

## CRITERION III – RESEARCH, INNOVATIONS AND EXTENSION

### 3.3 Research Publications and Awards

#### 3.3.1 Number of research papers published per teacher in the Journals notified on UGC website during the last five years

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## RESEARCH ARTICLE

# Taxonomic and Biochemical Composition and Digestive Enzyme Activity of Periphyton and Plankton: A Comparative Study

Barlaya Gangadhar<sup>1</sup> · Narasimhan Sridhar<sup>1</sup> · Harish Umalatha<sup>1</sup> · Hegde Ganesh<sup>1</sup> · Pallipuram Jayasankar<sup>1</sup>

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**Abstract** Periphyton grown on sugarcane bundles was analyzed for major digestive enzymes in order to quantify their possible exogenous digestive enzyme contribution to the grazing fish. The proximate and taxonomic composition of constituent planktonic organisms of periphyton was compared with that of free plankton. Further, the activity of major digestive enzymes in the extracts of periphyton and free plankton was also compared. The proximate composition analysis revealed periphyton to contain more ( $P < 0.05$ ) crude protein, ash, crude fibre and NFE (nitrogen-free extract) with lesser moisture content as compared to plankton. The species composition of periphyton from bagasse revealed that plankton belonging to Chlorophyceae were dominant (25.3 %), followed by Cyanophyceae (19.7 %), Bacillariophyceae (16.9 %), Conjugatophyceae (8.4 %), Desmidiaceae (4.2 %), Euglenophyceae (5.6 %), Ulvophyceae (4.2 %), Dinophyceae (1.4 %), Xanthophyceae (1.4 %), Florideophyceae (1.4 %), Trebouxiophyceae (1.4 %) and zooplankton (10 %). Free plankton consisted of Chlorophyceae (24.2 %), Cyanophyceae (15.1 %), Bacillariophyceae (9.1 %), Conjugatophyceae (6.1 %), Coscinodiscophyceae (3 %), Trebouxiophyceae (3 %) and zooplankton (39.4 %). The activity of majority of digestive protease and amylase was higher in plankton and that of chymotrypsin was higher in periphyton, while lipase activity did not show any difference between plankton and periphyton. The study indicates that

periphyton being a natural food is nutritionally superior to free plankton and can contribute digestive enzymes to the grazing fish, in addition to the nutrients.

**Keywords** Periphyton · Plankton · Digestive enzymes · Proximate composition · Taxonomy

## Introduction


The success in the hatchery production of fish fingerlings for stocking in the grow-out production system is largely dependent on the availability of suitable live food for feeding fish larvae, fry and fingerlings [1]. Feeding habit of fishes in natural water bodies is different among the species, but all of them require live food for growth, efficient breeding and survival [2]. Larval growth and survival during early development are complicated processes, and high mortality and deformity is seen under even the best rearing conditions [3]. Larval nutritional requirements after the transition from endogenous to exogenous feeding are affected by the ability to provide a satisfactory diet for the first-feeding larvae in practical aquaculture [4]. It has been suggested that the development of fish larvae during the early stages is limited by diet size, density and quality [5]. Artificial larval feeds are no match to live food organisms in terms of acceptance and nutritional factors. Several studies have compared the effect of artificial feeds over live feed on fish species like goldfish (*Carassius auratus*) and black-spot barb (*Puntius filamentosus*) [6, 7].

Increase in the production of several herbivorous fish species has been observed under periphyton-based aquaculture [8, 9]. Periphyton-based fish culture is a viable option to make semi-intensive aquaculture systems more nutrient-efficient, since periphyton is effectively utilized by

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[Home](#) > [Symbiosis](#) > [Article](#)[Published: 10 August 2017](#)

## Plant-symbiont interactions: the functional role of expansins

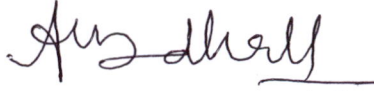
[Sudipta Kumar Mohanty](#), [Manoj-Kumar Arthikala](#), [Kalpana Nanjareddy](#) & [Miguel Lara](#) 

*Symbiosis* **74**, 1–10 (2018)

**836** Accesses | **11** Citations | [Metrics](#)

### Abstract

Expansins are non-enzymatic cell wall proteins that mediate plant growth by catalyzing loosening of cell walls without lysing the wall polymers. Advances in the field of bioinformatics have facilitated the prediction of the members of expansin gene family across several model plants. Expansins constitutes into four sub-families;  $\alpha$ -expansin,  $\beta$ -expansin, expansin-like A and expansin-like B. Biological functions of expansin gene family include diverse aspects of plant growth and development, shoot and root elongation, leaf morphogenesis, flower and fruit development, embryogenesis, pollen tube growth, stress tolerance, etc. Recent studies have demonstrated the role of expansins in plant-symbiotic interactions. The present review reveals the factors that govern plant-arbuscular mycorrhizal fungi (AMF) and legume-rhizobia



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# Pharmacophore Screening and Docking studies of AMPA Receptor Implicated in Alzheimer's disease with Some CNS Acting Phytocompounds from Selected Ayurvedic Medicinal Plants

**Preenon Bagchi<sup>1,2\*</sup>, Anuradha M<sup>1</sup> and Ajit Kar<sup>2,3</sup>**

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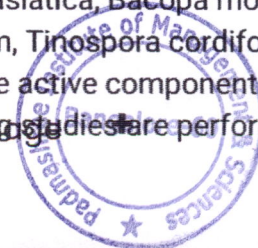
## Corresponding Author:

Preenon Bagchi

Padmashree Institute of Management and Sciences, Bangalore, India

## Abstract

Neuro-degeneration including dementia in Alzheimer's disease (AD) is an global alarming problem. AD accounts for 60 to 80 percent of dementia cases. AMPA (alpha-amino-3-hydroxy-5-methyl-4-isoxazole propionic acid) receptors are the main contributors of excitatory neurotransmission, mediating the fast, rapidly desensitizing excitation of many synapses, and are involved in the early response to glutamate in the synaptic space. The gene receptor AMPA responsible for AD is taken for this work. In the present study phytocompounds from Ayurvedic Medicinal plants like *Centella asiatica*, *Bacopa monnieri*, *Convolvulus pluricaulis*, *Mucuna pruriens*, *Ocimum sanctum*, *Tinospora cordifolia*, *Curcuma longa*, *Nardostachys jatamansi* are among others used. The active components of the plants are taken and pharmacophore screening along with docking studies are performed against



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AMPA receptor in silico. The docking scores are noted for further in-vitro receptor-ligand binding assay studies. The selected phytochemicals were screened against AMPA receptor. Again, ADME (drug-like properties) was determined for the shortlisted ligands. Based on virtual screening, shortlisted ligands selected were Quercetin dihydrate and Asiatic acid.

## Keywords

Alzheimer's disease (AD), AMPA, Modeling, Ramachandran plot, Pharmacophore, docking, ADME

## Introduction

Since ages various medicinal plants are part & parcel of major populations of India & other South East Asian countries. For the management of different neuro-degenerative diseases (Alzheimer's, parkinsonism, obsessive compulsive disorder (OCD), ageing related metabolic disorders and stress-induced dysfunctions, mania, depression, acute & chronic cases of dementia, etc.) - where chemical & synthetic drugs are not fully effective, different phytomedicinal compounds (phytochemicals from herbal sources) may be successfully utilized with minimum or without side effects even for long term therapy. For the management of different mental & neuronal disorders there is tremendous scope of discovery of specific phytochemicals from medicinal plants. The binding affinity of specific phytochemicals with the gene-products (i.e., specific proteins) of the above disorders using bioinformatic softwares can prove effective for future drug discovery using these phytochemicals [1-3].

Alzheimer's disease (AD) is a type of dementia that causes problems with memory, thinking and behavior; symptoms usually develop slowly and get worse over time, becoming severe enough that it interferes with daily tasks. The greatest known and studied risk factor is increasing age, and the majority of people with AD are 65 and elder. AD is a progressive disease, where dementia symptoms gradually worsen over a number of years and in its early stages, memory loss is mild, but with late-stage AD, individuals lose the ability to carry on a conversation and respond to their environment. Now, there is a worldwide effort under way to find better ways to treat and fight the disease and to delay its onset. Dementia is the loss of cognitive functioning— thinking, remembering, including reasoning— and behavioral abilities to such an extent that it interferes with a person's daily life and activities and it ranges in severity from the mildest stage, when it is just beginning to affect a person's functioning, to the most severe stage, when the person must depend completely on others for basic activities of daily living [4-6].

AD is named after Dr. Alois Alzheimer. In 1906, Dr. Alzheimer noticed changes in the brain tissue of a woman who had died of an unusual mental illness; her symptoms included memory loss, language problems, and unpredictable behavior. After she died, he examined her brain and found many abnormal clumps (also called amyloid plaques) and tangled bundles of fibers (now called neurofibrillary, or tau, tangles); these plaques and tangles in the brain are still considered some of the main features of AD. Another feature is the loss of connections between nerve cells, the neurons in the brain. Neurons transmit messages between different parts of the brain, and from the brain to muscles and organs in the body. Abnormal deposits of proteins form amyloid plaques and tau tangles are found throughout the brain. Once-healthy neurons stop functioning; they lose connections with other neurons and ultimately die. The damage initially appears to take place in the hippocampus, the part of





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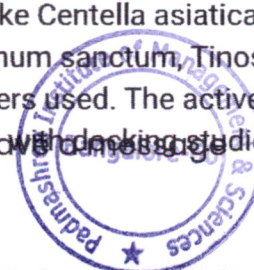
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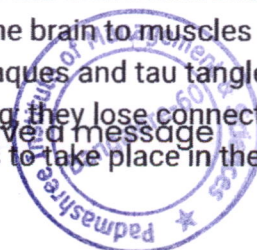
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## In Vitro Neuro-Protective Studies of Phyto-Compounds from *Azadirachta indica*, *Centella asiatica* and *Gloriosa superba*

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### Abstract

The test substances quercetin dehydrate, asiatic acid and colchicine were evaluated for its *in vitro* neuro-protective activity against Hydrogen peroxide induced toxicity in HEK-293-(Human embryonic kidney cell line). Firstly Test Substances were estimated for cytotoxicity with different concentrations ranging from 100 µg/ml to 1.56 µg/ml, which resulted high toxicity in HEK-293-(Human embryonic kidney) cell line, and hence the nontoxic concentrations were taken for further studies. In Cytoprotective studies Test Substances were showing significant activity in human embryonic kidney cells against hydrogen peroxide toxicant. These compounds are seen to express their activity in AMPA and SNCA expressed cells in HEK-293 cell line.

**Keywords:** Quercetin dehydrate; Asiatic acid; Colchicines; Neuro-protective; HEK cell line; Hydrogen peroxide toxicant

### Introduction

Since very ancient days various medicinal plants and their phyto-compounds form part and parcel of major populations of India, and other South East Asian countries. For the better management of different Central Nervous System (CNS) disorders, chemical and synthetic drugs studied are not seen to be fully effective; hence different phytomedicinal compounds (phyto-chemicals from herbal sources) are successfully utilized with minimum or without side effects even for long term therapy/treatment [1].

*Azadirachta indica* (commonly known as neem) have been used in India for over two millennia for its medicinal property. In Ayurveda, *Azadirachta indica* is reported to have antifungal, antidiabetic, antibacterial, antiviral, contraceptive and sedative properties including neurological property and has been evaluated for a wide spectrum of diseases including cancer, inflammation, ulcer, dementia, immune disorder, hyperlipidemia and liver disease. Phytocompound used in this work is Quercetin dehydrate [2-6].

*Centella asiatica* (commonly known as thankuni) has been used to treat various disorders and apart from wound healing, the herb is used for the treatment of various skin ailments such as leprosy, lupus, varicose ulcers, eczema, psoriasis, diarrhoea, fever, amenorrhoea, diseases of the female genitourinary tract and also for relieving anxiety and improving memory cognition. It is known to rejuvenate the brain and nervous system, increase attention span and concentration and also combat aging. Phytocompound used in this work is Asiatic Acid [7-11].

*Gloriosa superba* (commonly known as agnisikha or ulchandal), the alkaloid-rich plant is used as a traditional medicine in many cultures in Indian subcontinent [12]. It has been used in the treatment of gout, snakebite, ulcers, neurological [13], arthritis, cholera, colic, kidney problems, typhus, impotence, nocturnal emission, etc. and is in great demand for medicinal use. Phytocompound used in this work is Colchicine [12-14].

AMPA ( $\alpha$ -amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid) is a subtype of the ionotropic glutamate receptor coupled to ion channels that modulate cell excitability by gating the flow of calcium and sodium ions into the cell usually seen in schizophrenia and parkinsonism and (SNCA) alpha-synuclein which is a major constituent of Lewy bodies,

the protein clumps that are seen of Parkinson's disease are the neuro-receptors used in this work.

### Methodology

#### Outline of the method

The *in vitro* cytotoxicity was performed for all four test substances on HEK-293 (Human Embryonic kidney cell) to find toxic concentration of Test Substances to evaluate the cytoprotective activity against hydrogen peroxide.

#### Preparation of test solution

For cytotoxicity studies, 10 mg of Test Substances were separately dissolved and volume was made up with Ham's F12 supplemented media containing 2% inactivated FBS to obtain a stock solution of 1 mg/ml concentration, Further, sterilized by 0.22 µ syringe filtration. Serial two fold dilutions were prepared from this for carrying out cytotoxic studies. Placebo (Cell culture media with 2% FBS), which demonstrates the suitability of test system to yield a reproducible, appropriate reactive response in the test system [13].

#### Cytotoxicity studies

The monolayer cell culture was trypsinized and the cell count was adjusted to 100,000 cells/ml using Ham's F12 containing 10% FBS. To each well of the 96 well microtitre plate, 0.1 ml of the diluted cell suspension was added. After 24 h, when a partial monolayer was formed, the supernatant was flicked off, the monolayer once washed with medium and 100 µl of different test concentrations of Test Substances were added on to the partial monolayer in microtitre plates. The plates were then incubated at 37°C for 72 h in 5% CO<sub>2</sub> atmosphere, and microscopic examination was carried out and observations were

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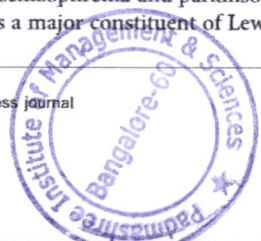
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# Establishing Novel Ligands for Rett Syndrome Receptors from Medicinal Plants

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**Abstract:** The Rett Syndrome is a peculiar, sporadic, atrophic disorder, almost entirely confined to females. Severe dementia, loss of hand skills, apraxia, ataxia, autistic features and irregular breathing with hyperventilation are the major symptoms. There is no cure but medication is provided as speech therapy, occupational therapy, physical therapy, feeding assistance for Rett Syndrome. RS is caused by mutations in the gene MeCP2 and in less than 10% of RS cases, mutations in the genes CDKL5 or FOXP1 have also been found to resemble it. This study was carried out to establish the novel ligands for Rett Syndrome receptors from medicinal plants. Steps involved in the study are choosing the ligands, Homology modeling of the gene receptors, docking of the receptors with ligands and ADME. As per the virtual screening results and ADME studies we find the compound Asiatic acid can be successfully considered as novel drug lead for Rett syndrome.

**Keywords:** Rett syndrome, X-linked, MeCP2 gene, CDKL5 gene, FOXP1 gene, modeling, docking, ADME

## I. INTRODUCTION

The Rett syndrome (RS) is a peculiar, sporadic, atrophic disorder, generally been considered an X-linked disorder in which affected females represent a new mutation, with male lethality with linkage studies suggesting a critical region at Xq28 [1, 2].

### Genes involved:

#### MeCP2 gene (methyl CpG binding protein 2):

MeCP2 is a transcriptional repressor, since it codes for a protein that controls the expression of other genes. Its mutation seems to be more common in X chromosome of sperm cells, explaining why RETT is rare in boys. The gene is found near the end of long arm of X chromosome at Xq28. Mutations in

this gene alter the MeCP2 protein or result in the production of less protein which appears to disrupt the normal function of neurons and other brain cells and impair their ability to communicate with one another [3, 4].

#### CDKL5 gene (cyclin-dependent kinase-like 5):

CDKL5 gene, also known as serine/threonine kinase 9, is essential for normal brain development. It is involved in formation, growth and movement of nerve cells as well as cell division and plays a role in the transmission of chemical signals at the connections between neurons [4].

#### FOXP1 gene:

FOXP1 gene provides instructions for making a protein known as Fork Head Box G1. The protein of this gene plays an important role in brain development, particularly in a region of embryonic brain known as telencephalon and the telencephalon ultimately develops into severe critical structures, including the largest part of brain (cerebrum), which controls the most voluntary activity, language sensory perception, learning and memory [4].

Table 1: Herbs with their phytochemical for treating Rett syndrome used in this work

Sl. No.	Plant Name	Corresponding phytochemical
1	MedhyaRasayana (Nootropic herbs)	Medicoside, Asiaticoside, Asiatic acid, Microphyllid acid
2	Ashwagandha ( <i>Withaniasomnifera</i> )	Isopelletierine, Anaferine, Sitoindoside
3	Chitrak ( <i>Plumbagozeylanica</i> )	Asparticacid
4	Patol ( <i>Tricosanthediodia</i> )	Sitoindoside
5	Nimba ( <i>Azadirachtaindica</i> )	Nimbidin, Quercetin, Nimbolimin, Nimbin,

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## Isolation Detection and Characterization of Syringolin A produced from the Probiotic Strain *Bacillus Cereus* Isolated from Donkey Milk

Rashmi D, Sharmila T, Sushama Patil, Onkar Apine, Srinivas Sistla, Jyoti Jadhav

Article ID: 626

Vol 1, Issue 2, 2018, Article identifier:

IEWS - **1203** (Abstract) **220** (PDF)

### Abstract

Syringolin A is a non-ribosomal virulence factor secreted by few *Pseudomonas* strains. Syringolin A is an well known irreversible proteasome inhibitor and antitumor compound. The present study is focused on the extraction of Syringolin A through a non-tedious and economical process. Syringolin A is extracted from culture supernatants by the immiscible organic layer by mixing of dichloromethane or chloroform (trichloromethane). Syringolin A was identified by the characteristic peak at 350 nm by UV spectra. The compound was further characterized by Thin Layer Chromatography (TLC) with the retention value,  $R_f$  was found to be in the range of 0.78-0.83 run using a combination of solvent systems water and methanol. The molecular weight of the compound was found to be 492.2614 g mol<sup>-1</sup> identified and analyzed by UHPLC-QTOF-MS analysis. Due to its significant pharmacological importance in proliferative diseases, further studies on production and optimization of these compounds are necessary.

### Full Text:

PDF

### References

1. References

2. Walls, T., Power, D., & Tagg, J. (2003). Bacteriocin-like inhibitory substance (BLIS) production by the normal flora of



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Research Article

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## Study of Antagonistic Properties of Bacteria from Cow's Milk by Real-Time Surface Plasma Resonance Biosensor (BIAcore)

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### ABSTRACT

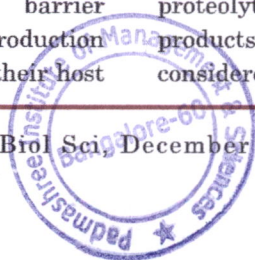
Probiotics are functional food natural or processed contains known live microorganism or biologically active compounds which confer multiple health benefits conferring in prevention, management and treatment of chronic diseases on the host. Foodborne bacteria confer probiotics that produce antimicrobial substances which shows narrow spectrum antagonistic property against food spoilage bacteria like *Escherichia coli*, *Listeria monocytogenes* and *Salmonella enterica*. The emergence of multidrug-resistant pathogens and the restriction on the use of antibiotics as growth inhibitors of the pathogens in the processed foods and feeds have drawn attention to the search for possible alternatives. Present work begins with the isolation of probiotics bacteria from raw cow's milk and screening for bacteriocin production by antagonistic assay. The culture's cell free supernatants were isolated from the bacteria for the comparative antimicrobial screening by conventional Kirby-Bauer disc diffusion method and advanced real-time surface plasma resonance biosensor (BIAcore).

**Keyword:** Antimicrobial activity, Bacteriocins, Kirby-Bauer disc diffusion, Surface Plasma Resonance Biosensor, BIAcore T200

### INTRODUCTION

Probiotics are the "live microbial culture or living microorganisms which beneficially influence the health and nutrition when ingested in appropriate concentration exert health benefits beyond inherent basic nutrition for the host" [1]. Probiotics exert their beneficial effects on the host through four main mechanisms: interference with important pathogens, improvement of gut barrier functioning, immunomodulation and production of appropriate neurotransmitters, and their host

targets varies from the resident microbiota to the cellular components of the gut-brain axis. The beneficial effect of the probiotics is mainly through their interactions with the intestinal microbiota and with the intestinal mucosa of the host. During fermentation, lactic acid bacteria can produce a number of bioactive peptides also known as metabolites such as bacteriocins, biogenic amines, exopolysaccharides and proteolytically released peptides [2]. Food products containing probiotics and prebiotics are considered as an important development in





# COMBINATORIAL STUDY OF BACTERIOCIN FROM *ACINETOBACTER VARIABILIS* WITH ESSENTIAL OILS AGAINST FOOD BORNE PATHOGENS

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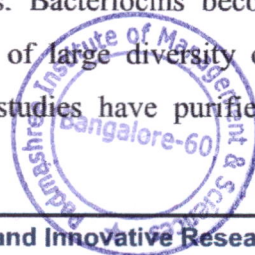
## ABSTRACT

Bacteriocins are a kind of ribosomal synthesized antimicrobial peptides produced by bacteria, which can kill or inhibit bacterial strains closely-related or non-related to the producing bacteria, but will not harm the bacteria themselves by specific immunity proteins. The application of combined preservative factors is very effective in controlling the growth of food spoilage and foodborne pathogenic bacteria. Antimicrobial activity of the bacteriocin extract from *Acinetobacter variabilis* and in combination with some natural organic essential oils (carvacrol, eugenol and thymol) on the growth of pathogenic bacteria *Escherichia coli*, *Listeria monocytogenes* and *Salmonella typhi* were investigated. All the organic compounds tested did not exhibit any antimicrobial activity against the microorganisms by Kirby-Bauer disc diffusion. Investigation of the interaction between the organic compounds and nisin against the test organisms revealed different patterns, varying from synergistic to antagonistic. Combinations of nisin with carvacrol, eugenol, or thymol resulted in synergistic action against the indicator organisms. The activity of bacteriocin with eugenol showed highest activity at lowed acidic pH against the indicator organisms wherein synergistic activity was not observed with carvacrol and thymol. This study highlights the potential of the combination of these organic compounds with bacteriocin to inhibit pathogen growth in food.

**Key words:** Antimicrobial activity, Bacteriocins, Essential oils, Kirby-Bauer disc diffusion, Synergistic action.

## INTRODUCTION

Bacteriocins are a kind of ribosomal synthesized antimicrobial peptides produced by bacteria, which can kill or inhibit bacterial strains closely-related or non-related to the producing bacteria, but will not harm the bacteria themselves by specific immunity proteins. Bacteriocins become one of the weapons against microorganisms due to the specific characteristics of large diversity of structure and function, natural resource, and being stable to heat. Many recent studies have purified and identified bacteriocins for



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**A STUDY ON DIGITAL MARKETING AND ITS IMPACT ON  
CONSUMER PURCHASE PROCESS**



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**Abstract**

Marketers are faced with new challenges and opportunities within this digital age. Digital marketing is becoming a hot topic in every business sector, and gradually plays a truly important role in any company's multi-channel marketing strategy. It uses the Internet to deliver promotional marketing messages to consumers. It includes email marketing, search engine marketing, social media marketing, many types of display advertising (including web banner advertising), and mobile advertising. The supreme purpose of the digital marketing is concerned with consumers and allows the customers to intermingle with the product by virtue of digital media. This article focuses on the magnitude of digital promotion for both customers and marketers, and Collectively shed light from many different angles on how consumers experience, influence, and are influenced by the digital environments in which they are situated as part of their daily lives. We scrutinize the result of digital marketing on the base of firm's sales. 100 respondents opinion are collected to get the clear picture about the present study.

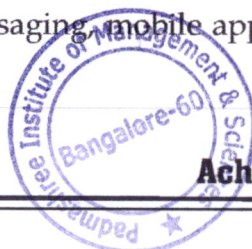
**Keywords:** Digital Marketing, Advertising, Promotion, Consumers, Product

**Introduction**

Using the internet, social media, mobile apps, and other digital communication technologies has become part of billions of people's daily lives. For instance, the current rate of internet use among American adults is about 87% and is closer to 100% for demographic groups such as college-educated and higher-income adults.

Digital marketing is one type of marketing being widely used to promote products or services and to reach consumers using digital channels. Digital marketing extends beyond internet marketing including channels that do not require the use of Internet. It includes mobile phones (both SMS and MMS), social media marketing, display advertising, search engine marketing and many other forms of digital media.

Digital Marketing is the promotion of products or brands via one or more forms of electronic media. The key objective is promotion of brands through Electronic media. It is the promotion of products or brands via one or more forms of electronic media, differs from traditional marketing in that it uses channels and methods that enable an organization to analyze marketing campaigns and understand what is working and what isn't - typically in real time. Digital marketers monitor things like what is being viewed, how often and for how long, sales conversions, what content works and doesn't work, etc. While the Internet is, perhaps, the channel most closely associated with digital marketing, others include wireless text messaging, mobile instant messaging, mobile apps, podcasts, electronic billboards, digital television and radio channels, etc.



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## Synthesis Characterization of New Polynucleating Ligands and their Biological Studies

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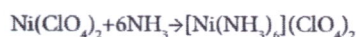
### Abstract

This article summarizes synthesis of three new poly-nucleating ligands successfully in alcoholic medium. The ligands synthesized are characterized quantitatively and qualitatively by using NMR, IR Spectroscopy and UV-visible. The further biological activity are made like anti-cancer, anti-inflammatory and anti-microbial, these activities revealed that ligands I to III are showing positive results.

**Keywords:** Polynucleating ligands; NMR; IR; UV-visible spectra; Anticancer; Anti-microbial; Anti-inflammatory; Drug designing

### Introduction

In the context of d-metal chemistry, the term complex means a central metal atom or ion surrounded by a set of ligands. The modern study of coordination compounds began with two men, Alfred Werner and Sophus Mads Jorgenson. The pioneering contribution of Werner to the study of coordination chemistry fetched him the Nobel Prize in Chemistry in 1913 and incidentally he is the first inorganic chemist to win the coveted distinction. The synthesis and study of coordination compounds have gained interest due to the role of the coordination compounds in the field of catalysis and its role in biochemistry. Coordination chemistry plays a most important role in biological systems. For example, haemoglobin an iron-porphyrin complex of human blood plays a vital role in oxygen transport mechanism [1]. Chlorophyll, magnesium containing porphyrin complex plays a role in plant photosynthesis. Molybdenum cofactor of nitrogenase enzyme is essential for nitrogen fixation [2]. Vitamin B12 (cyanocobalamin) is a cobalt containing complex plays an important role in carbohydrate, fat and protein metabolism. Vitamin B12 deficiency causes pernicious anaemia in human beings. At the start of the 20th century, inorganic chemistry was not a prominent field until Werner studied the metal-amine complexes such as  $[\text{Co}(\text{NH}_3)_6\text{Cl}_3]$ . Werner recognized the existence of several forms of cobalt-ammonia chloride. These compounds have different colour and other characteristics. The chemical formula has three chloride ions per mole, but the number of chloride ions that precipitate with  $\text{Ag}^+$  ions per formula is not always three. He thought only ionized chloride ions will form precipitate with silver ion. To distinguish ionized chloride from the coordinated chloride, Werner formulated the complex formula and explained structure of the cobalt complexes [3]. Coordination compounds have posed many challenges to the inorganic chemists. It is the chemistry of metals and its complexes/compounds with other organic/ inorganic groups called ligands. Coordination compounds are formed by almost all transition metals, lanthanide series metals and some of the non-metals like silicon etc. Coordination compounds play an important role in fields like medicine, polymers, pesticides, fungicides, biochemical reactions, petrochemicals etc. A complex is a combination of Lewis acid (the central metal atom) with a number of Lewis bases (the ligands). A Lewis acid is an electron pair acceptor and a Lewis base is an electron pair donor. Thus the interaction of the Lewis acid metal centre in  $\text{Ni}(\text{ClO}_4)_2$  with the Lewis base ammonia to form a complex, according to the equation given below provides an example of the formation of a coordination compound.



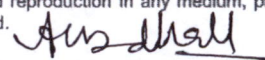
The Lewis bases attached to the metal ion in such compounds are called ligands. These may be simple ions such as  $\text{Cl}^-$ , small molecules such as  $\text{H}_2\text{O}$  or  $\text{NH}_3$ , larger molecules such as  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$  or  $\text{N}(\text{CH}_2\text{CH}_2\text{NH}_2)_3$ , or even macromolecules, such as proteins. The atom in the Lewis base ligand that forms the bond to the central atom is called the donor atom, because it donates the electrons for bond formation. The nature of a bond between metal ion and a donor atom in an coordination compound depends upon various factors like the nature of the metal ion, oxidation state of metal ions, nature of donor atoms, structure of the ligands, steric factors and metal ligand orbital interaction. The majority of ligands are either neutral or anionic. Those which coordinate to a metal ion through a single atom are described as mono-dentate or uni-dentate. Examples of such ligands include water, ammonia, chloride etc. Where two donor atoms can be used to bind to a metal ion, as with  $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ , the ligand is said to be bidentate and where several donor atoms are present in a single ligand as with  $\text{N}(\text{CH}_2\text{CH}_2\text{NH}_2)_3$ , the ligand is said to be polydentate. When a bi- or polydentate ligand uses two or more donor atoms to bind to a single metal ion, it is said to form a chelate complex (from the Greek for claw) [4]. A huge variety of ligands appear in coordination complexes. A variety of elements function as donor atoms towards metal ions, but the most commonly encountered are probably nitrogen, phosphorus, oxygen, sulfur and the halides. In addition, a large number of compounds are known which contain carbon donor atoms; these are known as organometallic compounds. Bidentate ligands may be classified according to the number of atoms in the ligand which separate the donor atoms and hence the size of the chelate ring formed with the metal ion. Thus 1,1-ligands form a four-membered chelate ring when bound to a metal ion, 1,2-ligands a five membered ring, and so on. Cyclic compounds which contain donor atoms oriented so that they can bind to a metal ion and which are large enough to encircle it are known as macro cyclic pro-ligands. Bicyclic pro-ligands are also known which can completely encapsulate a metal ion. Some of these systems have given the names cryptand or seculchrate, which reflect their ability to wrap up and entomb the metal ion [5]. Sometimes

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