulmonary carcinogenesis in mice

Naveenkumar Chandrashekar, Raghunandhakumar Subramanian, Devaki Thiruvengadam

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Abstract

Our current study is done to explore the possible mechanisms to elaborate on the growth inhibitory effect of baicalein (BE) in human lung carcinoma. Initially, BE (25 and 50 μM) treatment for 24 h, suppressed the viability and inhibited population growth in A549 cells. BE upholds the production of reactive oxygen species (ROS) with concomitant replenishment of glutathione, catalase, and glutathione peroxidase activity. The expression level of nuclear factor erythroid 2-related factor 2 and heme oxygenase-1 markedly increased after BE treatment will intimidate A549 cells proliferation by the ROS-independent pathway via the antioxidant pathway. In vivo investigations were carried out on BE (12 mg/kg, oral) in benzo(a)pyrene (B(a)P; 50 mg/kg, oral) induced lung carcinogenesis in mice. BE induces caspase-dependent apoptosis by increasing the levels of cytosolic cytochrome c accompanied by upregulating the outflow of p53, Bax, and caspase-3 with a concomitant abatement in the outflow of Bcl-2 in both in vitro and in vivo. In the murine model, BE treatment hindered the countenance of proliferation-related proteins (argyrophilic nucleolar organizing regions and proliferating cell nuclear antigen). Additionally, appraisal of the cell nucleus by transmission electron microscopic assessment uncovered that BE treatment adequately counteracts B(a)P-induced lung cancer cell survival. During the transition of the G_2/G_1 phase, BE is arrested in the cell cycle process. This might be the cause of a substantial increase in the appearance of $p21^{Cip1}$ with concomitant downregulating the expressions of CDK4, cyclin D, and cyclin E both in vitro and in vivo. The results conclude that BE treatment induced apoptosis and repressed pro[illegible] and in vivo of human lung carcinoma.

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MINI-REVIEW

COVID-19: comprehensive review on mutations and current vaccines

Ananda Vardhan Hebbani[1] · Swetha Pulakuntla[2] · Padmavathi Pannuru[3] · Sreelatha Aramgam[2,4] · Kameswara Rao Badri[5,6] · Vaddi Damodara Reddy[2]

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Abstract

Viral outbreaks had been a threat for the human race for a long time. Several epidemics and pandemics have been reported in the past with serious consequences on human health and subsequent social and economic aspects. According to WHO, viral infections continue to be a major health concern globally. Novel coronavirus, SARS-CoV-2 (Severe acute respiratory syndrome coronavirus-2) causes the most recent infectious pandemic disease, COVID-19 (Coronavirus disease-19). As of now, there were 249 million infections of COVID-19 worldwide with a high mortality of more than 5 million deaths reported; and the number of new additional cases is drastically increasing. Development of therapies to treat the infected cases and prophylactic agents including vaccines that are effective towards different variants are crucial to curtail the COVID-19 pandemic. Owing to the fact that there is a high mortality and morbidity rate along with the risk of virus causing further epidemic outbursts, development of additional effective therapeutic and preventive strategies are highly warranted. Prevention, early detection and treatment will reduce the spread of COVID-19 pandemic. The present review highlights the novel mutations and therapeutic updates associated with coronaviruses along with the clinical manifestations—diagnosis, clinical management and, prophylactic and therapeutic strategies of COVID-19 infection.

Keywords SARS-CoV-2 · Mutations · COVID-19 · Clinical management · Therapeutic strategies

Introduction

An incidence of unidentified pneumonia caused by 2019-nCoV/SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronovirus-2) was reported in the Wuhan city, China in the final months of 2019 (Zhou et al. 2020). The unidentified pneumonia was termed as COVID-19 (Coronavirus disease-19) considered to have spread from bats to humans. The mode of spreading from human to human is predominantly, through airborne respiratory droplet contact. The basic reproduction number (R_0) of the virus is analyzed to be in between 1.4 and 6.47 across different countries, which is not just of wider range when compared to the other corona viral infections, but also stands at a position very near after the other well-known infectious diseases such as Measles, Chickenpox, Mumps, Polio and Rubella (Liu et al. 2020; Tang et al. 2020). Genetic and phylogenetic analysis revealed that SARS-CoV-2 belongs to β-coronaviruses along with the other two predominant members, i.e., MERS-CoV (Middle East respiratory syndrome-related coronavirus) and SARS-CoV (severe acute respiratory syndrome coronavirus) (Leao et al. 2020). All the recent viral infection

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Journal of Ethnic Foods

REVIEW ARTICLE Open Access

Vegetarian ethnic foods of South India: review on the influence of traditional knowledge

Srinidhi K. Parthasarathi[1], Ananda Vardhan Hebbani[2*] and Padma Priya Dharmavaram Desai[3]

Abstract

South Indian cultures are diverse and unique amongst Indian traditions. In spite of many changes in Indian traditions over generations, South Indian states seem to have maintained a great extent of similarity with reference to vegetarian ethnic food habits and the reason behind is not convincingly known. Hindu traditional texts have extensive mention of the ethnic origins of many cultural practices prevailing in India and the present review aims to explore the different vegetarian ethnic foods of South India and also look into the influential role of food related ideologies mentioned in the traditional texts. Ethnographic study data about the prevailing vegetarian foods of the states were generated using multiple tools and presented. It is observed that there is a great extent of similarity amongst the varieties of vegetarian foods being prepared in Hindu communities of South India. Our study also highlights the strong influential role of tradition in evolution of vegetarian foods prevailing even today in South India.

Keywords: South India, Hinduism, Vegetarian ethnic foods, Philosophical perspective

Introduction

South India represented by five major Indian states viz., Tamil Nadu (TN), Karnataka (KA), Kerala (KL), Andhra Pradesh (AP) and Telangana (TG); is well known for its rich cultural heritage and food is one of the major contributors to its richness. Traditions and food are highly inter-influential throughout India, more so in South India. Based on the historical evidences, it is clear that the Dravidian civilization of South India is much more primitive (flourished approximately 4500 years ago) in comparison to the rest of Indian civilizations [1] and South Indian cuisines seemingly continue to retain many of the ancient Dravidian food culture elements.

According to India State of Forest Report (IFSR 2021), South Indian states (total geographical area of 6,35,748 km^2) comprises of a high percentage of forest cover viz., 20.31% in TN, 20.19% in KA, 54.7% in KL, 18.28% in AP and 18.93% in TG; which enriches the food heritage of South India [2]. The states are also major contributors of agricultural economy of India and nearly 48% of its population engage in agriculture. Paddy, sorghum, pearl millet, pulses, chilli and ragi are the major crops cultivated in the South India. The South Indian states are also predominant spice-producing Indian states [3] and thus cuisines here are relatively more flavoured and spicy when compared to other Indian cuisines because of the extensive usage of spices such as ginger, paprika, coriander, cinnamon, tamarind, pepper and cumin seeds [4]. With reference to the dietary practices, reports show that approximately 30% of South Indian people are vegetarians [5] and they generally belong to either of the Brahmin, Arya Vysya, Lingayat and Nambudiri communities under Hinduism.

South Indian vegetarian cuisines seem to be unaffected by other cultural influences and people continue

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Research Articles

Alcohol-induced hormonal and metabolic alterations in plasma and erythrocytes—a gender-based study

Daisy Kunnathuparambil Lonappan, Gouthami Kuruvalli, Althaf Hussain Shaik, Ananda Vardhan Hebbani, Hymavathi Reddyvari, Vaddi Damodara Reddy & ...show all

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Abstract

Purpose

This study aimed to understand the gender-specific alcohol-induced biochemical changes and TBARS association with the endocrine system.

Methods

Human male and female subjects ranging from 35 ± 10 years old with an 8-10-year drinking history were included in the study.

Results

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Ethno-pharmacological of Lilium Flower

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Ethno-pharmacological of Lilium Flower

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ABSTRACT

The Lilium flower have been regarded as an excellent source of biological active compounds. The present study reports the control of microbial load in air by open plate methods. The phytochemical analysis of the extract reveals the presence of phenols, flavonoids, tannins, terpenoids, glycosides, coumarins, and quinones. Bacterial identification of the isolates from the study area was confirmed with suitable tests.

Key words: Lilium flower, open plate method, phytochemical, bacteria.

I. INTRODUCTION

Lilium is a genus of herbaceous flowering plants growing from bulbs, all with large prominent flowers. They are the true lilies. India has a great treasure of medicinal plants due to which it is one of the richest nations in terms of a vast collection of genetic resources of medicinal plants in the world [1]. The members of the Liliaceae family have been found to contain phytochemicals such as alkaloids, steroidal saponins, vitamins, and fatty acids, which are responsible for their biological activity [2]. Flowers of various species of lily have been reported to possess broad-spectrum antimicrobial activity [3]. L. longiforum, has been studied and used as an anti-inflammatory agent for the treatment of bronchitis and blood clotting during the surgical procedures [4]. Lipid peroxidation and cholesterol oxidase enzyme inhibitor assays are used to determine the bioactive compounds in L. longiforum flower, which in turn shed light on its anecdotal medicinal use [5]. The Lilium candidum L. is also an ancient plant, which is used as an important edible plant and important biomedicine in China to alleviate the symptoms of various human inflammatory diseases and they are cultivated as an ornamental plant throughout the world [6]. This plant helped from time immemorial in the treatment of inflamed and suppurative wounds, ulcers, skin inflammations, burns and various injuries [7]. It is also used for muscle pain and gynecological problems. After surgery, it speeds up wound healing. Externally used is an alcohol or oil extract [8]. Mechanisms of Lilium anti-inflammatory activity and their bioactive components remain little known, but the therapeutic effects of lilies are confirmed by modern medicine, which has shown its healing, anti-inflammatory, analgesic, antioxidant, and other effects [9]. Many studies have been conducted for the chemical constituents of the genus Lilium, which illustrated their pharmacological effects of anti-tumor, hypoglycaemic, anti-bacterial, anti-inflammatory, hypolipidemic, reducing blood lipid, anti-depression anti-fatigue and hypoxia tolerance. The importance of the genus in the world flower market is due to diversity and large number of hybrid and cultivars commercially available. However, some species are also known for medicinal and food value which increase the economic importance many folds [10]. Outdoor concentrations of airborne bacteria generally were higher than those indoors but similar in summer and winter. Bacterial concentrations indoors showed more seasonal difference, which may be due to changes in occupant dress and activities as well as ventilation patterns during the cooling and heating seasons. The present work was aimed to control the microbes present in the environment with incorparating the Lilium flower extract in medium.

II. METHODOLOGY

Preparation of flower extract

Fresh Lilium flower were collected directly from the farmers and flower sellers of Bengaluru and brought to the laboratory. The flowers were rinsed twice with distilled water and allowed to air dry in shade. It was made into small pieces using sharp sterile scissors. Extraction was done at room temperature by simple extraction method [11]. 10 gm of dried flower material was weighed accurately using digital electronic monopan balance and soaked in 40ml of propylene glycol solvent [12] and kept in a shaker for 48 hours at 37^{o}C. Then the filtration was performed using muslin cloth and the filtrate was preserved for the further studies.

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Phytochemical screening

The aqueous extract of Lilium flower was screened to examine the presence of chemical groups and active compounds such as carbohydrates, saponins, phenols and tannins, coumarins, flavonoids, proteins, glycosides, terpenoids, and quinones. The examination of saponin was performed by the foam test. The flower extract (0.5 g) was vigorously mixed with 2mL of water and observed for the foam formation for more than 10 min as an indication of the presence of saponin [13]. The presence of phenols and tannins were detected by performing the ferric chloride test. Ferric chloride (0.5%) solution was added drop by drop to 2 mL of flower extract and observed for the formation of a bluish-black precipitate of phenols and tannins [13]. For the identification of glycosides, 1 ml of glacial acetic acid, few drops of ferric chloride solution, and concentrated H_2SO_4 (mixed slowly through the sides of the test-tube) were added to the flower extract and observed for the appearance of a reddish-brown ring of de-oxy sugars at the junction of the liquids [13].

To test the presence of flavonoids in the flower extract, a 10% lead acetate solution was added in the extract. The formation of yellow precipitate confirmed the presence of flavonoids [13]. To detect the presence of carbohydrates, the flower extract was dissolved in 5 mL distilled water and filtered. The filtrate was hydrolyzed with dilute HCl and further neutralized with alkali and subsequently heated with Fehling's solution A and B and observed for the formation of a red precipitate of reducing sugars [13]. The flower extract was treated with a few drops of concentrated H_2SO_4 and observed for the formation of yellow color as an indication of the presence of quinones compound [13]. For terpenoids identification in flower extract, 2 ml of chloroform was added in 5 ml of the flower extract and thereafter 3 ml of concentrated H_2SO_4 was added slowly and observed for the appearance of the reddish-brown color of terpenoids [13]. The presence of amino acids in flower extract was checked by employing a ninhydrin test. Few drops of ninhydrin solution were added to the flower extract and the appearance of blue color indicated the presence of amino acid [14]. About 0.5 g of the moistened flower extract was taken into the test-tube. The mouth of the test-tube was covered with the filter paper treated with 1N NaOH solution. The treated test-tube was placed in boiling water for a few minutes and examined for the formation of yellow color as an indication of the presence of coumarins [15].

Preparation of Nutrient agar plates

In open plate culture, the media are exposed for a specific period and then incubated at 37^0 C for 24 hrs and the number of colonies formed was counted [16]. But in the present study a new approach of open plate method was performed in which the researcher has prepared the medium by incorporating the flower extracts in different percentages. The preparation of the media with different concentration used in this study is clearly indicated in the table 1. The required nutrient agar (Hi-media) was weighed and it was dissolved in the distilled water. The distilled water quantity was planned in such a way that it will meet out the required percentage. The medium was sterilized at 15 lbs pressure (121^0C) for 15 minutes. Then the required Lilium flower extract for different concentration were added to the medium, mixed well and poured into the sterile Petri plates.

Table 1: The ingredients used in the preparation of different concentrations of Lilium flower extract medium.

% of flower extract	**Control**	**4**	**8**	**12**	**16**	**20**	**24**
Nutrient agar (gm)	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Volume of distilled water (ml)	20.0	19.2	18.4	17.6	16.8	16	15.2
Volume of flower extract (ml)*	-	0.8	1.6	2.4	3.2	4	4.8

(* Lilium flower extract added after the medium was sterilized)

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Study Area

A leading IT Industry established in the Bengaluru, Karnataka was used for the study. Everyday more than five hundred employers visit the workplace. During all the study time the office was fully occupied by the office workers. The samples for the study were collected.

Air Sampling and Microbiological Examination

The prepared nutrient agar plates of flower extracts with different percentages were exposed in the study area [17], leaving the Petri dish open to air for 1 hour and positioning it 80 – 100 cm above the floor and at 100 – 150 cm from the wall to obtain the average and useful value for the microbial fallout from the air in the environment [18]. The microbiological samples were collected two times a day that is, in the morning between 8.00 – 9.00am and in the evening 8.00 – 9.00 pm. A control plate was separately maintained without the Lilium flower extract. After exposure, the plates were transported in a clean container to the laboratory for microbiological examination. All the plates were incubated at 37^0 C for 24 hours and then the number of colonies formed were counted and tabulated. The total number of colony forming unit (cfu) was enumerated and converted to organisms per cubic meter of air [19]. Triplicates were maintained and mean of the triplicates were taken into consideration for the analysis of results.

Bacterial Identification

According to Cheesbrough (2009) procedures the identification of bacterial isolates were initially characterized by morphology and using staining techniques (Gram staining) and identified further by biochemical tests. Biochemical tests such as Catalase, Oxidase, Indole, Methyl Red test (MR), Coagulase, Voges Proskauer (VP) and Citrate utilization were carried out on the isolated bacteria.

III. RESULT AND DISCUSSION

In the Lilium flower extract the phytochemical studies shows the presence of phenols, tannins, glycosides, flavonoids, quinones, terpenoids and coumarins (table – 2) which act as a bioactive compounds in suppressing the growth of microorganisms. The bacterial identification of the isolates confirms Staphylococcus aureus, Escherichia coli and Bacillus subtilis (table – 4). Staphylococcus aureus was the dominant isolated organism and this bacterium is a common causative agent of various human diseases, it is responsible for many gastrointestinal tract infections, respiratory tract infections and skin disorders [20]. Escherichia coli is a leading cause of urinary tract infections and intra abdominal infections in which the extent of the disease can range from cystitis to life threatening sepsis [21]. Exposure to these airborne particles can result in respiratory disorders and other adverse health effects such as infections, hypersensitivity pneumonitis and toxic reactions. In addition, long-term contact of people with bioaerosols can influence a person's mental power and learning ability [22].

Different environmental conditions such as temperature, UV light, dryness and humidity, play a role in controlling the growth of airborne particles. Nevertheless the microbes manage to reach new hosts through the air for its survival. Poor ventilation, crowded conditions and increase in number of air conditions inside building nowadays can facilitate the spreading and the survival rates of airborne particles and also can increase the chance of people at risk of airborne infections. Among dust particles present in the indoor environment, fungus which reproduce by forming spores, some bacteria especially gram positive bacteria and some viruses can survive for a long time in the air [23].

In the present study, the open plate method was employed with slight modification, showed a significant good result that eradicate or prevent the growth of all types of microbes than the other methods employed. The result conducted at different concentration of Lilium flower extract have control the growth of microbes in the indoor environment. The microbial load was more in evening time (8-9pm) when compared to the morning time (8-9am) due to the workers present. The control of microbes was able to see in all the plates according to the increase in the contraction of the flower extract (table – 3). This result indicated that the extracts of flowers showed better performance in eradicating or preventing the growth of microorganisms in total than the extracts of other parts of plants which prevents specific microbes to certain extent in a specific concentration.

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Table 2: Phytochemical analysis of Lilium flower

S.No	Compounds	Aqueous Extract
1	Saponins	-
2	Phenols	+
3	Tannins	+
4	Glycosides	+
5	Flavonoids	+
6	Carbohydrates	-
7	Quinones	+
8	Terpenoids	+
9	Proteins	-
10	Coumarins	+

Table 3: Shows the number of colonies (cfu/m^3) observed in different percentage of flower extracts used. The values represented are the mean of three observations and ± SD. The values indicated in the parenthesis are the percent decrease in the number of colonies than the control.

Time	Control plate	Flower extract					
		4%	8%	12%	16%	20%	24%
8 – 9 am	278±8	211±5 (24)	158±4 (43)	115±5 (59)	67±4 (76)	9±2 (97)	0 (100)
8 – 9 pm	356±5	293±5 (18)	249±2 (30)	183±4 (49)	128±6 (64)	65±4 (82)	14±4 (96)

Table 4: Shows the confirmation test for the isolated organisms form the study area.

S.No	Test / Staining	Staphylococcus aureus	Escherichia coli	Bacillus subtilis
1	Gram staining	Gram-positive bacteria, cocci-shaped.	Gram-negative bacteria, rod shaped.	Gram-positive bacteria, rod shaped.
	Biochemical Test			
1	Catalase Test	Positive	Positive	Positive
2	Oxidase Test	Negative	Negative	Negative
3	Indole Test	Negative	Positive	Negative
4	Methyl Red Test (MR)	Positive	Positive	Negative
5	Voges Proskauer Test (VP)	Positive	Positive	Positive
6	Coagulase Test	Positive	Negative	Negative
7	Citrate utilization Test	Positive	Negative	Positive

IV. CONCLUSION

Using the open plate method it is proved that the flower extract prevents the growth of microbes present in the environment. In the control plate we have observed Staphylococcus aureus, E. coli and Bacillus subtilis. And these organisms can

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cause several infections to the workers. In order to develop the quality of indoor air in working place overcrowding has to be avoided, good ventilation systems has to be designed and good hygiene practice must be observed. Flower extract can also be used as an air sprayers or air fresheners to control the overload of microbes in indoor environments.

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Adoption of Internet of Things for Smart Monitoring of Aquaponics

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Kapil Joshi ; Priya Priya ; Vishal Kaushik ; Harishchander Anandaram ; Arati Mohapatro ; Anil Kumar **All Authors**

Abstract:

Aquaponics is a cutting-edge, clever, and ecological technology for agriculture that combines both aquaculture and hydroponics to produce vegetable products prototype. This method promises to be environmentally friendly and viable due to its high-water consumption efficacy, lack of use of pesticides, and decreased fertilizer use. The main task is to make aquaponics viable and dependable at a business scale because interest in it is growing. By recognizing, being listed, and thoroughly describing each of the characteristics detected in aquaponics, as well as the smart platforms and Internet of Things (IoT) devices in the examined literature, this article hopes to support study towards a feasible business aquaponics option. The suggested study also identifies future efforts needed for mechanized aquaponics and possible voids in the existing literature. This is anticipated the fact that the system for aquaponics backed by smart control units will benefit in terms of profitability, intelligence, accuracy, and effectiveness within the context of the research studies examined in this paper.

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CERTIFICATE OF PUBLICATION

This is to certify that the article entitled

DETERMINANTS OF FINANCIAL WELL-BEING: A QUANTITATIVE STUDY AMONG WORKING WOMEN IN HIGHER EDUCATION AT BANGALORE"

Authored By

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DETERMINANTS OF FINANCIAL WELL-BEING: A QUANTITATIVE STUDY AMONG WORKING WOMEN IN HIGHER EDUCATION AT BANGALORE"

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ABSTRACT
We often believe that the fiancé is whatever it can be in terms of money and lead to improving the economic situation of an individual and the family as a whole. Thus, the right financial behavior with a required amount of financial knowledge led to managing finance, this resulted in financial satisfaction which indicates a sign of financial well-being. The previous research regarding financial well-being focused on factors like financial stress, locus of control and work environment, etc. (zahariah mohd zain,marziah mokhtar, 2019) Thus, this research is an attempt to study the factors affecting financial well-being among working women in higher education institutions in Bangalore, Karnataka. This research paper is a quantitative study, data were obtained by a closed-end questionnaire. A total of 216 responses were collected through a google form. The measure of central tendency, SPSS, and AMOS was used to analyse the data collected through a questionnaire. The analyses reveal that Financial Behaviour, Financial Satisfaction, and Financial skills were significantly associated with Financial Well-being. It also depicts that financial satisfaction is the main and the most powerful variable affecting financial well-being, the another variable next to this is financial skills which also impacts financial well-being. The outcome of this study can be referred for analysis and further understanding of working women's financial behavior variable, which would be amplified by required training & education at the workplace.

Keywords: Financial well-being, Financial Behaviour, Financial Satisfaction, Financial skills

INTRODUCTION
People often understand that finance is all those things that impact the purchasing power of the family. Planning & controlling these financial situations and uncertainties sometimes led to financial dissatisfaction or satisfaction in the individual. Financial well-being is the situation that allowed people to enjoy their life without much worry about their financial situation. It is just not about having excess money it's all about the individual financial satisfaction, financial behavior, and financial skills which contribute to financial well-being among the people. Financial well-being plays important role in everyone's life. In India, the female population is 48.04% compared to 51.96% male population. The 21st century is witnessing the contribution of women in every area. Women's empowerment is becoming prioritized, in such a scenario the financial well-being of working women especially in higher education plays a pivotal role in the overall development of the family and the society as a whole. The innovation and financial inclusions provided a great platform for financial agencies. These

Journal of Ethnic Foods

REVIEW ARTICLE Open Access

Vegetarian ethnic foods of South India: review on the influence of traditional knowledge

Srinidhi K. Parthasarathi[1], Ananda Vardhan Hebbani[2*] and Padma Priya Dharmavaram Desai[3]

Abstract

South Indian cultures are diverse and unique amongst Indian traditions. In spite of many changes in Indian traditions over generations, South Indian states seem to have maintained a great extent of similarity with reference to vegetarian ethnic food habits and the reason behind is not convincingly known. Hindu traditional texts have extensive mention of the ethnic origins of many cultural practices prevailing in India and the present review aims to explore the different vegetarian ethnic foods of South India and also look into the influential role of food related ideologies mentioned in the traditional texts. Ethnographic study data about the prevailing vegetarian foods of the states were generated using multiple tools and presented. It is observed that there is a great extent of similarity amongst the varieties of vegetarian foods being prepared in Hindu communities of South India. Our study also highlights the strong influential role of tradition in evolution of vegetarian foods prevailing even today in South India.

Keywords: South India, Hinduism, Vegetarian ethnic foods, Philosophical perspective

Introduction

South India represented by five major Indian states viz., Tamil Nadu (TN), Karnataka (KA), Kerala (KL), Andhra Pradesh (AP) and Telangana (TG); is well known for its rich cultural heritage and food is one of the major contributors to its richness. Traditions and food are highly inter-influential throughout India, more so in South India. Based on the historical evidences, it is clear that the Dravidian civilization of South India is much more primitive (flourished approximately 4500 years ago) in comparison to the rest of Indian civilizations [1] and South Indian cuisines seemingly continue to retain many of the ancient Dravidian food culture elements.

According to India State of Forest Report (IFSR 2021), South Indian states (total geographical area of 6,35,748 km^2) comprises of a high percentage of forest cover viz., 20.31% in TN, 20.19% in KA, 54.7% in KL, 18.28% in AP and 18.93% in TG; which enriches the food heritage of South India [2]. The states are also major contributors of agricultural economy of India and nearly 48% of its population engage in agriculture. Paddy, sorghum, pearl millet, pulses, chilli and ragi are the major crops cultivated in the South India. The South Indian states are also predominant spice-producing Indian states [3] and thus cuisines here are relatively more flavoured and spicy when compared to other Indian cuisines because of the extensive usage of spices such as ginger, paprika, coriander, cinnamon, tamarind, pepper and cumin seeds [4]. With reference to the dietary practices, reports show that approximately 30% of South Indian people are vegetarians [5] and they generally belong to either of the Brahmin, Arya Vysya, Lingayat and Nambudiri communities under Hinduism.

South Indian vegetarian cuisines seem to be unaffected by other cultural influences and people continue

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COMPREHENSIVE REVIEW

Therapeutic potential of pyrrole and pyrrolidine analogs: an update

N. Jeelan Basha[1] · S. M. Basavarajaiah[2] · K. Shyamsunder[1]

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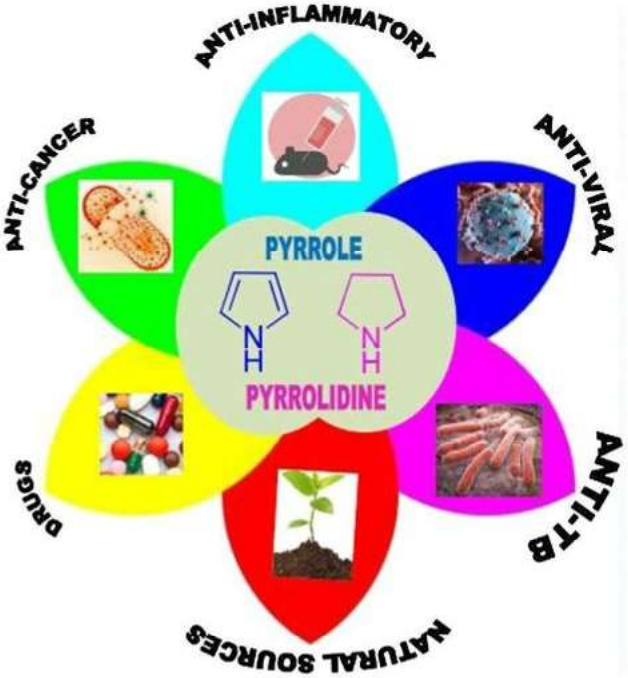
Abstract

The chemistry of nitrogen-containing heterocyclic compound pyrrole and pyrrolidine has been a versatile field of study for a long time for its diverse biological and medicinal importance**.** Biomolecules such as chlorophyll, hemoglobin, myoglobin, and cytochrome are naturally occurring metal complexes of pyrrole. These metal complexes play a vital role in a living system like photosynthesis, oxygen carrier, as well storage, and redox cycling reactions. Apart from this, many medicinal drugs are derived from either pyrrole, pyrrolidine, or by its fused analogs. This review mainly focuses on the therapeutic potential of pyrrole, pyrrolidine, and its fused analogs, more specifically anticancer, anti-inflammatory, antiviral, and antituberculosis. Further, this review summarizes more recent reports on the pyrrole, pyrrolidine analogs, and their biological potential.

Graphical Abstract



Keywords Pyrrole · Pyrrolidine drugs · Anticancer · Anti-inflammatory · Anti-viral · Antitubercular activity

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Introduction

Heterocycles are cyclic compounds that have at least one different element than carbon, such as sulfur, oxygen, nitrogen [1]. These heterocycles have received considerable

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Editor-in-Chief

Green Synthesis of Silver Nanoparticles using Marine Sea Weed *Acetabularia acetabulum* and their Activity as MMT-Ag Nanocomposites towards Antifouling Applications

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ABSTRACT:

The present study proposed the green synthesis of silver (Ag) nanoparticles using aqueous extract of *Acetabularia acetabulum* followed by their fabrication onto montmorillonite (MMT). Fourier transform infrared (FTIR) spectra revealed the involvement of multiple functional groups in the reduction of silver ions to Ag nanoparticles and their stabilization on MMT. The obtained MMT-Ag nanocomposites were characterized by UV–visible spectroscopy, powder X-ray diffraction (XRD), particle size analysis (PSA), scanning electron microscopy (SEM) and Energy Dispersive X-Ray (EDX) analysis. The synthesised Ag nanostructures were found to be cubic shaped with average size ranges from 37nm to 60 nm. The seaweed mediated MMT-Ag nanocomposites were evaluated for their potential antimicrobial properties against the isolated biofouling bacteria. Maximum bactericidal activity was recorded against *S. aureus* followed by *E. coli*, *M. flavus*, *Pseudomonas aeruginosa*, *B. cereus*, *M. leteus* and *B. subtilis*. In addition, the viability of incorporating MMT-Ag nanocomposites in paint was examined where a significant inhibition of marine fouling bacteria was exhibited by the panel coated by MMT-Ag nanocomposites-based paint as compared to water-based paint. The addition of MMT-Ag nanocomposites in water-based paint was also found to be effective against corrosion from marine water. The present study shows cytotoxicity of MMT-Ag nanocomposites as nanoclay/metallic nanocomposites against *A. salina* with LD50 values of 200±3.4 µg/ml. The results of the present study suggested the application of *A. acetabulum* extract as a good bio-resource for the synthesis of Ag nanoparticles and their implementation to combat marine biofouling on ship hulls.

KEYWORDS: *Acetabularia acetabulum*, Antifouling Paint, Bactericidal activity, Montmorillonite (MMT), Nanocomposites, Silver (Ag) nanoparticles.

INTRODUCTION

Metallic nanoparticles have attracted global interest in recent years in the area of industrial, environmental and biomedical applications owing to their exceptional physicochemical properties. Extensive use of nanomaterials has attracted global interest in sustainable strategies for their synthesis which can alter their properties. Inherent properties of the nanoparticles can be easily altered with minor changes in their process of synthesis.

Traditionally, nanoparticles are synthesized using physical and chemical approaches, however, these methods involve the use of non-biodegradable

emergent
Life Sciences Research

Review Article

Northeast India: A treasury of medicinal plants

Satayu Devi, Rituparna Sinha, Sibi G.

Abstract

The North-eastern region of India encompasses eight states viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. It is perhaps the most extravagant store of medicinal plants in the World. It is considered that the medicinal plants are the foundation of the conventional medicine. Almost 80% of the world populaces depend on conventional medications for essential medical services, a large portion of which include the utilization of extracts of medicinal plants. This conventional practice of medication assumes a significant part in the medical care of rural people for a wide range of diseases. They practice their own traditional healthcare system as they have an in-depth knowledge and understanding about plants, both conventional and non-conventional for their food and for medicine. This review thus underlines the different medicinal plants found across the entire north-eastern region and their respective potential uses or medicinal plant utilization for the significant well-being of mankind.

Keywords Northeast India, medicinal plants, pharmacology

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Introduction

India is known for its significant inheritance of natural and therapeutic knowledge. The ethnic individuals and tribals living in the distant backwoods territories actually rely upon the native frameworks of the remedy. The North East of India encircles the states namely Arunachal Pradesh, Assam, Mizoram, Manipur, Meghalaya, Nagaland, Tripura, and Sikkim [1]. The region is characterized by diverse physiography, ranging from plains, plateaus, and mountains with associated valleys [2]. The ordinary temperature all through the summer season remains 30 °C and ranges between 16 to 20°C during winter. The valleys and the sloping parts show a significant climatic divergence between them.

Therefore, tropical monsoon humid climates beat the north-eastern states. During the month of June -September the region gets incredibly heavy rainfall which is the South-west monsoon season, and in the long stretch of June, the region receives the maximum rainfall [3]. The richness of its land, good climatic condition, topographical, environmental diverseness, and vivid communities make the North East of India very unique and different from other subcontinent parts. Northeast India is consequently the geological 'entryway' for a lot of India's widely varied greenery, and as a result, the province is perhaps the wealthiest space of India in natural qualities [4]. The region is considered as one of the biodiversity hotspots of the world comprising about half of India's biodiversity hence it forms a unique biogeographic territory including significant biomes. Starting with prairie, marshes, swamps, muggy evergreen timberlands, deciduous woodlands also all types of alpine and temperate vegetation are found here. The diverse

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REVIEW Open Access

Cardioprotective effects of Ferulic acid against various drugs and toxic agents

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Abstract

Background: Homeostatic regulation of cardiomyocytes is indispensable in maintaining the normal physiological activity of cardiac tissue. Cardiotoxicity induced by drugs may lead to cardiac abnormalities such as arrhythmia, myocardial infarction and myocardial hypertrophy. Moreover, drug-induced cardiotoxicity confines the additional use of the implicated drugs. Several studies have reported that consumption of phytochemicals on regular intervals shall protect humans against numerous diseases such as diabetes, cardiovascular disease, inflammatory diseases and cancer.

Main body: Ferulic acid (FA) is a plant derived polyphenol abundantly found in vegetables, fruits and grains. FA is widely known for its antioxidant, anti-inflammatory, anticancer, nephroprotective and hepatoprotective effects. FA has been well documented for its cardioprotective activity against various drugs and toxic agents as well. However, the cardioprotective action of FA have remained a challenge with regard to understanding its mechanism in health and diseases.

Conclusion: The main purpose of this review is to explore the cardioprotective mechanisms of FA against several drugs and chemicals to recommend further studies to investigate the potential protective effect of FA.

Keywords: Ferulic acid, Antioxidant, Cardioprotective, Preclinical, Cell line, Human health

1 Background

Cardiotoxicity usually denotes toxicity that has a harmful effect on the heart, which may ultimately result in myocardiopathy such as arrhythmia, myocardial infarction and myocardial hypertrophy [1, 2]. In the last few years, more than 20% of clinical drugs were forced out of the market because of cardiovascular side effects, which hampered the drug development and extremely affected the improvement in patient health [3]. Several studies have showed that drug-induced cardiac dysfunction may be a stepwise process accompanied by the increase of cardiac biomarkers and structural myocardial deformation, finally resulting in reduced left ventricular ejection fraction (LVEF) [4, 5]. Recently, the most accepted term for cardiotoxicity is the reduction in LVEF of at least 10% to less than 55% [6]. Studies show that cardiac cell death or damage concurrently occurs with the progression of cardiotoxicity, demonstrating that drug-induced cardiomyocyte death may be the major reason for cardiotoxicity [7].

In the recent years, extensive research has been undertaken to investigate the action of phytochemical compounds found in the diet [8]. They are commonly found in fruits, vegetables, beverages and herbal remedies [9]. These alkaloid compounds contain numerous active substances like flavonoids, polyphenols, indoles and sulfur containing elements [10]. These phytochemicals have the tendency to safeguard humans against diabetes mellitus, hepatic disorders, cardiovascular disease, cancer, arthritis, and Alzheimer's disease and many more [11, 12]. Findings from numerous studies have demonstrated that

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cells

MDPI

Article

Carbon Ion Irradiation Downregulates Notch Signaling in Glioma Cell Lines, Impacting Cell Migration and Spheroid Formation

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Abstract: Photon-based radiotherapy upregulates Notch signaling in cancer, leading to the acquisition of the stem cell phenotype and induction of invasion/migration, which contributes to the development of resistance to therapy. However, the effect of carbon ion radiotherapy (CIRT) on Notch signaling in glioma and its impact on stemness and migration is not explored yet. Human glioma cell lines (LN229 and U251), stable Notch1 intracellular domain (N1ICD) overexpressing phenotype of LN229 cells, and Notch inhibitor resistant LN229 cells (LN229R) were irradiated with either photon (X-rays) or (carbon ion irradiation) CII, and expressions of Notch signaling components were accessed by RT-PCR, Western blotting, and enzymatic assays and flow cytometry. Spheroid forming ability, cell migration, and clonogenic assay were used to evaluate the effect of modulated Notch signaling by irradiation. Our results show that X-ray irradiation induced the expression of Notch signaling components such as Notch receptors, target genes, and ADAM17 activity, while CII reduced it in glioma cell lines. The differential modulation of ADAM17 activity by CII and X-rays affected the cell surface levels of NOTCH1 and NOTCH2 receptors, as they were reduced by X-ray irradiation but increased in response to CII. Functionally, CII reduced the spheroid formation and migration of glioma cells, possibly by downregulating the N1ICD, as stable overexpression of N1ICD rescued these inhibitory effects of CII. Moreover, LN229R that are less reliant on Notch signaling for their survival showed less response to CII. Therefore, downregulation of Notch signaling resulting in the suppression of stemness and impaired cell migration by CII seen here may reduce tumor regrowth and disease dissemination, in addition to the well-established cytotoxic effects.

Keywords: Notch signaling; Carbon ion irradiation; X-ray; migration; spheroid; stemness

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1. Introduction

Radiotherapy is one of the most commonly used treatments for a wide range of malignancies [1]. However, radioresistance in the cancer cells continues to be a key obstacle to the success of radiotherapy [2]. A recently developed particle therapy, especially carbon ion radiotherapy (CIRT), has emerged as a new promising therapeutic approach to treat cancers. CIRT has numerous therapeutic advantages over conventional radiotherapy, which include physical advantages, such as spread-out Bragg peak, enhanced dose distribution, lateral focusing, dose verification, superior linear energy transfer, and also biological advantages, such as lesser dependency on oxygen, induction of complex DNA damage, and

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Review Article

Degradation of synthetic polymers: Microbial approach

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ABSTRACT

A synthetic polymer is a plastic, which is having wide applications in our day-to-day life. The packaging industries, agriculture, cosmetics, etc. Plastics are not easily degradable, it takes 1000 years to degrade a plastic or even more than that. The pollution caused by plastic is not only because of the waste disposal method but it is also because it releases carbon dioxide and dioxins while burning. Plastics are considered a threat to the environment as they are not easily degradable. Our review is based on the microbial approach for plastic degradation. The waste management method being used for plastic disposal is not effective enough. Nowadays biodegradable polymers are also being used as they are more easily degradable compared to synthetic polymers. The bacteria and fungi degrade most of the organic and inorganic components like starch, lignin, cellulose, and hemicelluloses.

1. Introduction

Plastic is a synthetic polymer that is abundantly found in every corner of the world. It is used almost in every sector for packaging, textiles, electrical gadgets, automotive, furniture to medical healthcare. Now the worldwide production of plastic has reached 367million tonnes, the industry produces approximately 150kilograms of polymers per person annually in the United States, with the increase of production in the plastic it has become an environmental hazard, impacting on health and threatening wildlife and even marine life.[1]

In the environment, we can find natural polymers, like cellulose. Latex was first chemically modified in 19^{th} century to form celluloid and vulcanized rubber. Bakelite the first synthetic polymer was produced in 1907 and rayon fiber was the first semisynthetic fiber developed by cellulose.[2] The polymers are resistant to chemicals, insulators of electricity, and heat. Resin is the raw material for the production of plastic products. Polyethylene (PE), polystyrene (PS), polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET) are the most commonly used resins, they are used in packaging.[3] Plastic takes years to decompose, the chemicals present in the plastic-like lead, mercury, and cadmium are carcinogens, when it comes into direct contact with humans it can cause cancer, immunological problems, and even congenital disabilities. The plastic in marine impacts the ingestion, suffocation, entanglement, and death of hundreds of species.[4]

Many plastics are non-biodegradable but few plastics are biodegradable which can be decomposed by the action of the microorganisms. In 2016 the Japanese scientists had discovered a bacterium that can break down the polyethylene terephthalate plastic, the bacterium *Ideonella sakaiensis* degrades polyethylene terephthalate by the two enzymes PETase and MHETase produce by the bacteria, the PETase breakdowns the polyester polymer by which polyethylene terephthalate is constructed into smaller pieces, during the process polyethylene terephthalate is

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REVIEW ARTICLE **OPEN ACCESS**

Dietary Synbiotic as a Supplemental Therapy to Reduce Cancer Symptoms: A Review

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ABSTRACT
The significance of the human microbiome in the pathogenesis of cancer is becoming more widely recognized. Pre-, pro-, and synbiotics are some of the most well-studied ways to alter the microbiota for therapeutic purposes, and there is growing interest in their potential to be used in the diagnosis and treatment of cancer. In this review, we examine how these drugs may preserve the integrity of the intestinal barrier, regulate the immune system, regulate metabolism, and restrict the growth of host cells. We emphasize the epidemiological and trial-based evidence that pre-, pro-, and synbiotics play a role in cancer prevention. In the end, there is more evidence to support the use of these drugs as cancer treatment adjuncts. We go over their roles in enhancing the effectiveness of chemotherapy and radiation and/or reducing their side effects. The use of pre-, pro-, and synbiotics for clinical benefit in oncology patients has tremendous potential, but the discipline is still in its infancy, making it difficult for oncologists to provide their patients the right advice.
Keywords: *microbiome, oncology, probiotics, prebiotics, synbiotics.*

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INTRODUCTION

By specifically enhancing the growth and/or stimulating the metabolism of one or more numbers of health-promoting bacteria, a synbiotic product benefits the host by positively impacting the survival and implantation of live microbial dietary supplements in the gut. Because it suggests synergism. The word "synbiotics" should only be applied to products in which the prebiotic compound(s) benefit the probiotic organism(s). This review will examine the possible therapeutic uses of pre-, pro-, and syn -biotic concerning cancer. These agents now constitute the main treatments geared towards positive modification of the microbiota (as opposed to negative manipulation with antibiotics). As our grasp of science has evolved, pre- and probiotic classifications have undergone several changes. 'A substrate that is preferentially used by host microorganisms imparting a health advantage' is the definition of a prebiotic [1]. Numerous molecules fall under this category; the non-digestible oligosaccharides fructo-oligosaccharide (FOS, which may be found in foods like onions and garlic) and galacto-oligosaccharide have received the most research. These substances work by encouraging commensal bacteria to proliferate and/or operate in ways that are advantageous to the host. Probiotics, on the other hand, are "live microorganisms that, when administered in sufficient amounts, confer a health benefit on the host" [2].

Although many fermented foods (like kimchee, tempeh, kombucha, sauerkraut, probiotic yogurt or kefir) contain live organisms, the majority are not considered probiotics because the food itself confers the health benefit rather than the organisms, and they frequently do not contain enough organisms to be classified as probiotics. Synbiotics are a preparation that combines pre- and probiotics. Probiotics are a group of certain microorganisms that may be found in the *Lactobacilli* or *Bifidobacteria* genera and are available as single agents or multi-strain formulations. Probiotics are typically consumed orally and are made to survive transit to the lower gastrointestinal (GI) tract, whether they are consumed in the form of yogurt, freeze-dried live organisms taken as a powder, or in capsule form. [3] By competitive exclusion, direct antagonistic action, neutralization of pathogenic bacterial toxins, and preservation of intestinal barrier function, they may lessen the impact of pathogenic organisms on the host. Short-chain fatty acid (SCFA) generation, bile acid metabolism, vitamin biosynthesis, and carcinogen neutralization are only a few of the metabolic impacts of probiotics [4-6].

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Bulletin of the National Research Centre

REVIEW Open Access

Effects of D-pinitol on diabetes mellitus: an updated review

Anandakumar Pandi[1*], Vanitha Manickam Kalappan[2] and Naveenkumar Chandrashekar[3]

Abstract

Background: The awareness in the consumption of plant-based food has gained attention in the recent years. Phytochemicals are thought to play a critical role in health promotion and in the prevention and management of chronic diseases. These compounds have reported to produce little or no side effects and are thus significantly used in treating various ailments. D-Pinitol is the chief active compound found in soy and soy products. Several studies have shown the health benefits of D-pinitol such as antioxidant, anti-diabetic, anti-inflammatory and anticancer properties. In this review, an attempt has been made to review the effects of D-pinitol against diabetes mellitus in pre-clinical and clinical studies.

Methodology: Journal articles were sourced and filtered with relevant keywords on "D-pinitol and diabetes mellitus". Scientific databases, including PubMed, NCBI, Google Scholar, Science Direct, SciFinder and Web of Science, were accessed to identify the most relevant articles on the effect of D-pinitol in diabetes mellitus. The study duration was from September 2021 to February 2022.

Results: This comprehensive review demonstrates the application of D-pinitol against diabetes mellitus. Most of the animal and clinical studies included in this review reported that D-pinitol treatment effectively regulated hyperglycemia and prevented insulin resistance.

Conclusions: D-Pinitol could serve as an effective anti-hyperglycemic agent for the treatment of diabetes mellitus. Further research to study its safety and mechanism of action is recommended in order to employ this compound for clinical trials.

Keywords: D-Pinitol, Antioxidant, Glucose, Insulin, HbA1C

Background

Diabetes mellitus is one of the most common non-communicable diseases. It is group of metabolic disorders in which hyperglycemia lasts over a longer period leading to several other complications (Toi et al. 2020). It is characterized by supraphysiological glucose due to the deficiency in insulin secretion or insulin receptor or post-receptor events that results in the disturbances in the biochemical pathways of carbohydrates, fats and protein (Ruiz 2012). Moreover, the impaired metabolism leads to the progression and aggravation of oxidative stress through different mechanisms like glucose autoxidation, protein glycation, etc. (Dos Santos et al. 2019). The total number of people with diabetes is predicted to increase from 171 million in 2000 to 366 million in 2030 (Tao et al. 2015). Studies direct that the incidence of diabetes will continue to rise in the future due to growing prevalence of obesity, accelerating aging populations, environmental factors and sedentary lifestyles (Piché et al. 2020). Chronic blood sugar level and insulin resistance may in turn lead to severe impairment and dysfunction of heart, kidney, liver, eye, nerves, etc., which predominantly lead to mortality (Kautzky-Willer et al. 2016). At present, there is no known cure approaches for diabetes mellitus except in some very specific cases. Several efforts are

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COMPREHENSIVE REVIEW

Therapeutic potential of pyrrole and pyrrolidine analogs: an update

N. Jeelan Basha[1] · S. M. Basavarajaiah[2] · K. Shyamsunder[1]

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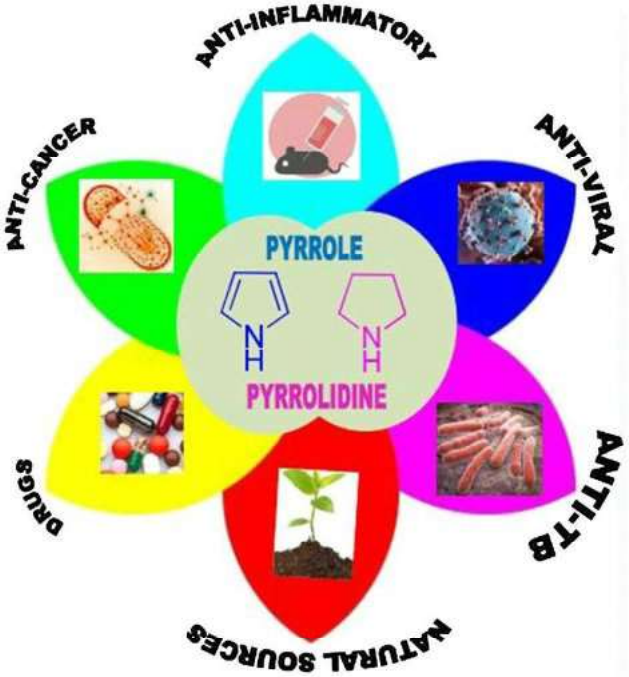
Abstract

The chemistry of nitrogen-containing heterocyclic compound pyrrole and pyrrolidine has been a versatile field of study for a long time for its diverse biological and medicinal importance**.** Biomolecules such as chlorophyll, hemoglobin, myoglobin, and cytochrome are naturally occurring metal complexes of pyrrole. These metal complexes play a vital role in a living system like photosynthesis, oxygen carrier, as well storage, and redox cycling reactions. Apart from this, many medicinal drugs are derived from either pyrrole, pyrrolidine, or by its fused analogs. This review mainly focuses on the therapeutic potential of pyrrole, pyrrolidine, and its fused analogs, more specifically anticancer, anti-inflammatory, antiviral, and antituberculosis. Further, this review summarizes more recent reports on the pyrrole, pyrrolidine analogs, and their biological potential.

Graphical Abstract



Keywords Pyrrole · Pyrrolidine drugs · Anticancer · Anti-inflammatory · Anti-viral · Antitubercular activity

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Introduction

Heterocycles are cyclic compounds that contain one different element than carbon, usually oxygen, nitrogen [1]. These heterocycles have received considerable

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Ethno-pharmacological of Lilium Flower

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ABSTRACT

The Lilium flower have been regarded as an excellent source of biological active compounds. The present study reports the control of microbial load in air by open plate methods. The phytochemical analysis of the extract reveals the presence of phenols, flavonoids, tannins, terpenoids, glycosides, coumarins, and quinones. Bacterial identification of the isolates from the study area was confirmed with suitable tests.

Key words: Lilium flower, open plate method, phytochemical, bacteria.

I. INTRODUCTION

Lilium is a genus of herbaceous flowering plants growing from bulbs, all with large prominent flowers. They are the true lilies. India has a great treasure of medicinal plants due to which it is one of the richest nations in terms of a vast collection of genetic resources of medicinal plants in the world [1]. The members of the Liliaceae family have been found to contain phytochemicals such as alkaloids, steroidal saponins, vitamins, and fatty acids, which are responsible for their biological activity [2]. Flowers of various species of lily have been reported to possess broad-spectrum antimicrobial activity [3]. L. longiforum, has been studied and used as an anti-inflammatory agent for the treatment of bronchitis and blood clotting during the surgical procedures [4]. Lipid peroxidation and cholesterol oxidase enzyme inhibitor assays are used to determine the bioactive compounds in L. longiforum flower, which in turn shed light on its anecdotal medicinal use [5]. The Lilium candidum L. is also an ancient plant, which is used as an important edible plant and important biomedicine in China to alleviate the symptoms of various human inflammatory diseases and they are cultivated as an ornamental plant throughout the world [6]. This plant helped from time immemorial in the treatment of inflamed and suppurative wounds, ulcers, skin inflammations, burns and various injuries [7]. It is also used for muscle pain and gynecological problems. After surgery, it speeds up wound healing. Externally used is an alcohol or oil extract [8]. Mechanisms of Lilium anti-inflammatory activity and their bioactive components remain little known, but the therapeutic effects of lilies are confirmed by modern medicine, which has shown its healing, anti-inflammatory, analgesic, antioxidant, and other effects [9]. Many studies have been conducted for the chemical constituents of the genus Lilium, which illustrated their pharmacological effects of anti-tumor, hypoglycaemic, anti-bacterial, anti-inflammatory, hypolipidemic, reducing blood lipid, anti-depression anti-fatigue and hypoxia tolerance. The importance of the genus in the world flower market is due to diversity and large number of hybrid and cultivars commercially available. However, some species are also known for medicinal and food value which increase the economic importance many folds [10]. Outdoor concentrations of airborne bacteria generally were higher than those indoors but similar in summer and winter. Bacterial concentrations indoors showed more seasonal difference, which may be due to changes in occupant dress and activities as well as ventilation patterns during the cooling and heating seasons. The present work was aimed to control the microbes present in the environment with incorparating the Lilium flower extract in medium.

II. METHODOLOGY

Preparation of flower extract

Fresh Lilium flower were collected directly from the farmers and flower sellers of Bengaluru and brought to the laboratory. The flowers were rinsed twice with distilled water and allowed to air dry in shade. It was made into small pieces using sharp sterile scissors. Extraction was done at room temperature by simple extraction method [11]. 10 gm of dried flower material was weighed accurately using digital electronic monopan balance and soaked in 40ml of propylene glycol solvent [12] and kept in a shaker for 48 hours at 37^{o}C. Then the filtration was performed using muslin cloth and the filtrate was preserved for the further studies.

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EVALUATION OF IN VITRO, ANTI-INFLAMMATORY AND ANTI-OXIDANT ACTIVITY ON THE AQUEOUS AND ETHANOLIC EXTRACT OF LEAVES OF HYGROPHILA BALSAMICA

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Abstract

Introduction and Background: The abundance of thousands of species of medicinal plants

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Green Synthesis of Silver Nanoparticles using Marine Sea Weed *Acetabularia acetabulum* and their Activity as MMT-Ag Nanocomposites towards Antifouling Applications

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Abstract

The present study proposed the green synthesis of silver (Ag) nanoparticles using aqueous extract of *Acetabularia acetabulum* followed by their fabrication onto montmorillonite (MMT). Fourier transform infrared (FTIR) spectra revealed the involvement of multiple functional groups in the reduction of silver ions to Ag nanoparticles and their stabilization on MMT. The obtained MMT-Ag nanocomposites were characterized by UV–visible spectroscopy, powder X-ray diffraction (XRD), particle size analysis (PSA), scanning electron microscopy (SEM) and Energy Dispersive X-Ray (EDX) analysis. The synthesised Ag nanostructures were found to be cubic shaped with average size ranges from 37nm to 60 nm. The seaweed mediated MMT-Ag nanocomposites were evaluated for their potential antimicrobial properties against the isolated biofouling bacteria. Maximum bactericidal activity was recorded against *S. aureus* followed by *E. coli*, *M. flavus*, *Pseudomonas aeruginosa*, *B. cereus*, *M. leteus* and *B. subtilis*. In addition, the viability of incorporating MMT-Ag nanocomposites in paint was examined where a significant inhibition of marine fouling bacteria was exhibited by the panel coated by MMT-Ag nanocomposites-based paint as compared to water-based paint. The addition of MMT-Ag nanocomposites in water-based paint was also found to be effective against corrosion from marine water. The present study shows cytotoxicity of MMT-Ag nanocomposites as nanoclay/metallic nanocomposites against *A. salina* with LD50 values of 200±3.4 µg/ml. The results of the present study suggested the application of *A. acetabulum* extract as a good bio-resource for the synthesis of Ag nanoparticles and their implementation to combat marine biofouling on ship hulls.

Top

Keywords

Acetabularia acetabulum, Antifouling Paint, Bactericidal activity, Montmorillonite (MMT), Nanocomposites, Silver (Ag) nanoparticles.

Top

Kirkuk Univ. J. Sci. Stud. Vol. 17, Iss. 2, p 1-10, 2022

Evaluation of Genetic Variability between Local White Chicken and Commercial Lines by RAPD-PCR and Sequencing of 18s rRNA Gene

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Abstract

The present study investigated and identified genetic diversity between native White chicken lines and two commercial Broiler (Rose) and Layer (Isa Brown) chicken breeds using RAPD markers and a sequencing technique. All primers applied produced 151 scorable bands with percentage polymorphic loci of 54.93% within chicken populations, as per the results of the RAPD marker. The maximum amplified fragment by primer OPC-11 was 22 and the fewest by primer OPAA-03 was 7. For all loci analyzed, the effective number of alleles (ne), means the observed number of alleles (na), Shannon's information index (I), and gene diversity (h) was 1.4394, 1.5493, 0.3496, and 0.2441, respectively. The presence of a high number of polymorphisms and targeted (71) loci across all chicken populations indicates that RAPD-PCR techniques provide sufficient genetic distance and higher genetic variation among chicken populations. The highest identity of the blasted sequences of the 18srRNA gene of local white chicken is 90.41% and 84.23%. Likewise, a total of 46 and 27 nucleotides are altered with 27 and 10 gaps in both sequences for the first and second regions, respectively. According to both phylogenetic trees, the local white chicken had a stronger sense of individuality and was slightly closer to the commercial broiler breeds than the layer chicken breeds. As a result, it suggests that enhancing the local chicken line requires a broiler breeding program, as well as cross-breeding with other native chicken lines to obtain hereditarily significant new strains.

1. Introduction:

Gallus sonneratii is the source of modern chicken breeds based on molecular data, as described by [1]. The domestic chicken is the most common domesticated animal species. However, a rising number of indigenous breeds are facing extinction, and essential genotypes and phenotypes are at risk of being lost [2],[3]. The loss of genetic polymorphism in particular traits that are currently insignificant in economic breeding strategies could result from the genetic erosion of these indigenous breeds [4]. Iraq's indigenous chickens (I.I.C.) have been purified and maintained, since 1986 and different genetic lines of I.I.C. were established from the local foundation population that was samples taken from throughout the country, based on feather colour and nakedness. Brown, white naked, white, barred, and black are the five genetic lines of I.I.C. that have been characterized. I.I.C. has a better taste and flavour of eggs and meat when compared to commercial breeds [5],[6]. Heating stress is the main cause of commercial broiler mortality during growing and transporting, resulting in significant financial losses and poor meat qualities [7]. But

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ORIGINAL ARTICLE

Synthesis, spectral analysis, DFT calculations, biological potential and molecular docking studies of indole appended pyrazolo-triazine

S. M. Basavarajaiah[1] · G. Y. Nagesh[2] · Mohammad Javeed[3] · Rashmi Bhat[1] · S. Nethravathi[1] · Jeelan N. Basha[4] · K. Ramakrishna Reddy[3] · C. Nisarga[1] · Pooja Srinivas[1]

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Abstract

A series of novel 5-(3,5-disubstituted-1*H*-indol-2-yl)-2,3-dimethyl-1-phenyl-2,6-dihydro-1*H*-pyrazolo[4,3-e][1,2,4]triazines (**3a-l**) were synthesized in single step from 3,5-disubstituted indole-2-carbohydrazide and 4-aminoantipyrine under acidic conditions with excellent yields. The various spectroscopic methods were used to prove the formation of all these products. The compounds **3a, 3b, 3e, 3f, 3i** and **3j** exhibited excellent antibacterial and antifungal activities with an MIC value of 3.125 µg/ml against the tested pathogens and anti-tuberculosis inhibitory potential against *M. tuberculosis* which is equivalent to standard drug. The antidiabetic activity of the compounds **3a** and **3b** showed the maximum potential as glucosidase inhibitors with $IC_{50} = 47.21$ µg/ml and $IC_{50} = 48.36$ µg/ml, respectively. The physicochemical characteristics like ADMET, drug-likeness and bioactivity scores for these molecules were also disclosed. To comprehend the electronic behavior of compound **3a,** density functional theory estimations at the DFT/B3LYP level via 6-31G++ (d, p) have been carried out to replicate the structure and geometry. The first-order hyperpolarizability calculation was used to calculate the nonlinear visual feature of compound **3a**. The charge transfer interface among the structure is elucidated by the estimated HOMO–LUMO analysis. Further, molecular docking studies were carried out for synthesized compounds with human maltase-glucoamylase (PDB: 2QMJ).

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Natural Product Research ›
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Research Articles

A comprehensive insight on the biological potential of embelin and its derivatives

N. Jeelan Basha, S. M. Basavarajaiah, Swathi Baskaran & Prasanna Kumar

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Abstract

Naturally occurring bioactive molecules are known for their diverse biological applications such as antimicrobial, antiviral, anti-inflammatory, and analgesic activities. Also, some of the natural products act as medicinal drugs. Further, bioactive cell-permeable molecule embelin has been reported for its diverse biological activities such as antimalarial, anticancer, and anti-inflammatory in the literature. With the continuation of our research work on biologically active molecules, based on structural activity relationship

PHYTOREMEDIATION OF OUTDOOR AIR POLLUTION – A LIST OF PLANTS AND THEIR CONTRIBUTION

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Department of Microbiology, Indian Academy Degree College-Autonomous, Bangalore, India

ABSTRACT

Air pollution has been a serious threat due to rapid industrialization and urbanization around the world. Ambient air pollution is composed of a high variety of primary and secondary pollutants, mainly including particulate matter (PM), polyaromatic hydrocarbons (PAHs), formaldehyde, volatile organic compounds VOCs such as benzene, toluene, ethylbenzene, xylene (BTEX), and inorganic pollutants (NO_x, SO_2, CO_2, O_3). Many of these outdoor air pollutants are also found indoor, in concentrations that often can be higher than the outdoors. About 7 million premature deaths occur every year by the outdoor air pollution which largely of heart disease, stroke, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections. The major outdoor pollution sources include power generation, agriculture/waste incineration, vehicles industry and building heating system. By anthropogenic activities more than 3 billion people worldwide are polluting the atmospheric environment by using fuels and polluting technologies such as coal, kerosene and biomass for heating, cooking and lighting which release smoke into the home. Phytoremediation is using plants to remove toxins, is a cost-effective way to improve air quality and can play an important role in controlling air pollution. The benefits of the phytoremediation is soil stabilization, self-maintaining, greater public approval and responsible for a specific pollutant by different phytoremediation process. The important role of phytoremediation is phytostabilization, rhyzodegradation, phytoextraction, phytodegradation, phytovolatilization and phytofiltration. The most efficient woody plants for phytoremediation include Eucalyptus viminalis, Populus nigra, Magnolia kobu, and Robinia pseudoacacia, and herbaceous plants include Erechtites hieracifolia, Crassocephalum crepidioides and Nicotiana tabacum.

CHEMICAL BIOLOGY & DRUG DESIGN

REVIEW

An insight into therapeutic efficacy of heterocycles as histone-modifying enzyme inhibitors that targets cancer epigenetic pathways

N. Jeelan Basha, S. M. Basavarajaiah

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Abstract

Histone-modifying enzymes are the key regulators involved in the post-translational modification of histone and non-histone. These enzymes are responsible for the epigenetic control of cellular functions. However, deregulation of the activity of these enzymes results in uncontrolled disorders such as cancer and inflammatory and neurological diseases. The study includes histone acetyltransferases, deacetylases, methyl transferases, demethylases, DNA methyl transferases, and their potent inhibitors which are in a clinical trial and used as medicinal drugs. The present review covers the heterocycles as target-specific inhibitors of histone-modifying enzyme, more specifically histone acetyltransferases. This review also confers more recent reports on heterocycles as potential HAT inhibitors covered from 2016 to 2022 and future perspectives of these heterocycles in epigenetic therapy.

HEALTHINNOVATIVE SCIENCERESEARCH ARTICLE

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Lab Grown Meat: A Low Carbon and Water Footprint Alternative

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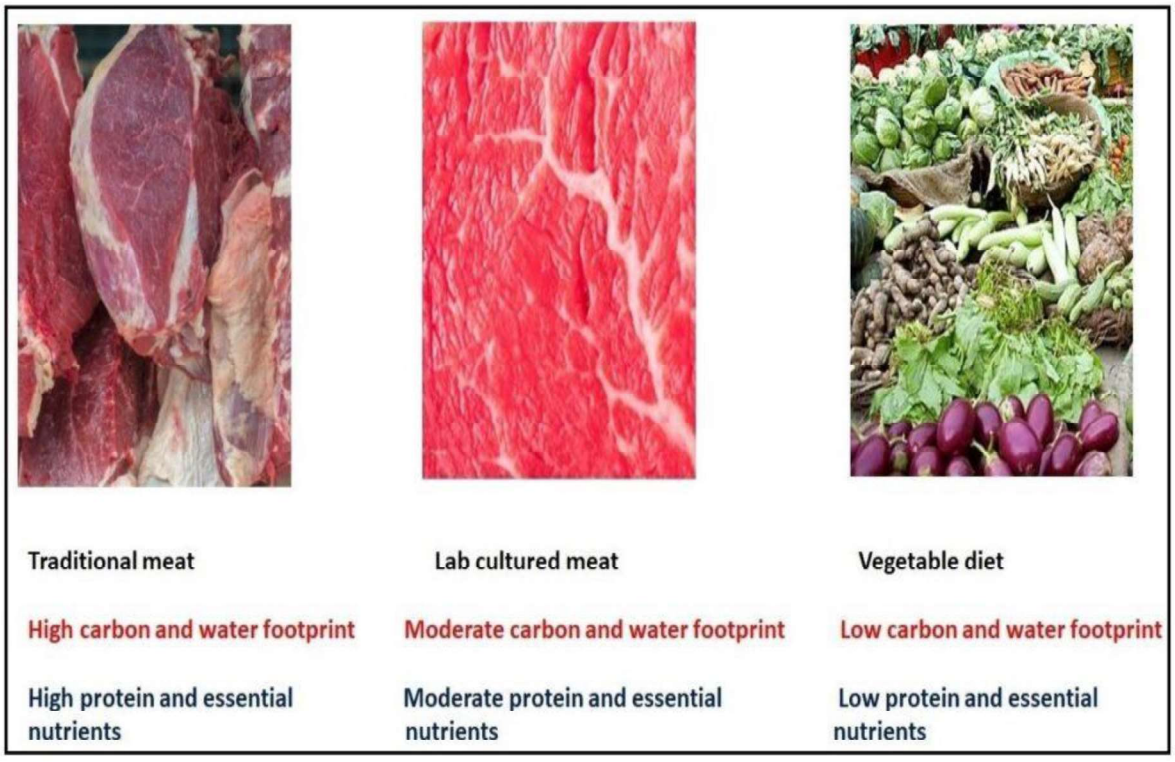

Figure 1: Comparison among traditional, lab-grown meat and vegetable diet.

SHARE

Abstract

As the global population continues to grow and dietary patterns shift towards higher protein consumption, traditional meat production faces mounting challenges. Lab-grown meat, a cutting-edge technology that allows meat to be cultivated in controlled laboratory settings, offers a promising solution. This article explores the emergence and potential of lab-grown meat as a sustainable and eco-friendly alternative. Lab-

Research Article

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Educational Awareness and Knowledge Concerning Field of Biotechnology among Biotechnology Students at Debre Birhan University, North Shewa, Ethiopia

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ABSTRACT

Background: Progressive natural sciences, for example, biotechnology, are assuming control over the million-dollar businesses because of their approaching applications, just as their significance in the well-being of living creatures. This investigation aims to decide the variables associated with choosing this field, their vocation inclinations, educational awareness, and knowledge of biotechnology.

Methods: The study undertook at Debre Birhan University through a pre-approved questionnaire given to the students joined in the biotechnology department. A total of 220 students, 130 (60.46%) females, 85 (39.53%) males, and 5 (2.32%), failed to give their data. Students who were involved in this study gave their agreement to record their responses. Student replies were analyzed using the Statistical Package for the social sciences (SPSS) [version 20.0].

Results: Out of 220 Biotechnology students, 215 participants filled the questionnaire; therefore, the response rate was (97.72%). Of 215 respondents, 116 (53.95%) were not mindful of the scope of biotechnology before getting admission in the biotechnology program, 20 (9.30%) were interested in research. In contrast, 29 (13.48%) were either indifferent or indeterminate about their choices.

Conclusion: Almost all participants, 186 (86.51%), we're able to seek a job in biotechnology after their graduation, and Personal curiosity was the prominent factor 139 (64.65%) included in the choice succeeded by status 31 (14.41%) and income 15 (6.97%) correspondingly

Keywords: Awareness; Biotechnology Students; Debre Birhan University; knowledge; North Shewa

Introduction

Biotechnology is a science and innovation field that shows a fast improvement in the 21st century. Ethiopia is one of the nations keen on using biotechnology to move the present economy towards a top-level economy. Science instruction has a significant task in creating human assets and abilities for the biotechnology field in non-industrial nations to make progress [1]. Biotechnology is one of the comparatively new expanses of science that progressively impacts our lives globally almost in all fields of society, from medical care and food items to environmental issues and energy sources [2,3]. Although cheese, wine, and beer are the products of old-style biotechnology, they are even now considered prominent parts of human innovation action. The present-day biotechnology displays remarkable high quality joined with restricted information on the part of the community [4,5]. Currently, scientific literature, the capacity to peruse and expound on science and innovation, biotechnology specifically inside the setting of this investigation, is planned for all because of its importance in traditional settings and that it empowers people to participate in argument and decision-making in settings highlighting scientific knowledge [6,7].

Hence, current contentions emphasize the requirement for individuals to know something about science and make science open

PHYTOREMEDIATION OF OUTDOOR AIR POLLUTION – A LIST OF PLANTS AND THEIR CONTRIBUTION

S.Maheswari*, P.Rajarajan, Anjana J, Ayesha G, Bhanushree C, Koteshwari M, Prakash B, and Priyanshi singh.

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ABSTRACT

Air pollution has been a serious threat due to rapid industrialization and urbanization around the world. Ambient air pollution is composed of a high variety of primary and secondary pollutants, mainly including particulate matter (PM), polyaromatic hydrocarbons (PAHs), formaldehyde, volatile organic compounds VOCs such as benzene, toluene, ethylbenzene, xylene (BTEX), and inorganic pollutants (NO_x, SO_2, CO_2, O_3). Many of these outdoor air pollutants are also found indoor, in concentrations that often can be higher than the outdoors. About 7 million premature deaths occur every year by the outdoor air pollution which largely of heart disease, stroke, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections. The major outdoor pollution sources include power generation, agriculture/waste incineration, vehicles industry and building heating system. By anthropogenic activities more than 3 billion people worldwide are polluting the atmospheric environment by using fuels and polluting technologies such as coal, kerosene and biomass for heating, cooking and lighting which release smoke into the home. Phytoremediation is using plants to remove toxins, is a cost-effective way to improve air quality and can play an important role in controlling air pollution. The benefits of the phytoremediation is soil stabilization, self-maintaining, greater public approval and responsible for a specific pollutant by different phytoremediation process. The important role of phytoremediation is phytostabilization, rhyzodegradation, phytoextraction, phytodegradation, phytovolatilization and phytofiltration. The most efficient woody plants for phytoremediation include Eucalyptus viminalis, Populus nigra, Magnolia kobu, and Robinia pseudoacacia, and herbaceous plants include Erechtites hieracifolia, Crassocephalum crepidioides and Nicotiana tabacum.

PROBIOTICS, PREBIOTICS & SYNBIOTICS – IMPACT ON HEALTH

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ABSTRACT:

Probiotics are live, nonpathogenic microorganisms that are given to patients to help with microbial balance, especially in the digestive system. They are controlled as dietary supplements and foods and are made of *Lactobacillus* and *Bifidobacterium* species or *Saccharomyces boulardii* yeast. Probiotics work to benefit the body through a number of processes, including as reducing intestinal pH, preventing the colonisation and invasion of the body by harmful organisms, and altering the host immune system. Benefits of probiotics linked to a particular species or strain may not apply to others. Probiotics may help prevent conditions such antibiotic-associated diarrhoea, travellers' diarrhoea, irritable bowel syndrome (IBS), ulcerative colitis, Crohn's disease and vulvovaginal infections, hypertension, mental illness although more research is required to fully understand this. A probiotic should normally contain several billion germs to improve the likelihood that proper gut colonisation will occur, but there is no agreement on the minimum quantity of microorganisms that must be consumed to have a positive effect. Probiotics are typically seen to be safe and well tolerated, with bloating and flatulence being the most common side effects. Since systemic infections can infrequently happen, they should be used cautiously in patients who are very ill, highly immunocompromised, or those who have central venous catheters. Probiotics made from bacteria should be taken at least two hours apart from antibiotics.

Keywords: Probiotics,Traveller's diarrhoea **,** irritable bowel syndrome (IBS),Hypertension .

Introduction

The word "probiotics" is a Greek word that means "for life" Probiotics were described by an expert panel FAO (Food and Agriculture Organisation) and WHO commissiond as "live micro-organisms" which, when provided in sufficient proportions, impart a health benefit on the host. The bacterial genera *Lactobacillus, Bifidobacterium, Escherichia, Enterococcus, Bacillus,* and *Streptococcus* are the most frequently employed in probiotic formulations. Additionally, some Saccharomyces-related fungal strains have been utilised. Eli Metchnikoff, the 1908 Nobel Prize laureate, proposed that the long life of Bulgarian peasants was due to their consumption of fermented milk products, which is when the idea of probiotics first emerged. Lilly and Stillwell

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Trichoderma Spp. – Applications For Use In Gene Cloning Strategies For Biological Control Of Fungal Phytopathogens In Agriculture

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Abstract: Protection of agricultural crops from diseases especially from a wide range of soil and foliar fungal pathogens is a great challenge for most of the agricultural practices being adopted. Unlike physical or chemical strategies of pest control the safest approach considered and applied include use of beneficial microorganisms like *Trichoderma* species in the management of fungal diseases of plants. Among many biocontrol agents known so far, the asexually reproducing filamentous fungi, *Trichoderma* remains a gold standard. It has been studied as biocontrol agent against various soil borne fungal phytopathogens. The antagonistic effect of *Trichoderma spp.* is based on direct and indirect mechanisms. Among them the most effect was observed during mycoparasitic interaction between *Trichoderma* and other fungal pathogens by secretion of hydrolytic enzymes mainly cellulases and glucanases that enable the degradation of host cell-wall components. Advances in understanding the genomics of *Trichoderma* has led the way to study about isolation, characterization, cloning, and expression of these genes that play major role in the biocontrol mechanism. In this review, emphasis is made to study the genetics and genomics of *Trichoderma* sp., the chitinase and glucanase enzymes functioning synergistically and also some advanced tools of bioinformatics like the Gateway and the Golden Gate cloning systems has revolutionized in the evolution of efficient and precise cloning techniques. The current review proposes the various mechanisms that have been naturally used by *Trichoderma* species and more updated information on the specific novel genes that code for cell-wall-degrading hydrolytic enzymes mainly chitinases and glucanases and their contribution in the development of transgenics with enhanced biocontrol activity.

Keywords: Biocontrol, Chitinases, Glucanases, Gene cloning, *Trichoderma*

1. Introduction

Agriculture has been a main mode for the production of desired crops for human consumption. Crops have been the major source of food since long time. But recently food security has become a major threat to agricultural industry due to the increase of various problems such as increase in population, lack of land availability (due to urbanization), climate changes leading to certain natural calamities, drought, increase in pests and pathogens causing various plant diseases etc. [1-4]. Among them, pests and diseases cause major losses for farmers in obtaining a good yield. Fungal infections are the major threat for good yield. But controls have been taken to protect these crops from various soil borne pathogens. Though, traditionally chemical pesticides have been used largely against crop diseases, they have not been as environmentally and consumer-friendly as certain fungicides [5, 6].

Continuous use of chemical treatment has led to increased pollution, damage to the environment and the resistant strains. The main challenge is to develop eco- friendly novel methods to improve quality and security of food. Due to various harmful effects of the chemical pesticides, other ecofriendly biological methods are being adapted. Certain biocontrol agents are used in the inhibitory activity of such pathogens which causes plant diseases. Use of beneficial microorganisms to protect plants from natural enemies like insects, pests, parasites, nematodes is called biocontrol agents. Among various microbes, one of the best biocontrol agent to overcome the crises from fungal pathogens is Trichoderma [7]. These organisms are asexually reproducing filamentous fungi that are distributed extensively in various mediums such as soil, plants, wood and decayed vegetation which are well known for their biocontrol capability and functions as a resistant agent as well as promote plant growth [8]. It has been well known

since plenty of years that they produce a broad range of antibiotic agents to parasitize other fungi [9-11]. *Trichoderma* species being a biocontrol agent, have shown effective against disease caused by pathogens *Rhizoctonia solani, Sclerotium rolfsii and Mycorhizza orzyae.* Thus, various diseases in plants can be managed by the involvement of *Trichoderma*. *Trichoderma* species also enhances the defense mechanism in plants, stimulates other mechanisms such as colonization of the rhizosphere, growth of roots etc. *Trichoderma* defends the pathogenic fungal attack on plants by process of antibiosis and mycoparasitism. *Trichoderma* induces biotic stress tolerance in plants by generating SAR (Systemic acquired resistance) and ISR (Induce systemic resistance) defensive mechanisms. Also, induce the production of antifungal enzymes such as glucanases and chitinases. In some plant species immune system is strengthened by increased activation of some antioxidant enzymes like guaiacol peroxidase (GPX), superoxide dismutase (SOD), catalase (CAT) and ascorbate peroxidase (APX) after pathogenic infection. Thus, the activation of multiple mechanisms has laid the basis for the antagonistic property of *Trichoderma* species [12].

Progress in molecular biology and novel transgenic approaches have imposed the foundation to confine beneficial genes and their transfer to desired plants [8]. Amongst various antifungal proteins chitinases, ß-1, 3-glucanases and proteases are the one best studied. Expression of chitinase genes improvise plant resistance to fungal pathogens by degrading the main cell wall component of most phytopathogenic fungi, linear homopolymer of ß-1, 4-N-acetyl- D-glucosamine, thus inhibit strongly the germination and hyphal growth of most of the phytopathogens *in vitro* [13]. Consequently, glucanases act on fungal pathogens which have β- glucans as the primary components of their cell walls [14]. Both the defense related enzymes, β-1, 3-glucanases and chitinases have shown to be mainly involved in the mycoparasitism interaction between *Trichoderma* species with its hosts (fungal pathogens) [15].

Chitinases are present in plants also, but are not as effective as microbial chitinase. Biocontrol microbes such as *Trichoderma* are utilized for cloning and characterization of genes responsible for chitinase expression and is most significant to prevent yield loss due to fungal infections on plant species. Cloning endochitinase and glucanase genes and their transfer is the key in the progress of transgenics against phytopathogenic fungi. For example cloning of ech33 endochitinase gene from *T. harzianum* (IABT1068), sequenced and functional analyses were done [16].

Jana and Yiash [17] in their studies in date palm identified five putative *PdGPX* genes (*PdGPX1–5*) from the genome, using computational tool and identified their expression profiles different stress conditions mainly oxidative, salinity and methylglyoxal stresses.

Among the abundant microbes, bacterial or fungal strains are the most frequently used against causal agents of plant aerial and soil diseases. However, *Trichoderma* remains remains one of the benchmarks of biological control. Several species of this genus, including *Trichoderma harzianum; T. viride; T. atroviride, T. virens, T. longibrachiatum; T. polysporum, T. stromaticum, T. hamatum, T. asperellum, T. citrinoviride, T. saturnisporum, T. aggressivum* have been mentioned as biological control agents (BCAs) against phytopathogens [18]. Divergent studies have shown that species in this genus present most mechanisms identified in biological control, namely competition for space and nutrients resources, production and secretion of specific antibiotics, cell wall-degrading enzymes like cellulase and glucanase, siderophores, mycoparasitism on phytopathogenic fungi, and induction of defense responses. Among these ways of defensive approaches, the most important mechanisms considered include competition, mycoparasitism, and the production of antifungal compounds Mycoparasitism is based on the recognition, binding, and disrupting of the cell wall of the host fungus by numerous enzymes, basically chitinolytic and glucanolytic enzymes [19].

Several types of *Trichoderma* are an effective source of biocontrol agent for a wide array of soil-borne phytopathogenic fungi. The hydrolytic enzymes, mainly chitinases, -1-3 glucanases, 1-6 glucanases, and proteases penetrate the host [6]. Certain strains of *Trichoderma such as Trichoderma virens (Tvk1, TvGv298)* transformed to overexpress hydrolytic enzymes exhibited better bicontrol activity compared with the parental strains. Consequently, many of these hydrolytic enzyme-encoding genes have been designated as mycoparasitism-related genes (MRGs). Sensing of such environmental conditions may occur through a variety of transduction pathways, which determine the adequate cellular response. This has been shown as a central mechanism that account for the antagonistic activity of *Trichoderma* species (Figure 1).

In one of the studies performed, various fungicidal tolerance of *Trichoderma* isolates was tested and 89-90% of various fungicides such as chlorothalonil, cyproconazole were removed by the application of these isolates. Moreover, the combination of agrochemicals and *Trichoderma* isolates promises an efficient strategy in the integrated pest management [3]. Systemic acquired resistance (SAR) is the broad-based resistance mechanism in plants and numerous signals are a part of it, mainly salicyclic acid and different components of salicyclic acid. Pathogenesis related (PR) proteins also interplay in SAR mechanism. Very limited information is available on the role of biotic elicitors derived from endophytic fungi on their host. In that scenario, *Trichoderma atroviride* D16 was able in enhancing the growth of roots and also induce secondary metabolites [20].

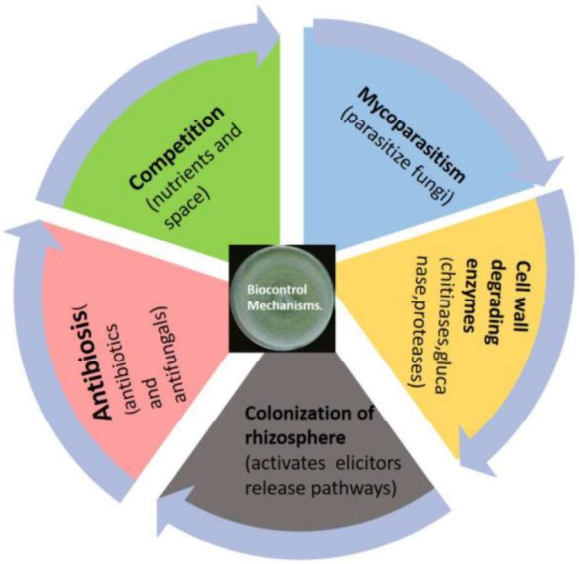

Figure 1. *Different approaches by Trichoderma to control fungal pathogens [11, 22].*

T. atroviride D16 strain could elicit chemical defence responses in the host plant with the purpose of confronting pathogens using polysaccharide fractions (PSF). These fractions influenced the host plants and expressed the relavant genes involved in the secondary metabolite biosynthesis pathway. According to Ming et al. [20], PSF treatments can be considered as an potential and efficient approach for the large-scale production of tanshinones in *S. miltiorrhiza* hairy root culture systems.

2. Biocontrol Genes- Genetics and Genomics of *Trichoderma*

2.1. Genes of Different Subspecies of Trichoderma in Biocontrol Mechanism

*Trichoderma s*pecies genes have been used for long time due to its involvement in multiple mechanisms of antagonistic property to manage the phytopathogenic fungal species [21]. *Trichoderma* can act as the best biocontrol agent in an ecofriendly system is mainly due to their various potential properties such as fast growth, multiple substrate utilization, and toxic chemicals, fungicides and other organic pollutants.

The effort of usage of *Trichoderma* as a biocontrol agent to combat a wide range of plant diseases have been recorded good success results since ages [22]. They have been studied for its antagonistic actions against varied soil borne plant pathogenic fungi. It is based on activation of single or multiple mechanisms [23]. These include antibiosis, mycoparasitism, promotion of plant growth, competition for nutrients and space, induced plant defence mechanisms and changes to environmental conditions. Strains of Trichoderma have been witnessed for a significant reducing effect on plant diseases caused by pathogens such as *Sclerotium rolfsii,, Fusarium oxysporum, F. culmorum, Gaeumannomyces graminisvar*, *Rhizoctonia solani* both in greenhouse and field conditions [23, 24]. It shows its action directly or indirectly.

Biological control, is the usage of living microorganisms to reduce the pathogenic infections, is a one of the promising approach in the management of plant diseases in Agriculture. They are considered to be safer and biocompatible than chemical pesticides. Also, they neither impart resistance in pathogens nor pollute the environment [25]. Morever, than chemicals to control crop destruction by pathogens the use of biocontrol agents are the main requirements of profitable markets that resulted in maximum limits of chemical residues left on fruits and vegetables. Among various organisms, genus *Trichoderma* was identified to possess significant biocontrol potential among various fungal antagonists to plant fungal diseases [4].

2.2. Competition

Most of the organisms compete with their neighbours for space and nutrition resources**.** Fungal competition for limiting nutrients has proved to be significant in biological control of fungal phytopathogens [11]. *Trichoderma* being fast growing filamentous fungi grow competitively in the soil due to its natural resistance property against various herbicides, fungicides, insecticides and phenolic compounds. This survival mechanism of competition for limiting nutrient availability in soil makes *Trichoderma* an efficient and successful biocontrol organism of various fungal pathogens [23].

Mycoparasitism: It is one of the direct antagonistic mechanism of *Trichoderma* species which involves the physical contact of mycelium with pathogen structures that works by parasitizing and directly killing pathogens and other plant associated fungi [22].The major stages of mycoparasitism include prey recognition, showing chemotropic growth towards it which attacks directly physically as well chemically that results in killing of fungal pathogen hyphae structures [10, 11].

2.3. Cell-Wall-Degrading Enzymes

Hydrolytic enzymes such as glucanase, chitinase and protease are the key parameters that give *Trichoderma* the biocontrol property [2]. Genes associated with synthesis of such pathogen cell wall degrading enzymes and other compounds like phytoalexins, pathogenesis related proteins, and further enhancing resistance for fungal pathogens are also one the major mechanism followed by many *Trichoderma* species [26]. Expression of plant genes resistance to pathogens and elicitors not only takes place by the stimulation of other organisms but even *Trichoderma* metabolites is more than enough to render plant defensive mechanism by expressing Cell-wall-degrading enzymes genes. The mechanism is quite complex that involves lysis of cell wall structures of pathogens either by producing these enzymes that is mediated by heterotrimeric G-proteins and MAP (mitogen-activated protein) kinases. Many species of *Trichoderma* like *Trichoderma virens, Trichoderma harzianum, Trichoderma atoviride* have been identified agents for the production highest quantity of these hydrolytic enzymes compare to other fungal species to combat the plant fungal diseases [11].

This lead the foundation for cloning and characterizing glucanase, chitinase and proteases genes responsible for plant resistance from *Trichoderma* species. Several strategies have been studied so far to use genes encoding cell wall-degrading enzymes of this mycoparasitic fungi. Studies of El-Badawy and Yehia [24] identified the most promising *Trichoderma* isolates for the control of root rot disease caused by *Fusarium oxysporium*. *Trichoderma harzianum* showed the maximum inhibition of 79.3% on dual culture plate assay technique. β-1,3 glucanase gene was characterized and cloned from this species successfully to control root rot disease by transgenic approach.

2.4. Colonization and Enhancing Plant Defense Mechanisms

Many studies have reported *Trichoderma* species as plant symbionts that colonize roots of plants [26, 27]. Root colonization helps Trichoderma firmly establish and bring about long lasting penetration and induce the release of metabolites responsible for localised or systemic plant resistance responses [10]. This has considerable yield increase when plant seeds were previously treated with *Trichoderma* spores resulted in greater crop productivity in fields after the addition of *Trichoderma hamatum* or *Trichoderma koningii* spores to the seeds [9].

Protection of plants against root pathogens has long been attributed to an antagonistic effect of *Trichoderma* strains against the invasive pathogen Root colonization by *Trichoderma* spp. enhances the expression of defence-related genes throughout the plant and bring about systemic acquired resistance (SAR), hypersensitive response (HR) in plants induced systemic resistance (ISR) in plants [11, 23].

HEALTHINNOVATIVE SCIENCERESEARCH ARTICLE

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Lab Grown Meat: A Low Carbon and Water Footprint Alternative

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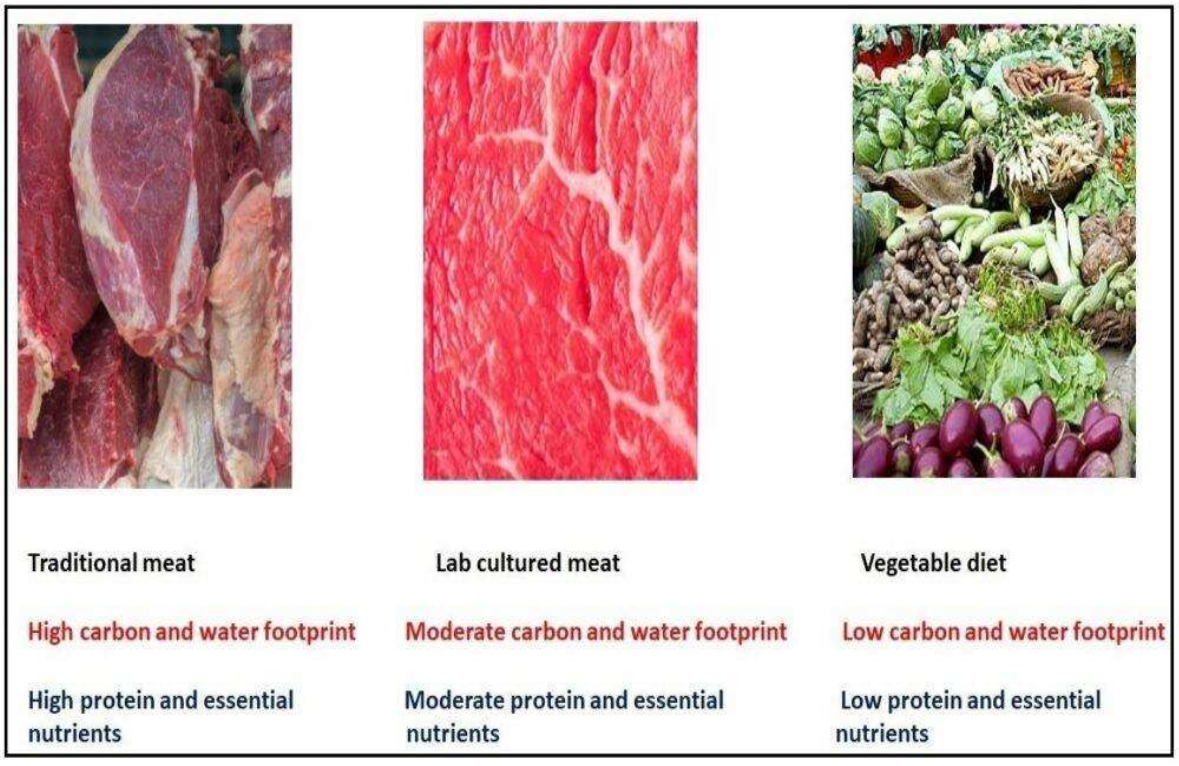

Figure 1: Comparison among traditional, lab-grown meat and vegetable diet.

Abstract

As the global population continues to grow and dietary patterns shift towards higher protein consumption, traditional meat production faces mounting challenges. Lab-grown meat, a cutting-edge technology that allows meat to be cultivated in controlled laboratory settings, offers a promising solution. This article explores the emergence and potential of lab-grown meat as a sustainable and eco-friendly alternative. Lab-

HEALTH · INNOVATIVE SCIENCE · RESEARCH ARTICLE

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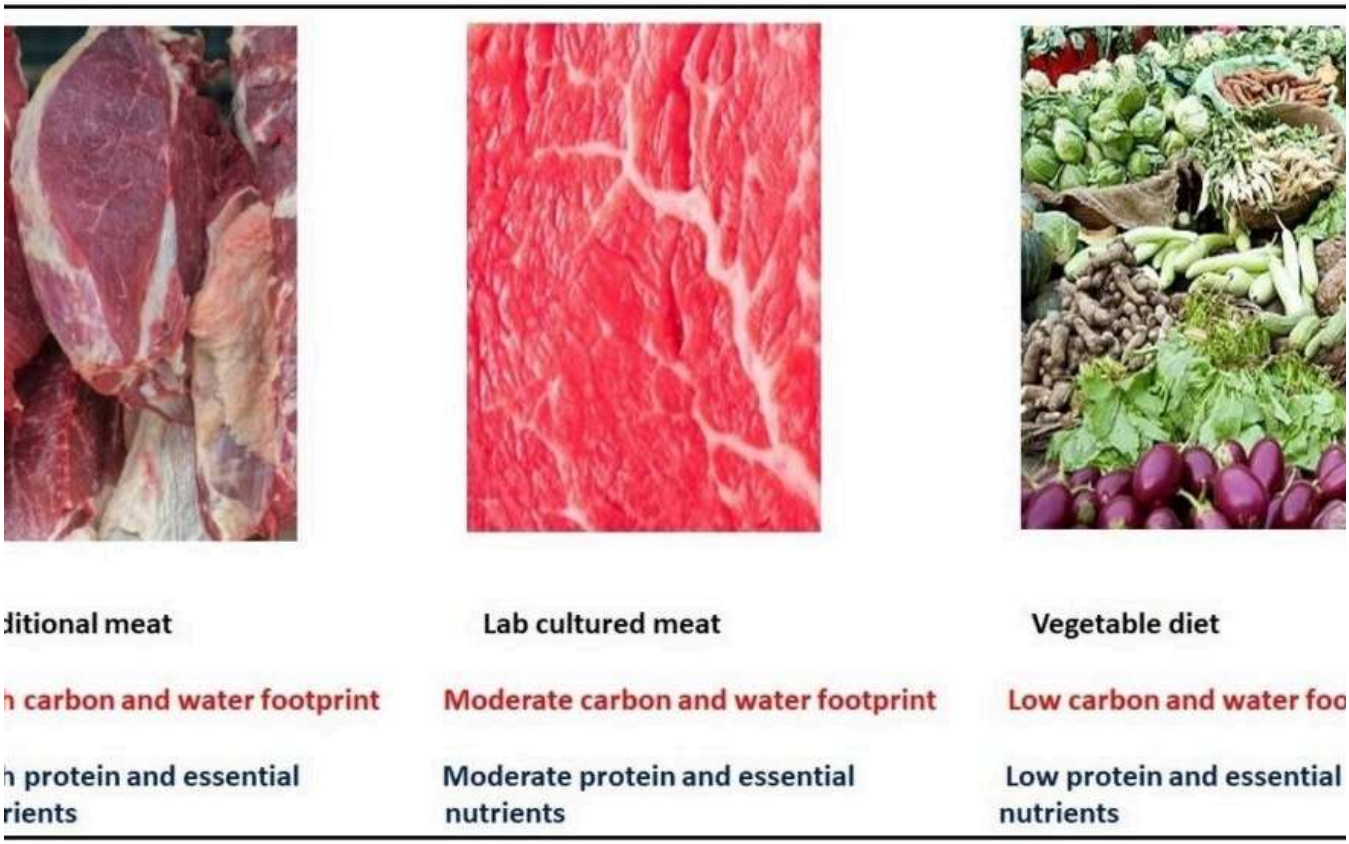

Figure 1: Comparison among traditional, lab-grown meat and vegetable diet.

Abstract

As the global population continues to grow and dietary patterns shift towards higher protein consumption, traditional meat production faces mounting challenges. Lab-grown meat, a cutting-edge technology that allows meat to be cultivated in controlled laboratory settings, offers

Strategies for Managing Vaginal Infection

Risav Banerjee[α] & Trisha Bhattacharya[σ]

ABSTRACT

Vaginal Infection is the most common problem which almost most girls suffer. It is neglected but it has a serious effect if it is not treated. It is diagnosed if the color of the vaginal discharge changes, has a strong fishy odor, irritation, and burning sensation. The normal microflora of the vagina, act as the first line of defense in preventing the infection from pathogenic fungi, bacteria or protozoa which can cause vaginal infection. Several treatment strategies have been adapted for vaginal infections. Vaginitis trigger UTI (Urinary Tract Infection) in most of the girls. This review, is focused on vaginal infections caused by different types of microorganisms, symptoms and their treatment method.

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I. INTRODUCTION

A healthy vagina contains some bacteria and a few yeast cells to maintain the natural balance of the vagina, whenever the number of bacteria and yeast cells goes imbalanced it leads to several vaginal infections [1]. Irritation and swelling of the vagina and vulva with unusual vaginal discharge which has a strong odour, and pain with a burning sensation during urination, are common symptoms of vaginal infection [2].

Whenever these symptoms occur, it causes discomfort and distress which lead women to seek medical consultation [3]. In the entire world, 3 out of 4 women suffer from vaginal infections once in their lifetime. The most common vaginal infection seen in women is bacterial vaginosis caused by bacteria, Candidal vaginitis caused by the fungus, and trichomoniasis which is caused by protozoa [4, 5, 6].

II. BACTERIAL VAGINOSIS

Bacterial vaginosis is the most common infection during the reproductive age of women it causes abnormal discharge and inflammation of the vagina [7, 8]. It is the most common infection in women. Bacterial vaginosis is occurred due to the replacement of the regular Lactobacillus bacteria with Prevotella, Mobiluncus, Ureaplasma, *Gardnerella vaginitis*, Mycoplasma, and many other uncultivated anaerobes [9, 10, 11]. *Lactobacillus* which is present normally in the vagina produces bacteriocins, lactic acid, and hydrogen peroxide, which help to maintain an acidic pH, and protect against other infections in the vagina [12, 13]. An enzyme produced by the bacteria which causes bacterial vaginosis degrades the gel layer protection of the vaginal epithelium and cervical [14]. They produce inflammatory proteins which associate with complications that occur during pregnancy like preterm labor and birth [14, 15], endometritis, gynecologic surgery, *Neisseria gonorrhoeae, Chlamydia trachomatis,* pelvic inflammatory disease, increased susceptibility to HIV type 1, and herpes simplex virus type 2 [16, 17, 18].

1. SYMPTOMS

- Burning during urination
- Thin, gray, white, or green vaginal discharge
- Vaginal itching
- Foul-smelling 'fishy' vaginal odor [19, 20]

2. RISK FACTOR

Bacterial vaginosis is not a sexually transmitted infection (STI) [21], but it resembles trichomoniasis, Chlamydia, and gonorrhea which are sexually transmitted infections [22]. Douching, having male partners who have sex with other women, having a new partner, having sex with women, use of an intrauterine device, use of an inconsistent condom, cigarette smoking, and black ethnicity [23, 24]. The use of oral contraceptives has an inverse relation with acquiring bacterial vaginosis [25].

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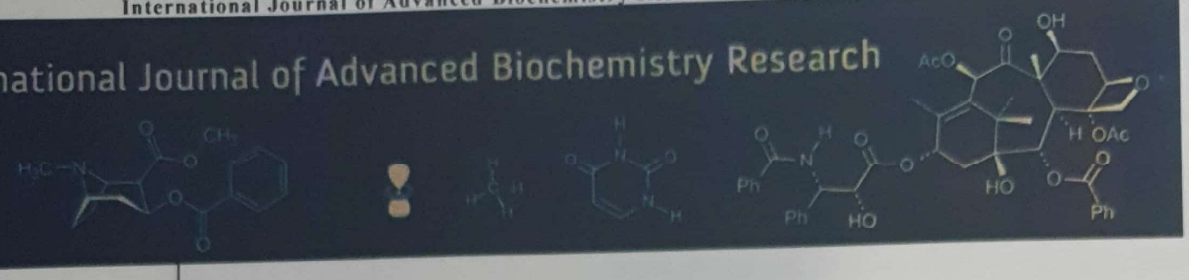

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Inhibition of Angiogenesis in the treatment of breast cancer

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Abstract
Worldwide every year more than 2million women suffer from breast cancer. The food habit and the current lifestyle, lead to an increase in obesity. Obesity is one of the chief causes of breast cancer. Angiogenesis is highly crucial for tumor growth. The tumor development and metastasis are fully dependent on angiogenesis or the newly formed blood vessels, which supply nutrients for the tumor development. Several early diagnosis methods for detection of breast cancer are there like, mammography which is an X-ray technique to visualize inside the breast. This technique is used for the early detection of breast cancer. Antiangiogenic treatment plays a major role in treating breast cancer, as it inhibits the supply of nutrients which is essential for tumor growth. Our review will be focusing on the anti-angiogenic drugs which inhibit the formation of new blood vessels. Inhibiting angiogenesis is an effective way to treat breast cancer as it is a safe and effective method.

Keywords: Angiogenesis, breast cancer, tumor, antiangiogenic treatments

Introduction

Cancer is a type of disease in which the body cells divide uncontrollably and spread to other parts in some cases. There are various types of cancer, but the main focus of our review is breast cancer. Breast cancer is a heterogeneous disease, which includes a broad variation prognosis [1], named after the location where it is found. It is more common in women than men. The chance of an individual dying of breast cancer is 1 in 35 [2].

Breast cancers are the most common carcinoma with approximately 1 million deaths per year. It is the second most common non-skin cancer and it is the fifth most common type of cancer [3]. Breast cancer comprises 7% of the total deaths caused due to cancer worldwide and includes almost 1% of the total deaths [4].

Cancerous cells are similar to the cells from where they have originated (have similar DNA and RNA but they are not identical to the cells) and hence, the immune system is unable to recognise the cancerous cells. Cancer is caused due to the modification or mutation of the genetic material, DNA, or RNA. The mutation of the genetic material results from various factors.

UK cancer registry data shows that there is an increasing trend of breast cancer worldwide from age 30 to 35. At the age of 60-65 years, it achieves its highest peak (Fig. 1). Average Women in India under 40 years are more prone to have breast cancer unlike UK [52].

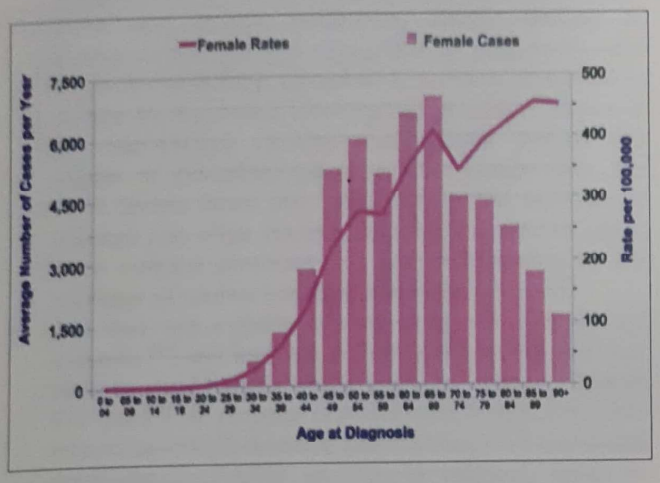

Fig 1: Trends for age distribution among UK cancer registry. (Adapted from Cancer Research UK) *S Malvia et al.*

Factors leading to the cancer cells

- Evolution: The cancerous cells grow by somatic cell evolution. In such processes when a clone cell is produced, it acquires many genetic changes over time and then proliferates to generate highly complex cancer [5].
- Aging of the genetic material (DNA or RNA) is also an important factor contributing to mutations. Aged cells are hypoactive with accumulated disadvantageous mutations, cell division inability, and a decreased ability for energy production and consumption [6].
- Advanced age: Breast cancer occurs in females with advancing age, doubling about every 10 years until she reaches menopause. It is also noticeable in certain countries that there is a flattening of the age incidence curve after menopause [7].
- Poor diet: Poor dietary habits are directly related to causing cancer in humans. Studies have indicated that obesity is a risk factor resulting in 13 different types of cancer in humans [8].
- Micro-organisms (bacteria and viruses): Double-stranded DNA breaks in HeLa cells were induced by bacteria like *E. coli* and *Staphylococcus epidermidis*. Another bacteria *Fusobacterium* sp. is a well-known cancer-promoting pathogen [9].
- Parasites: Certain parasites like *Schistosoma haematobium*, *Echinococcus granulosus*, *Theileria* sp., *Fasciola hepatica*, *Opisthorchis viverrini*, bladder cancer, cholangiocarcinoma are associated to cause cancer. Certain plasmodium parasites like *Plasmodium falciparum* are indirectly a reason for the cause of cancer [10].
- Fungi: 7 fungal families *Aspergillus* sp, *Candida* sp, *Coccidioides* sp., *Cunninghamella* sp., *Geotrichum* sp, *Pleistophora* sp., and *Rhodotorula* sp. are seen to be present in more than 1 type of cancer [11].
- Chemicals: Chemical substances that are responsible for causing cancer are called carcinogens. These substances cause cancer only when they are in contact with the body in a specific way like touching, swallowing, or intense exposure. Some carcinogenic substances include asbestos, cadmium, radon, benzidine, benzene, and vinyl chloride which are capable of increasing the risk of cancer [12].
- Nuclear radiation: Exposure to ionizing radiation is capable to cause mutation in normal cells causing the cells to transform into cancerous cells [13].
- Injury to the cells: Cell injury indicates that lifestyle is a major upstream initiator of cancer development, however, this does not exclude randomness as an unavoidable contributor to the disease [14].
- Irritation of cells: A particular type of inflammation called 'chronic inflammation' begins and does not stop, which throughout time can result in damaging DNA affecting the cell growth and cell division eventually leading to cancer and tumors [15].
- Free radicals: These are oxygen-containing molecules with an uneven number of electrons. The uneven number allows free radicals to easily react with other molecules. Free radicals can cause large chain chemical reactions in the body because they react easily with other molecules. At higher concentrations, free radicals are capable of damaging major components of the cells including components like DNA, proteins, and even cell membrane. When free radicals damage DNA, it results in the development of cancer [16, 17].
- The organ, the breast is composed of two types of tissues namely, the glandular tissue and the stromal tissue. The stromal tissues perform the supporting function including the connective tissues, whereas the glandular tissues include the glands producing the milk and helping in the passage of milk (lobules and ducts). Tumors can be found in different parts of the breast. This tissue cancer commonly begins in the ducts or lobules [18]. Major factors contributing to causing breast cancer include age [19], an iodine-deficient diet [20], high hormonal levels [21, 22], and economic status [23].

Types of breast cancer

- Breast cancer is commonly divided into three major groups, including:
- **Non-invasive Breast Cancer:** It is a type of breast cancer that is confined to the location where it originates and does not spread to the surrounding tissues of the breast. Example: Ductal carcinoma (this cancer is initiated in the cells that line the milk duct)
- **Invasive Breast Cancer:** It is a type of breast cancer that can spread within the breast or nearby lymph nodes or tissues. Example: Infiltrating Lobular
- Carcinoma is commonly called Invasive Lobular Carcinoma (this cancer initiates in the milk gland known as lobules and has the capability of spreading to other parts)
- **Metastatic Breast Cancer:** It is an advanced type of invasive breast cancer (stage 4) in which the cancerous cells advance and enters the blood vessels or lymph vessels, from where the cancerous cells can travel into the bloodstream or lymphatic system to reach different body parts [24, 25].

Genetics of Breast Cancer

- In cancers, malignant cells are formed which reduces the rate of apoptosis. Apoptosis is a series of molecular steps that eventually lead to the death of the cells. Apoptosis involves many pathways or complex mechanisms.

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Review Article

Degradation of synthetic polymers: Microbial approach

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ABSTRACT

A synthetic polymer is a plastic, which is having wide applications in our day-to-day life. The packaging industries, agriculture, cosmetics, etc. Plastics are not easily degradable, it takes 1000 years to degrade a plastic or even more than that. The pollution caused by plastic is not only because of the waste disposal method but it is also because it releases carbon dioxide and dioxins while burning. Plastics are considered a threat to the environment as they are not easily degradable. Our review is based on the microbial approach for plastic degradation. The waste management method being used for plastic disposal is not effective enough. Nowadays biodegradable polymers are also being used as they are more easily degradable compared to synthetic polymers. The bacteria and fungi degrade most of the organic and inorganic components like starch, lignin, cellulose, and hemicelluloses.

1. Introduction

Plastic is a synthetic polymer that is abundantly found in every corner of the world. It is used almost in every sector for packaging, textiles, electrical gadgets, automotive, furniture to medical healthcare. Now the worldwide production of plastic has reached 367million tonnes, the industry produces approximately 150kilograms of polymers per person annually in the United States, with the increase of production in the plastic it has become an environmental hazard, impacting on health and threatening wildlife and even marine life.[1]

In the environment, we can find natural polymers, like cellulose. Latex was first chemically modified in 19^{th} century to form celluloid and vulcanized rubber. Bakelite the first synthetic polymer was produced in 1907 and rayon fiber was the first semisynthetic fiber developed by cellulose.[2] The polymers are resistant to chemicals, insulators of electricity, and heat. Resin is the raw material for the production of plastic products. Polyethylene (PE), polystyrene (PS), polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET) are the most commonly used resins, they are used in packaging.[3] Plastic takes years to decompose, the chemicals present in the plastic-like lead, mercury, and cadmium are carcinogens, when it comes into direct contact with humans it can cause cancer, immunological problems, and even congenital disabilities. The plastic in marine impacts the ingestion, suffocation, entanglement, and death of hundreds of species.[4]

Many plastics are non-biodegradable but few plastics are biodegradable which can be decomposed by the action of the microorganisms. In 2016 the Japanese scientists had discovered a bacterium that can break down the polyethylene terephthalate plastic, the bacterium *Ideonella sakaiensis* degrades polyethylene terephthalate by the two enzymes PETase and MHETase produce by the bacteria, the PETase breakdowns the polyester polymer by which polyethylene terephthalate is constructed into smaller pieces, during the process polyethylene terephthalate is

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converted into mono-(2-hydroxyethyl) terephthalate acid (MHET), terephthalate (TPA) and bis(2-hydroxyethyl) TPA (BHET).[5] The MHETase enzyme produced by the *Ideonella sakaiensis* converts the MHET into terephthalate and ethylene glycol. Environmental pollutants caused by the polyethylene terephthalate can be effectively solved by the bacterial enzymes. In 2017, biologist Federica Bertocchini at the Institute of Biomedicine and Biotechnology of Cantabria reported that wax worm caterpillars could break down polyethylene.[6]

After their initial observation, they exposed a paste made from mashed-up caterpillars to a sample of polyethylene film, which generated new peaks during a scan with an infrared spectrometer. Bertocchini and her team attributed the peaks to a breakdown product, ethylene glycol, likely generated by the caterpillar or by the microbe present in the guts of the caterpillar.[7] Microorganisms that are capable of degrading the polyolefins (Polyethylene, Polystyrene, and Polypropylene) polyvinyl chloride, polyethylene terephthalate are isolated from the open environment, the soil of plastic dumpsite, sewage sludge, landfills, marine water, and the plastic-eating worm.[8]

2. Preparation of Different Polymers

Types of synthetic polymer which forms hazardous to health and the environment is mostly the most common polyethylene, low-density polyethylene produced by free radical polymerization at high pressures above 1000atm, high temperatures of 200°C, and the high-density polymer are obtained by Ziegler-Natta catalysis at a temperature below 100°C, less than 100 atm of pressure. Polyethylene is produced more every year compared to any other plastics, they are relatively inexpensive and lightweight.[9] Polypropylene is rigid due to Ziegler-Natta catalyzed polymerization, they are thermally stable polymers with excellent resistance to stress and chemical reaction.

It costs more than polyethylene and it is much stronger than polyethylene. Polytetrafluoroethylene, it's a gas that is boiled at -76^{0}C and stored in cylinders at very high pressure. In 1938 Roy Plunkett received a cylinder of tetrafluoroethylene, that did not deliver as much gas as it should have, instead of returning the cylinder, he cut open with a hacksaw and discovered a white waxy powder that was the first polytetrafluoroethylene polymer. Later a less fortuitous route for this polymer was discovered, polytetrafluoroethylene or Teflon became commercially available.

Teflon has got the best resistance to the chemical attack of any polymer, it can withstand temperatures between -73°C to 260°C with no effect on its properties. It got a very low coefficient of friction, it has a waxy or even material as sticky as rubber, adhesives, bread dough, and candy. Insects get stuck to a Teflon-coated surface.

Teflon is extremely slippery that they used to spray on plants so prey on the plants fall off.

Polyvinyl Chloride, the chlorine substituents on the polymer chain make polyvinyl chloride more fire-resistant than polyethylene, they also increase the force of attraction between polymer chains, which increases the hardness of the plastic. PVC has got a wide range of uses by adding in plasticizers, stabilizers, fillers, and dyes making PVC one of the most versatile plastics.[10]

Acrylics, acrylic acid is the common name for 2-propenoic acid, Orlon is the acrylic fibers made by polymerizing the derivative of acrylic acid known as acrylonitrile. Some other acrylic polymers are formed by polymerizing an ester of methyl acrylate.

Polymethyl methacrylate is the most important acrylic polymer, it is a lightweight, crystal-clear, glasslike polymer that is used in airplane windows, taillight lenses, and light fixtures. As it is hard and stable to sunlight and extremely durable. The transparency of PMMA makes the polymer ideal for hard contact lenses, PMMA is impermeable to oxygen and water. By copolymerizing, the mixture of acrylic acid and the sodium salt of acrylic acid the product called Sodium polyacrylate is formed, the polymer network and the solution in which the polymer is immersed generate an osmotic pressure that draws water into the polymer.[11] The amount of liquid that can be absorbed depends on the ionic strength of the solution, the total concentration of positive and negative ions in the solution, this is a superabsorbent polymer that can be found in disposable diapers.

The first plastic Celluloid and the first artificial fiber Rayon were produced from cellulose. The first truly synthesized plastic was Bakelite, which starts with the reaction between formaldehyde and phenol to form a mixture of ortho- and para-substituted phenols. If the temperature is above 100°C, these phenols condense to form a linkage.

The families of condensation polymers known as polyamides and polyesters were obtained by reacting a diacyl chloride with a diamine[12] and the polyesters are made by reacting the diacyl chloride with alcohol. It was soon realized that playful exercise had oriented the polymer molecules in two dimensions and produced a new material with superior properties. The first polyester fibers were produced by reacting ethylene glycol and either terephthalic acid or one of its esters to give polyethylene and poly terephthalate, this polymer is still used to make thin films Mylar and textile fibers Dacron and Fortrel.[13]

Phosgene reacts with alcohols to form esters that are analogous to those formed when acyl chlorides react with alcohols. The product formed is called carbonate ester because it is the diester of carbonic acid, polycarbonates are produced when one of the esters reacts with appropriate alcohol has got very high resistance to impact and is

Green Synthesis of Silver Nanoparticles using Marine Sea Weed *Acetabularia acetabulum* and their Activity as MMT-Ag Nanocomposites towards Antifouling Applications

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ABSTRACT:

The present study proposed the green synthesis of silver (Ag) nanoparticles using aqueous extract of *Acetabularia acetabulum* followed by their fabrication onto montmorillonite (MMT). Fourier transform infrared (FTIR) spectra revealed the involvement of multiple functional groups in the reduction of silver ions to Ag nanoparticles and their stabilization on MMT. The obtained MMT-Ag nanocomposites were characterized by UV–visible spectroscopy, powder X-ray diffraction (XRD), particle size analysis (PSA), scanning electron microscopy (SEM) and Energy Dispersive X-Ray (EDX) analysis. The synthesised Ag nanostructures were found to be cubic shaped with average size ranges from 37nm to 60 nm. The seaweed mediated MMT-Ag nanocomposites were evaluated for their potential antimicrobial properties against the isolated biofouling bacteria. Maximum bactericidal activity was recorded against *S. aureus* followed by *E. coli*, *M. flavus*, *Pseudomonas aeruginosa*, *B. cereus*, *M. leteus* and *B. subtilis*. In addition, the viability of incorporating MMT-Ag nanocomposites in paint was examined where a significant inhibition of marine fouling bacteria was exhibited by the panel coated by MMT-Ag nanocomposites-based paint as compared to water-based paint. The addition of MMT-Ag nanocomposites in water-based paint was also found to be effective against corrosion from marine water. The present study shows cytotoxicity of MMT-Ag nanocomposites as nanoclay/metallic nanocomposites against *A. salina* with LD50 values of 200±3.4 µg/ml. The results of the present study suggested the application of *A. acetabulum* extract as a good bio-resource for the synthesis of Ag nanoparticles and their implementation to combat marine biofouling on ship hulls.

KEYWORDS: *Acetabularia acetabulum*, Antifouling Paint, Bactericidal activity, Montmorillonite (MMT), Nanocomposites, Silver (Ag) nanoparticles.

INTRODUCTION

Metallic nanoparticles have attracted global interest in recent years in the area of industrial, environmental and biomedical applications owing to their exceptional physicochemical properties. Extensive use of nanomaterials has attracted global interest in sustainable strategies for their synthesis which can alter their properties. Inherent properties of the nanoparticles can be easily altered with minor changes in their process of synthesis.

Traditionally, nanoparticles are synthesized using physical and chemical approaches, however, these methods involve the use of non-biodegradable

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Remediation potential of mushrooms and their spent substrate against environmental contaminants: An overview

Sahithya K, Mouli T, Ankita Biswas, Mercy Scorlet T

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Abstract

The large-scale application of synthetic compounds in industrial and agricultural sectors has contaminated the natural environment that further led to exacerbating the pollution-related problems in the ecosystem and human health. The rapid industrialization and anthropogenic activities of the present era have further increased environmental contamination with various organic chemicals and inorganic metals, including compounds like pesticides, industrial dyes, petroleum hydrocarbons, pharmaceutical waste and heavy metals. Hence, an effective strategy needs to be developed in order to eliminate pollutants from the environment. Since many decades, microbial based remediation approaches using bacteria, algae and fungi have been proved to be an

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REVIEW Open Access

Cardioprotective effects of Ferulic acid against various drugs and toxic agents

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Abstract

Background: Homeostatic regulation of cardiomyocytes is indispensable in maintaining the normal physiological activity of cardiac tissue. Cardiotoxicity induced by drugs may lead to cardiac abnormalities such as arrhythmia, myocardial infarction and myocardial hypertrophy. Moreover, drug-induced cardiotoxicity confines the additional use of the implicated drugs. Several studies have reported that consumption of phytochemicals on regular intervals shall protect humans against numerous diseases such as diabetes, cardiovascular disease, inflammatory diseases and cancer.

Main body: Ferulic acid (FA) is a plant derived polyphenol abundantly found in vegetables, fruits and grains. FA is widely known for its antioxidant, anti-inflammatory, anticancer, nephroprotective and hepatoprotective effects. FA has been well documented for its cardioprotective activity against various drugs and toxic agents as well. However, the cardioprotective action of FA have remained a challenge with regard to understanding its mechanism in health and diseases.

Conclusion: The main purpose of this review is to explore the cardioprotective mechanisms of FA against several drugs and chemicals to recommend further studies to investigate the potential protective effect of FA.

Keywords: Ferulic acid, Antioxidant, Cardioprotective, Preclinical, Cell line, Human health

1 Background

Cardiotoxicity usually denotes toxicity that has a harmful effect on the heart, which may ultimately result in myocardiopathy such as arrhythmia, myocardial infarction and myocardial hypertrophy [1, 2]. In the last few years, more than 20% of clinical drugs were forced out of the market because of cardiovascular side effects, which hampered the drug development and extremely affected the improvement in patient health [3]. Several studies have showed that drug-induced cardiac dysfunction may be a stepwise process accompanied by the increase of cardiac biomarkers and structural myocardial deformation, finally resulting in reduced left ventricular ejection fraction (LVEF) [4, 5]. Recently, the most accepted term for cardiotoxicity is the reduction in LVEF of at least 10% to less than 55% [6]. Studies show that cardiac cell death or damage concurrently occurs with the progression of cardiotoxicity, demonstrating that drug-induced cardiomyocyte death may be the major reason for cardiotoxicity [7].

In the recent years, extensive research has been undertaken to investigate the action of phytochemical compounds found in the diet [8]. They are commonly found in fruits, vegetables, beverages and herbal remedies [9]. These alkaloid compounds contain numerous active substances like flavonoids, polyphenols, indoles and sulfur containing elements [10]. These phytochemicals have the tendency to safeguard humans against diabetes mellitus, hepatic disorders, cardiovascular disease, cancer, arthritis, and Alzheimer's disease and many more [11, 12]. Findings from numerous studies have demonstrated that

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REVIEW PAPER

Antimicrobial and Environmental Applications of Inorganic Nanoparticles Synthesised from Plants

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ABSTRACT

Nanoscale materials are widely used in many fields including medicine, engineering, and the environment that focuses on the synthesis of nano dimensional particles is a timely topic. Nanomaterials synthesized by chemical approaches have intended effects on the environment and human health. In response to these challenges, plant-mediated synthesis of inorganic nanoparticles has been a highly innovative research area over the last decade. Aqueous and solvent extracts have been employed as efficient resources in synthesis-controlled nanostructures and the fabrication of various nanomaterials. The present article unveils the possible role of plant biomolecules including amino acids, aldehydes, terpenoids, ketones, tannins, and phenolics in the reduction and stabilization of various metal and metal oxide nanoparticles. The green synthesized nanoparticles evolved as efficient alternative agents in solving the serious threats faced in the field of biomedical, energy conversion, environment, automobiles, electronics, and optical. Moreover, catalytic, and antimicrobial applications of green nanoparticles are also critically discussed.

Keywords: *Antimicrobial applications, Biogenic nanoparticles, Environmental pollutants, Plant extracts, Remediation.*

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INTRODUCTION

Advances in material chemistry in the last few decades have played a prominent role in the development of nanoscience and nanotechnology which deals with the modification and utilization of particles of the order of one billionth of a meter (1×10^{-9} m) called nanomaterials. Nanoscience is a microscopic and molecular approach to the regulation of matter on larger scales, where the physiochemical properties of nanoparticles vary significantly from their larger counterparts. Unique characteristic features of nanomaterials have paved the way for new scientific inventions in the field of nanoscience and nanotechnology [1,2]. Nanomaterials have been categorized as organic (e.g., carbon-based nanomaterials) and inorganic (e.g., metal and metal oxide nanoparticles). Based on their overall dimension, nanomaterials are classified as zero-dimensional (e.g., quantum dots), one-dimensional (e.g., nanotubes), two-dimensional (e.g., nanosheets), and three-dimensional (e.g., nanoflowers). Further depending on their physicochemical features, they are subdivided into polymeric-based nanomaterials (e.g., nanobiocomposites), carbon-based nanomaterials (e.g., carbon nanotubes), lipid-based nanomaterials (e.g., liposomes), semiconductor-based nanomaterials (e.g., CdTe), layered nanomaterials (e.g., perovskites and LDH)

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Life Sciences Research

Review Article

Northeast India: A treasury of medicinal plants

Satayu Devi, Rituparna Sinha, Sibi G.

Abstract

The North-eastern region of India encompasses eight states viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. It is perhaps the most extravagant store of medicinal plants in the World. It is considered that the medicinal plants are the foundation of the conventional medicine. Almost 80% of the world populaces depend on conventional medications for essential medical services, a large portion of which include the utilization of extracts of medicinal plants. This conventional practice of medication assumes a significant part in the medical care of rural people for a wide range of diseases. They practice their own traditional healthcare system as they have an in-depth knowledge and understanding about plants, both conventional and non-conventional for their food and for medicine. This review thus underlines the different medicinal plants found across the entire north-eastern region and their respective potential uses or medicinal plant utilization for the significant well-being of mankind.

Keywords Northeast India, medicinal plants, pharmacology

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Introduction

India is known for its significant inheritance of natural and therapeutic knowledge. The ethnic individuals and tribals living in the distant backwoods territories actually rely upon the native frameworks of the remedy. The North East of India encircles the states namely Arunachal Pradesh, Assam, Mizoram, Manipur, Meghalaya, Nagaland, Tripura, and Sikkim [1]. The region is characterized by diverse physiography, ranging from plains, plateaus, and mountains with associated valleys [2]. The ordinary temperature all through the summer season remains 30 °C and ranges between 16 to 20°C during winter. The valleys and the sloping parts show a significant climatic divergence between them.

Therefore, tropical monsoon humid climates beat the north-eastern states. During the month of June -September the region gets incredibly heavy rainfall which is the South-west monsoon season, and in the long stretch of June, the region receives the maximum rainfall [3]. The richness of its land, good climatic condition, topographical, environmental diverseness, and vivid communities make the North East of India very unique and different from other subcontinent parts. Northeast India is consequently the geological 'entryway' for a lot of India's widely varied greenery, and as a result, the province is perhaps the wealthiest space of India in natural qualities [4]. The region is considered as one of the biodiversity hotspots of the world comprising about half of India’s biodiversity hence it forms a unique biogeographic territory including significant biomes. Starting with prairie, marshes, swamps, muggy evergreen timberlands, deciduous woodlands also all types of alpine and temperate vegetation are found here. The diverse

woodlands types found in the area are home to various plants and creatures [5]. For its high biodiversity and conventional knowledge, the north-eastern part has been at the center of attention, also this region has been a preference for driving preservation and protection organization of the world. The locale is rich in therapeutic plants and numerous other limited as well as endangered taxa [6]. An enormous number of ethnic individuals or clans are likewise possessed in this side of India. A broad traditional insight or information on compelling natural medicines are acquired by the tribes of the northeast, which was obtained through the experience, are typically passed on by oral practices as a protected mystery of specific families [7]. The greater part of the therapeutic plants utilized by tribes and local people of the province of Assam are native and are likely unknown to the huge world of phytochemical research and science. The dynamic fixings and intense phytochemicals with promising pharmacological properties present in those plants are beneficial to human health and few are yet to be investigated [8]. Perhaps some lifesaving drug formulation can be found from one or a few of those native medicinal plants of the northeast which are being utilized with trust and certainty by a large number of individuals, the villagers, and the tribes living in the northeast and can be a milestone in the realm of drug sciences and a gift to humankind everywhere on the globe [9]. Their recognizable proof, preservation of medicinally significant plant species, conventional information is a supreme prerequisite for our time. Even though many ethnomedicinal studies on Northeast of India has been completed by various scientist, yet at the same time, it is accepted that utilization of various plant for medical services is caught in the isolated space of the area [10].

Climatic condition

Northeast India gets the most noteworthy measure of rainfall in the world in the course of June to September, despite, it is encountering a fast parching over the most recent thirty years. This land is regarded as one of the biodiversity hotspots of the world and is confronting the biggest risks from anthropogenic exercises and climate variation. Since the rich vegetation, fauna, agricultural management has genuine ramifications on the biodiversity and subsistence of the occupants of this land [11]. It is considered that the moisture pattern of North Eastern India has gone through observed transformation in the new past. Tea crops experience the ill effects of dampness stress during the dry time followed by insufficient moisture [12]. The communications between the biotic components such as harvest plants, weeds, insect-pests, microorganisms, nematodes and so on and the abiotic components, for example, temperature, dampness, day-length, moisture, soil boundaries, etc. rule the ambience of a biological system. When take place together the abiotic stress elements regulate the impacts of biotic burdens and radically impact crop development and efficiency [13].

Tribes and traditional knowledge

An enormous number of native and worker ethnic and tribal communities are inhabited in this area with inexplicable physical and societal attributes. In the North-eastern states, in an excess of 200 unique clans with area lingo, custom, faith, inheritance, and socio-strict practice got resolved. It is accepted that this piece of India utilized as an essential hallway for human movements including, possibly, the primary relocations from Africa towards East Asia and Australia over 40,000 years prior [2,10]. The rates of ancestral populace change altogether in the northeastern region of India. The percentages of tribal population in the states of Manipur, Tripura and Assam are 34.41%, 30.95% and 12.82% respectively to the total populace. On the other hand, the percentage of tribal population in Arunachal Pradesh, Meghalaya, Mizoram and Nagaland are very high, where Mizoram itself holds 94.75% of the tribals to the total state's populace [14]. India consists of a total of 427 tribal groups out of which 180 important ones are nurtured by the eight states of the North-Eastern region. The tribal of the region exercise their own conventional wellness practice. They have immense knowledge about both traditional and novel food and medication and also inside and out comprehension about plants [15]. The Khasis, Bodos, Khyniams and Pnars, Mizos, Garos, Mishings and Karbis are the largest of all tribes in the northeast region. The Bodos stretch out from North Bengal toward the western Nagaon and the western Darrang. The biggest of the relative multitude of clans are the Bodos, Khasis, Khynriams and Pnars, Garos, Mizos, Karbis and Mishings. The Bodos stretch

out from North Bengal toward the western Nagaon and the western Darrang [16]. The Mizos are basically found in Mizoram and Cachar-Manipur line. The Karbis spread over north-eastern Meghalaya, western Nagaland and Karbi-Anglong. In Nagaland, Konyak, Sema, Aoand Angami are the biggest ancestral communities whereas Thado, Tangkhul, Kabui and Hmar are the significant ancestral communities of Manipur. In Arunachal Pradesh, the biggest gatherings are Galong, Nishi, Wancho and Adi. The north-eastern locale has outrageous heterogeneity as far as dissemination of ancestral populaces in various parts, their social constructions and cultural motif. Every single tribe has a spatial variety in tribal characteristics. For instance, the sub-divisions of the Khasis, namely the Wars, Khynriams, Pnars and Bhois are regional gatherings as well as every one of them has obtained recognizable diverse socio-social characteristics. The Dimasa Kacharis are conveyed in places of Assam and in the adjoining territory of Nagaland. The Dimasa Kacharis living in the North Cachar Hill area seem to have held a lot of their customary ancestral mores. On the other hand, on account of the Dimasa Kacharis living in Nagaon locale of Assam, the impact of Assamese culture is a lot perceptible, and thereby the Dimasa Kacharis living in the Cachar area of Assam, the impact of Bengali culture can be noticed in them. The level of acculturation in various areas of socio-cultural existence of the clans is unique [17]. Ethnic groups have consistently produced, refined and gave conventional apprehension from one age to another. This information depends on their requirements, sense, perception, experimentation and long insight. Such information is regularly a significant piece of their social personalities. Conventional information has played and still plays, an indispensable part in the day-by-day lives of those individuals. Customary information is fundamental for food security, safe house, custom and medical care framework. An enormous number of ethnic individuals are still live on distant woods and slopes. Farming through 'Jhum' of 'Moving' developments is the primary occupation of individuals. They are profoundly subject to regular assets including backwoods. The particular clans of the locale have their own and rich conventional information and using climate in day-by-day life. The information and method of usage of nearby plants differ with ethnic gatherings. The utilization of restorative plants assumes a fundamental part in the medical care of ancestral individuals [10].

Significance of medicinal plants

For ages medicinal plants are in use for human health management and still today through various scientific assessments it is serving the need with stability according to the necessity for the management of diseases. Likewise, it has made the stage for investigation and identification of the plants in various climatic zones, regions, areas, and at the state level [18]. The importance of medicinal plants and the traditional well-being system has an expanding focus on taking care of the health care issues of the world. During the investigation in various north-eastern states, it was seen that therapeutic plants are categorized in the structure having an entrenched system of medicines like Ayurveda, Unani, Siddha, Homeopathy, also, current remedy, and besides, the plants utilized by locals give wellbeing administrations by getting locally accessible herbs from nature. Therefore, northeast India addresses an amazingly different ecological community wealthy in the medicinal plant [19]. Among these numerous species of therapeutic plant, the northeast beginning has reformed the allopathic frameworks of medication. The medicinal plants likewise have basically connected with a significant situation in the socio-culture, profound and therapeutic field of individuals in the area. As per the World Health Organization (WHO), 80% of the provincial populace in Asian and African nations uses locally accessible therapeutic plants for their essential medical care needs. About 90% of the therapeutic plants of India are found in timberland territories, while just 10% of the therapeutic plants are conveyed among other scene components like open fields, horticultural fields, squander land, and in and around new water bodies [20]. Conventional clinical practice is a fundamental segment of the culture of individuals of North East India. Despite this condition, classical medical services endured difficulty during modernized human advancement, industrialization and lost support, especially in metropolitan regions. There is a escalate target around the significance of therapeutic plants and systems of traditional healthcare in taking care of the medical services issues of the world [21]. Natural items are acquiring worldwide owing to this advanced, occupied, and violated climate. As compared to the synthetic components, traditional herbal medication, enhancements, and beautifying agents are better, as they are

Table 1. List of medicinal plants from North East India and their uses

Botanical Name	Local Name	Medicinal Value	Reference
Abelmoschus manihot	Usipak	Improves renal inflammation and glomerular injury in chronic kidney disease	[26]
Abelmoschus moschatus	Gorokhia koroi	Insulin sensitivity	[27]
Abies spectabilis	Talishpatra	Expectorant, bronchial sedative, decongestant, anticatarrhal, antiseptic, carminative	[28]
Abroma augusta	Gorokhia koroi	Beneficial effect on diabetes	[29]
Abrus precatorius	Latumoni	Antiasthmatic property	[30]
Abutilon indicum	Pera petari	Analgesic, hepatoprotective, hypoglycemic properties	[31]
Acacia catechu	Khair	Anti-inflammatory, chemoprotective properties	[32]
Acacia concinna L.	Shikakai	Malaria, jaundice	[33]
Acacia polyacantha	Samaidh	Gastrointestinal infections	[34]
Acalypha indica	Mukuta-manjari	Antiulcer, bronchitis, asthma, wound healing	[35]
Achyranthes aspera	Hatisur	Arthritis, joint inflammation	[36]
Achyranthes bidentata Blume	Apamarga	Cures osteoporosis	[37]
Aconitum heterophyllum	Vatsanabh	Urinary infections, diarrhea	[38]
Aconitum palmatum	Visha	Antidiarrheal, antirheumatic, antiperiodic	[39]
Acorus calamus L.	Vacha, Bhadra	Constipation, asthma, fevers, bronchitis	[40]
Acronychia pedunculata (L.) Miq.	Laojan	Treats scabies, sores, ulcers, and intestinal infection	[41]
Actinodaphne angustifolia	Petarichawa	Urinary disorder, diabetes	[42]
Adiantum capillus-veneris L.	Hansraj	Antidiabetic, anticonvulsant, analgesic, hypocholesterolemic, goitrogenic, anti-thyroidal, wound healing, antiobesity, anti-asthmatic	[43]
Adiantum lunulatum Burm. f.	Hansavati	Cures atrophy, cachexia, emaciation, erysipelas	[44]
Aegle marmelos	Bel	Treatment and prevention of cancer.	[45]
Ageratum conyzoides L.	Puspaya	Antidysenteric property	[46]
Agrimonia pilosa Ledeb.	Roiseng	Cures astringent, hepatic, cholagogue, mild haemostatic, intestinal tract infection, gall bladder diseases	[47]
Ajuga bracteosa	Nilakantha	Anti-inflammatory, analgesic, antidepressant, anticoagulant properties	[48]
Alpinia allughasRosc.	Taraka	Cures rheumatism, bronchial catarrh, dyspepsia	[49]
Alstonia scholaris R. Br.	Saptaparan	Cardiotonic, antiarthritic, antidiabetic, antiplasmodial, analgesic properties	[50]
Alternanthera sessilis (L.) R.Br.	Matsyakshi	Febrifuge, galactagogue, cholagague	[47]
Altingia excelsa	Jutuli	Cures skin disorders	[51]
Amaranthus spinosus L.	Tenduliya	Antipyretic, antileprotic, leucorrhoea, acute bronchitis	[52]
Amomum subulatum Roxb.	Sthulela	Stomachic, antiemetic, antibilious, astringent	[47]
Abrus precatorius	Latumoni	Neuroprotective, abortifacient, nephroprotective, immunomodulator, immunostimulatory properties, antidiabetic effect	[53]
Aristolochia indica L.	Ishvari	Cures cholera, bowel troubles, menstrual problems, antineoplastic,	[54]

		abortifacient	
Artemisia vulgaris L.	Nagadamani	Menstrual regulator, nervine, stomachic, anthelmintic, choleretic, diaphoretic	[47]
Atlantia monophylla	Liimbu	Antibilious property	[47]
Bacopa monnieri (L.) Penn	Nira-brahmi	Treats skin diseases	[55]
Bambusa arundinacea (Retz.) Willd.	Vams	Anthelmintic, astringent, antiulcer, anti-diabetic properties	[56]
Barleria cristata L.	Hemtacho	Cures anaemia	[47]
Bauhinia purpurea L.	Kovidar, Vanaraja	Astringent, antidiarrhoeal, dysentry,	[47]
Berberis wallichiana DC.	Daru haridra	Treats diarrhoea	[57]
Boerhavia diffusa L	Punarnava	Diuretic, antiarthritic, anticonvulsant, analgesic properties	[47]
Brugmansia suaveolens L.	Dhattura	Treats asthma	[47]
Buddleja asiatica Lour.	Ointapin	Cures inflammation, rheumatism, skin disease, malaria	[58]
Butea monosperma (Lam.) Kuntze	Palasha	Antidiarrhoeal, dermal wound healing, antidiabetic, anticonvulsive, antihepatotoxic, antiestrogenic and anthelmintic activities	[59]
Caesalpinia crista L.	Lata Karanja	Anti-tumour, anticancer, anti-diabetic, anti-inflammatory, analgesic, cardioprotective, wound healing, anthelmintic, antipyretic and antiulcer activities	[60]
Callicarpa arborea Roxb.	Priyangu	Anti-diabetic activity	[61]
Callicarpa macrophylla Vahl.	Priyangu	Anti-inflammatory property	[62]
Calotropis gigantea (L.) R.Br.ex Ait.	Arka	Treats bronchial asthma, dyspepsia, constipation, flatulence	[47]
Cassia alata L.	Dadmardan	Cures skin diseases, bronchitis and asthama	[63]
Cassia fistula L.	Aragvadha	Treats constipation, convulsions, diarrhoea, dysuria and epilepsy	[64]
Cassia occidentalis L.	Kasmarda	Antidiabetic, anti-inflammatory, anticancerous, antimutagenic and hepatoprotective activity	[65]
Centella asiatica (L.)	Urban Brahmi	Anticancer, anti-inflammation, neuroprotection, antioxidant, wound healing, and antidepressant activities	[66]
Chenopodium ambrosioides L.	Mexican tea	Used to rid the body of parasitic intestinal worms	[67]
Chloranthus offlcinalis Blume	Lakangtaklang	Treats fracture	[68]
Cinnamomum tamala Nees and Eb.	Tamalaka	Carminative antidiarrhoeal, spasmolytic, hypoglycaemic activities	[69]
Cissampelos pareira L.	Ambastha	Analgesic antipyretic, diuretic, antilithic and emmenagogue properties	[70]
Cissus repens Lam.	Puraini	Treats sloughing, fetid ulcerations, boils and small abscess	[71]
Citrus maxima (Burm.) Merrill.	Madhukarkati	Treats convulsive cough, chorea, epilepsy, also in the treatment of haemorrhagic diseases	[47]
Citrus reticulata Blanco	Airavata	Dyspepsia, gastro-intestinal distension, cough with profuse phlegm, hiccup and vomiting	[72]
Cleome gynandra L.	Surjavarta	Epilepsy, irritable, bowel syndrome and in protozoal and worm infection	[73]
Clerodendrum serratum (L.) Moon.	Bharangi	Diuretic, gastric acidity	[47]
Clerodendrum viscosum Vent.	Bhantaka	Cough and cold, itching, effective against indigestion and abdominal pain	[74]
Coccinia indica W. and A.	Bimbi	Carminative, antipyretic, galactagogue,	[47]

		antidiabetic properties	
Coptis teeta Wall.	Mamira/ Mishmiteeta	Dyspepsia, dysentery and intestinal catarrh	[47]
Cordia dichotoma Forst.	Lasora	Astringent, demulcent, expectorant, diuretic, anthelmintic, mucilaginous properties	[47]
Crataevanurvela Buch-Ham	Varuna	Diuretic property	[47]
Croton caudatus Grisel.	Sonaphuli	Anticancer	[47]
Cryptolepis buchanani Roem. and Schult	Karanta	Blood-purifier, treats rickets	[47]
Curculigo orchioides Gaertn.	Talamuli	Nervine, adaptogenic, sedative, anticonvulsive, androgenic, anti-inflammatory and diuretic properties	[47]
Curcuma aromatica salisb	Sugandh Haldi	Antimicrobial, antifungal and anthelmintic properties	[47]
Curcuma caesia Roxb.	Narkachura	Carminative	[47]
Cyclea arnotii Miers.	Pathabheda	Treats smallpox, bone fractures, malarial fever, jaundice, stomachache.	[47]
Cynoglossum wallichii G. Don.	Lakshamana	Check bleeding	[76]
Datura metel L.	Sadah-dhatura	Antitumour, antirheumatic, anti-inflammatory, antiasthmatic, anticatarrhal, febrifuge, antidiarrhoeal, antidermatosis properties	[47]
Deeringia amaranthus Merrill	Latman	Cures sores	[77]
Desmodium triflorum (L.) D.C.	Kudaliya	Galactagogue, diarrhoea, diuretic properties	[47]
Dillenia indica L.	Bhavya	Laxative, carminative, bechic, febrifuge, antispasmodic, astringent properties	[47]
Dioscorea bulbifera L.	Vaarahi	Treats swellings, boils, ulcers, dysentery, piles, venereal sores	[47]
Diospyros kaki L. f.	Shimbi	Hypotensive, hepatoprotective, dyspnoea	[47]
Drymariadiandra Blume.	Kadokara	Treats ant febrile	[78]
Drynaria quercifolia (L.) J. Smith	Asvakarti	Treats chest diseases, cough, hectic fever, dyspepsia, loss of appetite, chronic jaundice and cutaneous affections	[47]
Eclipta prostate L.	Bhringaraja	Antihepatotoxic, anticatarrhal, febrifuge properties	[47]
Elaeocarpus sphaericus (Gaertn) Sch.	Rudraksha	Epileptic fits and headache	[47]
Embeliaribes Burm. f.	Vidanga	Ascaricidal, anthelmintic, carminative, diuretic, astringent, anti-inflammatory, antibacterial, febrifuge properties	[47]
Emilia sonchifolia (L.) DC.	Shashshruti	Analgesic, anti-inflammatory, antioxidant, anti-diarrheal anti diabetic, hepatoprotective, anti-anxiety, anti-convulsion and anti-cataract	[79]
Euphorbia hirta L.	Pusitoa	Pectoral, anti-asthmatic, antispasmodic properties	[47]
Euphorbia nerifolia L.	Snuhi	Diuretic, anti-asthmatic properties	[47]
Euphorbia thymifolia L.	Laghudugdhika	Antispasmodic, bronchodilator, anti-asthmatic, amenorrhoea properties	[47]
Exacum tetragonum Roxb.	Ava-chiratta, Kiratatikta	Stomachic, febrifuge, antifungal properties	[47]
Ficus carica L.	Falgu/bhadrodumbara	Analgesic, anti-inflammatory properties	[47]
Ficus hispida L.	Kokadumbara	Galactagogue, purgative properties	[47]

Ficus racemosus L	Udambara	Astringent, menorrhagia, leucorrhoea, urinary disorders, skin diseases, swellings, boils, haemorrhages.	[47]
Flemingia strobilifera R.Br.	Kushtunthi	Epilepsy, hysteria, insomnia	[80]
Gentiana kurroo Royle	Keri	Treats jaundice, nausea, vomiting, diarrhoea, malaria	[47]
Girardinia heterophylla Decne.	Bichhua	Treats swollen joints	[47]
Gmelina arborea Roxb.	Gambhari	Stomachic, laxative, antibilious, demulcent, galactagogue, anticephalalgic, febrifuge	[47]
Gnaphalium luteo-album L.	Shutamento	Astringent, haemostatic	[47]
Hedyotis corymbosa (L.) Lamk.	Parpata	Purifies blood, improves digestion, stimulates action of liver.	[47]
Hedyotis scandens Roxb. ex D. Don.	Shimbi	Treats bone fracture	[81]
Heracleum lanatum Michx.	Chem-mem	Stimulant, nervine tonic, spasmolytic.	[47]
Hibiscus abelmoschus L.	Latakasturi	Diuretic, antispasmodic, stomachic, nervin	[47]
Hibiscus esculentus L.	Gandhamula	Syphilis, catarrhal infections, ardorurinae, dysuria, gonorrhoea	[82]
Hibiscus rosa-sinensis L.	Japa	Bronchial catarrh, emmenagogue, menorrhagia	[47]
Houttuynia cordata Thunb.	Masundari	Anti-inflammatory	[83]
Hydnocarpus kurzii (King) Warb.	Tuvarakpratinidhi	Antileprotic, dermatic, febrifuge, sedative	[47]
Hydrocotyle javanica Thunb.	MandookaparniBheda	Blood purifier, indigestion, dysentery	[47]
Hydrocotyle rotundifolia Roxb	Mandukaparni	Treats diarrrhoea, dysentery	[84]
Hypodematium crenatum Forsk. Kuhn	Bhutkeshar	Dysentry	[78]
Illicium griffithii Hook. f. Thomson	Lissi	Carminative	[85]
Indigofera tinctoria L.	Nilika	Hepatoprotective, hypoglycaemic, nervine tonic, skin diseases, piles, anti-inflammatory, diuretic, hepatitis.	[47]
Jatropha curcas L.	Kanakeranda	Cures scabies, ringworm, eczema, whitlow, warts, syphilis.	[47]
Juglans regia L.	Aksoda	Laxative, antiseptic, mild hypoglycaemic, anti-inflammatory, antiscrofula	[47]
Kaempferia angustifolia Rosc.	Chandramulika	Cold, stomach ache, dysentery, and cough	[47]
Kalanchoe pinnata (Lamk.) Pers.	Patharchura	Anti-inflammatory, antifungal, antibacterial, burns, boils, swellings.	[47]
Lagerstromia parviflora Roxb.	Arjuna pratinidhi	Astringent, fungitoxic.	[47]
Lantana indica L.	Chaturangi	Treats cancer and tumors	[87]
Laportea crenulata Gaud	Utigun	Cures swellings and abscesses.	[47]
Leea indica (Burm. f.) Merrill	Karkatajihva	Antidiarrhoeal, antidysenteric, antispasmodic	[47]
Leucas indica L Nees	Pushpin	Antidiarrhoeal, antidysenteric, antispasmodic, cooling, sudorific.	[47]
Leucas lavandulaefolia Nees	Dronapushpi	Sedative in nervous disorders, stomachic and vermifuge	[47]
Lindenbergia indica (L.) Oktze.	Bheetchatti	Chronic bronchitis	[47]
Litsea cubeba BI.	Santu	Anticancer, anti-inflammatory, antidiabetic activity	[88]
Lobelia nicotianifolia Heyne	Devanala	Anti-asthmatic, antispasmodic, broncho-dilator, expectorant, mild sedative	[47]

Ludwigia octovalvis (Jac.) Raven	Shulavanga	Antidiabetic	[89]
Luffa acutangula (L.) Roxb.	Rajkoshataki	Splenic enlargement, cough and asthma	[47]
Luffa aegyptiaca (Mill.) L.	Dhamargava	Pharyngitis, rhinitis, mastitis, oedema, swellings and burns, chronic bronchitis.	[47]
Lycopodium clavatum L.	Nagbeli	Sedative, antispasmodic, diuretic.	[47]
Lygodium flexuosum Sw.	Kali jhanta	Carbuncles, treatment of jaundice	[90]
Mahonia napalensis DC	Tamen	Antiprolific, antipsoriatic, demulcent, diuretic, antidysenteric.	[47]
Melastoma malabathricum L.	Lakhori	Antidiarrhoeal, antiseptic, astringent, anti-leucorrhoeic	[47]
Mesua ferrea L.	Nagakeshara	Antidysenteric, astringent, haemostatic, anti-inflammatory, stomachic.	[47]
Michelia champaca L.	Champaka	Diarrhea, cough, bronchitis, hypertension, dyspepsia, fever, rheumatism, abscesses, dysmenorrhea and inflammation	[91]
Mirabilis jalapa L.	Krishnakeli	Used for treating uterine discharge, as poultice for abscesses and boils, inflammations and bruises	[47]
Mollugo pentaphylla L.	Paraptaka	Anti-inflammatory, analgesic, antipyretic	[92]
Morus alba L.	Tula/Tuda	Used for sore throat, dyspepsia, melancholia, expectorant, diuretic, hypotensive, hypoglycaemic, anti-inflammatory, emollient, diaphoretic	[47]
Mucuna pruriens (L.) DC.	Atmagupta	Astringent, nervine tonic, local stimulant, used in urinary troubles, leucorrhoea	[47]
Myrica esculenta Buch. D. Don.	Katphala	Carminative, antiseptic, used in fever, cough and asthma, also as a snuff in catarrh with headache, used externally for ulcers, pectoral, sedative.	[47]
Nicotiana tabacum L.	Tamahu	Arthralgia, lumbago, rheumatism and gout	[47]
Oenanthe javanica (Blume) DC.	Komprek	Strong antimutagenic and antitumour activity	[47]
Oganum vulgare L.	Van Tulasi	Anticancer, anti-inflammatory, antioxidant and antimicrobial activities.	[93]
Opuntia dillenii Haw.	Nagaphani	Applied as poultice to allay inflammation and heat	[47]
Oroxylum indicum Vent.	Shyonaka	Carminative, stomachic, spasmolytic, antidiarrhoeal, used for amoebic dysentery	[47]
Oxalis corniculata L.	Amlika	Tympanitis, dyspepsia, biliousness and dysentery anti-inflammatory, analgesic, antipyretic and antiscorbutic	[47]
Oxalis debilis H.B.K.	Changeribhed	Cuts/injuries and fire burn	[94]
Paederia foetida L.	Prasarani	Carminative, anti-inflammatory, astringent, spasmolytic, anti-diarrhoeal, diuretic, anti-inflammatory. Used for rheumatic affections, piles, inflammations of the liver, spleen	[47]
Panax pseudoginseng	Ginseng	Antiarrhythmic, digestive relaxant	[47]
Pandanus fascicularis Lamk.	Ketaki	Carminative, stomachic, antiseptic, ulcers, dysuria, scabies and other skin diseases.	[47]

Papaver somnifera L.	Ahiphena	Narcotic, sedative, hypnotic, analgesic, sudorific, anodyne, antispasmodic	[47]
Paris polyphylla Sm.	Mithi Vacha	Sedative, analgesic, haemostatic, anthelmintic	[47]
Pavetta indica L.	Parpata	Fomenting piles and for haemorrhoidal pains	[47]
Pericampylus glaucus (Lam.) Merill	Barakkanta	Treats asthma and high fever	[47]
Phlogacanthus thyrsiflorusNeesa	Chuhai/Titavasa	Whooping cough and menorrhagia	[47]
Phyllanthus reticulatus Poir	Krishna kambhoja	Astringent, diuretic, antidiabetic, antiviral, anticancer, antiplasmodial, hepatoprotective, antibacterial and anti-inflammatory	[95]
Phyllanthus urinaria L.	Tamar Valli	Diuretic, astringent, anti-inflammatory, styptic, used in prescriptions for dyspepsia, indigestion, chronic dysentery, urinary tract diseases, diabetes, skin eruptions	[47]
Physalis angulata Ham.	Phooligach	Diuretic	[47]
Pinus roxberghii L.	Saral	Cough and cold remedies	[47]
Piper longum L.	Pippali	Used for diseases of the respiratory tract, as sedative, cholagogue	[47]
Piper nigrum L.	Maricha	Stimulant, carminative, diuretic, antiasthmatic, used in fevers, dyspepsia, flatulence, indigestion, and as mucous membrane and gastro-intestinal stimulant	[47]
Plantago erosa Wall.	AshvagolBhed	Constipation, improves digestion, astringent, demulcent, diuretic, expectorant, anti-inflammatory	[96]
Podophyllum hexandrum Royle	Bankakri	Antineoplastic, strongly irritant to skin and mucous membranes	[47]
Pongamia pinnata (L.)	Pierre Karanj	Scabies, herpes, leucoderma and other cutaneous diseases	[47]
Portulaca oleracea L.	Lonika	Refrigerant, mild spasmodic, diuretic, antiscorbutic, used in scurvy and in diseases of liver, spleen, kidney and bladder, also in dysuria, stomatitis and dysentery	[47]
Potentilla sundaica (Bl.) Okbze	Vajradanti	Sore throat and cough	[97]
Pouzolzia viminea Wedd.	Phutibum	Root paste is applied on haemorrhages and as haemostastic	[98]
Premna latifolia Roxb.	Agnimanthabhed	Diuretic, spasmolytic, hypoglycaemic.	[47]
Punica granatum L.	Dadima	Astringent, stomachic, digestive, diarrhoea, dysentery, dyspepsia, uterine disorders	[47]
Rauvolfia serpentina	Chotachand	Insomnia and schizophrenia	[99]
Rauvolfia tetraphylla L.	SarpagandhaBhed	Sedative, hypotensive	[47]
Rhododendron arboreum Sm.	Kurbak	Anticephalalgic, spasmolytic, used in diarrhoea and dysentery.	[47]
Ricinus communis L.	Eranda	Purgative, dermatosis and eczema	[47]
Rorippa indica L.	Hiern	Antiscorbutic, stimulant, diuretic, laxative, prescribed in the treatment of asthma	[47]
Rumex maritimus L.	Jungli Palak	Catharitic, externally applied to burn	[47]
Rungia pectinata (L.) Nees	Pindi	Febrifuge, refrigerant	[47]
Saccharum officinarum L.	Ikshu	Laxative, demulcent, diuretic, antiseptic, haemophilic conditions, jaundice and urinary diseases.	[47]

Saccharum spontaneum L	Kash	Astringent, diuretic, galactagogue, dysuria, dyscrasia, kidney and bladder stones, dysentery, bleeding piles, galactagogue.	[47]
Sambucus hookeriRehder	Utikhamal	Cures fever	[105]
Saraca asoca L.	Ashoka	Uterine tonic, haemorrhagic dysentery, bleeding piles	[47]
Saurauia armata Kurz.	Poparar	Leaves applied on the wounds	[100]
Saussurea lappa C.B. Clark.	Kuth	Antispasmodic, expectorant, carminative, astringent, antiseptic	[47]
Schima wallichii (DC.)	KorthChilauni	Anthelmintic, rubefacient	[47]
Sida acuta Burm. f.	Bala	Astringent, stomachic, febrifuge, diuretic, demulcent	[47]
Smilax glabra Roxb.	Bari Chobchini	Syphilis, venereal diseases and sores	[47]
Smilax ovalifolia Roxb.	Maitri	Urinary infections, rheumatism, dysentery	[47]
Solanum nigrum L.Medd	Kakamachi	Anti-inflammatory, antispasmodic, sedative, diuretic, laxative, antiseptic	[47]
Solanum torvum Gaertn.	Swetkantakari	Digestive, diuretic, sedative	[47]
Solanum verbascifolium L.	Vidari	Skin disease and as an abortivum	[101]
Solanum viarum Dunal	Khasianum	Treatment of cancer therapy, rheumatism, chronic asthma, skin disease, obesity, and leukaemia	[102]
Spermacoce hispida L.	Madanaghanti	Astringent in haemorrhoids, gall stones, diarrhoea and dysentery	[47]
Stephania glandulaefolia Miers	Rotunda	Heals knee joint during rheumatic arthritis	[103]
Stephania japonica (Thunb.)	Rajpatha/ Vanatiktika	Malarial fever, stomach and cardiac disorders, and diabetes	[104]
Stereospermum chelonoides (L.f.) DC.	Patoli	Oedema and retention of urine	[47]
Symplocos racemosa Roxb	Lodhra	Remedy for uterine complaints, vaginal diseases and menstrual disorders, menorrhagia, leucorrhoea	[47]
Syzygium cumuni (L.) Skeel	Jambu	Stomachic, carminative, diuretic, antidiarrhoeal, hypoglycaemic	[47]
Tamarindus indicus L.	Chincha	Carminative, laxative, antiscorbutic, infusion prescribed in febrile diseases and bilious disorders	[47]
Taxus wallichiana L.	Talisa Patra	Antiepileptic, anti-inflammatory, anticancer, antipyretic, analgesic	[105]
Tephrosia candida DC.	Mashaparni	Antitumor	[106]
Terminalia arjuna (Roxb. ex DC.) W and A.	Arjuna	Cardioprotective and cardiotonic, as a diuretic in cirrhosis of liver and for symptomatic relief in hypertension, externally in skin diseases, Herpes and leukoderma	[47]
Terminalia bellirica (Gaertn.) Roxb.	Bahera	Diarrhoea, dyspepsia, biliousness, cough, bronchitis and upper respiratory tract infections, tropical pulmonary eosinophilia and allergic eruptions	[47]
Terminalia chebula Retz	Haritaki	Constipation, diarrhoea, dysentery, cyst, vomiting, enlarged liver and spleen, cough and bronchial asthma, and for metabolic harmony, diuretic	[47]
Thalictrum foliolosum DC.	Pitamulikapratinidh	Used against gout and rheumatism, febrifuge, antiperiodic	[47]
Thevetia peruviana (pers.) Merill.	Karvira	Bitter cathartic, emetic	[47]
Thunbergia grandiflora Roxb.	Kakanasa	Treats cut, wounds, gastric ulcers	[107]
Tinospora cordifolia (Willd.)	Guduchi	Antipyretic, antiperiodic, anti-	[47]

Miers		inflammatory, antirheumatic, spasmolytic, hypoglycaemic, hepatoprotective	
Toddalia asiatica (L.) Lamk.	Kanchana	Febrifuge, diuretic, antispasmodic, antipyretic, diaphoretic, antiperiodic	[47]
Trichosanthes anguina L.	Shwetraji	Antibilious, vermifuge, antidiarrhoeal, improve appetite, cure biliousness	[47]
Trichosanthes tricuspidata (Lour.) Voight	Mahakala	Asthma, earache andozoena	[108]
Triumfetta rhomboids Jacq.	Jhinjhirita	Astringent, anticholerin, demulcent, Used in diarrhoea and dysentery, diuretic, galactogenic	[47]
Urena lobata L.	Vanabheda	Diuretic, emollient, antispasmodic, antirheumatic	[47]
Valeriana jatamansi Wall.	Tagara	Remedy for hysteria, sedative	[47]
Vanda coerulea	Bhatouphul	Effect against glaucoma and cataract	[109]
Vernonia albicans DC	Sahadevi	Treat earache problems	[110]
Viola pilosa Bl.	Vanafsha	Expectorant, anti-inflammatory, diaphoretic, antipyretic, diuretic	[47]
Vitex negundo (L.)	Nirgundi	Anti-inflammatory, analgesic, astringent, febrifuge, antidiarrhoeic	[47]
Zanthoxylum armatum DC	TumbruBheda	Treats diarrhoea, carminative, antispasmodic, anthelmintic, dyspepsia and skin diseases	[47]
Ziziphus mauritiana Lamk	Tumbru	Astringent, stomachic, styptic, expectorant, antidiarrhoeal, antispasmodic, antiemetic, diaphoretic	[47]

effectively accessible, cost-effective, better viable with physiological verdure, and in particular, have no side effects [22]. Aside from medical care, the underprivileged communities trade the medicinal plant as an alternate income profound source. Thus, enhancing this area may benefit and improve the ways of life and everyday comforts of destitute people [23]. The need of great importance is to saddle this normal asset economically for the financial advancement of the nearby and native individuals while securing the biodiversity simultaneously. The procedures like planting of medicinal plants merged with viable collection use from the wild would be valuable in accomplishing this objective. In the 21st century, preservation, practical utilization of therapeutic plants of North East India will enrich the confidence of millions for India's own wellbeing needs and has worldwide significance. In contrast, many species of medicinal plants are used in animal husbandry as an essential source of health care in this region [24]. The dependence on medicinal plants is likewise because of cultural inclinations. Medicinal plants have strong acknowledgment in religious practices of local communities in north-eastern states, who worship the plants as different divine [25]. In view of different identification and review medicinal of plants, researchers have made various reports on it. Likewise, a broad investigation of medicinal plants in various North-eastern states and archived data on those plants which are utilized in the administration of different afflictions in the human body are described.

Discussion

Medicinal plants are assets of conventional medicines and a large number of the advanced drugs are created by implication from plants. They have additionally assumed a fundamental part in the improvement of human civilization. Since the beginning of history, man has depended much on therapeutic plants for wellbeing and food needs. There was conventional utilization of medicinal plants for relieving and forestalling diseases, together with the advancement of both physical and profound prosperity among individuals. The utilization of herbs to cure illness is practically all-inclusive among non-industrialized social orders and the decency and mending properties of herbal plants were examined by individuals for ages. The regional community has a long history of conventional plant use for therapeutic purposes. Indeed, the antiquated man was absolutely reliant upon green plants for his everyday requirements of medicaments.

The more we find out about plants, the more we discover approaches to utilize them to help wellbeing. At an extremely fundamental level, we can also utilize them in the preparation of food. Medicinal plants are significant components of native clinical frameworks everywhere in the world.

All societies have a background marked by natural medication use, typically utilizing the plants found nearest to home. Indeed, even today in the hours of trend-setting innovation, clinical science actually relies upon plants for their mending. Northeast India has the most extravagant supply of plant variety in India and is one of the 'biodiversity areas of interest' which falls underneath the Himalaya and the Indo-Burma biodiversity, shaping a novel biogeographic territory holding onto significant biomes perceived on the planet. This area is likewise notable for different cultures of human races and is occupied by countless tribals of different ethnic classes. These ethnic networks are wealthy in conventional learning and honing conventional mending since the days of yore. There is an immense potential to do ethnobotanical exploration in the area, principally, in light of the fact that, a big part of the complete Indian ancestral people inhabit and exercise their traditions in their own novel manner. Conventional mending is the primeval type of organized strategy for medication that depends on elemental ideology and the set of fundamentals by which it is exercised. Ethnic people have consistently created, refined and gave conventional information from one age to another. This information depends on their necessities, intuition, perception, experimentation and long insight. Such information is frequently a significant piece of their social characters. Conventional information has played and still plays, an imperative job in the everyday lives of these individuals. The helpful action of such plants has made a remarkable commitment in the beginning and development of numerous customary herbal treatments, yet such society conventional framework they had or acquired as an inheritance is disappearing quick or contaminated with the effect of advancement. The bio-assets alongside the rich native information frameworks are exhausting so quickly because of different anthropogenic exercises and fast urbanization. A portion of the therapeutic plants is circulated in high power while certain others continue draining from their natural environment. This consumption is because of the high pressing factors for their un-foundational abuse through shifting cultivation extension of urbanization, horticultural land and street advancement just as some regular catastrophes like land sliding, and so on. Subsequently, it needs critical precise examination utilizing biotechnological devices to validate and establish new novel medications from the rich bio-assets of the land. Logical methodology for their examination, use, protection and worth expansion might be the central issues for business venture improvement by abusing the native innovation information. In light of the above study, it very well may be presumed that therapeutic or medicinal plants are incredible practical herbs, which are for the most part gainful to mankind. It is the various synthetic component, which dwells inside the therapeutic plants that bring out a specific physiological activity on the human body. For the most part, synthetic compounds which are available inside the medicinal plants are phenolic, alkaloids, flavonoids and tannins and so forth.

Conclusion

Nevertheless, the boundless utilization of medicinal plants is not limited to developing countries. The resurrection of the natural remedies, which, has occurred in the developing nations, occurred on account of the restoration of interests in the logical data of plants. The doctors cannot overlook the utilization of herbal medications. They ought to acknowledge is that an enormous number of patients are actually utilizing herbal medications. The divulgence from the patients utilizing natural medicines may divert them to utilize therapeutic plants for the cure as well. The patients and the doctors ought to go into a conversation and should analyze the aptness of herbal medications over pharmaceutical drugs.

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Review Article

Northeast India: A treasury of medicinal plants

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Abstract

The North-eastern region of India encompasses eight states viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. It is perhaps the most extravagant store of medicinal plants in the World. It is considered that the medicinal plants are the foundation of the conventional medicine. Almost 80% of the world populaces depend on conventional medications for essential medical services, a large portion of which include the utilization of extracts of medicinal plants. This conventional practice of medication assumes a significant part in the medical care of rural people for a wide range of diseases. They practice their own traditional healthcare system as they have an in-depth knowledge and understanding about plants, both conventional and non-conventional for their food and for medicine. This review thus underlines the different medicinal plants found across the entire north-eastern region and their respective potential uses or medicinal plant utilization for the significant well-being of mankind.

Keywords Northeast India, medicinal plants, pharmacology

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Introduction

India is known for its significant inheritance of natural and therapeutic knowledge. The ethnic individuals and tribals living in the distant backwoods territories actually rely upon the native frameworks of the remedy. The North East of India encircles the states namely Arunachal Pradesh, Assam, Mizoram, Manipur, Meghalaya, Nagaland, Tripura, and Sikkim [1]. The region is characterized by diverse physiography, ranging from plains, plateaus, and mountains with associated valleys [2]. The ordinary temperature all through the summer season remains 30 °C and ranges between 16 to 20°C during winter. The valleys and the sloping parts show a significant climatic divergence between them.

Therefore, tropical monsoon humid climates beat the north-eastern states. During the month of June -September the region gets incredibly heavy rainfall which is the South-west monsoon season, and in the long stretch of June, the region receives the maximum rainfall [3]. The richness of its land, good climatic condition, topographical, environmental diverseness, and vivid communities make the North East of India very unique and different from other subcontinent parts. Northeast India is consequently the geological 'entryway' for a lot of India's widely varied greenery, and as a result, the province is perhaps the wealthiest space of India in natural qualities [4]. The region is considered as one of the biodiversity hotspots of the world comprising about half of India's biodiversity hence it forms a unique biogeographic territory including significant biomes. Starting with prairie, marshes, swamps, muggy evergreen timberlands, deciduous woodlands also all types of alpine and temperate vegetation are found here. The diverse

Stable expression of *Helicobacter pylori cagA* oncoprotein in brinjal

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Abstract

Helicobacter pylori is closely connected to upper gastrointestinal tract diseases including gastric cancer. Transgenic plants are found to be successful in expressing the bacterial antigens, which could elicit an immune response when consumed. The Cytotoxicity-associated immunodominant antigen protein (*cagA*) of *H. pylori* is kindred with pathogenicity and cancer risk. We expressed the *cagA* transgenically in the brinjal. We amplified the *cagA* gene from *H. pylori* strain 26695 chromosomal DNA and transformed it into brinjal callus derived from leaf explants using the pBI121 expression vector. The stable expression and accumulation of the recombinant *cagA* gene were confirmed by using quantitative real-time PCR**,** western blot analysis and ELISA. The RT-PCR, western blot and ELISA showed stable expression of *cagA* gene in the transgenic lines B3, B5, B11, B17 and B21. Among them, B11 and B17 samples showed higher expression of the *cagA* compared to the other samples. Besides, the immunohistochemistry assay showed the abundant expression of *cagA* protein in the parenchymal regions of the transgenic plants. Out of the 52 plants, a set five plants were found to be positive for *cagA* expression. Our experimental outcomes can be used further to design the vaccines against *H. pylori* from the transgenic brinjal plants.

Keywords: *Helicobacter pylori*; transgenic brinjal; *cagA*

Introduction

Helicobacter pylori, a stomach colonizing bacterium is widely and infectious (Ohnishi et al., 2008). It is a chronic bacterial infection that is the primary reason for spawning gastric cancer in humans (Nešić et al., 2014). It is a human gastric pathogen, infecting more than half of the world's population (Hooi et al., 2017), which leads to chronic infection in the absence of antibiotic treatment (Malfertheiner et al., 2017). Gastric cancer is thought to be frequently caused by chronic *H. pylori* infection (Fallone et al., 2016). Around the world, more than 89% of gastric cancer cases are found to be related to *H. pylori* infection (Josephson and Skole, 2018; Turabi et al., 2022). In 1994, the WHO International Agency for Research on Cancer (IARC) confirmed *H. pylori* as a Group I carcinogen and its eradication is very important to prevent gastric cancer among both developed and developing nations (Hooi et al., 2017; Chatterjee et al., 2021). Increasing antibiotic resistance is also responsible for the failure in prophylaxis against this pathogen, which is again leading to a downfall in the prognosis of *H. pylori* eradication (BARZIGAR et al., 2020). In Europe alone, the traditional usage of triple therapy was stopped and replaced with quadruple therapy (Graham and Shiotani, 2008). However, due to the lack of proper guidelines in quadruple therapy, antibiotics are suggested randomly just to reduce the rate of antibiotic resistance.

People infected with *H. pylori cagA*-positive strains are said to be more prone to gastric cancer. *cagA* (cytotoxin-associated gene A) is a 120–145kDa protein that is responsible for the virulence of the strain to cause human cancer (Barzigar et al., 2021). This *cagA* protein encoded by the *cagA* gene is dispatched into epithelial cells of the stomach through bacterial type IV secretion which then encounters tyrosine phosphorylation. This in turn flirts as a non-physiological protein

interacting with many signaling molecules like pro-oncogenic phosphatase and polarity-regulating kinase (PAR1) (Backert et al., 2011). This manipulation conciliated by intracellular signaling not only boosts neoplastic malformations but also destroys the epithelial lining of stomach cells (Hatakeyama, 2017).

The most effective way to control the infection of this bacterium is vaccination (Pan et al., 2018). As urease subunit B (*ureB*) gene was found to be more protective than urea it was considered as a potential antigen against *H. pylori*. Cost is one of the major barriers to produce new vaccines for populations that need them urgently. It has been estimated that downstream processing and purification of recombinant proteins represent 80% to 90% of the cost of recombinant pharmaceuticals (Sabalza et al., 2014). Several factors such as plant pathogens, phenolic compounds, and secondary metabolites could affect the difficulty of purification at an industrial level (Abdoli-Nasab et al., 2013). Plant-derived recombinant proteins will be inexpensive in production with good product quality and free from other animal viruses. The development of new vaccines and drugs is one of the vital goals in molecular farming especially in developing countries (Soria-Guerra et al., 2007). One of the advantages of plant expression systems is the production of edible vaccines using leafy plants, fruits or vegetables. The oral-based plant delivery system would eliminate the purification process, sterile injection hazards, health care workers, and also cold storage (Streatfield and Howard, 2003). Oral delivery promotes the induction of systemic and mucosal immunity; additionally, bioencapsulation by cellulosic plant cell walls protects proteins from digestion (Tiwari et al., 2009).

Brinjal or aubergine, commonly called eggplant, is notably known as the common man's vegetable in India and many Asia and Latin American countries (Wei et al., 2019). It is also

crowned as a poor man's vegetable owing to its accepted usage among people and farmers with low income, and it is often crowned as the 'King of Vegetables' (Meyer et al., 2012). It is very often used in ayurvedic formulations to cure diabetes, blood pressure and obesity. The brinjal plant belongs to the family *Solanaceae,* and it is cultivated in many parts of the world. The brinjal has the ability to respond well in tissue culture, particularly plant regeneration from cultured seedling explants (leaf, cotyledon and hypocotyl). Brinjal also responds well to *Agrobacterium*- mediated transformation with both cointegrate and binary vectors (Iannacone et al., 1997). A number of plant systems including *Arabidopsis,* rice, carrot and tomato were used as recombinant models for the expression of various genes including potential pharmaceuticals (Saini and Kaushik, 2019). However, brinjal is not explored to a great extent as a potential genetic engineering model in this field and only limited reports describing the use of eggplant in molecular farming (Mehran et al.; Mehran et al., 2021). So, we have decided to use brinjal for our study. To probe for the possible usage of plants to produce *H. pylori cagA*, efforts have been made in this study to express the clone of *cagA* gene from *H. pylori* strain 26695 in the brinjal, *Solanum melongena L. Cultivar* Arka Keshav. Using brinjal plants, we demonstrated the expression of the *cagA* gene. Our results insinuate that further studies could throw more light in bringing out possible vaccines against *H. pylori* from the brinjal plant.

Materials and Methods

Amplification of *cagA* gene from *H. pylori* 26695

cagA forward and reverse primer pairs were used for PCR amplification. To clone the DNA corresponding to ~1700bp, synthetic oligonucleotide primers determining the sequence of *H. pylori* were constructed.

In a total volume of 25µl, the amplification reaction contains roughly 50ng of total gDNA as template, Hotstart Taq DNA polymerase (1U), dNTPs (0.2mM each), 1 PCR buffer, MgCl2 (3mM), and primers (10pmol of each primer). Initial denaturation at 94°C for 10 minutes was followed by 35 cycles (94°C, 30sec; 55°C, 30sec; 72°C 2min) and a final extension at 72°C for 10 minutes. After that, the produced products were separated on a 1% agarose gel and the results were determined using a UV transilluminator (Paul et al., 2018; Ramasamy Rajesh Kumar, 2020; Saravanakumari et al., 2020; Paul et al., 2022b). The DNA fragments were purified from the agarose gel using the Genei clean purification technique (Genei Gel Extraction Kit). According to the instructions, the Miniprep Kit (Genei) has been used to obtain pure super-coiled plasmid DNA with excellent yield (35µl) (Arumugaperumal et al., 2020; Garcia Jr et al., 2020; Kumar et al., 2020).

Cloning of *cagA* gene in pBI121

We cloned the *cagA* gene, which is around 1700bp long, in order to utilise the plants to stimulate an immunological response in *H. pylori* infected individuals. After that, the gene was amplified, and the pure product (1%) from an agarose gel was cleaved with *BamHI* and *SacI* (37^0C for 2hr). The restriction enzymes were also used to digest the vector. Using the Genei gel extraction kit, the bands were removed and cleaned. The linearized vector and *cagA* product then were ligated overnight at 16^0C using T4 DNA ligase, then transformed into the DH5α strain and verified by sequencing (Eurofins, Bangalore).

Preparation of competent cells and transformation

All *E. coli* cells are made competent using the calcium chloride approach (Chang et al. 2017), then streaked on LB-agar plates without antibiotics and incubated for 12 hours at 37°C. A single

colony was injected into 10mL of LB medium and cultured at 37°C until the culture attained an optical density of 0.4-0.5 at 660nm (3- 4hr). The cells were cooled on ice for 30 minutes before being extracted in autoclaved tubes using an SS 34 rotor (Sorvall refrigerated centrifuge) for 15minutes at 4°C (Evolution RC). The cell pellets were resuspended in 30ml of filter-sterilized ice-cold acid salt buffer (100mM $CaCl_2$, 70mM $MnCl_2$, and 40mM sodium acetate, pH 5.2-5.5) and incubated for 45 minutes on ice.

The pellet was dissolved in $1/25^{th}$ volume of bacterial suspension in acid salt buffer containing 20% glycerol after being spun at 3000rpm for 15 minutes at 4°C (cell pellet from 90 ml culture was suspended in 4.5ml of buffer). 50µl aliquots were prepared and kept at -70°C until needed. By incubating competent DH5α *E. coli* cells on ice for 30 minutes and then heat shock at 37^oC for 5 minutes, the pBI121 vector harboring the *cagA* gene was transformed. The *E. coli* cells were then cultured on LB agar plates with antibiotics (Kanamycin 20µg/ml). The plates were then incubated for 12 hours at 37 degrees Celsius, and bacteria were tested for pBI121 insertion.

Isolation of plasmid DNA

Single isolated colony was inoculated in 5ml of antibiotic-laced LB media and cultured for 12 hours on a shaker incubator at 37°C (120rpm). The alkaline lysis procedure was used to isolate the plasmid DNA (Sambrook and Russell, 2006). The pellet from a 5ml overnight culture was spun at 6000g for 5 minutes at 4°C and resuspended in 200µl of prechilled solution I. 200µl of freshly made solution II were added and carefully mixed by tipping the container upside down. After solution II, 200µl of solution III was poured and carefully mixed, then maintained on ice for 10 minutes. The cell lysate was spun at 8000g for 10 minutes at 4°C after incubation. An

equal volume of phenol, chloroform, and isoamylalcohol mixture (25:24:1; v/v) was added to the supernatant and well mixed.

The contents then were spun at 8000g for 10 minutes at 4 °C before being mixed with an equivalent amount of pre-chilled isopropanol. The DNA then was pelleted at 8000g for 10 minutes at 4°C before being reconstituted in 10mM TE buffer. On a 0.8 percent agarose gel electrophoresis, the purity of the recovered plasmid DNA was verified. Restriction digestion and DNA sequencing were used to confirm positive clones.

Callus induction

Eggplant seeds of the variety Arka Keshav were surface sterilised using sodium hypochlorite (6%) plus water in a 1:1 ratio, then washed 3-4 times with sterile distilled water. About 20 seeds were inoculated on Petri plates with N6 callus induction medium (pH 5.75) containing 10,000mg/l Myoinositol, 200mg/l Glycine, 50mg/l Thiamine HCl, 50mg/l Pyridoxine HCl, and 50mg/l Nicotinic acid. After autoclaving the previously mentioned contents, 10M BAP and 1M NAA were added to the medium. The medium was solidified with 0.8 percent agar. After that, the Petri plates were incubated in the dark at 252°C. The calli were then extracted from the growing seeds and subcultured on a new callus induction medium. Explants in our investigation included median sections of cotyledonary leaves plus crosswise cut hypocotyl segments.

***Agrobacterium*-mediated transformation**

With minor modifications, the calli produced from the seeds were employed in *Agrobacterium* (EHA105)-mediated transformation as described by Patel et al., 2013 (Patel et al., 2013). Electroporation was used to introduce the vectors into *Agrobacterium*. In a nutshell, 5 litres of

plasmid DNA were put to 45 litres of cells and gently mixed. The contents are electroporated after being put to a prechilled cuvette. The vector constructs were implanted into 5ml of YEP (yeast-extract-mannitol medium; pH 7.0) medium (containing 20mg/l Rifampicin and 50mg/l Kanamycin) and cultured at 28°C in a shaking incubator (200rpm) overnight. Overnight culture broth was added to 45ml of infection medium (MS baseline media with Thiamine HCl [1mg/l], Myoinositol [250mg/l], Casein hydrolysate [1.0g/l], Proline [690mg/l], Glucose [30g/l], 2,4-D [5.0mg/l], and Acetosyringone [200M]) at pH 5.2 and incubated at 28°C. *Agrobacterium* colony PCR was used to validate the insert *cagA*.

Isolation of genomic DNA from leaves

Genomic DNA was isolated from the leaves by the CTAB method as described by Li, Z *et al.*, 2020 (Li et al., 2020). In brief, about 100mg of leaf tissue was homogenized in a micro pestle with 0.5ml of extraction buffer (2% CTAB, 1.4M NaCl, 20mM EDTA, 10mM Tris HCl; pH 8.0) with a 10µ1 of beta-mercaptoethanol. The contents were mixed thoroughly and incubated for 30-40min at 65°C in a water bath, and added with equal volumes of chloroform: isoamyl alcohol (24:1) following incubation. The contents were then centrifuged at 5000rpm for 15min at room temperature and added with $1/10^{th}$ volume of 5M NaCl and added with 0.8volumes of ice-cold isopropanol to precipitate the DNA. The DNA obtained was then pelleted at 8000rpm for 10min and washed with 70% ethanol. Following washing, the pellet was resuspended in 100µl of TE buffer. 5µl of RNase (l0mg/ml) was added to the DNA and stored at -20° C following incubation at 37°C for 1 hour.

PCR amplification of *cagA*

Real-time PCR as well as western blot were used on total RNA separated from leaves of wild-type and transgenic plants to measure the expression level of *cagA* mRNA. In the control group, no bands were seen. As described in the preceding chapter, PCR amplification was carried out. The template was made using genomic DNA extracted from the plants. To validate the *cagA* gene insert, the products then were tested on a 1% agarose gel. The Primer 3 programme (version 4.13) was used to create all primers utilised in this work (Table 1), which were predicated on mRNA sequences deposited in GenBank (Untergasser et al., 2012). Primers were crosschecked for specificity using BLASTN algorithm (Chinnadurai et al., 2018; Alaguponniah et al., 2020; Kumavath et al., 2021; Miao et al., 2022). They may amplify genomic DNA and also cDNA since each primer set is placed on the same exon of the gene. As a result, DNase treatment was used to guarantee that the RNA samples were devoid of DNA. The amplification of cDNA using the chosen primers was verified using conventional RT-PCR tests followed by gel electrophoresis (Bleve et al., 2003; Rana et al., 2022b; Rana et al., 2022a).

RNA extraction and cDNA synthesis

The plant leaves are flash-frozen with liquid nitrogen and preserved at –80°C after steady transformation of the Brinjal plant expression. The whole leaves were pounded into a fine powder in liquid nitrogen using a mortar and pestle. The RNeasy Plant Mini Kit (Genei Laboratories Pvt Ltd) was used to extract total RNA from 100mg of ground tissue according to the manufacturer's instructions. With the M-MuLV RT-PCR Kit, the cDNA was generated as reported by Ramalho *et al* 2004 (Ramalho et al., 2004). As a starting material, around 2µg of the RNA produced in the preceding phase was employed. We utilised around 1.02 litres of total RNA, random primers, and 1µl of RT enzyme because the RNA concentration was 40µg/ml.

Following the initial incubation, the contents were incubated at 25°C for 10 minutes and then at 70°C for 45 minutes. The generated cDNA was utilised to amplify the entire *cagA* gene as well as for qPCR expression experiments. The *cagA* was successfully amplified to determine the amount of *cagA* mRNA expression in the tissues. The amplification was carried out as per the protocols mentioned by Green *et al.*, 2019 (Green and Sambrook, 2019). To validate the *cagA* gene insert, the products were tested on a 1.2 percent agarose gel.

Real-time PCR

On cDNA templates, a quantitative RT-PCR experiment was performed using the SYBR Green PCR master mix (Bio-Rad) as per the manufacturer's protocols (BioRad) using the designed oligonucleotide primers given in table 1 (Schmidt and Delaney, 2010). A 25µl reaction including 2.5µl of 10x PCR buffer with SyBr green, 2.5µl of 10mM dNTPs, 10pmoles/l of each primer, 10.4µl of PCR water, 0.1µl of 5U Taq polymerase (Genei), and 2µl of cDNA was used to amplify the *cagA* and housekeeping genes (Actin) (Expósito-Rodríguez et al., 2008; Paul et al., 2021b; Paul et al., 2023; Ponesakki et al., 2023).

Initial denaturation of cDNA was performed at 94°C for 10 minutes, followed by 35 cycles of amplification at 94°C for 30 seconds, 55°C for 30 seconds, and 72°C for 30 seconds. At the end of the run, a last extension at 72°C for 10 minutes was performed. Duplicates were done on all of the samples, and samples without cDNA served as a negative control. The output of RT-PCR was analyzed using the CFX Maestro Software and the fold change values were calculated using the $\Delta\Delta CT$ and $2^{-\Delta\Delta CT}$ formula (Paul et al., 2021a; Tatta et al., 2023). The unpaired t-test was used to determine the statistical significance and the P value ≤ 0.05 was considered as statistically significant for our study (Livak and Schmittgen, 2001; Paul et al., 2022a).

Protein extraction and western blot:

Using a mortar and pestle, the leaf samples (both transgenic and control) were thoroughly pulverised in liquid N2. 0.2gm tissue powder is reconstituted in 2ml cold acetone and vortexed for 30 seconds (Wang et al., 2003). Centrifuging at 10000g for 3 minutes at 40C, the pellet was washed with acetone. The pellet was then moved to a mortar and finely powdered with quartz sand. The powder was washed 3–4 times with ice-cold 10% TCA before being mixed with cold 80 percent acetone. The pellet was maintained at room temperature after centrifugation for extraction. The study employed a slightly modified version of the phenol extraction technique (Wang et al., 2003).

In a nutshell, around 0.1gm of powder was reconstituted in 0.8ml phenol (Tris-buffered, pH 8.0) and 0.8ml SDS buffer (sucrose 30 percent , SDS 2 percent , 0.1M Tris-HCl, pH 8.0, 5 percent 2-mercaptoethanol). The components are well mixed for 30 seconds before being centrifuged at 10000g for 3 minutes. To precipitate the proteins, the top phenol phase was recovered in new tubes and mixed with 5 volumes of cold methanol and 0.1M ammonium acetate. After that, the proteins were centrifuged at 10,000g for 5 minutes before being rinsed with methanolic ammonium acetate and 80% acetone. After drying the pellet, it was reconstituted in 2-DE rehydration solution (8M urea, 4% CHAPS, 2% IPG buffer, 20mM dithiothreitol). Using bovine serum albumin as a reference, the proteins were measured using a protein assay (Genei, Bangalore).

With minor adjustments, the expression levels of transgenic plants encoding *cagA* were measured by western blotting. SDS–polyacrylamide gel electrophoresis (4.75 percent stacking and 12 percent resolving gel with 12 percent glycerol) was used to separate soluble proteins,

which were then transferred to Nylon membranes (Genei, Bangalore). The resolving buffer (Tris-HCl, pH 8.8) was increased to a final concentration of 0.75M. The protein samples were denatured at 95°C for 3 minutes before being resolved at constant 200V. After blocking with 3 percent bovine serum albumin in TBST buffer (20mM Tris-HCl, pH 7.6, 0.8 percent NaCl, 0.1 percent Tween20), the blots were hybridized for about 1 hour at room temperature with affinity-purified Biotin conjugated anti *cagA Helicobacter pylori* antibody (ThermoFischer, Biotin dilution 1:500). The investigation employed the secondary antibody streptavidin (1:1000) which was identified using a western blotting detection kit (Genei, Bangalore). The study employed beta-actin with a molecular weight of ~42KDa.

Immunohistochemistry assay:

Leaf samples were taken from both transgenic and control plants and implanted using the Technovit 7100 Embedding Kit (Heraeaus Kulzer, Wehrheim, Germany). The immunohistochemistry test was carried out according to Bo Hu et al., 2012's procedure (Hu et al. 2012). 5mm thick transverse slices were cut and dried on slides using a microtome. At room temperature, the slices were treated in H2O2 (3%) for roughly 15 minutes to prevent any peroxidase activity. The sections were rinsed three times with distilled water and masked with BSA after incubation (10 percent). After that, the slides were treated at 4°C overnight with affinity-purified Biotin conjugated anti *cagA Helicobacter pylori* antibody (ThermoFischer, Biotin dilution 1:2000). The slides were then washed 3-4 times in PBS before being treated for 30 minutes at room temperature with a biotin-labeled goat anti-rat IgG antibody. After washing with PBS, the slides were incubated for 30 minutes at room temperature with SABC (streptavidin and biotinylated horseradish peroxidase complex (SABC) reagent (Sigma-Aldrich, USA). The slides were then stained with the AEC agent kit (HiMedia Ltd) at 370C after

thorough washing with PBS (0.02% Tween 20 and PBS). After that, the slides were cleaned in distilled water and inspected with an Olympus IX-70 microscope. Negative controls were slides treated with PBS/BSA but not with primary antibodies.

ELISA

The *cagA* transgenic brinjal leaves extracts were diluted as 1:5 and 1:10 in sodium bicarbonate (pH 9.8) and coated to the wells of the ELISA plate by adding 4.5–5 mg/mL concentration of antigen solution and incubating at 37 °C for 2 h, followed by three washes with washing buffer (0.1 percent Tween 20 in PBS) for 5 min each time (Barzigar et al., 2022). The plate was blocked for 90 minutes with 2 percent skim milk, then cleaned three times with washing solution. The plate was then treated for 1 hour at room temperature with anti *cagA Helicobacter pylori* antibody (ThermoFischer, Biotin dilution 1:500). Wells were rinsed again with the washing solution after incubation, and of streptavidin-HRP conjugate (1:10,000) was added to each well and incubated for 30min. The reaction was terminated with 0.5 M HCL, and the absorbance was measured at 450 nm with a Bio-Rad microplate reader (Nayeri and Anbuhi, 2019). As a negative control, total protein was isolated from non-transgenic brinjal leaves. All of the trials were carried out in threes.

Results

Amplification and cloning of *cagA* gene into pBI121

The PCR amplification with *cagA* primers resulted in a positive amplicon of around 1700bp as confirmed by the bands [Figure 1]. The isolated plasmids run on an agarose gel revealed two

products after digestion with restriction enzymes, one of which contained the *cagA* gene product at around 1700bp. The acquired nucleotide sequences were then compared to their GenBank counterparts. Using BLAST, the sequence was discovered to have a "perfect" match (97.93 percent similarity) with sequences of respective corresponding gene *cagA* from GenBank (GenBank® accession no. CP026326.1). This variation could be widespread among strains.

Agrobacterium-mediated genetic transformation

Agrobacterium-mediated transformation was used to rejuvenate 52 separate brinjal plants [Figure 2]. The positive expression of *cagA* was also verified by *Agrobacterium* colony PCR. In the gel, there were bands with a size of 1700bp. PCR amplification and immunoblot analysis were used to check for *cagA* expression. The genomic DNA of all five transgenics, as well as the cDNA of the transgenic plants, yielded a PCR result of the predicted size (1700bp), indicating that the gene is expressed positively [Figure 3]. The control (independent non-transgenic) genomic DNA and cDNA revealed no band with negative amplification, as predicted. There is no evidence of non-specificity, indicating that the DNA is pure and specific.

Expression analysis of the *cagA* gene by real-time PCR

To determine the quality of the translation among the samples, the Amplicons from the real-time PCR were performed on a 2% agarose gel. HKG was found to be expressed at roughly 150bp in all of the samples. The *cagA* gene was found to be expressed in each of the five samples studied. Despite the fact that the expression was consistent and visible at around 151bp, the samples B3, B5, B11, and B17 were determined to be overexpressed compared to B21. The *cagA* gene was overexpressed in samples B11 and B17, with 17.3302 0.42466 and 21.2610 0.416804, respectively. B5 (11.59 0.284) was found to be underexpressed [Figure 4].

These numbers correspond to the band expression on the gel. The F-value (0.003**) is significant, according to the results. As a result, no assumption of equal variance is made. We reject the null hypothesis since the p-value (0.009**) is significant at a 5% level, indicating that there is statistical significance in terms of relative expression levels between non-transgenic (control) and transgenic Brinjal. There is a statistically significant difference between the average relative expression level of Brinjal non-transgenic plants (control) and Brinjal transgenic plants. The following hypotheses were investigated using the t-test (paired t-test) in SPSS (Statistical Package for Social Science) on the differences between Brinjal non-transgenic plants (control) and Brinjal transgenic plants. At the 5% level, the t-value for all five pairings, B3 *cagA* – Control (0.025*) & B5 *cagA* – Control (0.012*) & B11 *cagA* – Control (0.012*) & B17 *cagA* – Control (0.009**) & B21 *cagA* – Control (0.041*), is significant. We reject the null hypothesis because the p-value is significant at 5%, indicating that there is a statistical difference verifying B3, B5, B11, B17, B21 relative expressions larger than or equal to Control [Figure 4].

Expression analysis of *cagA* protein in transgenic brinjals

The study's primary goal was to create *cagA* proteins in transgenic plants. Within transgenic brinjal plants, Western blotting indicated large levels of *cagA* protein at around 63.5 kDa [Figure 5]. There was no protein band at the appropriate molecular size on a blot of protein from non-transgenic or control mice. The transgenic brinjal lines B3, B5, B11, B17, and B21, on the other hand, showed a high positive connection between *cagA* transcripts and protein levels. In comparison to the other samples, the *cagA* protein was expressed more in the B11 and B17 samples. The RT-PCR results and the amount of *cagA* protein acquired from western blot

analysis were determined to be in agreement. Bands of beta-actin were detected with a diameter of 42 kDa [Figure 5].

Immunohistochemistry assay

Immunohistochemical analysis was used to examine the changes in *cagA* protein distribution inside the leaves of both transgenic and non-transgenic plants. The distribution of *cagA* in non-transgenics was scarcely apparent in the samples, whereas *cagA* immunohistochemistry specific staining was found in the parenchymal cells underneath the epidermal areas of the leaves in transgenics. The epidermal layer had very little specific signal, whereas the parenchymal sections had a lot. The signal appears to be entirely visible in the cytoplasm rather than in the cell walls. To our knowledge we feel this is the first time this study has been published. According to research published by Qing Gu et al., 2006, a systemic strain of *H. pylori*, ZJC02, produced a full-length *ureB* gene in transgenic rice plants, resulting in antigen-based protection (Gu et al., 2006). The immunohistochemistry findings obtained in our investigation were similar to those reported by Qing Gu et al, with the exception that our protein was *cagA* [Figure 6].

ELISA analysis

The ELISA test demonstrated that transgenic brinjals generate a large quantity of *cagA* protein. The spectrophotometric measurement of the diluted samples' antibody concentrations was shown on a graph [Figure 7]. The largest quantity of *cagA* antigen between the transgenic brinjal lines was detected in B11 and B17 samples at both 1:5 and 1:10 dilutions, with the p-value significant at the 1% level, comparable to the RT-PCR and western blot. In the control sample, however, no antigen was found. The results of the RT-PCR and ELISA tests revealed a high positive connection between *cagA* transcripts and protein levels in transgenic brinjal.

Discussion

The production of recombinant proteins within plants has been achieved with a vast number of expression systems (Mehran et al., 2014a; Mehran et al., 2014b). However, there are a number of issues that still rate limit the routine use of this technique to us plants as factories to produce recombinant biopharmaceuticals including vaccines. There is need to optimize a number of factors to make it most cost-effective. *Helicobacter pylori,* a worldwide prevalent bacterial strain, is stated to span about 40–50% of people globally (Nešić et al., 2014) and is usually associated with ulcers and cancers of the stomach, intestine and mucosa-associated lymphoid tissue (MALT) . This pathogen is known to colonize the stomach and usually accompanies chronic gastritis and other ulcers, which are proved to be risky to develop adenocarcinoma and lymphoma (Lyon, 1994).

Vaccines improve immunity against specific diseases and play vital role in managing disease pandemics. Vaccine is a protein that mimics the pathogen made by heat killing or weakening of the strain (Kurup and Thomas, 2020). They aid the immune system to detect the foreign antigen and subsequently act on it. While there are a number of approaches to produce vaccines, the plant-based vaccines known to reduce the concerns of conventional vaccines. Furthermore, the cost of plant based vaccine production less and the number of interventions are minimum (Zendehbad et al., 2014; Ma et al., 2020). Expressing biopharmaceutical proteins within the transgenic plants is a cost-effective mode to reduce the production costs and other limitations associated with the expression systems (Yao et al., 2015). Plant based vaccines are modified genetically and gene-encoding pathogens (bacteria or virus) can be directly inserted into plants

without fading off their immunogenicity (Stern and Markel, 2005). In this present study, *cagA* protein was transgenically produced in brinjal plants. This is the first report regarding the expression of *cagA* gene in brinjal plants. Our experimental data demonstrated that *cagA* protein could be expressed in transgenic brinjal plants. The expression of the *cagA* gene in brinjal plants was verified by RT-PCR and protein electrophoresis. Our PCR amplification and blotting methods also confirmed the expression of *cagA* gene. Further, the western blot analysis revealed the accumulation of *cagA* protein in the tissue, which could be the vaccine of choice. Previously, *Helicobacter pylori ureB* antigen gene was also expressed into the rice genome using *Agrobacterium*-mediated transformation and a set of 30 regenerated plants were reported to occumulate *ureB* antigen, which was confirmed by PCR and blotting (Gu et al., 2006).

Antibiotics resistance in strains is a major problem ,hence, developing a new vaccine is the need of the hour (Yang et al., 2011). In both developing and developed countries, *H. pylori*, has high infection rates and also gained multiple antibiotic resistance (Schillberg et al., 2003). Even then, the cost-effectiveness of the vaccination has remained an important area of research. Even though many of the eukaryotic proteins can be produced at a low cost and in a more viable manner, most of the post-translational modifications cannot occur in prokaryotes, making them inefficient (Giddings et al., 2000).

The *cagA* gene was successfully cloned into the binary vector pBI121 using kanamycin resistance gene as marker. The gene was successfully cloned and transformed into the brinjal callus through *Agrobacterium*-mediated method. Out of the 52 plants, a set five plants were found to be transgenic based on presence of the *cagA* gene product. Expression of the *cagA* gene at mRNA level in five plants was confirmed by RT-PCR and translation by Western blot

analysis. The outturn of these experiments suggests that the *cagA* transgenic brinjal can further be evaluated to be used as a vaccine candidate against *H.pylori*.

Edible vaccines are produced by inserting the desired transgene into the selected plant cell. In the current scenario, edible vaccines are developed for both veterinary and human use. The main challenge lies in convincing people to use such vaccines. Moreover, these edible vaccines are economical and safe when compared to other conventional vaccines available in the market (Kalbina et al., 2010). In conclusion, our results demonstrated the successful integration of the desired *cagA* gene into the nuclear genome of the transgenic brinjal and can serve as potential candidate events for prospecting the purification and use as vaccine.

Declarations

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Conflict of Interests

The authors declare no potential conflicts of interest.

Availability of data and material

All the data and supplementary materials are available from the corresponding author on reasonable request.

Consent for publication

All authors consent to publish this work.

Ethics approval

The experimentation was conducted with prior approval from the Institutional Biosafety Committee (IBSC) of JSS College, Mysore at Postgraduate Department of Biotechnology, JSS College, Mysuru, Genei India Pvt. Ltd., Bangalore and Department of Biotechnology and Crop Improvement, College of Horticulture, University of Horticulture Sciences, GKVK Post, Bangalore (IBSC Registration number: JSSC111220191080). Appropriate permission for the collection of plant or seed specimens has been obtained from College of Horticulture, University of Horticulture Sciences, GKVK Post, Bangalore.

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Figures Legends:

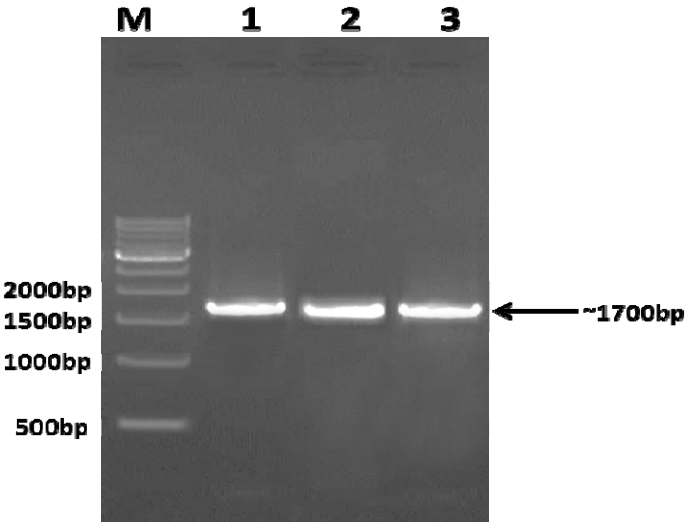


Figure 1: PCR amplification of *cagA* gene *H.pylori* 26695 by specific primers. Image showing the *cagA* gene PCR amplification on 1% agarose gel. Lane description: *cagA* gene product lane 1, 2, 3 and molecular-weight ladder (M). Image as viewed on Gel Dock.

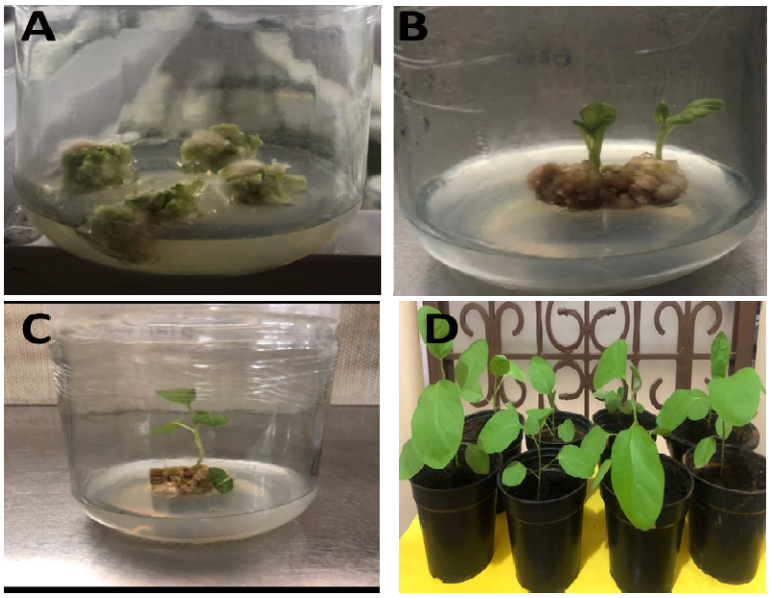


Figure 2: Production of transgenic brinjal plants by *Agrobacterium*-mediated Transformation. Images showing the development of transgenic brinjal *cv* Arka Keshav, A: Callus initiation from *Agrobacterium* transformed leaf discs on selection medium, B, C: Kanamycin-resistant transgenic shoots cultured on MS medium for rooting, D: Potted transgenic brinjals grown in the soil.

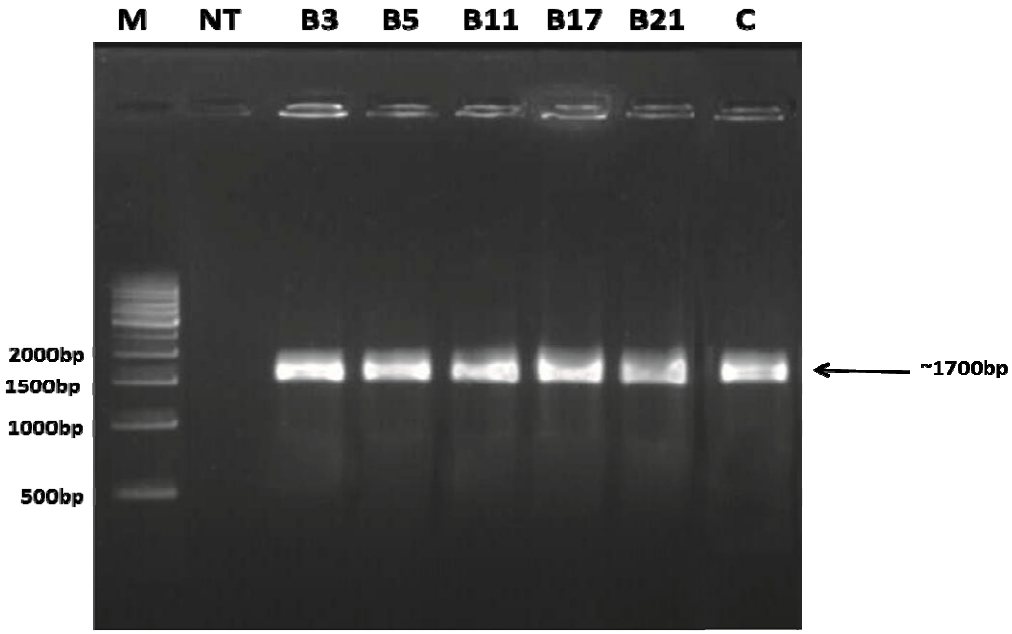


Figure 3: RT-PCR products amplified from the total RNA of transgenic plant. Primers designed for PCR amplification of the *cagA* gene which specifically amplified DNA fragments of ~ 1700bp. Lane description: molecular-weight ladder (M), RT-PCR product of cDNA from a non-transformed plant (NT), RT-PCR products of cDNA from transformed plant lane No. B3, B5, B11, B17, B21. pBI121-*cagA* plasmid was used as positive control (C).

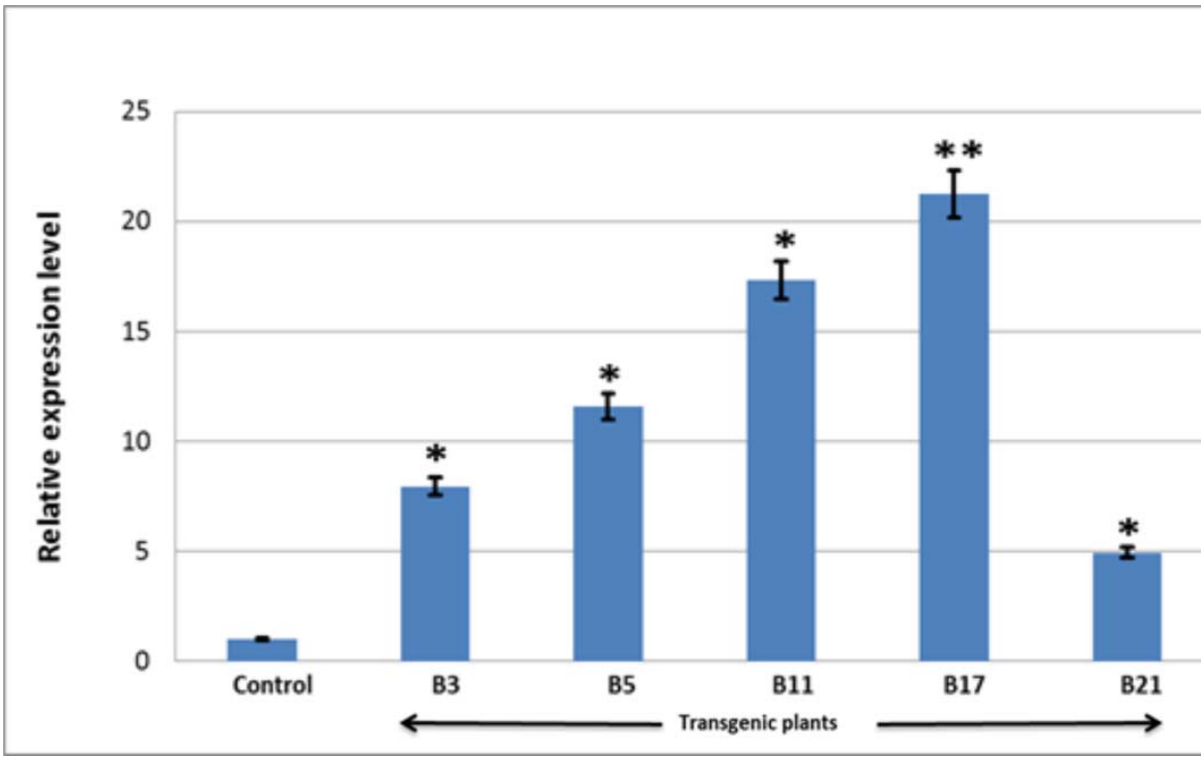


Figure 4: Relative expression levels of the *cagA* gene in transgenic plant brinjals. Graph showing the relative expression levels of *cagA* gene of the transgenic and control plants. Control expression was considered to be 1 and 100%. All the values are average of duplicates. Values are expressed as value ± SD. ** Highly significant; * Significant at 5% level.

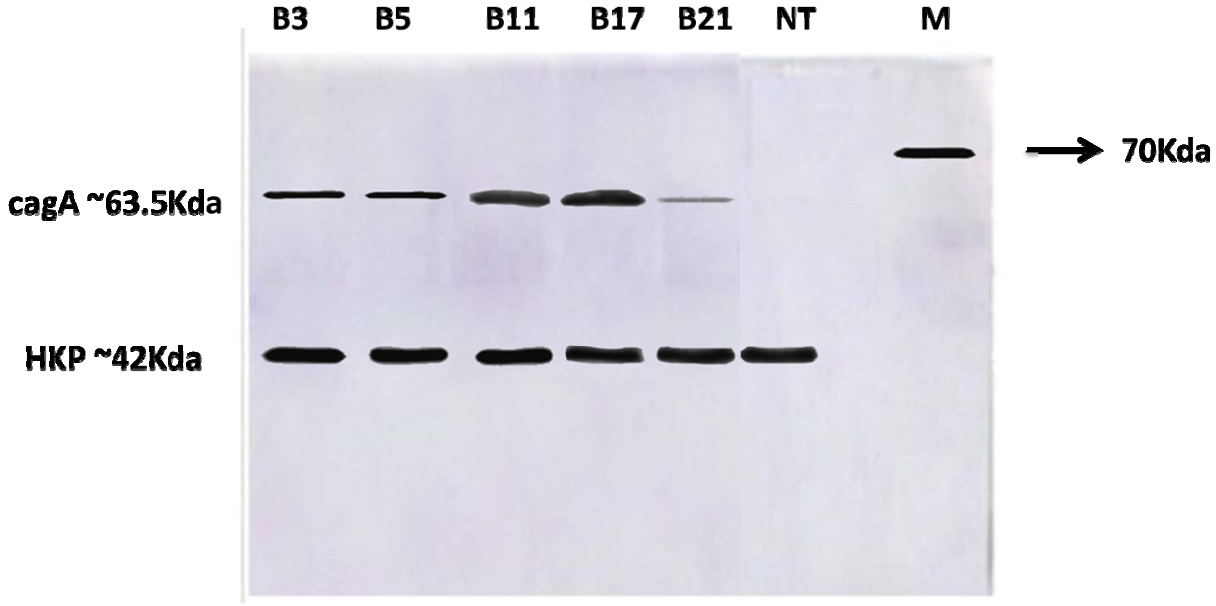
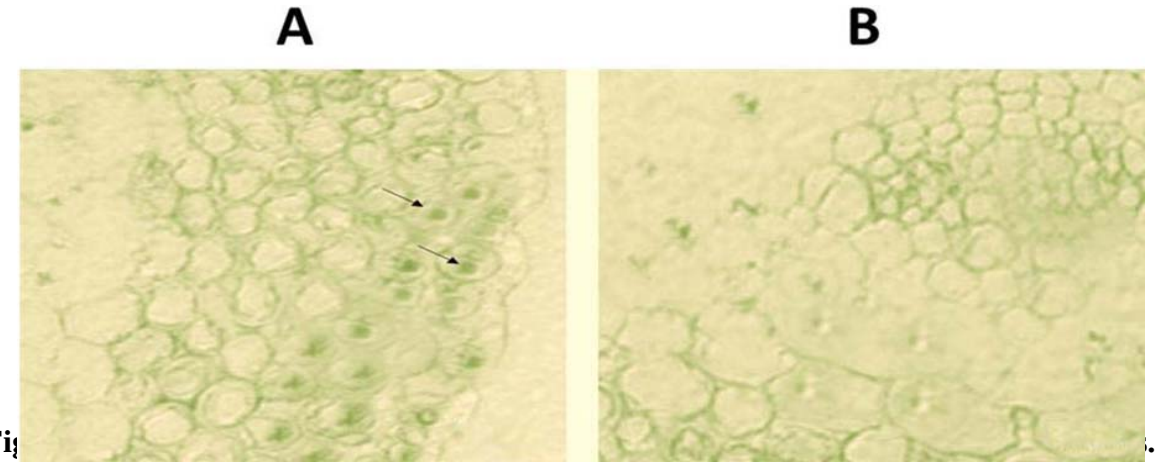


Figure 5: Western-blot analyses of transgenic brinjals. Western-blot analysis of *cagA* protein from independent transgenic plants. B3, B5, B11, B17, B21 independent transgenic brinjals and NT is the non-transgenic plant brinjal, Beta Actin was used as HKP. Bands seen at ~63.5KDa corresponds to *cagA* protein and Beta Actin bands (HKP) were seen at ~42KDa.



Fi . (A): Transgenics expressing the *cagA* protein as shown with arrows. (**B):** Non-transgenics without

expression. Samples without antibodies and with PBS was used as negative control (not shown in the study). All the images shown here are represented from three independent cross-sections and three-leaf samples (Bars = 30μm).

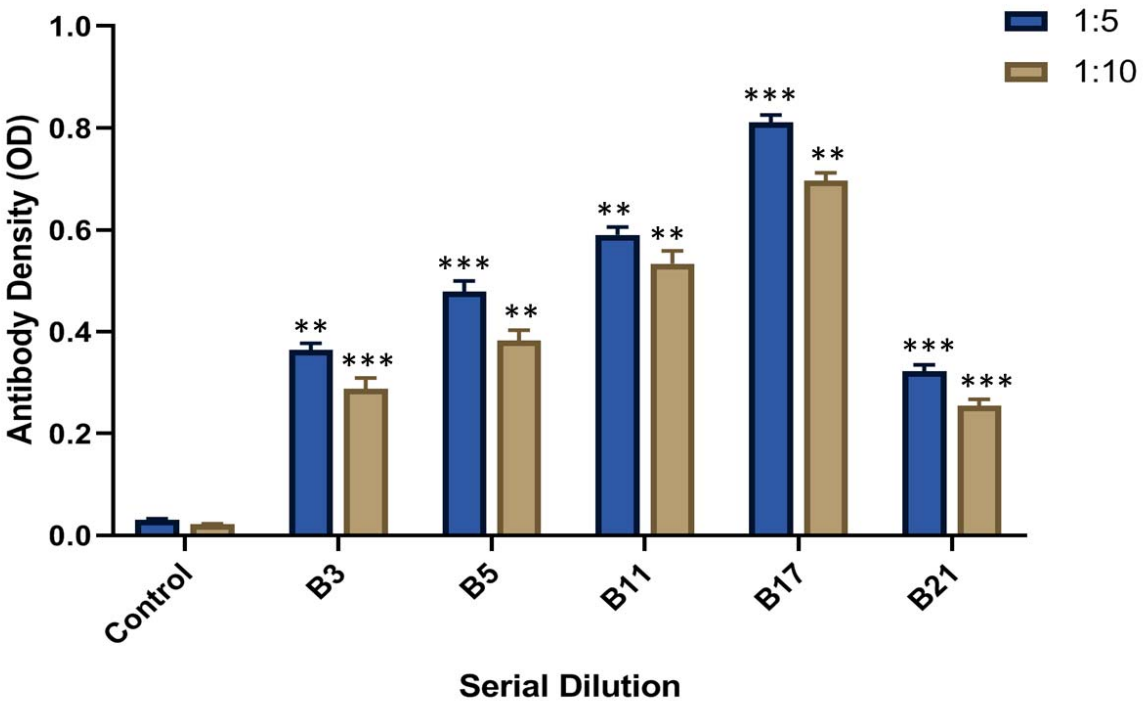


Figure 7: Data graph obtained from ELISA reader shows that the different amount of *cagA* antigen in transgenic brinjals and control plant with respect to 1/5 and 1/10 dilution ratios. No signal was observed in the control plant. All the values are average of triplicates. Values are expressed as value ± SD. *** Highly significant; ** Significant at 1% level.

Original Article

Garlic Mediated Green Synthesis of Silver Nanoparticles as Antifungal Agents against *Magnaporthe oryzae*

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ABSTRACT

Background: Plant elements such as carbohydrates, lipids, flavonoids, polyphenols, enzymes, terpenoids, and alkaloids are used as reducing substance in the green production of silver nanoparticles. The strategy proved to be highly straightforward, cost-effective, and practical. **Materials and Methods:** The synthesis of nanoparticles was validated using optical inspection, in which the yellow colour solution became brown. UV-visible spectroscopy, XRD, FTIR analysis, and SEM were used to further characterise the material. **Results:** Transmission electron microscopy have shown that the silver nanoparticles size was between 10–46 nm (SEM). Size of silver nanoparticles was found to be between 10–46nm approximately as determined by transmission electron microscopy (SEM). Well diffusion method demonstrated the antifungal activity of AgNPs on *Magnaporthe oryzae* with the zone of inhibition of 5 and 11mm when 12.5 and 25µg/ml of AgNPs was used respectively. Lowest inhibitory concentration was found to be 5.2. **Conclusion:** The leakage of reducing sugars and proteins was used to explore the mode of action of nanoparticles' antifungal activity, indicating that AgNPs were able to reduce membrane permeability.

Keywords: *Allium sativum*, *Magnaporthe oryzae*, Silver nanoparticles, Conidia germination inhibition assay, Colony growth inhibition assay.

INTRODUCTION

The fungus *Magnaporthe oryzae* is the reason of rice blast disease (RBD) in rice cultivars.[1] During the whole development cycle, the rice blast pathogen grows in the nodes, leaves, collars, necks, panicles, seeds, and roots.[2] The harm caused by the rice blast assault mechanism has been discovered to be heavily impacted by environmental conditions. Although conidia do not germinate in direct sunshine, gloomy circumstances and humidity helps the development of the illness throughout the year in the air.[3] Their life cycle lasts 7 to 14 days,[4-6] after which they damage plants in 15 to 20 days, resulting in yield losses.[7]

Diseases caused by insects, bacteria, fungus and other pathogens in the environment have been the greatest challenge to agriculture since its inception.[8,9] Phytopathogenic fungi cause numerous diseases in agriculture.[10] Phytopathogenic fungi are now mostly managed with inexpensive and readily available chemical agents.[11,12] However, because of their widespread usage, they have resulted in environmental contamination, animals and human illnesses and ecological imbalances.[13,14] Furthermore, the use of chemical agents has resulted in fungus acquiring greater resistance to chemical compounds, making them stronger.[15,16] Currently, friendly and good alternatives for the environment are being used to control phytopathogen fungi, such as biological control,[17,18] plant extracts[19] and essential oils.[20,21] Such alternatives have been beneficial and are therefore considered as a good choice.

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Nanomaterials, employed effectively in other industries such as energy, health, and electronics, are another newly researched and applied method in agriculture.[22,23] Nanomaterials have grown in importance as a result of their distinct physicochemical features from bulk materials.[24,25] Chemical, physical and green approaches are the methods that may be used to make AgNPs. Several research organisations have recently implemented green plant-based reduction approaches, which are also regarded safe, easy and cost-effective protocols.[26] The presence of naturally occurring biomolecules such as proteins, enzymes, tannins, phenols, sugars, and flavonoids in the green technique was the key benefit. The existence of naturally occurring biomolecules such as proteins, enzymes, tannins, phenols, sugars, and flavonoids, which may be employed safely as reducing and stabilising agents to generate stable nanometals, was the major benefit of the green technique.[27,28] Due to their simplicity of handling and synthesis, nanoparticles provide environmentally friendly, efficient, and contemporary solutions for the control of phytopathogenic diseases that may be utilised as biomanufacturing agents.[29,30] Metal nanoparticles are thought to be a promising option for controlling phytopathogenic fungus in agriculture. Several metal nanoparticles (Ag, Cu, Se, Ni, Mg, and Fe) produced and tested as antifungal agents to date.[31]

Because of their antioxidant, antibacterial, and anticancer qualities, as well as their biocompatibility, ease of manufacture, cheap cost and non-toxicity, Ag nanoparticles have been intensively studied in a variety of scientific domains.[32,33] Ag nanoparticles have been the most used nanoparticles for controlling phytopathogenic fungi due to their features and strong antifungal activity.[34,35]

The size distribution, shape, content, crystallinity, agglomeration and surface chemistry of the nanoparticles all have an impact on their antifungal activity.[36,37] Small nanoparticles, for example, favour the surface area to volume ratio, which may enhance their antifungal efficacy.[38] These parameters may be adjusted and regulated by synthesis pathways, as is well known.[39,40] It has also demonstrated that the production technique might influence antifungal action, as metal precursors or surfactants are sometimes difficult to remove from nanoparticles. As a result, synthesis residues can alter the surface chemistry of nanoparticles, hence influencing their antifungal effectiveness.[41]

However, it has been demonestrated that smaller nanoparticles, between 10 and 30 nm, have stronger antifungal activity.[42-49] The reason is the smaller nanoparticles enter or damage the pathogen's cell membrane more quickly, uniting the fungal hyphae and mycelium and deactivating the pathogens.[50] Nonetheless, despite the bigger size has a higher antifungal ability, it is slower to penetrate the pathogen's membrane, causing damage to mycelium and spores or inhibiting fungal development.[51] While the greater size has a strong antifungal potential, it penetrates the pathogen's membrane more slowly, causing harm to mycelium and spores or inhibiting fungal development.[52-54]

Various plant extracts, such as garlic, ginger, onion, curry leaf, and palak, have been employed in the green production of nanoparticles. Garlic (*Allium sativum* L.), which is widely used even as a spice, food, and traditional medicine, has also been demonestrate to have antimicrobial and antioxidant properties. Garlic extract is a rich source of phenolics and flavonoids, which has an important role in the reduction process for the synthesis of metal nanoparticles.[55] Furthermore, garlic extract has shown as an effective bio-reducing agent for the production of AgNPs.[56]

In this study, Garlic cloves extract was used to reduce silver nitrate to silver nanoparticles, and X-ray diffraction (XRD), UV-visible spectroscopy, Fourier transform infrared spectroscopy (FTIR), Scanning electron microscope (SEM), and were used to characterise the synthesised nanoparticles. Antifungal property of the produced nanoparticles was tested against pathogenic fungus *M. oryzae*. Antifungal property was evaluated by agar well diffusion method, conidia inhibition assay and colony growth inhibition.

MATERIALS AND METHODS

Garlic cloves were purchased from local market stores and peeled off and were sundried for 4–5 days so as to remove moisture completely. Dried cloves were pulverized to fine powder and stored in dry container for further use. Silver nitrate ($AgNO_3$) was purchased from HiMedia Ltd., Bangalore. All the reagents used in the study were of analytical and molecular grade. For the experiment, all of the solutions were prepared fresh with deionized water and maintained in the dark to avoid any photochemical reactions.

Micro-organisms: Antifungal activity of green synthesized silver nanoparticles was studied against *Magnaporthe oryzae*. Fungal culturesisolated from the infected paddy seeds. Oatmeal agar was used to maintain the strain. The fungal culture grown in the laboratory was rechecked for the specific conidia to confirm the strain (Figure 1).

Green Synthesis of silver nanoparticles: AgNPs were synthesized by reduction of silver nitrate with garlic

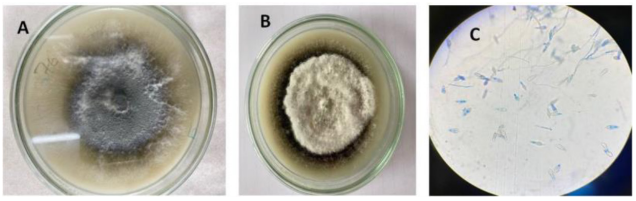

Figure 1: Image of oat meal agar plate showing *Magnaporthe oryzae* culture. A, B: *Magnaporthe oryzae* culture; C: *Magnaporthe oryzae* conidia under (100x) microscope.

extract by the following method. 200ml de-ionized water was added to 20g of garlic powder prepared in the previous section. The contents were then kept on magnetic stirrer for one hour at 40°C and filtered with Whatman No.1 filter paper and finally centrifuged at 10000rpm for 20min. The filtrate was then evaporated in rotary evaporator and about 50mg of extract was then suspended in 40ml of deionized water. Equal volume of 0.5mM $AgNO_3$was added to the suspension incubated for 2 days at 50-70°C with constant stirring on magnetic stirrer. pH of the solution was maintained at 10.

Characterization of nanoparticles: Synthesized AgNPs were then analysed for spectral analysisusing a UV–Vis spectrophotometer (Shimadzu UV1800) at the resolution of 1nm with wavelength range from 200 to 800nm for each sample. Both control and experimental solution of the synthesized AgNPs were subjected to FTIR analysis (Perkin-Elmer FTIR-1600, USA) in the range of 450–4000 cm^{-1} at a resolution of 4cm^{-1}. The crystalline structure of the synthesized AgNPs was further studied with X-ray diffraction system. The diffraction pattern was recorded with the scanning mode on a Rigaku Miniflex II operated at about 30kV with a current of 15mA and Cu/Ka radiation in the range of 3°–80° in 2hr angles. Standard powder was used along with samples. The morphology of the synthesized particles was characterized by scanning electron microscopy (SEM, Hitachi S-5500) at an accelerating voltage of 2.0kV. Nanoparticle tracking and analysis (NTA) was done for the study of the particle size and distribution using LM-20 (NanoSight Ltd. UK). NTA usually aids in separating the particles population by size and intensity simultaneously determining their Brownian motion.

Antifungal Activity of AgNPs: Antifungal activity against *Magnaporthe oryzae* was conducted through agar well diffusion method, colony growth assay and through conidia germinationfollowing the medium as described by Huang (2020).

Agar well diffusion assay: Zone of inhibition formed on an agar plate reflects the antifungal property of AgNPs. An agar-discs or cylinder from previously grown culture was cut aseptically with a 5mm diameter sterile cork borer and plated on a series of OMA agar plates. About 20μL of synthesized AgNPs was added onto the well made at equidistant points. Bavistin (20mg/ml) was used as positive control. The plates were then incubated at 28°C for 7 days.

Colony Growth Assay: The synthesized AgNPs after oven drying were suspended in sterile water and the concentration was 10mg/mL.5mL of diluted AgNPs were added to 50mL of OMA medium at 55°C. Nanoparticles were added at two different concentrations of 12.5 and 25μg/mL separately. The control was maintained with 5mL of sterile de-ionized water without silver nanoparticles. Bavistin (20mg/ml) was used as positive control. A fungal culture disc was taken with a cork borer was placed at the centre of each OMA plate and then incubated at 28°C for 7days.

Conidia Germination inhibition assay: Germination assay was followed according to the procedure of Weidong Huang (2020). In brief, the density of *Magnaporthe oryzae* conidia was diluted to 10^6spores /mL using a neubauer chamber. Synthesized AgNPs and conidial suspension of the test fungus were mixed at a ratio of 1:9 (by volume) and the AgNPs were used at varying concentrations of 12.5, 25, 50, 100 and 200µg/mL. Conidial suspension without AgNPs was used as negative control and Bavistin 20mg/ml) was used as positive control. The tubes were incubated at 25°C for about 12 to 48hr.

Statistical Analysis

All the experiments were performed in triplicates and expressed as the mean ± standard deviation. Statistical analysis was performed using ANOVA to determine the variance and relation ($p \leq 0.05$).

RESULTS

The brown colour of AgNPs in water is widely known and it results from the activation of surface plasmon vibrations in the metal nanoparticles. Initial detection was by visual observation where in specific colour change i.e. to dark brown colour of the mixture was observed on constant stirring (Figure 2A, 2B). UV-visible spectroscopy, scanning electron microscopy, X-ray diffraction and FTIR spectroscopy were used to demonstrate the production of AgNPs.

UV-Vis spectroscopy was used to characterise the AgNPs, which were then tested for antifungal efficacy. The wavelength scale was set to 200–800nm and the solution was scanned in that range. The maximum absorbance was recorded at 440nm, which is typical

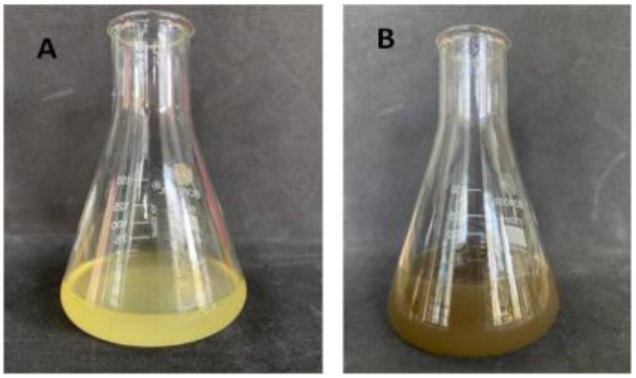

Figure 2: Image showing the green synthesis of AgNPs (0.5mM) with garlic extact. A: yellow colour (control); B: Colour change to dark brown after synthesis of AgNPs.

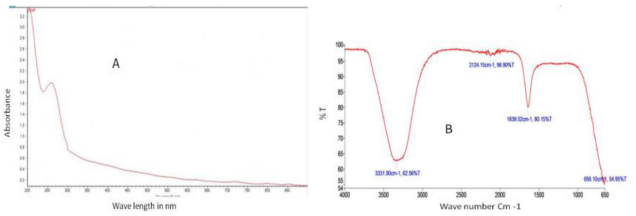

Figure 3: A: Image showing the UV spectra at 280nm. B: Image showing the FTRI spectra observed for the synthesized AgNPs.

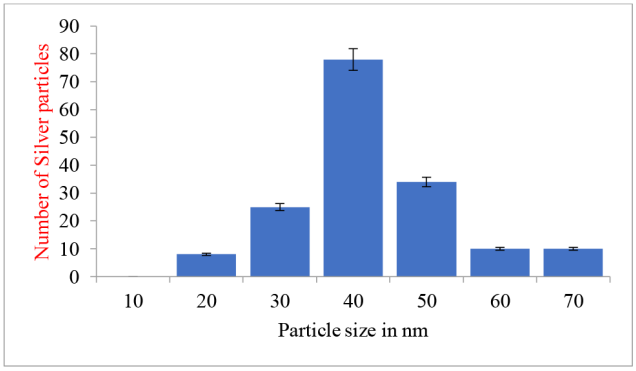

Figure 4: Graph showing the total size distribution of AgNPs as viewed from SEM. All the values are average of triplicates expressed as number ±SD.

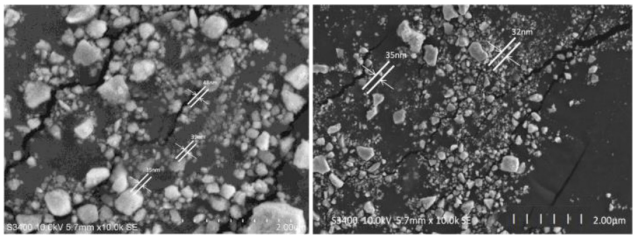

Figure 5: HR-SEM analysis of synthesized AgNPs showing spherical shape and size of nanoparticles ranging between 10 – 46nm.

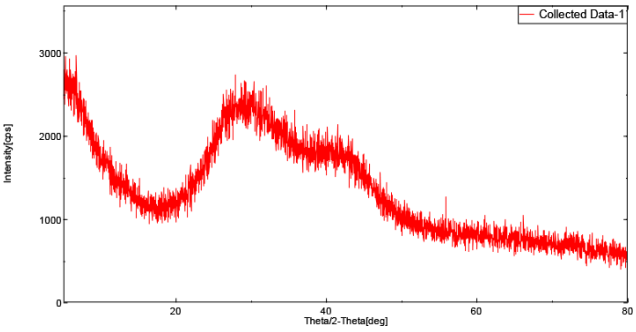

Figure 6: Image showing the XRD spectra of AgNPs?

for silver nanoparticles as reported by Bahuguna *et al.* (2016). The curve demonstrates that the absorbance of silver nitrate and seed extract increases as the incubation duration (30 min, 45min and 1hr) increases.

The synthesized silver nanoparticles were subjected to FTIR analysis for further characterization. FTIR analysis showed two peaks at 1760 and 3324. For the size of AgNPs nanopartcile tracking analysis (NTA) analysis by the NanoSight (LM-20) was carried out (Figure 3). The NTA images showed most of the synthesized NPs are having an average size diameter of 46nm which was calculated on the basis of Brownian motion of particles (Figure 4). The shape and the size of the produced AgNPs were also investigated using SEM. The AgNPs were primarily scattered and more or less spherical in form. The particles ranged in size from 10 to 40nm (Figure 5). XRD results demonestrated that the synthesized particles are face-centred round structures of silver (Figure 6).

Antifungal activity: *In vitro* antifungal property of synthesized AgNPs with commercially available antifungal agent was done against *Magnaporthe oryzae*. AgNPs showed remarkable activity against *Magnaporthe oryzae* when compared to positive control (Bavistin @ 20mg/ml). The diameter for the AgNPs was found to be 5 and 11mm for 12.5 and 25μg/mL, respectively. The results are satisfactory and significant when compared to positive control at 25μg/mL (14mm) (Figure 7 and 8). Similar inhibition zones were observed with Tricyclozole (30mm for 3.0µg/ml chemical used in controlling blast disease) at different concentrations.[57] Silver nanoparticles synthesized by the *Allium sativum* (garlic) extract showed maximum antimicrobial activity against both bacteria and fungus.[58] Many of the species of *Candida* were found to be susceptible with silver nanoparticles,[59] confirmed the potential antagonistic activity of silver nano particles against several fungal pathogens.[60] Their experiments reported that this anti fungal activity is due to loss of membrane integrity leading to electrolyte leakage. Similarly present results

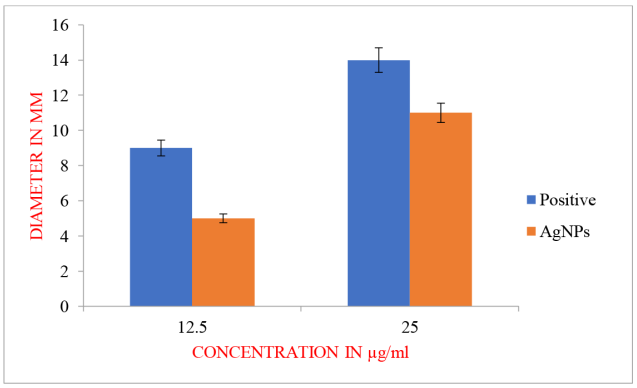

Figure 7: Formation of the zone of inhibition observed in well diffusion assay. Bavistin was used as positive control. All the values are the average of triplicates and are expressed as number ±SD.

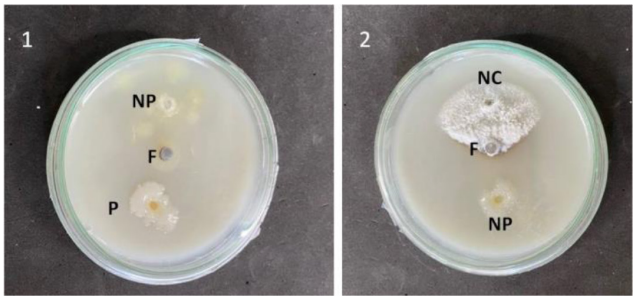

Figure 8: Images showing the Antifungal activity of AgNPs (NP) against *Magnaporthe oryzae*. Inhibition zones are measured in mm. 1: Nanoparticles and positive control (P) against fungal strain. 2: Nanoparticles and negative control (NC, deionized water) against fungal strain.

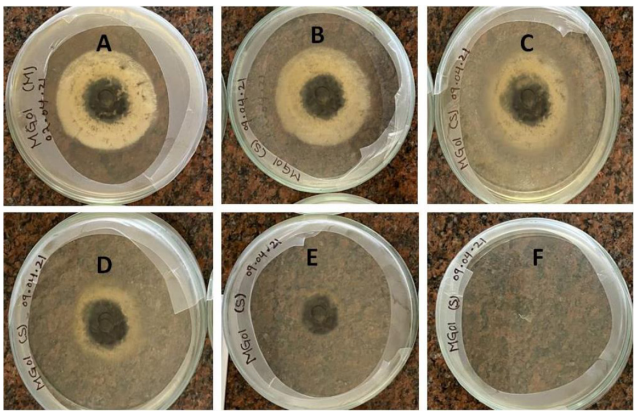

Figure 9: Image of the plates showed *in vitro* colony inhibition assay. Varying concentrations of the nanoparticles are added to the plates. A: control; B: 12.5µg/mL; C: 25µg/mL; D: 50µg/mL; E: 100µg/mL; F: 200µg/mL.

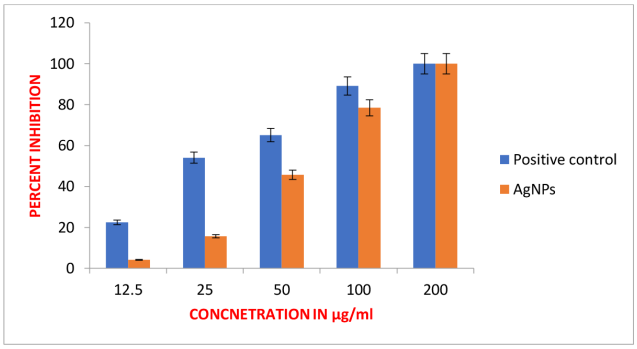

Figure 10: Graph showing the percent colony growth inhibition of *M. oryzae*. All the values are average of triplicates and values are expressed as value ±SD.

are in accordance to these reports suggesting the possible role of the green synthesized AgNPs in the loss of membrane integrity.

Colony Growth Inhibition: *Magnaporthe oryzae* colonies were significantly inhibited by AgNPs. The colony diameter of the control was about 14.5cm where it gradually got diminished with increasing concentration of AgNPs. The diameter descended to its minimum value (5.1cm) at 200µg/mL. The inhibition rate was shown to be in the range of 4.11% - 100% for 12.5-200µg/mL, respectively (Figure 9 and 10).

The application of four concentrations of silver nanoparticles to *M. grisea* culture exhibited considerable reduction of both hyphal development and the number of colonies generated in a dose-dependent manner under lab conditions. The silver nanoparticles delayed and greatly inhibited fungal growth at low concentrations, according to radial growth measurements.[61] found that secondary metabolites extracted from *C. elatum* showed antifungal activity against *P. oryzae* with an ED_{50} of 231ppm.[62]

Conidia Germination Inhibition: Because fungi need a large number of germinated conidia to successfully infect plant tissue, inhibiting conidia germination is critical in reducing or preventing the formation of plant diseases. Controlled growth with optimum temperature and humidity showed 93% germination rate for conidia in the absence of AgNPs. The percentage was found to diminish with increase in concentration of AgNPs (12.5, 25, 50, 100 and 200µg/mL). It was shown that the conidia were completely inhibited or not seen at 200µg/mL. The results are based on present agar well diffusion method. The percent inhibition for positive control was shown to be in the range of 87% at 12.5µg/mL to zero percent at 200µg/mL. Synthesized nanoparticles are found to be inhibited at the range of 90% at 12.5µg/mL to zero percent at 200µg/mL (Figure 11).

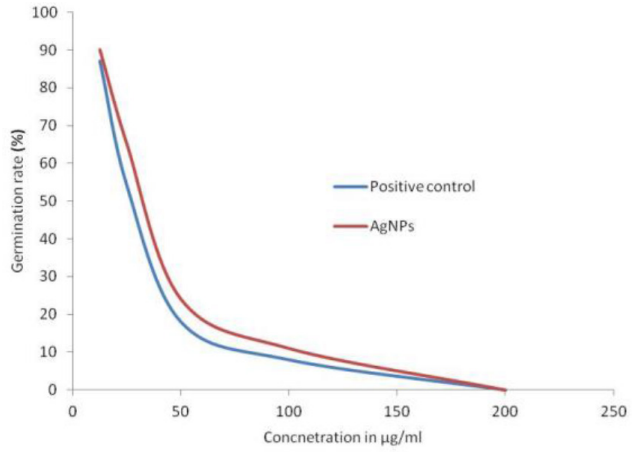

Figure 11: Graph showing the conidial inhibition with the treatment of AgNPs against *Magnaporthe oryzae* All the values are average of triplicates and the values are expressed as value ±SD.

DISCUSSION

Our reports suggest of the potential role of the antifungal activity of the green synthesized silver nanoparticles. Silver nanoparticles synthesized by the *Allium sativum* (garlic) extract showed maximum antimicrobial activity against both bacteria and fungus.[58] Many of the species of *Candida* were found to be susceptible with silver nanoparticles,[59] confirmed the potential antagonistic activity of silver nano particles against several fungal pathogens.[60] Their experiments reported that this anti fungal activity is due to loss of membrane integrity leading to electrolyte leakage. Similarly present results are in accordance to these reports suggesting the possible role of the green synthesized AgNPs in the loss of membrane integrity.

The application of four concentrations of silver nanoparticles to *M. grisea* culture exhibited considerable reduction of both hyphal development and the number of colonies generated in a dose-dependent manner under lab conditions. The silver nanoparticles delayed and greatly inhibited fungal growth at low concentrations, according to radial growth measurements.61 found that secondary metabolites extracted from *C. elatum* showed antifungal activity against *P. oryzae* with an ED_{50} of 231ppm.[62]

In field testing on cucumbers and pumpkins, the treatment of 100ppm silver nanoparticles exhibited the greatest inhibition rate both before and after the disease onset. In addition, *in vivo* experiments revealed that 100ppm silver nanoparticles inhibited the development of fungal hyphae and conidial germination the most.[63] The present study is focused on the extracellular synthesis of silver nanoparticles (AgNPs) using culture supernatant of an agriculturally important bacterium, *Serratia* sp. BHU-S4 and demonstrates its effective application for the management of spot blotch disease in wheat. Similar reports were made and the findings were confirmed in the green house, where bsAgNPs administration drastically decreased *B. sorokiniana* infection in wheat plants.[64]

CONCLUSION

Magnaporthe oryzae is a serious phytopathogen that has caused severe blast infections in rice all over the world. Controlling that illness in an environmentally sustainable manner is a huge task. In this investigation, garlic clove extract-derived AgNPs showed strong antifungal efficacy against *M. oryzae*. In conclusion, the production of silver nanoparticles using garlic clove extract is a straight forward, safe and one-step technique. These extracts operate as a reducing agent in the production of nanoparticles. The method does not require any chemical reagents or surfactant templates, giving the bioprocess the advantage of being ecologically benign. These findings not only offer a novel strategy to plant pathogen management, but they also significantly reduce or eliminate drug resistance. In the near future, modifications to AgNPs such as surface charge, acid-base property and aggregation behaviour will be carried out to assess their impact on AgNPs' antimicrobial activity.

ACKNOWLEDGEMENT

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

AgNPs: Silver Nanoparticles; **NTA:** Nanoparticle tracking and analysis; **SEM:** Scanning Electron Microscopy; **FTIR:** Fourier Transform Infrared Spectroscopy; **XRD:** X-Ray Diffraction; ***M. oryzae*:** *Magnaporthe oryzae*; **RBD:** Rice Blast Disease.

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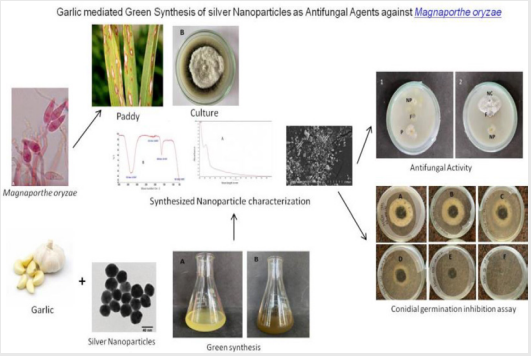
PICTORIAL ABSTRACT



SUMMARY

Many natural compounds are used and being tried as reducing agents to green synthesize silver nanoparticles which could be economical and more effective in terms of biological activities. Keeping in line with this aim, we tried to green synthesize silver nanoparticles using Garlic extract and used against the most potential plant pathogen *Magnaporthe oryzae*. We green synthesized, characterized and studied for antifungal activity. We found significant antifungal activity against *Magnaporthe oryzae*. The synthesized nanoparticles were of 20nm and might be the possible role of these AgNPs is they could be acting as leaking agents for the membrane. This could have lead to the growth inhibition of the fungus.

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Original Article

Monitoring of Defense Enzymes (Phenylalanine Ammonia Lyase and Peroxidase) in *Magnaporthe oryzae* Infected Leaves after Treatment with Green Synthesized Silver Nanoparticles

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ABSTRACT

Objectives: In this study, we focus on the amount of the two defence enzymes phenylalanine ammonia-lyase (PAL) and peroxidase (POX) expressed with regard to the treatment of green synthesized silver nanoparticles. **Materials and Methods:** The leaf blades were infected with Fungal spores and silver nanoparticles by spraying, and following infection, we estimated the enzyme activity of PAL and POX. The PAL activity is considered by using cinnamic acid as a standard. **Results:** Our results showed both the PAL and POX enzymes were found to be elevated on infection with spores, and on treatment, the activity was reduced in both cases. There was a significant elevation of PAL (8.937±0.55) in infected leaves, which could be due to infection and on treatment, the enzyme activity was reduced which possibly could be because of the antifungal activity of the synthesised nanoparticles. The POX levels exceeded the control by 417.86%, 807.14% and 921.43% respectively for infected, treatment with AgNPs and treatment with positive control. This confirms the role of the peroxide enzyme in disease control and resistance. **Conclusion:** This enzyme activity study to our knowledge is the first report done on the infected rice plants with *Magnaporthe oryzae* and on treatment with silver nanoparticles. This could pave the way to understanding the role of these enzymes in defence activity.

Keywords: *Magnaporthe oryzae*, PAL, POX, Silver Nanoparticles, Defense enzymes.

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INTRODUCTION

Magnaporthe oryzae causes critical diseases called rice blast. In tropical Asian nations like India and China, the output of rice decreased by up to 69%.[1] The use of chemical fungicides to treat rice blast disease posed a serious risk to the environment and to the general public's health. Earlier, chemical fungicides were employed to treat soil-borne fungal diseases, but these chemicals are still present in the agriculture ecosystem today, where they harm helpful bacteria and allow plant pathogens to become resistant to them.[2] As a result, we must discover a different biocontrol strategy that can control plant diseases without endangering human health or the environment.[3] One of the best options recently as a reliable and safe clarification for sustainable agriculture is biological control. An environmentally beneficial way for lowering the possibility of resistance to selection pressure is biocontrol.[4]

Recent findings reported that nanoparticles can be an eco-friendly solution for fungal diseases and many plant extracts are used for metal ion reduction to produce metal nanoparticles. among different metals, silver has shown very good antifungal activity.

There are passive and active defence mechanisms which are being used to defend themselves during pathogen attack.[5] In the passive defence mechanism, antimicrobial molecules are vital compounds while in active barriers pathogenesis-related proteins, hypersensitive response, phytoalexins, the production of reactive oxygen species (ROS) and lignification.[6] The resistance or susceptible reaction to fungal infection is determined by the influence of defence responses by the plants during pathogen infection. In plant fungal infection, penetration may induce different plant cell defence responses during different infection stages.[7] We should say that the defence enzymes are vital to the plant during infection.[8] The activity of Peroxidase (POX) and Phenylalanine Ammonia-Lyase (PAL) are observed to be crucial in the wheat defence mechanism. We can say changes in PAL and

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Dietary Synbiotic as a Supplemental Therapy to Reduce Cancer Symptoms: A Review

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ABSTRACT
The significance of the human microbiome in the pathogenesis of cancer is becoming more widely recognized. Pre-, pro-, and synbiotics are some of the most well-studied ways to alter the microbiota for therapeutic purposes, and there is growing interest in their potential to be used in the diagnosis and treatment of cancer. In this review, we examine how these drugs may preserve the integrity of the intestinal barrier, regulate the immune system, regulate metabolism, and restrict the growth of host cells. We emphasize the epidemiological and trial-based evidence that pre-, pro-, and synbiotics play a role in cancer prevention. In the end, there is more evidence to support the use of these drugs as cancer treatment adjuncts. We go over their roles in enhancing the effectiveness of chemotherapy and radiation and/or reducing their side effects. The use of pre-, pro-, and synbiotics for clinical benefit in oncology patients has tremendous potential, but the discipline is still in its infancy, making it difficult for oncologists to provide their patients the right advice.
Keywords: *microbiome, oncology, probiotics, prebiotics, synbiotics.*

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INTRODUCTION

By specifically enhancing the growth and/or stimulating the metabolism of one or more numbers of health-promoting bacteria, a synbiotic product benefits the host by positively impacting the survival and implantation of live microbial dietary supplements in the gut. Because it suggests synergism. The word "synbiotics" should only be applied to products in which the prebiotic compound(s) benefit the probiotic organism(s). This review will examine the possible therapeutic uses of pre-, pro-, and syn -biotic concerning cancer. These agents now constitute the main treatments geared towards positive modification of the microbiota (as opposed to negative manipulation with antibiotics). As our grasp of science has evolved, pre- and probiotic classifications have undergone several changes. 'A substrate that is preferentially used by host microorganisms imparting a health advantage' is the definition of a prebiotic [1]. Numerous molecules fall under this category; the non-digestible oligosaccharides fructo-oligosaccharide (FOS, which may be found in foods like onions and garlic) and galacto-oligosaccharide have received the most research. These substances work by encouraging commensal bacteria to proliferate and/or operate in ways that are advantageous to the host. Probiotics, on the other hand, are "live microorganisms that, when administered in sufficient amounts, confer a health benefit on the host" [2].

Although many fermented foods (like kimchee, tempeh, kombucha, sauerkraut, probiotic yogurt or kefir) contain live organisms, the majority are not considered probiotics because the food itself confers the health benefit rather than the organisms, and they frequently do not contain enough organisms to be classified as probiotics. Synbiotics are a preparation that combines pre- and probiotics. Probiotics are a group of certain microorganisms that may be found in the *Lactobacilli* or *Bifidobacteria* genera and are available as single agents or multi-strain formulations. Probiotics are typically consumed orally and are made to survive transit to the lower gastrointestinal (GI) tract, whether they are consumed in the form of yogurt, freeze-dried live organisms taken as a powder, or in capsule form. [3] By competitive exclusion, direct antagonistic action, neutralization of pathogenic bacterial toxins, and preservation of intestinal barrier function, they may lessen the impact of pathogenic organisms on the host. Short-chain fatty acid (SCFA) generation, bile acid metabolism, vitamin biosynthesis, and carcinogen neutralization are only a few of the metabolic impacts of probiotics [4-6].

Probiotics may alter the immune response of the host to produce an oncosuppressive phenotype [7]. Finally, strains may alter stool consistency, gas production, and intestinal motility [8]. It is significant to remember that probiotics do not need to colonize the host to have positive effects because they are administered during intestinal transit [9]. Pre-, pro-, and synbiotics have been studied in both pre-clinical and clinical research in a variety of contexts relevant to patients with cancer. Mammalian microbiota's potential to influence cancer therapy toxicity and effectiveness as well as tumor genesis, cell growth, and metastasis is gaining more scientific support [10]. Before examining the data supporting the use of pre-, pro-, and synbiotics in the prevention and treatment of cancer, we will briefly explore the broad anticancer mechanisms of these symbiotic agents.

Mechanisms of pre-, pro- and synbiotics as anticancer agents

Strong evidence suggests that the human microbiome participates in the development of cancer and is an important member of a trio of "interactomes" that also includes the host and the environment [11, 12]. A lot of research has been conducted on how the regulation of the microbiome by pre-, pro-, and synbiotics may help in the prevention and treatment of cancer because of this important role. There are possible pathways that may be roughly categorized into intestinal barrier function, immunomodulatory, metabolic, and anti-proliferative effects that support a non-carcinogenic impact of pre-, pro-, and synbiotics [13].

Intestinal barrier function

One of the fundamental principles of their symbiosis is the physical isolation of the microbiota from the host. One of the main causes of illness, including cancer, is recognized to be the disruption of the physical barriers between the microbiota and the host [12]. This barrier in the gut is made up of enterocytes, cell junction proteins, immune cells, secretory IgA, goblet cells, mucus, Paneth cells, and antimicrobial peptides (creating the "tight junction" between cells). The intricate and interconnected interaction between barrier failure, carcinogenesis, and inflammation is best shown by mucin 2 homozygous mutant mice, which spontaneously develop colorectal cancer (CRC) and lack the intestinal mucus needed to serve as a barrier. Additionally, patients with ulcerative colitis have impaired barrier function, which raises their risk of CRC [14, 15]. Probiotics have been shown to enhance the development of epithelial tight junctions and mucus production in preclinical studies using colonocyte cell lines and animal models [16, 17]. Studies on humans have also shown that probiotic therapy improves colonic epithelial integrity [18, 19]. Additionally, a synbiotic cocktail prevented the growth of CRC in a mouse model by up-regulating genes linked to the creation of tight junctions and the production of mucus [20].

Immunomodulation

The immune system's development and the activation of an anticancer response, both in the gut and at other places, depend on the microbiota. The main effectors for locating and eliminating damaged and possibly cancerous host cells are dendritic cells, natural killer (NK) cells, and T cells [21]. Toll-like receptors are cell-surface pattern recognition receptors that probiotics use to connect with dendritic cells, which in turn triggers responses from T cells and NK cells. In both rodent models [22] and human investigations [23, 24], formulations of probiotics and synbiotics containing *Lactobacillus casei* or *Bifidobacterium lactis* have been demonstrated to increase NK cell activity. Additionally, probiotic-induced NK cell activity has been found to inhibit cancer development in rodent models [25, 26]. Sivan et al. (2015) reported an especially intriguing case in which genetically comparable mice kept by several providers had varied development rates of subcutaneously implanted melanoma cells [27]. When compared to mice from Jackson Laboratory (JAX), Taconic Farms (TAC) animals showed considerably faster tumor growth. Prior to the injection of cancer cells into TAC mice, however, oral gavage of live, but not heat attenuated, Bifidobacterium spp. was able to limit tumor development to that observed in JAX animals. The researchers came to the conclusion that enhanced dendritic cell activity was responsible for this anticancer impact [27].

Metabolism

Numerous methods exist through which the metabolic activity of the microbiota might have a co-suppressive impact. The byproducts of bacterial non-digestible carbohydrate fermentation known as SCFAs, such as butyrate, acetate, and propionate, operate as a significant source of energy for colonocytes and have anti-inflammatory, anti-proliferative, and pro-apoptotic effects. Perhaps the most well-researched SCFA, butyrate causes NF-B downregulation and Treg cell induction [28]. Butyrogenic lactic acid bacteria can develop more quickly when prebiotics are present. Rats given prebiotics produced more SCFA had higher relative abundances of *Bifidobacteria* and were protected from CRC brought on by chemically induced colitis [29]. However, there have been conflicting findings about how pre-, pro-, or synbiotic treatment affects SCFA synthesis in humans. In one research, consuming resistant starch for three weeks (a prebiotic) was shown to raise feces SCFA [30], while in another, giving healthy human volunteers synbiotics failed to reveal any changes in fecal SCFA content or serum inflammatory markers

[31]. Because neither research had a sizable sample size (n = 17 at most), neither side can make definitive conclusions. Through the detoxification of pro-carcinogens, probiotics may also reduce the risk of cancer. Physiologically beneficial effects have not been seen in vivo investigations despite certain probiotic strains having cell-surface peptidoglycans that have been proven to bind mutagens in vitro [32]. Antioxidant characteristics in some probiotic strains can prevent carcinogenesis in mouse models [33]. Because they can produce carcinogens from substances found in the gut lumen, ß-glucuronidase and nitro reductase, for example, are involved in the development of cancer through their actions. Probiotics can lower the intestinal activity of these enzymes, according to several human investigations [34–36].

Antiproliferative effects

Probiotic strains have been shown to be both pro-apoptotic and anti-proliferative. Cancer cell lines have been found to be affected by lactic acid bacteria, and comparable effects have been shown in mouse models [38, 39]. Different mechanisms have been put forth to explain these effects. Tumor Necrosis Factor and caspase-dependent apoptosis can be induced by altering cell signaling cascades (such as NF-B and MAPK), whilst SCFAs like butyrate can suppress cell proliferation by inhibiting histone deacetylase [40]. Probiotics have antigenotoxic characteristics in animals exposed to mutagens, and DNA damage is frequently both a cause and a driver of unchecked cancer cell growth [41]. Sadly, not much research has looked at how pre-, pro-, or synbiotics affect human cellular proliferation. According to Worthey et al [31], administering a synbiotic to human volunteers had no impact on the expression of the epithelial proliferation marker ki67 or the cellularity of the crypts in later rectal biopsies. Though O'Keefe et al did discover that moving from a low-fiber, high-animal fat diet to a high-fiber (resistant starch), low-animal fat diet decreased ki67 staining in intestinal mucosal biopsies in their well-conducted dietary swap trial [42]. It is impossible to attribute these changes explicitly to the fiber element given the nature of the dietary adjustment, but the findings are unquestionably intriguing.

Cancer prevention

Due to the colorectal cancers (CRC) widespread occurrence, the high density of microbiota in the colon (orders of magnitude greater than any other host niche), and the significant influence of environmental (rather than genetic) risk factors, probiotics' effects on CRC are among the topics of research that have received the most attention. Large-scale epidemiological studies have looked at the effects of yogurt and unpasteurized milk intake, which often include living microorganisms, even though no long-term prospective cohort investigations are looking at the effect of pre, pro, or synbiotic usage on CRC incidence. A prospective cohort study of 45,241 people found a significant relationship between higher versus lower yogurt consumption and a reduced risk of CRC (hazard ratio 0.65, 95% confidence interval (CI) 0.48–0.89) [43] while a study of 41,836 people found a relationship between unpasteurized milk consumption and a reduced risk of rectal (but not colon) cancer (relative risk (RR) 0.26, 95% CI 0.1–0.69) [44]. Consuming milk that has undergone fermentation or culture has also been linked to a reduced incidence of bladder cancer [45, 46]. However, a meta-analysis found no significant connection between CRC and milk or all dairy products alone [47], while milk and total dairy products were linked with a lower risk of CRC (RR 0.81, 95% CI 0.74-0.90). The evidence is intriguing but debatable, and there is a paucity of prospective data on pre-, pro-, and synbiotic usage in general as well as on primary cancer risk, as is the case with many epidemiological studies of dietary variables. A few studies have examined their function in reducing the risk of recurring cancer. Rafter et al [48] showed that various CRC indicators, including DNA damage and cellular proliferation, improved in the intervention group in a randomized controlled trial (RCT) comparing synbiotics to placebo in polypectomies or CRC patients. The secondary prevention of cancer recurrence in individuals with a history of CRC, however, was not found to be avoided by synbiotic treatment in a different study [49]. High dietary fiber consumption was found to be related to a decreased relative risk of eventual advancement to CRC (RR 0.72, 95% CI 0.63-0.83) in a meta-analysis involving approximately 11,000 participants with colorectal adenomas [50]. Interestingly, oral *Lactobacillus casei* Shirota treatment has shown more promise in preventing recurrent bladder cancer (after transurethral resection), with positive outcomes reported in two human studies as compared to placebo [49, 51].

Cancer treatment

It is not novel for bacterial agents to be employed in the therapy of cancer; since 1977, superficial bladder cancer has been effectively treated with Bacillus Calmette-Guérin implantation. Probiotics have been proven to have direct anticancer benefits in several mouse models (mentioned above), and researchers are looking at how bacteria may be genetically engineered for increased anticancer efficacy or employed as delivery systems for chemotherapeutics. The primary use of microbiome modifying treatment in treating human cancer, however, is now as an adjuvant therapy, enhancing the efficacy and/or reducing the side effects of chemotherapy, radiation, antibiotics, and surgery.

Chemotherapy and radiotherapy

It is important to draw attention to the specific circumstances in which probiotics may be advantageous [52]. The interaction between chemotherapeutic drugs and the microbiota has already been covered in great detail elsewhere in this special issue. The healthy gut microbiome has a varied microbial population as a vital component, and current research indicates that this community may also affect chemotherapy response and overall cancer survival. The role of the microbiota in chemotherapeutic drug anticancer activity has been emphasized in murine models [53, 54]. Low microbial diversity was separately linked to both a lack of clinical response to an immune checkpoint inhibitor in patients with advanced melanoma [56] and a decreased survival in patients following allogeneic hematopoietic stem cell transplantation [55].

Additionally, it has been demonstrated that chemotherapy itself substantially decreases microbial diversity [57]. As a way to preserve variety and enhance the efficiency of chemotherapy in this situation, pre- and probiotic treatment may be taken into consideration before and concurrently with chemotherapy. Although studies addressing this issue have not yet been published, it is an intriguing area for further research. Following pelvic radiation, which is frequently given to patients receiving treatment for urgynecological or rectal malignancies, changes in bowel function have been well-documented. The involvement of the microbiota in radiation-induced intestinal damage and the potential therapeutic use of probiotics are topics of considerable interest [58].

Following pelvic irradiation, dysbiosis has been linked to the emergence of postradiotherapy diarrhea [59], and several randomized trials have shown that probiotics can lessen the GI adverse effects of radiation [60]. Similar to GI mucositis, which can be dose- or treatment-limiting, is a frequent side effect of several chemotherapy drugs. Probiotics may interfere with the pathogenesis of mucositis on several levels, including triggering cytoprotective pathways, reducing reactive oxygen species, displacing pathogenic bacteria, and maintaining the integrity of the intestinal barrier. In 150 patients undergoing 5-fluorouracil-based chemotherapy for CRC, a randomized trial comparing probiotic supplements to placebo revealed substantially less grade 3/4 diarrhea in the intervention group (22 versus 37%, $p = 0.027$) [61]. Additionally, a meta-analysis has demonstrated that using probiotic supplements helped cancer patients experience less diarrhea (odds ratio antibiotics (OR): 0.52; 95% confidence interval (CI): 0.34-0.78) [62]. Expert recommendations have recently been published and encourage the use of probiotics including Lactobacillus in patients receiving chemotherapy or radiation for pelvic cancer in order to avoid diarrhea [63].

CONCLUSION

To sum up, pre-, pro-, or synbiotics have a lot of potential for preventing and treating cancer, but the science is still extremely young. Although there are well-established mechanisms through which probiotics may have positive benefits, clinical investigations tend to be scarce, small, heterogeneous, and frequently prone to bias [62]. It is difficult to infer that these treatments are more effective at preventing cancer than a balanced diet that is low in animal meat and rich in fiber, but many Westerners do not eat this way and have additional cancer risks factors, such as obesity and diabetes. The expenditures of long-term usage would not be small, but the hazards of taking pre- and probiotic supplements seem to be quite low. The most important research to determine any reduction in cancer risk is prospective longitudinal cohort studies. A stronger body of research supports the use of pre-, pro-, and synbiotics as adjuncts in the treatment of cancer. There is moderate evidence to support their usage, in particular, in the avoidance of infectious problems after surgery, antibiotic-associated diarrhea, and diarrhea linked to chemotherapy or radiation for pelvic cancer. Randomized interventional studies on people are crucial for understanding the possible advantages of co-administration with immunotherapy. However, for patients to gain the most from probiotics, we need to have a better understanding of the precise formulations that are effective in certain patient cohorts. Probiotic and prebiotic research is advancing at a fast rate, especially in the field of cancer where several promising therapeutic advantages are tantalizingly near. However, to achieve them, there must be a strong emphasis on performing high-quality, well-reported studies.

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Contents

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Unravelling the Microbial Symphony Within: A Comprehensive Review of Gut Microbiota

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Chapter - 4

Unravelling the Microbial Symphony Within: A Comprehensive Review of Gut Microbiota

Sidra Khousin, M.P. Sandhya and Dr. S. Anu Kiruthika

Abstract

The gut microbiota is a complex ecosystem of microorganisms, including bacteria, viruses, fungi, and archaea, that inhabit the human gastrointestinal tract. This microbial consortium plays a crucial role in various physiological processes and has gained increasing attention in recent years. The gut microbiota's functions extend beyond digestion, contributing to nutrient metabolism, immune system development, and protection against pathogens. The balance and composition of gut microbiota are regulated by factors such as diet, host genetics, and environmental influences. Disruptions in this balance can lead to health issues. A diverse gut microbiota is associated with better health outcomes. The links between microbiota diversity and conditions like obesity, diabetes, and autoimmune diseases are discussed, with potential therapeutic implications. External and internal factors, such as dietary choices, antibiotic use, and stress, significantly impact gut microbiota composition. Imbalances in the gut microbiota, known as dysbiosis, have been implicated in a range of diseases, including inflammatory bowel disease, allergies, and mental health disorders. Understanding the composition, functions, and regulation of the gut microbiota provides opportunities for innovative therapeutic interventions. Future research holds promise for advancing our understanding of the gut microbiota's role in health and disease. This comprehensive review article offers insights into the gut microbiota, providing a foundation for future research and therapeutic developments.

Keywords: Gut microbiota, microbial diversity, host-microbiota interaction, dysbiosis, gut-brain axis

Introduction

Microbiome refers to the collective genomes of the microorganisms in a particular environment, and microbiota is the community of micro organisms themselves. The human gastrointestinal system contains 100 trillion

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REVIEW Open Access

Effects of D-pinitol on diabetes mellitus: an updated review

Anandakumar Pandi[1*], Vanitha Manickam Kalappan[2] and Naveenkumar Chandrashekar[3]

Abstract

Background: The awareness in the consumption of plant-based food has gained attention in the recent years. Phytochemicals are thought to play a critical role in health promotion and in the prevention and management of chronic diseases. These compounds have reported to produce little or no side effects and are thus significantly used in treating various ailments. D-Pinitol is the chief active compound found in soy and soy products. Several studies have shown the health benefits of D-pinitol such as antioxidant, anti-diabetic, anti-inflammatory and anticancer properties. In this review, an attempt has been made to review the effects of D-pinitol against diabetes mellitus in pre-clinical and clinical studies.

Methodology: Journal articles were sourced and filtered with relevant keywords on "D-pinitol and diabetes mellitus". Scientific databases, including PubMed, NCBI, Google Scholar, Science Direct, SciFinder and Web of Science, were accessed to identify the most relevant articles on the effect of D-pinitol in diabetes mellitus. The study duration was from September 2021 to February 2022.

Results: This comprehensive review demonstrates the application of D-pinitol against diabetes mellitus. Most of the animal and clinical studies included in this review reported that D-pinitol treatment effectively regulated hyperglycemia and prevented insulin resistance.

Conclusions: D-Pinitol could serve as an effective anti-hyperglycemic agent for the treatment of diabetes mellitus. Further research to study its safety and mechanism of action is recommended in order to employ this compound for clinical trials.

Keywords: D-Pinitol, Antioxidant, Glucose, Insulin, HbA1C

Background

Diabetes mellitus is one of the most common non-communicable diseases. It is group of metabolic disorders in which hyperglycemia lasts over a longer period leading to several other complications (Toi et al. 2020). It is characterized by supraphysiological glucose due to the deficiency in insulin secretion or insulin receptor or post-receptor events that results in the disturbances in the biochemical pathways of carbohydrates, fats and protein (Ruiz 2012). Moreover, the impaired metabolism leads to the progression and aggravation of oxidative stress through different mechanisms like glucose autoxidation, protein glycation, etc. (Dos Santos et al. 2019). The total number of people with diabetes is predicted to increase from 171 million in 2000 to 366 million in 2030 (Tao et al. 2015). Studies direct that the incidence of diabetes will continue to rise in the future due to growing prevalence of obesity, accelerating aging populations, environmental factors and sedentary lifestyles (Piché et al. 2020). Chronic blood sugar level and insulin resistance may in turn lead to severe impairment and dysfunction of heart, kidney, liver, eye, nerves, etc., which predominantly lead to mortality (Kautzky-Willer et al. 2016). At present, there is no known cure approaches for diabetes mellitus except in some very specific cases. Several efforts are

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REVIEW Open Access

Cardioprotective effects of Ferulic acid against various drugs and toxic agents

Anandakumar Pandi[1*], Mahto Hemanti Raghu[1], Naveenkumar Chandrashekar[2] and Vanitha Manickam Kalappan[3]

Abstract

Background: Homeostatic regulation of cardiomyocytes is indispensable in maintaining the normal physiological activity of cardiac tissue. Cardiotoxicity induced by drugs may lead to cardiac abnormalities such as arrhythmia, myocardial infarction and myocardial hypertrophy. Moreover, drug-induced cardiotoxicity confines the additional use of the implicated drugs. Several studies have reported that consumption of phytochemicals on regular intervals shall protect humans against numerous diseases such as diabetes, cardiovascular disease, inflammatory diseases and cancer.

Main body: Ferulic acid (FA) is a plant derived polyphenol abundantly found in vegetables, fruits and grains. FA is widely known for its antioxidant, anti-inflammatory, anticancer, nephroprotective and hepatoprotective effects. FA has been well documented for its cardioprotective activity against various drugs and toxic agents as well. However, the cardioprotective action of FA have remained a challenge with regard to understanding its mechanism in health and diseases.

Conclusion: The main purpose of this review is to explore the cardioprotective mechanisms of FA against several drugs and chemicals to recommend further studies to investigate the potential protective effect of FA.

Keywords: Ferulic acid, Antioxidant, Cardioprotective, Preclinical, Cell line, Human health

1 Background

Cardiotoxicity usually denotes toxicity that has a harmful effect on the heart, which may ultimately result in myocardiopathy such as arrhythmia, myocardial infarction and myocardial hypertrophy [1, 2]. In the last few years, more than 20% of clinical drugs were forced out of the market because of cardiovascular side effects, which hampered the drug development and extremely affected the improvement in patient health [3]. Several studies have showed that drug-induced cardiac dysfunction may be a stepwise process accompanied by the increase of cardiac biomarkers and structural myocardial deformation, finally resulting in reduced left ventricular ejection fraction (LVEF) [4, 5]. Recently, the most accepted term for cardiotoxicity is the reduction in LVEF of at least 10% to less than 55% [6]. Studies show that cardiac cell death or damage concurrently occurs with the progression of cardiotoxicity, demonstrating that drug-induced cardiomyocyte death may be the major for cardiotoxicity [7].

In the recent years, extensive research has been undertaken to investigate the action of phytochemical compounds found in the diet [8]. The reason commonly found in fruits, vegetables, beverages and herbal remedies [9]. These alkaloid compounds contain numerous active substances like flavonoids, polyphenols, indoles and sulfur containing elements [10]. These phytochemicals have the tendency to safeguard humans against diabetes mellitus, hepatic disorders, cardiovascular disease, cancer, arthritis, and Alzheimer's disease and many more [11, 12]. Findings from numerous studies have demonstrated that

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JOURNAL OF BIOCHEMICAL AND MOLECULAR TOXICOLOGY

RESEARCH ARTICLE

Baicalein inhibits cell proliferation and enhances apoptosis in human A549 cells and benzo(a)pyrene-induced pulmonary carcinogenesis in mice

Naveenkumar Chandrashekar, Raghunandhakumar Subramanian, Devaki Thiruvengadam

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Abstract

Our current study is done to explore the possible mechanisms to elaborate on the growth inhibitory effect of baicalein (BE) in human lung carcinoma. Initially, BE (25 and 50 μM) treatment for 24 h, suppressed the viability and inhibited population growth in A549 cells. BE upholds the production of reactive oxygen species (ROS) with concomitant replenishment of glutathione, catalase, and glutathione peroxidase activity. The expression level of nuclear factor erythroid 2-related factor 2 and heme oxygenase-1 markedly increased after BE treatment will intimidate A549 cells proliferation by the ROS-independent pathway via the antioxidant pathway. In vivo investigations were carried out on BE (12 mg/kg, oral) in benzo(a)pyrene (B(a)P; 50 mg/kg, oral) induced lung carcinogenesis in mice. BE induces caspase-dependent apoptosis by increasing the levels of cytosolic cytochrome c accompanied by upregulating the outflow of p53, Bax, and caspase-3 with a concomitant abatement in the outflow of Bcl-2 in both in vitro and in vivo. In the murine model, BE treatment hindered the countenance of proliferation-related proteins (argyrophilic nucleolar organizing regions and proliferating cell nuclear antigen). Additionally, appraisal of the cell nucleus by transmission electron microscopic assessment uncovered that BE treatment adequately counteracts B(a)P-induced lung cancer cell survival. During the transition of the G_2/G_1 phase, BE is arrested in the cell cycle process. This might be the cause of a substantial increase in the appearance of $p21^{Cip1}$ with concomitant downregulating the expressions of CDK4, cyclin D, and cyclin E both in vitro and in vivo. These results conclude that BE treatment induced apoptosis and repressed proliferation in vitro and in vivo of human lung carcinoma.

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ENDOPHYTES FROM MEDICINAL PLANTS AS BIOCONTROL AGENTS ; A COMPARITIVE STUDY

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ABSTRACT

Aim: To isolate endophytic microorganisms from the leaves of *Ocimum sanctum, Plectranthus amboinicus,* and from the flower of *Hibiscus rosa-sinensis*..To assess and comparatively study the antibacterial effect of secondary metabolites of endophytic bacteria and fungi.
Methods: Surface sterilization of collected samples, pre-treatment of sterilized samples, isolation, and preliminary characterization of these endophytes was carried out via microscopic observations and biochemical characterization. These endophytes were screened for their antibacterial activity.
Results: A total of 3 fungi and 31 bacteria were isolated from these medicinal plant samples. Out of which only three fungal and four bacterial endophytes were chosen based on the agar plate activity, sub-cultured and screened for the production of bioactive compounds. Later the effect of their secondary metabolites was studied against multidrug-resistant bacteria such as *Staphylococcus aureus, Klebsiella pneumoniae, Pseudomonas aeruginosa*, and *Serretia* sp. All the chosen endophytes except one fungi showed promising inhibitory effects against the test organisms.
Conclusion: The zones of inhibition obtained from the fungal metabolites were wider and had better inhibitory effect on all the test organisms even at a lower concentrations where as, the secondary metabolites obtained from the four bacterial endophytes displayed as varying effect on the above mentioned organisms. Hence its confirmed that the fungal metabolites are more efficient in controlling the growth of these test organisms. The increased concentrations of the bacterial metabolites enhances its antibacterial effects.

Keywords: Endophytic microorganisms, *Ocimum sanctum, Plectranthus amboinicus, Hibiscus rosa-sinensis,* secondary metabolites, bioactive compounds, antibacterial activity, biocontrol agents.

1. INTRODUCTION

Like human beings, plants have certain amount of micro-flora consists of bacteria, actinomycetes and fungi present in its system. These micro-organisms residing within the live plant tissues without causing any significant symptoms or disease in the plants are known as endophytic microorganisms. De Bary in 1866 coined the term endophytes. The term 'Endophyte' is derived from Greek words "Endon" meaning "within" and "phyton" meaning "plants". A wide variety of microorganisms live in close proximity to plants (Anjum *et al*., 2015; Geetha *et al.*, 2019). Numerous surveys have been conducted, the majority of which focused on pathogenic interactions between plants and microorganisms associated with them. However, several studies were conducted on the role of microbial diversity in relation to various plant species, it was assumed that only a small percentage of the microbes interacting with the plant are pathogenic in nature. Most microorganisms that inhabit plants play an important role in the plant's health and development, though some are neutral. A single plant species may contain thousands of microbes, which are classified as epiphytes (microbial inhabitants of the rhizosphere and phyllosphere; those near or on plant tissue) or endophytes (microbes residing within plant tissues in leaves, stems, and roots) (Sushanto *et*

al., 2016). Endophytes are promising, underutilized, and useful sources of novel natural products for use in agriculture, medicine, and industry. Endophytes have long been recognized as a source of pharmaceutical bio-active compounds, as many endophytes have been explored to produce novel bio-active metabolites such as anti-bacterial, anti-fungal, anti-viral, anti-tumor, anti-oxidant, anti-inflammatory, immuno-suppressive drugs, and many other compounds. They are well known for producing various classes of natural products and have been reported to exhibit a wide range of biological activity, including alkaloids, terpenoids, steroids, lactones, phenolic compounds, quinones, lignans, and others (Anjum *et al*., 2015). The most active bioactive compounds produced by these endophytes are antibiotics that are low molecular weight natural bioactive compounds which are basically proteins that are active against other microorganisms. Most of the chemotherapeutically important antibacterial or antifungal drugs are either microbial metabolites or their semi synthetic derivatives obtained through bioconversion or biotransformation processes (Kumar *et al*, 2015).

Taking into account the afore-mentioned benefits, the current study was carried out to isolate and evaluate bacterial and fungal endophytes from selected plant parts and to assess their potential for antibacterial activities.

About the sample plants

1. ***Ocimum sanctum*** (Holy Basil) commonly known as Tulsi, belongs to the family Lamiaceae is a widely distributed medicinal plant in India. Tulsi leaves contains bright yellow-colored volatile oil reported to possess antibacterial properties and is known to work as an insecticide. Traditionally its leaves are used as remedies for cold, bronchitis, cough, digestive issues etc., (Anjum *et al*., 2015). Holy Basil plant is considered as a sacred plant in India, which possesses antibacterial, antipyretic, immunomodulatory, anti-inflammatory, anti-stress, anti-asthmatic, hypotensive, hypoglycemic, and analgesic effects (Bhargava *et al*., 1981; Chattopadhyay *et al*., 1993).
2. ***Hibiscus rosa-sinensis***, commonly known as *Hibiscus* belongs to the family of Malvaceae. *Hibiscus* is used as a herbal medicine to treat hypertension, cholesterol production, and cancer progression, in addition to casual consumption. Traditionally the flowers have been used as anti-asthmatic medications. Previous pharmacological studies revealed that *Hibiscus rosa-sinensis* had reproductive, anti-inflammatory, anti-diabetic, analgesic, fibrinolytic, hypolipidemic, antioxidant, antipyretic, immuno-modulatory, anticonvulsant, antidepressant, memory enhancement, cytotoxic, antimicrobial, antiparasitic, dermatological, anti-haemolytic, urinary, hepatoprotective, neuroprotective effects etc., (Ali, 2018). Hence, further studies can help in developing newer drugs using *Hibiscus* flowers.
3. ***Plectranthus amboinicus L.*** *(Coleus amboinicus),* commonly known as Indian borage is a medicinal plant of Lamiaceae family. It has been extensively studied and recognized for its antifungal, antioxidant and antiinflammatory properties. Traditionally this plant has been used to treat high fever, throat infection, nasal congestion, cough, indigestion constipation and other digestive issues (Patrick *et al*., 2019). This plant's leaves have been shown to have in vivo antimalarial activity against *Plasmodium berghei yoelii*. Carvacrol, flavonoid, rosmarinic, caffeic acid, and chlorogenic acid are all found in the leaves of *Coleus amboinicus*. Flavon salvigenin, 6-methoxygenkwanin, quercetin, chrysoeriol, luteolin, apigenin, flavanon eriodyctol, and flavanol taxifolin are among the flavonoid constituents of this plant (Astuti *et al*., 2014).

Need of the study

In this modern era, excessive use of chemotherapeutic drugs and antibiotics - both natural and synthetic, has led to the development of antibiotic resistance in microorganisms specifically in human bacterial pathogens. But these pathogens are still sensitive to certain medicinal plants due to the presence of diversified compounds in it. Various studies prove that compounds present in plants are not only plant products but also a contribution of endophytes present in them. Therefore, these endophytes can be studied and explored for their potential to produce various bio-active compounds which can be practically used as drugs in treatment of various diseases. It also can be used as antipyretic drugs, anti-diabetic drugs, anticancer drugs etc.

2. MATERIALS AND METHODOLOGY

2.1 Sample Collection

Different medicinal plants such as *Coleus amboinicus* (Mexican mint herb), *Ocimum sanctum* (Tulsi), and *Hibiscus* flower were used as samples. Fresh leaves from Mint, Tulsi plant, and hibiscus flower samples were collected using sterile forceps from Bangalore, Karnataka, and subjected to surface sterilization in order to isolate endophytic microorganisms.

2.2 Surface Sterilization

The freshly collected leaves and flower samples were thoroughly washed under running tap water for 15 to 20 minutes in order to remove debris, soil particles, pollens, etc. from their external surfaces. The samples were then washed thrice using sterile distilled water and pat dried to remove excess water. The plant materials were rinsed again using 70% ethanol and methanol separately for 3 minutes each. Finally, the samples were washed using sterile distilled water and dried using sterile blotting papers and tissues (Anjum *et al.,* 2015).

Sterility check: The effectiveness of surface sterilization was confirmed by inoculating 1ml of sterile distilled water (in which the surface sterilized leaves and flower was dipped) on nutrient agar plates and incubating for 24 hours and checking for the presence of microbial growth (Anjum *et al.,* 2015).

2.3 Preparation and Sterilization of Media

The choice of the media used plays a major role in favoring the growth of endophytes. Nutrient agar being a basic medium supports all types of microbial growth, hence it was used for isolation of endophytes from the chosen samples. Other media such as Muller-Hinton agar, Nutrient agar, and potatoes dextrose agar were also used for the growth of isolates. These media were prepared and sterilized at 121ºC under 15lbs using an autoclave. The sterile media was poured into sterile petriplates under aseptic conditions and respected media containing plates were clearly labeled and used to isolate the endophytes from the samples (Garba *et al.,* 2020).

2.4 Pre-treatment of sterilized samples and isolation of endophytes

The surface sterilized plant samples were crushed using sterilized mortar and pestle, and the finely crushed samples were stored in the sterile Eppendorf tubes. Then the prepared samples were inoculated (using spread plate and pour plate techniques) onto Nutrient agar (NA) plates and Potatoes dextrose agar plates (PDA) to isolate Endophytic bacteria and fungi respectively. The plates with respective samples were wrapped using parafilm tape and incubated at 28±2ºC for 24 to 48 hours. After the incubation period growth of various endophytic bacteria and fungi was observed. Morphologically different bacterial and fungal colonies were chosen and based on their agar plate activity (antagonistic effect) the bacteria and fungi were randomly picked and used in further process. The pure cultures of selected isolates were prepared in duplicates and preserved at 4ºC for further use. The fungal and bacterial pure cultures were stained using LPCB staining technique and Gram staining technique respectively.

2.5 Detection of Bioactive Compound produced by the chosen Endophytes

The bacterial and fungal colonies were sub-cultured in the broth medium and the presence of bioactive compounds from the cultured broth medium was detected using the well diffusion method where the wells were created by puncturing the Muller Hinton agar medium using sterile 1ml micropipette tips. Then the plates were labeled and swabbed with different test organisms. The swabbed plates were incubated for 10 minutes. 20µl of overnight grown bacterial broth samples and 20µl of 7 days old fungal broth samples were inoculated into the respectively labelled wells and all the inoculated plates were incubated for 24 - 48 hours at 28ºC. After the incubation period, the plates were observed for the presence of clear zones which indicates the presence of bioactive compounds. A total of 7 isolates containing three fungal colonies and 4 bacterial colonies showed the clear zones indicating the presence of bioactive compounds in the inoculated brothes.

Test organisms used were - *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, and *Serratia* sp.

Inorder to analyse the effect of plant extract on microorganisms, an experiment was performed by air exposing the plant extract contaning plates and results were observed.

2.6 Effect of plant extract on growth of microorganisms using cold extraction method.

In this method, sample plant leaves were surface sterilized and crushed using a sterile mortar and pestle. The finely crushed sample was then filtered using a whatmann filter paper. The filtrate was then plated using pour plate technique in the aliquotes of 1ml - 5ml respectively. A plate containing only nutrient agar media was used as a control to comparitively analyse the effect of plant extract with increasing concentrations on the air exposed microorganism. After 24 hours of incubation, plates were compared to check the effect of plant extract in its increasing concentrations. With the increase in concentration, the plates showed decrease in the microbial diversity in the air exposed plates. This indicates that the plant extract has lesser effect on air microfloral growth.

Figure. 1. Filtration of plant extract

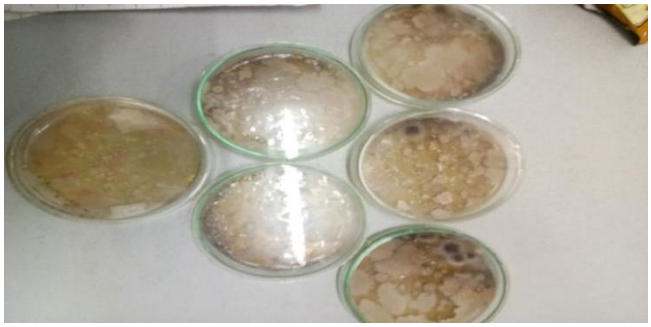

Figure. 1.1 Plates containing Plant extract in different concentrations

Table 1. Effect on Plant extract on Air Micro-flora by Pour Plate technique.

Sl. No.	Volume of NA (ml)	Volume of filtrates plant extract (ml)
(Control)	20.0	0.0
1	19.0	1.0
2	18.0	2.0
3	17.0	3.0
4	16.0	4.0
5	15.0	5.0

3. RESULT AND DISCUSSION

3.1 Isolation of Endophytes

In this project, a total of 3 fungi and 31 bacteria was isolated from three different medicinal plant samples, i.e., from the leaves of *Ocimum sanctum* and *Plectranthus amboinicus* , and from the flower of *Hibiscus rosa-sinensis.* The isolates were named as ISL1 to ISL7 out of which, ISL1 - ISL3 were fungal cultures and ISL4 - ISL7 were bacterial cultures. On LPCB staining of pure fungal cultures, one common fungi was identified and only different fungal colonies were further studied and screened based on their colony morphology. The details of the selected isolates is given below in the tabular form.

Table 2. Total Endophytic Isolates obtained from Three different Medicinal plants. [code ISL stands for isolate]

SL. NO	Medicinal plant name.	Bacteria	Fungi	Selected isolates (Bacteria + Fungi)
1.	***Ocimum sanctum***	9	2	1+2 = 3 isolates
2.	***Plectranthus amboinicus***	10	1	1+1 = 2 isolates
3.	***Hibiscus rosa-sinensis***	12	2	2+2 = 4 isolates

Table 3. Chosen Isolates for further Screening of Bioactive Compounds. [ISL means Isolate]

SL. NO	Medicinal plant name.	Bacteria	Fungi
1.	*Ocimum sanctum*	ISL6	ISL1
2.	*Plectranthus amboinicus*	ISL7	ISL2
3.	*Hibiscus rosa-sinensis*	ISL4, ISL5	ISL3

Figure 2 : Selected medicinal plants
A. *Ocimum sanctum.* B. *Plectranthus amboinicus* C. *Hibiscus rosa-seninsis*

Figure 3: Endophytes isolated from the medicinal plant parts
(a), (b), (e), and (g) are streak plates of Mexican mint, Hibiscus flower and Tulsi leaves samples.(c), (d), and (h) are spread plated samples of Mexicant mint, Hibiscus and Tulsi leaves respectively.

3.2 Screening for Antimicrobial Activity.

The pure cultures of endophytic bacteria and fungi were tested for its antimicrobial activity against the multi-drug resistant human pathogens such as *Staphylococcus aureus, Klebsiella pneumoniae, Pseudomonas aeruginosa*, and *Serretia* sp., by well diffusion method.

Out of three fungal isolates, two isolate, ISL1 and ISL3 showed inhibitory action against all four test organisms. The bacterial isolates ISL4- ISL7 had inhibitory effects on *Serratia* sp. and *Klebsiella* sp with different zones of inhibition. Whereas the ISL1 and ISL3 showed the zone of inhibition of 28mm wide against *Pseudomonas aeruginosa*, and had zone of about 15mm against *S. aureus.* The bacterial isolates ISL4, ISL5 and ISL6 demonstrated a very small zone of inhibition against *P. aeruginosa.* Out of four bacterial isolates only isolate ISL4 and ISL5 were able to inhibit *S. aureus* and showed a very narrow zone of inhibition. This suggests that the increase in the concentration of these bioactive compounds have the ability to significantly inhibit the growth of MRSA.

These results suggest that the fungal extracts can be used to significantly treat the diseases caused by the above mentioned pathogens than the bacterial extracts. Therefore, these isolates can be studied further and used to produce therapeutically important drugs.

Table 4. Effect of the Secondary Metabolites produced by Endophytic Microbes on Human Pathogens. [ISL stands for isolate]

Microbial codes	***S. aureus***	***K. pneumoniae***	***P. aeruginosa***	***Serratia sp.***
ISL2	–	–	–	–
ISL3	+	+	+	+
ISL4	+	+	+	+
ISL5	+	+	+	+
ISL6	–	+	+	+
ISL7	–	+	–	+

Figure. 3 Antibacterial Effect of Isolates on Human Pathogens

Triplets for each sample were maintained, and the zone of inhibition was measured for each sample. The total data is given in the tabular column

Table 3.1. Measured Zones of Inhibition [ISL represents Isolates].
[Zone of inhibition measured in millimeter (mm)]

Isolates	***S. aureus*** (Radius in mm)			***K. pneumoniae*** (Radius in mm)			***P. aeruginosa*** (Radius in mm)			***Serratia sp.*** (Radius in mm)		
ISL 1	16	18	20	18	17	20	24	20	25	26	23	26
ISL 3	15	17	18	22	20	18	26	23	24	25	23	26
ISL 4	5	9	12	24	22	25	10	7	12	13	12	15
ISL 5	14	10	15	15	17	16	7	6	9	10	8	9
ISL 6	0	0	4	12	10	13	6	4	5	7	5	4
ISL 7	0	0	2	7	5	8	0	0	0	5	3	6

All the zones of inhibition were measured from each plates in triplet sets against all the test organisms and the data is given above in the tabular form. The statistical analysis was performed when in the mean and standard deviation for each sample was calculated and the data is given below in the tabular form.

Table. 3.2 Statistical Analysis. (Code SD means Standard deviation)

Isolates	***S. aureus***	***K. pneumoniae***	***P. aeruginosa***	***Serratia sp.***
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
ISL 1	18±1.6	18±1.2	23±2.1	25±1.4
ISL 3	16±2.4	20±1.6	24.3±1.2	24.6±1.2
ISL 4	8±2.8	23±1.2	9±2.0	13.3±1.2
ISL 5	13±2.1	16±0.8	7.3±1.2	9±0.8
ISL 6	1±1.8	11.6±1.2	5±0.8	5.3±1.2
ISL 7	0.6±0.9	6.6±1.2	0	4.6±1.2

3.4Characterization of the Isolates for their Identification

3.4.1 Identification of Fungal Isolates

The pure cultures of fungal isolates were maintained, its colony morphology was observed and lactophenol cotton blue staining was performed. The colony morphology of ISL1 and ISL 3 was same on the MRBA plates and the LPCB staining of this fungal cultures confirmed that though these two fungi were isolated from two different medicinal plants (i.e., from *Ocimum sanctum* and *Hibiscus rosa-sinensis)* was identified as *Aspergillus flavus*. Where as the other fungi which showed a black background and white mycelium was isolated from *P. amboinicus* and *O. sanctum* hence it was maintained as only one pure culture. On LPCB staining it was confirmed that isolate ISL2 is *Alternaria* sp.

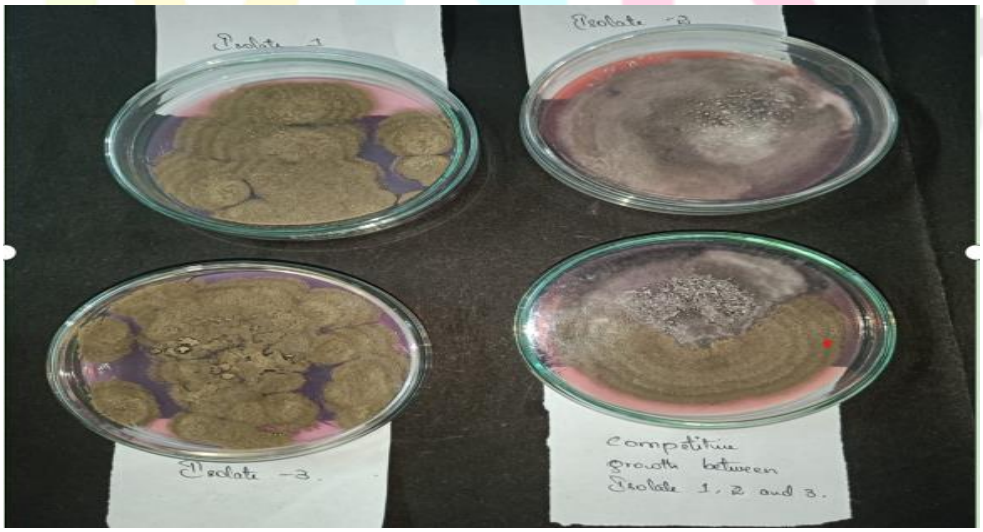

Figure. 5. Pure Cultures of Fungal isolates

A). ISL1, B). ISL2, C). ISL3 and D). Competitive growth between the ISL1 and ISL2

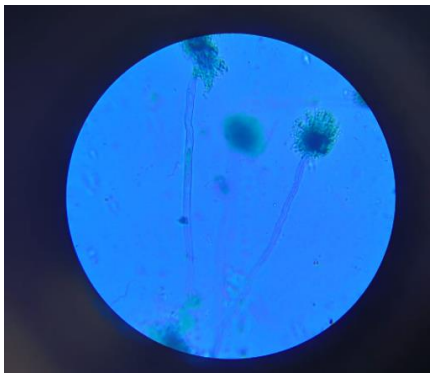

Figure 5.1. Microscopic Observation of ISL1 and ISL3.

ISL1 and ISL3 are found to be same fungi and were identified as *A. flavus.* This isolate displayed a comparitively higher inhibitory action against all the test organisms.

3.4.2 Characterization of Bacterial Isolates

The bacterial isolates ISL4, ISL5, ISL6 and ISL7 were maintained as pure cultures and gram staining was performed. The microscopic observation revealed the shape and gram character of the isolates. The microscopic observations are given below.

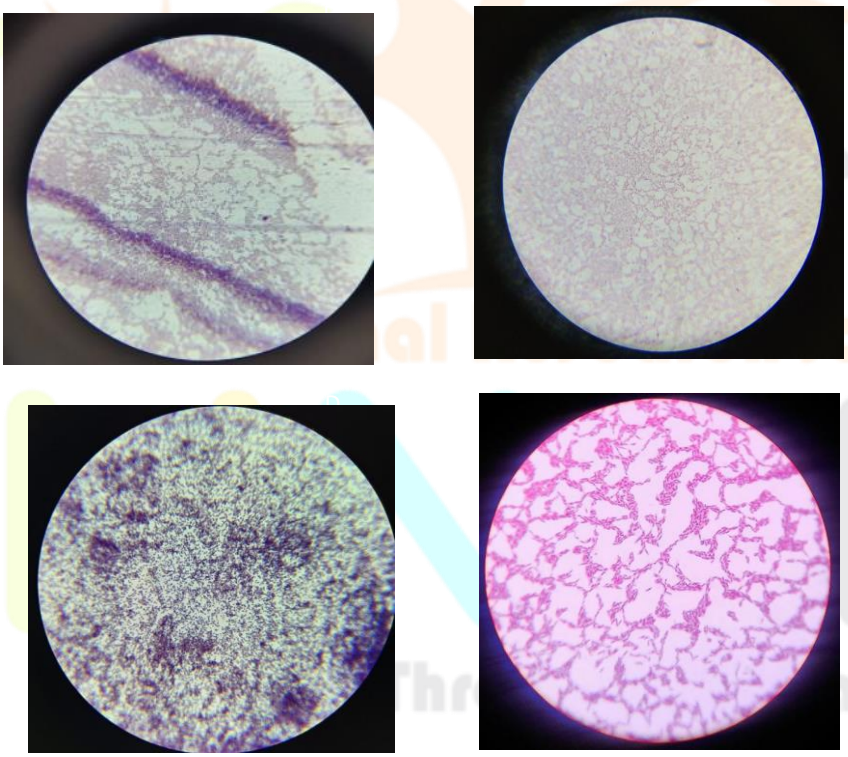

Figure 6. Gram staining [A). ISL 4, B). ISL 5, C). ISL 6 and D). ISL 7.

Table 5. Phenotypic Characterization (Colony Morphology)

Colony Morphology	ISL4	ISL5	ISL6	ISL7
Colour	Creamish	White	Bright yellow - creamish	Creamish
Form	Circular	Irregular	Irregular	Rhizoidal
Margin	Entire	Undulate	Undulate	Undulate
Elevation	Raised	Flat	Flat	Convex
Opacity	Translucent	Translucent	Translucent	Translucent

Table .6. Biochemical Characterization of Bacterial Endophytes.

Biochemical test	ISL 4	ISL 5	ISL 6	ISL 7
Gram staining	+	+	+	–
Shape	cocci	Rods	Rods	Rods
Glucose	+	+	+	+
Lactose	+	+	+	+
Sucrose	+	+	+	+
Motility	+	+	+	+
Citrate ultilization	+	+	+	+
Catalase	+	+	+	+
Oxidase	+	+	+	+
Indole	–	–	–	–
Methyl red	–	–	–	–
VP test	–	–	–	–

The bacterial isolates, ISL4, ISL5, ISL6 and ISL7 stained using Gram staining technique and their shapes and gram character were identified. The isolate ISL4 was found to be as gram positive cocci, where as ISL5, ISL6 were gram positive rods and ISL7 was identified as gram negative rods. All four bacterial cutures were found to be motile in nature. These were also identified to be catalase positive, oxidase positive and citrate positive. The ISL4, ISL5, ISL6 and ISL7 isolates showed negative results to IMVIC tests.

4. SUMMARY

In this study, 3 different medicinal plants samples were collected, i.e; the leaves of *Ocicum sanctum* and *Plectranthus amboinicus* and flowers of *Hibiscus rosa-sinensis* from a region of Bangalore, Karnataka. The collected leaves and flower were surface sterilized under 70% ethanol, methanol and distilled water. These plant samples were crushed to isolate the endophytes. A total of 3 fungi and 31 bacteria were isolated from these medicinal plants. The selected isolates were screened for their antimicrobial activity against human pathogens such as *Staphylococcus aureus*, *Klebsiella* sp., *Pseudomonas aeruginosa* and *Serretia* sp., by well diffusion method. Out of 3 fungal isolates, two isolates showed inhibition against all four test organisms. The bacterial isolates ISL4-ISL7 had inhibitory effects on *Serratia* sp. and *Klebsiella* sp. with different zones of inhibition. Whereas the ISL-1 and ISL-3 showed the zone of inhibition of 1.4cm wide against *Pseudomonas aeruginosa*, and had zone of about 15mm against *Staphylococcus aureus*. The bacterial isolates ISL-4, ISL-5 and ISL-6 demonstrated a very small zone of inhibition against *Pseudomonas aeruginosa*. Isolate ISL-4 and ISL-5 were able to inhibit *Staphylococcus aureus* and showed a very narrow zone of inhibition. Characterization of the isolates was done by LPCB staining for fungi and Gram staining and biochemical test for bacteria. On LPCB staining it was confirmed that isolates ISL-1 and ISL-3 (i.e., from *Ocimum sanctum* and *Hibiscus rosa-sinensis*) was identified as *Aspergillus flavus* and isolate ISL-2 is *Alternaria* sp.

5. CONCLUSION

The results obtained in this study indicates the potential of endophytic bacteria and fungi isolated from the chosen medicinal plants as sources of novel natural products with possible applications in medicine, agriculture and the pharmaceutical industry. Furthermore, it is possible that endophytic strains of *Aspergillus* species play a crucial role in the production of beneficial chemical compounds by *Plectranthus amboinicus* and contribute in the medicinal attributes of the plant, as endophytic fungi play important physiological and ecological roles in the life of their hosts. This finding also supported that the increase in the concentration of these bioactive compounds have the ability to significantly inhibit the growth of MRSA. Therefore, these results suggested that the fungal extracts and bacterial extracts can be used to significantly not only to treat the diseases caused by the above-mentioned pathogens but may also be effective against other microbes. With this we conclude that the endophytes can be explored not only to treat the resistant microbes but can also be used as biocontrol agents (the endophytes can be used as PGPR or even as Biofertilizers). Further research and latest developments in research associated with endophytic microorganisms can draw the attention of the research community toward this emerging field and possible exploitation of the available sources for their therapeutic uses in various fields, such as the agriculture, medical, pharmaceutical and food.

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ENDOPHYTES FROM MEDICINAL PLANTS AS BIOCONTROL AGENTS ; A COMPARITIVE STUDY

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ABSTRACT

Aim: To isolate endophytic microorganisms from the leaves of *Ocimum sanctum, Plectranthus amboinicus,* and from the flower of *Hibiscus rosa-sinensis*..To assess and comparatively study the antibacterial effect of secondary metabolites of endophytic bacteria and fungi.
Methods: Surface sterilization of collected samples, pre-treatment of sterilized samples, isolation, and preliminary characterization of these endophytes was carried out via microscopic observations and biochemical characterization. These endophytes were screened for their antibacterial activity.
Results: A total of 3 fungi and 31 bacteria were isolated from these medicinal plant samples. Out of which only three fungal and four bacterial endophytes were chosen based on the agar plate activity, sub-cultured and screened for the production of bioactive compounds. Later the effect of their secondary metabolites was studied against multidrug-resistant bacteria such as *Staphylococcus aureus, Klebsiella pneumoniae, Pseudomonas aeruginosa*, and *Serretia* sp. All the chosen endophytes except one fungi showed promising inhibitory effects against the test organisms.
Conclusion: The zones of inhibition obtained from the fungal metabolites were wider and had better inhibitory effect on all the test organisms even at a lower concentrations where as, the secondary metabolites obtained from the four bacterial endophytes displayed as varying effect on the above mentioned organisms. Hence its confirmed that the fungal metabolites are more efficient in controlling the growth of these test organisms. The increased concentrations of the bacterial metabolites enhances its antibacterial effects.

Keywords: Endophytic microorganisms, *Ocimum sanctum, Plectranthus amboinicus, Hibiscus rosa-sinensis,* secondary metabolites, bioactive compounds, antibacterial activity, biocontrol agents.

1. INTRODUCTION

Like human beings, plants have certain amount of micro-flora consists of bacteria, actinomycetes and fungi present in its system. These micro-organisms residing within the live plant tissues without causing any significant symptoms or disease in the plants are known as endophytic microorganisms. De Bary in 1866 coined the term endophytes. The term 'Endophyte' is derived from Greek words "Endon" meaning "within" and "phyton" meaning "plants". A wide variety of microorganisms live in close proximity to plants (Anjum *et al*., 2015; Geetha *et al.*, 2019). Numerous surveys have been conducted, the majority of which focused on pathogenic interactions between plants and microorganisms associated with them. However, several studies were conducted on the role of microbial diversity in relation to various plant species, it was assumed that only a small percentage of the microbes interacting with the plant are pathogenic in nature. Most microorganisms that inhabit plants play an important role in the plant's health and development, though some are neutral. A single plant species may contain thousands of microbes, which are classified as epiphytes (microbial inhabitants of the rhizosphere and phyllosphere; those near or on plant tissue) or endophytes (microbes residing within plant tissues in leaves, stems, and roots) (Sushanto *et*

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