



SRI SATHYA SAI COLLEGE FOR WOMEN, BHOPAL
Kasturba Hospital Road, Habibganj, Bhopal -462024



BOTANY

DEPARTMENT

Phytochemical Analysis of *Catharanthus roseus* L. leaves crude Extract

Sneha Kumari Sao*, Dimple Khairwar, Supriya Gupta & Dr. Renu Mishra

Abstract

India is rich in medicinal plants that are widely used in traditional medicine. Medicinal plants are widely used in traditional cultures all over the world and are good alternatives to synthetic chemicals which are beneficial to health. They are rich in polyphenols, which are good in their antioxidant properties. These plants have several bioactive molecules which belong to secondary metabolites such as polyphenols, alkaloids, and flavonoids. *Catharanthus roseus* belongs to the family of Apocynaceae and is an important medicinally important plant whose leaves are used for cancer treatment. It is a potent medicinal plant which has many pharmacological actions such as antimicrobial, antioxidant, anthelmintic, antidiabetic effect etc. The pharmacological properties of the plant were found to be associated with the alkaloids that occupy almost most of the parts of the plant. In this research paper, we investigated the different phytochemicals present in the crude leaf extract.

Keywords: *Catharanthus roseus*, Pharmacological, Antimicrobial, Anthelmintic, Antidiabetic, Alkaloid etc.

Introduction

India is an emporium of medicinal plants used in various traditional medical therapies since a long time ago. Plants contain several active compounds called phytochemicals like carbohydrates, terpenoids, steroids, tannins, alkaloids, flavonoids etc. which have a significant effect on the physiology of the human body. Secondary metabolites are chemically and taxonomically extremely diverse compounds. A large number of phytochemicals belong to several chemical classes that show inhibitory effects on all types of microorganisms in vitro. This can be derived from seeds, barks, flowers, leaves, fruit, root. (Yadav & Agarwal *et al.*, 2011).

Catharanthus roseus also known as Madagascar Periwinkle, Sadabahar belongs to the family of Apocynaceae. It is an important plant with numerous medicinal properties. It is an evergreen, perennial herb growing one meter tall in tropical countries. It is cultivated as an ornamental plant almost throughout the tropical world. (Kaushik *et al.*, 2017) Different parts of the plant like roots, bark, leaves and flowers are of medicinal significance. It has glossy,

dark green leaves and produces attractive, star-shaped flowers in various colors including white, pink, red, and lavender. The synonyms of the plant name include *Lochnera rosea*, *Ammocallis rosea* and *Vincarosea*. (Gajalakshmi *et al.*, 2013). There are two common varieties of *C. roseus* which is named on the basis of colour of the flowers, i.e. the pink flowered 'Rosea' and the white flowered 'Alba'. The plant leaves contain more than 70 types of chemical constituents such as indole type of alkaloids, serpentine and reserpine. The alkaloids have shown significant medicinal properties and are used in the treatment of certain types of cancer, such as leukemia and Hodgkin's lymphoma. They work by inhibiting the growth of cancer cells. Due to the presence of these alkaloids in *Catharanthus roseus*, it has anti-hypertensive and anti-spasmodic properties. (Kabesh *et al.*, 2015)

Phytochemical Properties of *Catharanthus roseus*

Patil *et al.*, (2022) reported that *Catharanthus roseus* is rich in carbohydrates, alkaloids, flavonoids, triterpenoids, tannins, coumarin, quinone and phenolic compounds. More than 400 alkaloids are present in the plant used as pharmaceuticals, agrochemicals, flavor and fragrance, ingredients, food additives and pesticides. The alkaloids like Actinocoplasteridemic, Vinblastin, Vincristine, Vindesine, Vindoline, Tabersonine etc, are mainly present in aerial parts whereas Ajmalicine, Vincine, Vincamine, Raubasine, Reserpine, Catharanthine etc. are present in roots and basal stem. Rosindin is an anthocyanin pigment found in the flower of *C. roseus*. (Mishra *et al.*, 2017)

The leaves of *Catharanthus roseus* are rich in alkaloids and carbohydrates. It has demonstrated antibacterial and antidiabetic effects and is able to reduce the blood sugar (Singh *et al.*, 2001). Flowers are rich in tannins, triterpenoids and alkaloids and help in wound healing. (Zhou *et al.*, 2009) Lahare *et al.*, (2020) concluded that flowers of *C. roseus* contain Catharanthine, Vindoline, Leurosine, Locherine, Tricin while seeds contain Vingramine, Methylvingramine etc.

Ethno medicinal properties of *Catharanthus roseus*

In India Ayurveda, Physicians used fresh juice from flowers of *C. roseus* for treatment of skin diseases e.g. dermatitis, eczema and acne. In certain traditional systems of medicine, preparations made from *C. roseus* have been applied topically to treat fungal skin infections such as ringworm, athlete's foot, and candidiasis. The leaves are used for various treatments such as diabetes mellitus, high blood pressure and infection. Leaf juice of the plant is used as application in bee sting and wasp sting. Crude extract of leaf and root was used for treatment of cancer. (Gajalakshmi *et al.*, 2013)

Pharmacological Properties of *Catharanthus roseus*

1. Anti-cancer activity

The anti cancer alkaloids Vinblastine and Vincristine are derived from stem and leaf of *Catharanthus roseus*. These alkaloids have growth inhibition effect to some human tumors. (Mishra & Verma *et al.*, 2017)

2. Anti-diabetic activity

The ethanolic extracts of the leaves and flower of *C. roseus* showed a dose dependent lowering of blood sugar in comparable to the standard drug glibenclamide. The Hypo glycaemic effect as appeared due to the result of the increase glucose utilization in the liver. (Mishra & Verma *et al.*, 2017)

3. Anti-helminthic activity

Helminthes infections are the chronic illness, affecting human beings and cattle. *Catharanthus roseus* was found to be used from the traditional period as an anti-helminthic agent. The anti-helminthic property of *C. roseus* has been evaluated by using *Pheretima posthuma* as an experimental model and with Piperazine citrate as the standard reference. The ethanolic extract of the concentration of 250mg/ml was found to show the significant anti helminthic activity. (Mishra & Verma *et al.*, 2017)

4. Antimicrobial activity

C. roseus has been discovered to be an important medicinal plant for the creation of the novel pharmaceuticals as most of the bacterial pathogens were improving resistance against many of the available anti microbial drugs. (Paarakh *et al.*, 2019).

5. Anti-oxidant property

The anti-oxidant potential of the Ethanolic extract of the roots of the two varieties of *C. roseus* namely rosea (pink flower) and alba (white flower) was obtained by using different system of assay such as Hydroxyl radical-scavenging activity, super oxide radical-scavenging activity, DPPH radical-scavenging activity and nitric oxide radical inhibition method. (Mishra & Verma *et al.*, 2017)

5. Anti-diarrheal property

The anti-diarrheal activity of the plant ethanolic leaf extract as tested in the wistar rats with castor oil as a experimental diarrhea inducing agent in addition to the pretreatment of the extract. The anti-diarrheal effect of ethanolic extracts *C. roseus* showed the dose dependant inhibition of the castor oil induced diarrhea. (Mishra & Verma *et al.*, 2017)

Material and Method

1. Collection of Plant material:

Leaves of *Catharanthus roseus* were collected from the campus of Sri Sathya Sai College for Women, Bhopal, India. The leaves were dried under shade and grinded in coarse powder for extraction.

2. Extraction procedure:

The dried leaves were extracted with distilled water. 10gm of dried powder was mixed with 100ml of distilled water and stirred properly. The solution is kept for 3-4 hours and then strained. Filtrate was kept in a beaker and covered for further Phyto chemical analysis.

3. Phytochemical Analysis:

The extracts obtained were subjected to various qualitative tests to detect the presence of plant constituent.

Estimation of Primary Metabolites

1. Detection of carbohydrates

Extracts were separately dissolved and filtered in 5ml distilled water. The filtrates were used to analyse the occurrence of carbohydrates.

- a) Molisch's test: 2 drops of alcoholic naphthol solution was mixed with filtrates in a test tube and 2ml of conc. Sulphuric acid was added carefully. Violet ring formation at the intersection shows the existence of carbohydrates.
- b) Benedict's test : Filtrates were handled and boiled in a water bath with Benedict's reagent. An orange red precipitate formation shows the existence of sugar reduction.
- c) Iodine test: Crude extract has been mixed with Iodine solution of 2ml. The presence of carbohydrate is indicated by a dark blue or purple colour.

2. Detection of proteins and amino acids

- a) Millon's test : Crude extract was mixed with 2ml of Millon's reagent. White precipitate formed that turned red on gentle heating confirming protein presence.
- b) Xanthoproteic test : Crude extract was mixed with few drops of conc. Nitric acid solution. Yellow colour formation shows protein presence.

3. Detection of fixed oils and fats

- a) Stain test: Between two filter papers, a little amount of leaf extracts were pressed. Presence of fixed oil is indicated by an oily stain on filter paper.

Estimation of Secondary Metabolites

1. Detection of alkaloids

Extracts were separately dissolved and filtered in diluted hydrochloric acid. The filtrates were used to analyse occurrence of alkaloids.

a) Mayer's test: Few drops of Mayer's reagent have been added to 2-3ml of filtrate. Creamy precipitate formation suggested existence of alkaloids.

b) Wagner's Test: Wagner's reagent was used to treat filtrates. Reddish brown precipitate formation shows that alkaloids are present.

2. Detection of glycosides

Dil.HCl was used to hydrolyse extracts and then used for glycoside screening.

a) Keller Kiliani test : Crude extract was blended with 2ml of glacial acetic acid with 1-2 drops of 5%FeCl₃ solution. Then 2ml conc. Sulphuric acid was added. At the interphase, a brown ring indicated that cardiac glycosides were present.

3. Detection of steroid

a) Salkowski's test : Extracts were mixed with chloroform and filtered. A few drops of conc. Sulphuric acid were added to the filtrates and shaken. Golden yellow appearance shows the existence of triterpenes.

4. Detection of saponins

a) Froth test: Extracts were diluted to 15ml with distilled water and shaken for 5 minutes. Formation of 1cm foam layer shows saponin existence.

b) Foam test : Small quantity of extract has been shaken with little water. It shows the existence of saponins if the foam generated and persists for ten minutes.

5. Detection of flavonoids

Alkaline Reagent test: Extracts were mixed with little quantity of sodium hydroxide solution. Intense yellow colour formation, which becomes colourless when dilute acid is added, shows the existence of flavonoids.

6. Detection of phenols and tannins

Ferric chloride test: Extracts were mixed with little quantity of ferric chloride solution. Bluish black colour formation shows the existence of phenols.

Gelatin test : 1% gelatin solution comprising sodium chloride has been added to the extract. White precipitate formation shows the presence of tannin.

Results and Discussion

Systematic Classification

Kingdom: Plantae
 Division: Angiosperms

Class: Asterids

Order: Gentianales

Family: Apocynaceae

Genus: *Catharanthus*

Species: *roseus*

Vernacular names: Oldmaid, Red periwinkle, Madagascar periwinkle, Hindi: Sadabahar, Baramasi, Sadampuspa, Sadapushpi.



Fig- 1. *Catharanthus roseus* Habitat, collected plant leaves, Powdered leaves, Crude extract .

Distribution

Plant is commonly seen in tropical countries and are native to Madagascar and Southern Asia. The plant has spread all over tropical and subtropical parts of India and grows wild all over the plains and lower foot hills in Northern and Southern hills of India. (Kaushik *et al.*, 2017). In India, it is distributed throughout tropical and sub-tropical parts of India. Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat, Madhya Pradesh and Assam are ideally suited for the cultivation of the plant.

Morphological Characteristics

Catharanthus roseus is a perennial small herb or sub-shrub, up to 90 cm in height. Stem: Erect, branching with flexible long branches, purple or light green. Leaves: 2.5cm–9.0cm long and 1.0–3.5cm broad, glossy green, hairless, with a pale midrib and a short petiole of about 1.0–1.8cm long and they are arranged in the opposite pairs.

Flower : The flowers look white or pink, with a purple, red, pale yellow or white centre. Follicle and a basal tube of 2.5–3.0cm long with a corolla of about 2.0–5.0cm diameter with five petals like lobes.

Fruit Pair of follicles about 2-1cm long and 3.(Kaushik *et al.*, 2017)

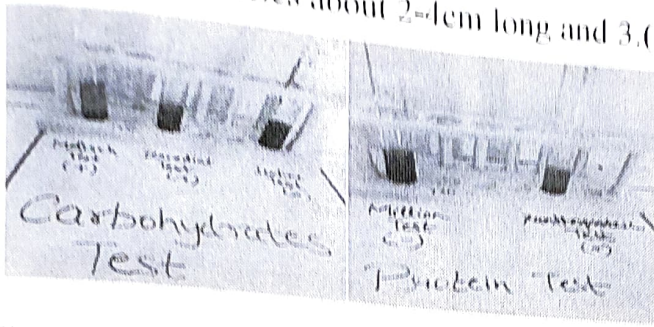


Fig2. Phyto chemical analysis (Primary Metabolites) of *Catharanthus roseus*

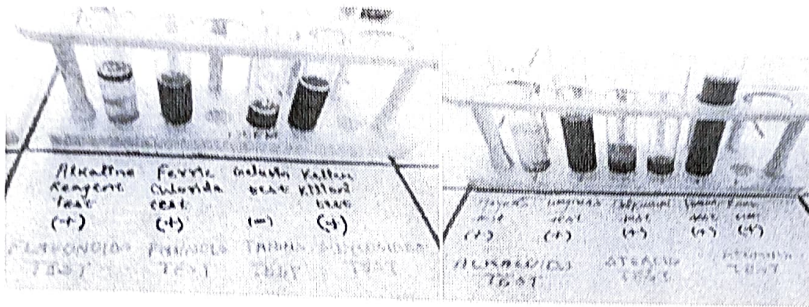


Fig3. Phytochemical analysis (Secondary Metabolites) of *Catharanthus roseus*

Metabolite	Chemical constituents	Chemical test	Test result
Primary metabolite	Carbohydrate	a. Molisch test b. Fehling test	+ +
	Protein	a. Millon test b. Xanthoproteic test	- +
	Fats and oils	a. Stain test	+
Secondary Metabolite	Alkaloid	a. Mayer test b. Wagner test	+ +
	Glycoside	a. Keller test	+
	Steroid	a. Salkowski test	+
	Saponin	a. Froth test	+
		b. Foam test	+
	Flavonoid	a. Alkaline test	+
	Phenol+Tannin	a. Ferric test	+
		b. Gelatin test	-

Fig4. Phytochemical Analysis of Crude leaves extract of *Catharanthus roseus* Medicinal plants is the major source of drugs. They contain small active compounds which have significant effect on human physiology. They play a vital role in human health care. about 80% of the world total population use traditional medicine based upon plant material. (Dash *et al.* 2011)

The leaves of plant *C. roseus* has a very great medicinal value. Our findings shows that the leaves of this plant contain alkaloid, flavonoids, saponin, phenol, tannin, steroids, glycosides other than carbohydrate protein and fat. Similar findings were replied by (Kritikza *et al.* 2013) that these leaves contain more than 70 types of chemicals. Due to presence of these alkaloids it has medicinal properties and wide pharmaceutical uses. (Rischer H. *et al.* 2006)

Conclusion

In the present study, Phytochemical analysis of crude leaves extract of *Catharanthus roseus* was done. The study showed that in *Catharanthus roseus* leaves has all the phyto constituents like Alkaloids, Flavonoids, Glycosides, Saponins, Glycosides etc. It revealed the medicinal property in the leaves of this plant.

References :

- Dash, B.K., Sultana, S., Sultana, N. (2011). Anti bacterial activities of methonal and acetone extracts of Fenugreek and coriander. *Life Sciences and Medical Research Journal*, 27: pp:1-8
- Gajalaskshmi, S., Devi Rajeshwari. (2013). Pharmacological activities of *Catharanthus roseus*: A perspective review. *International Journal of Pharmaceutical Research and Applications*. 7(4). ISSN:2456-4494
- Kabesh, K., Senthilkumar, P., Ragnathan, R., & Kumar, R. R. (2015). Phytochemical Analysis of *Catharanthus roseus* Plant Extract and its Anti microbial Activity. *International Journal of Pure and Applied Bioscience*, 3(2):162-172.
- Kaushik, S., Tomar, R. S., Gupta, M., & Mishra, R. K. (2017). An overview of *Catharanthus*. *Academic Research*. 5(2).
- Kratzka Kumari., Gupta Sharmita. (2013). Phytopotential of *Catharanthus roseus* L.(G.) Don. var. "rosea" and "alba" against various pathogenic microbes in vitro. *International Journal of Research in Pure and Applied Microbiology*. 77:82(3)
- Lahare, R.P., Yadav, H.S., Dashahre, A.K., & Bisen, Y.K. (2020). An Updated Review on Phytochemical and Pharmacological Properties of *Catharanthus rosea*. *Saudi Journal of Medical and Pharmaceutical Sciences*. ISSN2413-4910
- Mishra, J.N., & Verma, N.K. (2017). A brief study on *Catharanthus roseus*: A review. *International Journal of Research in Pharmacy and Pharmaceutical Sciences*, 2(2), 20-23.
- Paarakh, M. P., Taj, T., Tejashwini, V., & Tejashwini, B. (2019). *Catharanthus roseus*

- Linn—A Review. *ActaScientificPharmaceuticalSciences*, 3(10), 19-24.
- Patil, N., & Dusane, P. (2022). A Brief Review :on *Catharanthus roseus*. *International Journal of Pharmaceutical Research and Applications*. ISSN: 2456-4494
 - Rischer, H., Oresic, M., Seppanen-Laakso, T., Katajamaa, M., Lammertyn, M. and Ardiles-Diaz, W., (2006). Gene-to metabolite networks for terpenoid indole alkaloid biosynthesis in *Catharanthus roseus* cells. *Proceedings of the national Academy of sciences of the United States USA*. 103:5614-5619
 - Singh, S., Vats, P., Suri, S., Shyam, R., Kumria, M., Ranganathan, M., & Sridharan, K. (2001). Effect of anantidiabetic extract of *Catharanthus roseus* on enzymic activities in streptozotocin induced diabetic rats. *Journal of Ethnopharmacology*. 76(3):269-77
 - Yadav R., & Agarwala, M. (2011). Phytochemical analysis of some medicinal plants. *Journal of Phytology*, 3(12):10-14.
 - Zhou, M., Shao, J., & Tang, Y. (2009). Production and metabolic engineering of terpenoid indole alkaloids in cell cultures of the medicinal plant *Catharanthus roseus* (L.) G. Don (Madagascar peri winkle). *Biotechnology and applied biochemistry*. 52(Pt4):313

Microbial Degradation of Azo Dye: A Review

Ms Sheetal Sahare*, Dr Renu Mishra

Abstract

Water and Soil are lifelines for the globe as well as for human development. Textile industries are a huge source of pollution to the environment and for health hazards, various dyes are used as coloring agents. One of the most widely used dyes among all is azo dye- a class of synthetic dyes causing carcinogenic, mutagenic, genotoxic, cytotoxic, and neurotoxic which is extensively used in textile, printing, food, and biomedical industries worldwide. Congo Red (a type of azo dye) and other dyes of this group are carcinogenic due to their cleaved product such as benzidine while some azo dyes are carcinogenic without being cleaved into aromatic amines. Various physicochemical methods are used to remove dyes from wastewater and wasteland but the best way to treat our mother earth is biological methods like microbial degradation- it is a method in which degradation of compounds takes place with the help of microbes. Biodegradation is a powerful, effective, and eco-friendly tool to treat the environment. It is a promising technique for the mineralization and detoxification of azo dyes. Microbes are well-known biological agents which breakdown dyes and convert them into harmless components such as CO_2 and H_2O . The overall review study will evaluate the mechanism of biodegradation of Azo dye by bacterial treatment for its safe disposal into the environment.

Keywords: Textile industries, Health hazards, Azo dye, Congo Red, Microbial degradation, Mineralization, and Detoxification.

Introduction

Industries are the backbone of the economic sector among all industries, the textile industry is a significant source of economic growth and employment opportunities for the nation and its people. Besides these benefits, textile industries produce hazardous waste in the form of dye effluent. Colors are the major component of

textile industries. It creates aesthetic value for the product. The different shades and contours of color we see are all derived from the dye that we used in textile industries for the pigmentation of cloth (Ngo et al., 2022). Various types of dyes are used in textile industries which are discharged as colored wastewater. Approx 70% of synthetic-azo dyes are used dyes in textile industries across the world. The wastewater containing dyes is very harmful to aquatic animals which increases the biological oxygen demand in water bodies (Srinivasan et al., 2020). The colored effluent discharged by textile industries can also have negative impacts on the terrestrial environment. (Nanjani et al., 2021). Water and soil are the major resources of the globe. Hence, the removal of dyes from the wastewater is very expensive, it can be done by various physicochemical methods but they are very expensive, have high energy required, and time taken process. The most effective and promising strategy to solve this problem is microbial degradation- it is the biodegradation process in which with the help of beneficial microbes we can remove the toxicity of dye-containing wastewater (Haque et al., 2021).

Properties of azo dyes

As colorants, azo dyes are widely used synthetic dyes in paper manufacturing, printing complexes, food, cosmetic, textile industries, etc. On account, 70% of dyes are used in the textile industry. Most disperse dyes, reactive dyes, and azo dyes are widely used for fabric dyeing and printing purpose (El Harfi et al., 2017; Benkhaya et al., 2020).

Azo group dyes are generally bonded to aromatic heterocyclic groups, benzene rings, naphthalenes groups, and enolizable aliphatic groups (Towns, 1999). The bonding with specific groups is responsible for the coloring effect of an azo dye, this gives different shades according to their intensities. The backbone of azo dye is made up of the auxochrome groups, the chromophoric groups, and the solubilizing groups. The shades of color can be determined by the bonding present in the azo groups and their association with the chromophores and auxochromes (Benkhaya et al., 2016). These azo dyes are belonging to organic compounds and azo groups are attached to the aromatic and heterocyclic rings. On mineralization, these dye compounds can be dissociated into an aryl amine and an aromatic compound that is

more hazardous and tends to be carcinogenic. Most azo dyes are soluble in water and absorb readily through inhalation or skin. If azo dyes consume or inhaled intentionally or non-intentionally it causes cancer, irritation to the eyes, allergic reactions, and high toxicity(Sudha et al., 2014).

Classification and Characterisation of azo dye

Mainly Azo dyes are categorized into three major groups (mono, di, and poly). They are strictly classified according to the number of azo groups in their structure. These azo groups are attached to heterocyclic or aromatic compounds on one side and aliphatic or unsaturated groups are attached on the other side of the structure(Al-Tohamy et al., 2020; Liu et al., 2020).

Table 1: Commonly used azo dyes and their properties.

Types of Azo Dye	IUPAC name	Uses	Toxicity	References
Acid violet 7	disodium;5-acetamido-3-[(4-acetamidophenyl)diazenyl]-4-hydroxynaphthalene-2,7-disulfonate	Used for silk, wool, wood, soap, medicine, cosmetics, leather, fiber, polyamide, and biological dyeing	Chromosomal aberrationinhibits the activity of acetylcholinesterase and membrane lipid peroxidation	Tomar et al., 2022.
Congo red	disodium;4-amino-3-[[4-[4-[(1-amino-4-sulfonatophthalen-2-yl)diazenyl]phenyl]phenyl]diazenyl]naphthalene-1-sulfonate	Used to dye cotton	Carcinogenic and mutagenic effects	Goud et al., 2020.
Direct blue 15	tetrasodium;5-amino-3-[[4-[4-[(8-amino-1-hydroxy-3,6-	Mostly used for cotton, such as the glue	Mutagenic effect due to reduction	Selvaraj et al., 2021.

	disulfonatonaphthalen-2-yl)diazenyl]-3-methoxyphenyl]-2-methoxyphenyl]diazenyl]-4-hydroxynaphthalene-2,7-disulfonate	cellulose fiber, silk, and rayon. It was also used for pulp, biological, film footage of dyeing, and used to make ink. Used in biological and staining applications.	process, and also having a strong carcinogenic effect	
Malachite green	4-[(4-dimethylaminophenyl)-phenyl-methyl]-N,N-dimethyl aniline	Textile, leather, biological staining, and paper industries	Carcinogenesis, mutagenesis, chromosomal fractures, teratogenicity, and respiratory toxicity.	Roy et al., 2020.

Microbial biodegradation of azo dye

Usually, azo dyes are not fully biodegradable. Therefore, conventional methods such as absorption, coagulation, filtration, settling, etc. are widely accepted, but the production of sludge in high amounts, secondary pollution elimination, and high cost are the major drawbacks of this method. In the present situation, the removal of dye by the microbial degradation process gives a new direction to microbial research. This microbial degradation process is an effective, easy, inexpensive, and permanent solution for the treatment of deteriorated land and water bodies (Etezzad et al., 2021).

Table 2: Microorganisms involved in dye degradation.

Types of Azo Dye	Microorganism	References
Acid violet 7	Transformed <i>E. coli</i>	Patel et al., 2022.
Congo red	<i>Pantoeaananatis Sd-1</i> , <i>Bacillus sp. strain MR-1/2</i> , <i>Daldinia sp.</i> , <i>Myrothecium verrucaria</i>	Goud et al., 2020.
Direct blue 15	<i>Alcaligenes faecalis</i> , <i>Sphingomonas sp. EBD</i> , <i>Bacillus subtilis</i> , <i>Bacillus thuringiensis</i> , <i>Enterobacter cancerogenus</i>	Kumar et al., 2007.
Malachite green	<i>Klebsiella aerogenes S27</i> , <i>Citrobacter</i> , <i>Aeromonas</i> , <i>Pseudomonas</i>	Shang et al., 2019.

Biodegradation mechanism of azo dye

The biodegradation process gains more attention due to its effective and eco-friendly treatment. Microbes can acclimatize to toxic waste, which can lead to the development of new and resistant strains that naturally transform various toxic chemicals into less harmful products. The biodegradation of recalcitrant compounds by the microbes occurs due to the presence of biotransformation enzymes. The mechanism by which azo dyes are degraded by microbes involves the use of azoreductase to facilitate the reductive cleavage of the azo bonds (-N=N-). The degradation process results in dye decolorization and the formation of colorless solutions due to the presence of intermediate compounds (Shah, 2014). On treatment with microbial culture, Congo red has two intermediates, naphthylamine, and benzidine analyzed by GC-MS (Sarkar et al., 2021). The biodegradation of malachite green by *Pseudomonas species*, 4-(dimethylamino) benzophenone, 4-dimethylaminophenol, benzaldehyde, hydroquinone, and leucomalachite green were identified by LC-MS analysis as intermediate products. (Song et al., 2020).

Future prospects

From the current overview, we predict that isolated potential microbes may degrade dye from the effluent and soil and helps in the bioremediation of textile industry wastewater and waste soil. The intermediate metabolites study predicts the degradation pathway used by bacteria. The findings make positive results that we can apply as environmental and agricultural good practices for the betterment of the society and ecosystem. This study gives an outlook on the biodegradation process furthermore molecular, proteomics, nano-technologies, etc. would be promising and effective tools for exploring new bioremediation strategies to control xenobiotic environmental pollution. Strategies to enhance biodegradation techniques have been the subject of exploration to enable the effective utilization of these information.

References

- Al-Tohamy, R., Sun, J., Fareed, M. F., Kenawy, E. R., & Ali, S. S. (2020). Ecofriendly biodegradation of Reactive Black 5 by newly isolated *Sterigmatomyceshalophilus* SSA1575, valued for textile azo dye wastewater processing and detoxification. *Scientific Reports*, 10(1), 1-16.
- Benkhaya, S., Cherkaoui, O., Assouag, M., Mrabet, S., Rafik, M., & El Harfi, A. (2016). Synthesis of a new asymmetric composite membrane with bi-component collodion: application in the ultra filtration of baths of reagent dyes of fabric rinsing/padding. *J. Mater. Environ. Sci*, 7(12), 4556-4569.
- Benkhaya, S., M'rabet, S., & El Harfi, A. (2020). Classifications, properties, recent synthesis and applications of azo dyes. *Heliyon*, 6(1), e03271.
- Didier de Vasconcelos, G. M., Mulinari, J., de Arruda GuelliUlson de Souza, S. M., Ulson de Souza, A. A., de Oliveira, D., & de Andrade, C. J. (2021). Biodegradation of azo dye-containing wastewater by activated sludge: a critical review. *World Journal of Microbiology and Biotechnology*, 37(6), 101.
- El Harfi, S., & El Harfi, A. (2017). Classifications, properties and applications of textile dyes: A review. *Applied Journal of Environmental Engineering Science*, 3(3), 00000-3.

- Etezzad, S. M., & Sadeghi-Kiakhani, M. (2021). Decolorization of malachite green dye solution by bacterial biodegradation. *Progress in Color, Colorants and Coatings*, 14(2), 79-87
- Goud, B. S., Cha, H. L., Koyyada, G., & Kim, J. H. (2020). Augmented biodegradation of textile azo dye effluents by plant endophytes: a sustainable, eco-friendly alternative. *Current Microbiology*, 77, 3240-3255.
- Haque, M., Mosharaf, M. K., & Marcus, P. K. (2021). Novel bacterial biofilm consortia that degrade and detoxify the carcinogenic diazo dye Congo red. *Archives of Microbiology*, 203(2), 643-654.
- Kumar, K., Devi, S. S., Krishnamurthi, K., Dutta, D., & Chakrabarti, T. (2007). Decolorisation and detoxification of Direct Blue-15 by a bacterial consortium. *Bioresource technology*, 98(16), 3168-3171.
- Liu, S. H., Tsai, S. L., Guo, P. Y., & Lin, C. W. (2020). Inducing laccase activity in white rot fungi using copper ions and improving the efficiency of azo dye treatment with electricity generation using microbial fuel cells. *Chemosphere*, 243, 125304.
- Nanjani, S., Paul, D., & Keharia, H. (2021). Genome analysis to decipher syntrophy in the bacterial consortium 'SCP' for azo dye degradation. *BMC microbiology*, 21, 1-19.
- Ngo, A. C. R., & Tischler, D. (2022). Microbial degradation of azo dyes: Approaches and prospects for a hazard-free conversion by microorganisms. *International Journal of Environmental Research and Public Health*, 19(8), 4740.
- Patel, H., Yadav, V. K., Yadav, K. K., Choudhary, N., Kalasariya, H., Alam, M. M., ... & Jeon, B. H. (2022). A recent and systemic approach towards microbial biodegradation of dyes from textile industries. *Water*, 14(19), 3163.
- Roy, D. C., Biswas, S. K., Sheam, M. M., Hasan, M. R., Saha, A. K., Roy, A. K., ... & Tang, S. S. (2020). Bioremediation of malachite green dye by two bacterial strains isolated from textile effluents. *Current Research in Microbial Sciences*, 1, 37-43.
- Sarkar, S., Echeverría-Vega, A., Banerjee, A., & Bandopadhyay, R. (2021). Decolourisation and biodegradation of textile di-azo dye Congo red by *chryseobacteriumgeocarposphaerae* DD3. *Sustainability*, 13(19), 10850.

- Selvaraj, V., Karthika, T. S., Mansiya, C., & Alagar, M. (2021). An overview review on recently developed techniques, mechanisms and intermediates involved in the advanced azo dye degradation for industrial applications. *Journal of molecular structure*, 1224, 129195.
- Shah, K. (2014). Biodegradation of azo dye compounds. *Int Res J BiochemBiotechnol*, 1(2), 5-13.
- Shang, N., Ding, M., Dai, M., Si, H., Li, S., & Zhao, G. (2019). Biodegradation of malachite green by an endophytic bacterium *Klebsiella aerogenes* S27 involving a novel oxidoreductase. *Applied microbiology and biotechnology*, 103, 2141-2153.
- Song, J., Han, G., Wang, Y., Jiang, X., Zhao, D., Li, M., ...& Mu, Y. (2020). Pathway and kinetics of malachite green biodegradation by *Pseudomonas veronii*. *Scientific reports*, 10(1), 1-11.
- Srinivasan, S., & Nagaraj, S. (2020). Latest innovations in bacterial degradation of textile azo dyes. In *Emerging Technologies in Environmental Bioremediation* (pp. 285-309). Elsevier.
- Sudha, M., Saranya, A., Selvakumar, G., & Sivakumar, N. (2014). Microbial degradation of azo dyes: a review. *International Journal of Current Microbiology and Applied Sciences*, 3(2), 670-690.
- Tomar, P. C., & Dahiya, P. (2022). Microbial Degradation of Azo Dyes Present in Textile Industry Wastewater. *Microbial Remediation of Azo Dyes with Prokaryotes*, 89-103.
- Towns, A. D. (1999). Developments in azo disperse dyes derived from heterocyclic diazo components. *Dyes and Pigments*, 42(1), 3-28.

An Illustration of Writing a Research Paper and Review Paper

Supriya Gupta*, Dr. Renu Mishra, Dr. Alka Verma

Abstract

*Research simply means innovating new discoveries. Good use of research knowledge especially in writing is imperative to make it beneficial for larger community. During research, writing work plays a significant role. Good writing skill increases clarity, reliability, uniformity and critical evaluation of evidence. A **Research Paper** is based on original research work. The research paper will be based on detailed, original experimentation, analysis and interpretation of the data. It presents the authors unique investigation of a specific research question. A **Review Paper or Review article** is a critical analysis on previously published literature on a specific topic. It is based on other's published research paper. It does not report any original research. It generally summarizes the existing literature and updated research work on a certain topic for better understanding. As per NAAC (National Assessment and Accreditation Council, an Autonomous Organization founded by UGC for assessing and accrediting Indian higher Institutions) **Criteria 3, Research, Innovation and Extension** emphasize on Promotion of research and facilities. Innovative ecosystem, research publications, writing work, code of ethics to check malpractices and Plagiarism etc. The aim of this article is to present an illustrative guide regarding writing a Research paper and Review paper in an efficient manner to facilitate research writing.*

Keywords- *Research Paper, Review Paper, NAAC, UGC, Research, Innovation, Plagiarism.*

Introduction

Research in common parlance means a search for knowledge. It is organized and systematic method of finding answers to questions. It is an art of scientific investigations. (Kothari, 2004)

Research is a scientific approach of answering a research question, solving a problem or generating new knowledge through a systematic and orderly collection, organization and analysis of information. (Klimova, 2012)

Good writing skills

In Research, Writing work plays an important role. Good writing skill increases clarity, reliability, uniformity and critical evaluation of evidence. Writing work is as important as research work is necessary. It helps to develop reading for critical evaluation for the purpose

of knowledge gain and authenticating your research work in the scientific world. (Singh, 2021) Writing a research work helps you understand the process of scientific discovery and then how to document that because without documentation it cannot reach other people. Different writing works are present like narrative, descriptive, persuasive and expository. Knowing how to write a good research work is a valuable skill that will serve you well throughout your career. (Ross, R 1974)

A General Outlook Of: National Assessment and Accreditation Council (NAAC)
National Assessment and Accreditation Council (NAAC), an Autonomous Organization established in 1994 by the University Grants Commission (UGC). Its Headquarter is in Bangalore. The main purpose of the Institution is assessing and accrediting Indian higher Institutions.

The vision of the NAAC is to make Quality education in India through a combination of self and external quality evaluation, promotion and sustenance initiatives. The accreditation depicts the institutional quality in terms of its education, research, faculty, infrastructure etc., as well as student's progression towards a quality institution. (naac.gov.in)

According to the Revised Assessment and Accreditation Framework (2017) of NAAC Criteria 3rd, Research, Innovation and Extensions Institutions must focus on directing students towards research & innovation and also addressing real-life problems & solutions to enable students to grow personally. It seeks information on the policies, practices and outcomes of the institution with reference to Research, Innovation and Extension. It deals with the facilities provided and efforts made by the institution to promote a '**Research Culture**'. (naac.gov.in)

So, here it becomes very necessary to discuss about research writing which plays a crucial role in research work. Research work becomes effective in the scientific world only when it is presented in an efficient, clear, complete and chronological order. A step by step approach regarding Writing of Research paper and Review paper are explained below.

Research Paper

A Research Paper is based on original research work. The research paper will be based on detailed, original experimentation, analysis and interpretation of the data. It presents the authors unique investigation of a specific research question. Research can vary depending on the topic (experiments, survey, interview, questionnaire etc.). (Cahyono, 1997). A good Research paper includes an abstract, hypothesis, background study, methodology, results, interpretation, references etc. **For basic format, IMRAD structure can be followed which stands for Introduction, Methods, Results and Discussion. (Cooper, 2015)**

How to write a Research Paper: A step by Step approach

Title

It includes the title or heading of the paper, Author's name and affiliations, Contact details and date of Submission.

Abstract

The abstract is a brief summary of the research article, thesis, review, conference or depth analysis of a particular topic. It can also be termed as the map of the paper. It summarizes background, aims, methods, result and conclusion. It should be clear, complete, concise part of the research that conveys all the essential elements of the research as brief and accurately as possible.

Introduction

The Introduction is the foremost preliminary step in research writing. This explains why anyone perform the research in the context of available knowledge and what is aimed to be achieved. It has three parts: what is known already, what is unknown, and what is the problem or research question, preliminary hypothesis and aim to achieve. The Research question is an important statement as it depicts the relevance of the study.

Literature Review

The literature review means reading and understanding all the previously done research work on the selected title. The good literature review can help in a better background knowledge about title.

Aims & Objectives

This section mainly includes the aims of the concerned person with the particular research work. It comprises why one is performing research.

Methodology

The methodology includes sufficient detail about the methods to be used for solving the research questions. Thus, this section should be specific, concrete, technical and fairly detailed. Detailed analysis about the sampling strategy used, instruments, data collection methods and analysis strategies should be described. It also gives a justification for using the methods you chose.

Results

The results are the findings of the research work in an orderly manner which is straightforward and factual. All results that relate to the research question should be given in detail i.e. tables, figures, graphs, percentages.

Discussion

The Discussion section allows the results in the form of available literature. Thus it is the most difficult section. It includes a summary of previous work, integration and implication of new research knowledge.

Conclusion

The Conclusion is the last step that may form part of the discussion and one just concludes the major findings and their importance of his research in the scientific world. It mentions how the research work is significant for all and indicates where future research is needed.

Reference

References are the List of the content source either text, images, reports, factual data etc. need to be acknowledge in order to provide appropriate credit to researcher that conducted original study. Reference also helps in further detailed evaluation of the research paper. The pattern of citation depends on the academic discipline involved and differs for websites, books, images etc. For example:

- **APA (American Psychological Association) used by Education, Sciences, Psychology**

Eg- (APA 7th edition)

Surname, A., Surname, B. (Year of publication). Title of book. *Publication. Volume*. URL

- **MLA (Modern Language Association) used by the Humanities**

Eg- (MLA 9th edition)

Surname, A., Surname, B. "Title of book". *Name of Publisher*. Volume. Year. URL.

- **Chicago/Turabian style is used by Business, History, and the Fine Arts**

Eg- Reference to a book Author (Chicago 17th edition)

Surname, A., Surname, B. "Title of book". Publisher. Year

1. Acknowledgement

The Acknowledgements mentions an opportunity to thank all those who have helped and supported you personally and professionally during your research process. It may be Institutions, organization, individuals etc. **So, this is the steps to write a Research Paper in a clear, complete and effective way.** (Kamraju, 2019) (Conroy *et. al.*, 2020) (Rumman *et. al.*, 2019)(Kallestinova, 2011)

Review Paper

A Review Paper or Review article is a critical analysis of previously published literature on a specific topic. It is based on other's published research paper. It does not report any original research. It generally summarizes the existing literature and updated research work on a certain topic for better understanding. Review articles can be of three kinds:

- A **narrative review** explains the existing knowledge on a topic based on all the published research available on the topic.
 - A **systematic review** searches for the answer to a particular question in the existing scientific literature on a topic.
 - A **meta-analysis** compares and combines the findings of previously published studies, usually to assess the effectiveness of an intervention or mode of treatment.
- Writing a review of literature is to provide a critical evaluation of the data available from previous studies. A good Review Paper includes abstract, background, discussion, conclusion, re

Writing a Review Paper: A Step by Step Approach

1. Title

The Review Paper also includes the title or heading of the paper, Author's name and affiliations, Contact details and date of Submission.

2. Abstract

Review Paper Abstract will summarize the background, aims, methods, result and conclusion. One should write the abstract very carefully so that it will convey all the essential elements of the research as briefly and accurately as possible.

3. Introduction

It includes the purpose of the review and a brief overview about the topic. The introduction will also state the previous knowledge as well as current status of knowledge in this area of research.

4. Main Body

The main body includes a detailed analysis about the selected topic. It represents all the previously work done information's from various resources. Since the review paper is based totally on other's published research papers, thus the Number of research paper studied should be more to get a detailed analysis about the subject. It summarizes the complete literature section in detail.

5. Conclusion

It provides a summary of findings from the literature review. It summarizes a critical analysis of the material to conclude the overall state of the literature, what is presently and what needs to be done. Some recommendations or implications for practice, education and research should be included.

6. References

Citing references at appropriate places in the article is important and important to avoid plagiarism. The number of references in review paper is usually higher than research paper. It is necessary to enlist the entire reference source as the whole review paper depends on the other literature, thus the referencing is very essential in review paper. Each journal has its referencing style. Thus, a review paper is completed with referencing. (Lichtfouse, 2015) (Benjos 2003) (Ramdhani 2014)

Difference between Review Paper and Research Paper

Review Paper	Research Paper
Contains summaries of each relevant research work to address a problem.	Contains original and new knowledge to solve a problem.
Do not have original work.	Have author's or researcher's original work.
It finds a gap or problem in already existing knowledge.	It fills a gap or solves a problem with new knowledge.
Address or suggest a solution.	Provides a solution.
Do not need wet lab work.	Needs extensive wet lab work.
Said as secondary literature.	Said as primary literature or research.
The result can't be patented.	The result can be patented.
Has discussions of each search work and conclusion.	Has Introduction, Material & Methods, Results & discussion and conclusion.

Image source- <https://thephdhub.com/differences-between-review-paper-and-research-paper/>

Conclusion

According to the Revised Assessment and Accreditation Framework (2017) of NAAC Criteria 3rd, Research, Innovation and Extension, Institutions must encourage and facilitate research related activities in order to ensure an innovative ecosystem. Research Writing is as significant as the research is necessary. A Good writing skill will helps to convey all the information's that you want to explain via your research. It makes your research work authentic and acceptable in the scientific world. In this review article, we illustrate about the step-by-step approach for writing a Research Paper and Review Paper and how the research and review paper differ from each other. This paper highlights the orderly format of writing academic research work, which will definitely help the researchers in the future. (Singh, 2021)

References

- Benjos, Dale. Kirk, Kevin. Hall john. (2002). How to review a paper. *Researchgate*. https://www.researchgate.net/publication/279723949_How_to_Review_a_Paper
- Cahyono, Yudi Bambang. (1997). Effective of Journal Writing in supporting skills in writing. *Researchgate*. https://www.researchgate.net/publication/307834026_Effectiveness_of_Journal_Writing_in_Supporting_Skills_in_Writing_English_Essay

SPECIAL ISSUE: NAAC Sponsored One Day National Seminar (Hybrid Mode) On "Revised Assessment and Accreditation Framework of NAAC" Organised by Internal Quality Assurance Cell (IQAC) on 24th Sept., 2022

- Conry, Ronan. (2020). How to write a Research paper. *Researchgate*.
https://www.researchgate.net/publication/339569726_How_to_write_a_research_paper
- Cooper, Diana. (2015) How to write a original Research paper. *National Library of medicines*.
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4404856/>
- https://www.researchgate.net/publication/275040893_Writing_a_review_article_in_7_steps
- Kallestinova, Elena,. (2011). How to write your First research Paper. *Researchgate*.
https://www.researchgate.net/publication/51687160_How_to_Write_Your_First_Research_Paper
- Kamraju , M. Prathap, Siva. Ali, Mohd.(2019). How to write an academic Research paper.
Researchgate.https://www.researchgate.net/publication/342916764_HOW_TO_WRITE_AN_ACADEMIC_RESEARCH_PAPER
- Klimova, B. (2012). The importance of writing. *Researchgate*.
<https://www.researchgate.net/publication/274925223>
- Kothari, C.R. (2004). *Research Methodology: Methods & Techniques*. *New age International Publications, New delhi*.
- Lichtfouse, Eric. (2015). Writing a review article in 7 steps. *Researchgate*.
- Ramdhani, Abdullah. Ramdhani, Muhammad. Amin Abdusy. (2014). Writing a literature research paper: A step by step approach. *Researchgate*.
https://www.researchgate.net/publication/311735510_Writing_a_Literature_Review_Research_Paper_A_step-by-step_approach
- Ross, Robert. (1974). *Research: An Introduction*. *Barnes and Noble Books, New York, London*.
- Rumman, Abu Ayman. (2019). How to write a effective research paper. *Researchgate*.
https://www.researchgate.net/publication/333943952_How_to_write_an_effective_research_paper
- Singh, Ajit. (2021). Significance of Research Process in Research world. *Researchgate*. 2021
https://www.researchgate.net/publication/350467546_Significance_of_Research_Processes_in_Research_Work

Mycodiversity of fruit of *Phyllanthus emblica*: A Review

Ms Shobhana Soni *, Dr. Renu Mishra



Abstract

Medicinal plants have served humans since prehistoric times to treat various ailments. Both developed and underdeveloped countries rely on traditional systems of medication using natural sources from plants. *Phyllanthus* is one of the largest genus in the family *Phyllanthaceae*, comprising over 700 well known species cosmopolitan in distribution mainly in the tropics and subtropics. Amla fruit contains a high concentration of vitamin C, as well as calcium, phosphorus, iron, nicotinic acid, and a number of amino acids including asparagine, alanine, glutamic acid, lysine, and proline. Amla fruits are cardioprotective, antiscorbutic, diuretic, and laxative, according to an inventorization of medicinal herbs. Numerous pharmaceutical businesses use amla fruit in the production of well-known "Triphala" and "Chawanprash" due to its therapeutic significance. Numerous postharvest diseases caused by fungal pathogens have been reported in Indian gooseberry. Some of common fungal pathogens reported from the Amla fruits are *Aspergillus*, *Penicillium*, *Cladosporium*, *Alternaria* and *Fusarium*. These fungi produce mycotoxins, a group of secondary metabolites, which are hazardous to human health. Infection in Amla caused by fungi many occur during growing season, at harvest time, during handling, storage, transport & marketing. The economic losses due to these fungal pathogens is difficult to estimate.

Keywords: *Phyllanthus emblica*, traditional medicines, phytochemicals, Mycodiversity

In addition to a strong foundation of numerous medical systems like Ayurveda, Unani, Siddha, and various regional medical practises, India is gifted with a great richness of medicinal plants. Alkaloids, glycosides, corticosteroids, and essential oils are a few of the complex chemicals that give medicinal plants their curative qualities (Silva *et al.* 2011). The feasibility and popularity of traditional medical practises and the use of medicinal plants to treat a variety of minor and serious illnesses are still present in our nation, despite the astonishing advancements made in modern synthetic pharmaceuticals, it has been noted. India has not been able to capitalise on its abundance in medical plants, despite having a rich history of doing so, mostly due to the quality of its finished medicinal plant products and raw botanicals.

The plant *Phyllanthus emblica*, sometimes known as amla, is a member of the Euphorbiaceae family (Hooker, 1897). It is known as the "Indian gooseberry" since it is believed to be an Indian native. Amla is grown commercially in Uttar Pradesh (Bajpai, 1963), but it is also being grown more often in other Indian states due to the fruit's strong medical value and promising business prospects. Amla fruit has a high concentration of vitamin C (400-600mg/100g), as well as calcium, phosphorus, iron, nicotinic acid, and a variety of amino acids including aspartic acid, alanine, glutamic acid, lysine, and proline (Hanif, 1966). Medicinal plant inventorization Amla fruits are cardioprotective, antiscorbutic, diuretic, and laxative, according to research (Bajpai et al., 1985). Because of its therapeutic value, numerous pharmaceutical companies use amla fruit to make well-known ayurvedic formulations such as Brahmarasayan, Sanjivani-vati, Agnitundivati, and Arogyavardhini. a number of foods, most frequently grains, dried fruits, tree nuts, ground nuts, and spices. According to Morton (1987), embalming materials found in stores had blue mould and rotting caused by *Penicillium islandicum*, as well as being determined to be infected with bacteria, yeast, and moulds. Fungi and bacteria infection can happen at any moment, including throughout the growing season, harvest, handling, storage, transit, and marketing, as well as after the consumer has made a purchase (Dennis, 1988).

According to Sharma and Koul (1999), practically all horticultural product is high in moisture and nutrients, making it vulnerable to damage and subsequent assault by a

wide range of mycopathogens. *Phyllanthus emblica*, like other fruits, is vulnerable to mycobial infections throughout the pre- and post-harvest stages. The pH of these fruits is quite low. As a result, they may be attacked by a distinct group of fungus with specialised nutritional requirements and enzymatic capabilities that allow them to cause fruit rot.

During the last 40 years, fungi in meals have received unique attention due to their ability to produce poisonous metabolites. even though some fungi which include *Claviceps purpurea* had been known for hundreds of years because of their high and acute toxicity, it after them changed only after the discovery of the aflatoxins, carcinogenic metabolites produced by the *Aspegillus flavus*, (Northolt & Soentoro, 1988).

According to reports, the physico-chemical environment in which the mould grows affects the synthesis of mycotoxins, a class of secondary fungal metabolites (Jimenez et al., 1991). These fungus thrive in favourable conditions of temperature and humidity.

These Amla (*Phyllanthus emblica* L.) fruits It includes tannins, calcium, iron, phosphorus, carotene, thiamine, riboflavin, and niacin. They also come into play in producing high-quality ink, common dyes, shampoos, and in the tanning business. Dried Amla fruit is also used in Ayurvedic and Unani medicine to treat a variety of illnesses, including fever, liver disorders, indigestion, anaemia, heart complaints, and urinary issues (Bhattacharjee, 2004). It is difficult to determine the economic loss brought on by the contamination of food products by mycotoxins and fungi.

In order to check the samples of amla for the presence of fungal species, a study was carried out in retailer markets of three distinct places, namely Hyderabad, Hala, and Tando Allah Yar, taking into account the economic and medical worth of amla. From surface sterilised and non-sterilized fruits, a total of 19 genera and 42 fungal species were isolated. The most often isolated species from fruits of all three locations belonged to the genera *Aspergillus* (5 species), *Penicillium* (4 species), *Fusarium* (4 species), *Alternaria* (4 species), *Cladosporium* (5 species), and *Curvularia* (3 species). The samples from Tando Allah Yar had a higher fungal frequency. The two

most prevalent fungus discovered in fruits from all three locales were *A. niger* and *A. flavus*. (Akhund *et al.*, 2010)

25 fresh samples of *Phyllanthus emblica* fruit from various Jammu province orchards and wholesale and retail stores were examined for fungal flora over the course of the investigation. Total 25 fungal species from 12 genera were found. most of the fungal species found in *Phyllanthus emblica* various fresh fruit samples were belongs to class Zygomycetes, Ascomycetes, and Deuteromycetes. Two species of *Mucor* (*M. hiemalis* and *M. microsporus*) and one species of *Rhizopus* (*R. stolonifer*) were members of the Zygomycetes class. Ascomycetes was addressed by *Emericella nidulans* var. *echinulatus*, while nine *Aspergillus* species (*A. japonicus*, *A. flavus*, *A. fumigatus*, *A. niger*, *A. nidulans*, *A. parasiticus*, *A. ochraceous*, *A. terreus*, and *A. sydowii*) were the most common in Deuteromycetes. three *Penicillium* species (*P. chrysogenum*, *P. funiculosam*, and *P. waksmanii*); two species every one of *Fusarium* (*F. verticilloides* also, *F. solani*); *Paecilomyces* (*P. liliacinus*), *Cladosporium* (*C. cladosporioides* and *C. oxysporum*), and one *Acremonium* species (*Acremonium implicatum*); *Alternaria* (*Alternaria alternata*); *Doratomyces*, specifically *D. purpureofuscus*; *Trichothecium*, or *Curvularia lunata*, and *Curvularia*, or *Trichothecium roseum*,

Conclusion

These review paper are calculate that focused on the study of surface mycoflora of diverse herbal medical plants during storage and marketing to increased awareness of the value of medicinal plant quality. Many researchers discovered a wide variety of fungi, notably *Aspergillus*, *Penicillium*, *Rhizopus*, *Chaetomium*, *Fusarium*, *Eurotium*, and *Cladosporium* species from the surface of the medicinal plant.

References

- Akhund S.; Suhail M.; Rani I.; Memon I F.; and Abro H. (2010). fruit borne mycoflora of amla (*PHYLLANTHUS EMBLICA* L.) Institute of Plant Sciences, University of Sindh, Jamshoro, Pakistan. *Pak. J. Bot.*, 42(6): 4229-4233, 2010.

- Bajpai, P.N., Shukla, H.S. and Chaturvedi, O.P. (1985). History importance and scope of tropical and subtropical fruits in India. In: *Fruits of India* (Ed. Bose, T.K.). *NayaPrakash : Calcutta six: India*, pp. 1-20.
- Bhattacharjee, S.K. (2004). Hand book of Medicinal Plants. 4th ed. *Pointer publishers, Jaipur 302 003(Raj) India*
- Dennis, C.J. (1988). *Postharvest Pathology of Fruits and vegetables*. Acad. Press, London.
- Hanif, M. (1966). *Pakistan J. Sci. Res*, 18:61-63
- Hooker, J.D. (1897). *Flora of British India; The University of California: 1-149*
- Jimenez, M., R. Mateo., J.J. Mateo., T. Huerta and E. Hernandez. (1991). Effect of the incubation conditions on the production of patulin by *Penicillium griseofulvum* isolated from wheat. *Mycopathologia*, 63-168
- Morton, J. (1987). Emblic. In: *Fruits of warm climates*. pp. 213-217 *Julia F. Morton*, Miami, Fl. <http://www.hort.purdue.edu/newcrop/morton/emblic.html>
- Sharma, R.C. and Koul, J.L. (1999). Post-harvest disease of temperate fruits and their management. In. *Diseases of horticultural crops : Fruits* (Eds. Verma, L.R and Sharma, R.C) *Indus Publishing Company, New Delhi*, pp. 582-623
- Sharma R. and Sharma V. (2018). Investigation on the mycodiversity of fresh fruits of *PHYLLANTHUS EMBLICA L.*, an important medicinal plant, from jammu province (india). University of Jammu, Department of Botany, *Int. J. Adv. Res.* 6(1), 168-173
- Silva, J.O.C., Costa, R.M.R., Teixeira, F.M. and Barbosa W.L.R. (2011). Processing and Quality Control of Herbal Drugs and Their Derivatives. *Prof. Yukihiro Shoyama (Ed.)*, ISBN: 978-953-307-682-9
- Stevic, T., Pavlovic, S., Stankovic, S., and Savikin, K. (2012). Pathogenic microorganisms of medicinal herbal drugs. *Arch. Biol. Sci., Belgrade*, 64 (1), 49-58.

Recycling Institutional Waste into Organic Fertilizer by Vermi composting : A Review

Jiya Khasdev* and Aditi Kushwaha

Abstract

An organic method in which eco-friendly earthworms are used to convert the organic material into humus material, the whole process is said to be Vermicomposting. Vermicomposting is one of the best practices to improve growth and yield of different crops, plants in garden like vegetables, flowering and fruit plants in a institute. Vermicomposting is better treated in soil, aeration, bulk density, and water retention physically. Vermicomposting has the same chemical properties such as pH, electrical conductivity, and many more. Our institution uses the vermicomposting method to keep our surrounding healthy. The organic matter content is also improve yields and quality. Vermicomposting is one of the best organic matter recycling options environmentally and economically. It is an activity produced by earthworms rich in macro-micro nutrients, vitamins, growth hormones enzymes, etc. Vermicomposting is so beneficial and stable fine granular manure that enriches soil quality by improving its physiochemical and biological properties. Vermicomposting can fulfill the organically grown product. It is becoming popular as a major component of an organic farming system. When vermicomposting is added to soil, it boosts the nutrients available to plants and enhances soil structure and drainage. Vermicomposting has also been shown to increase plant growth and suppress plant diseases and insect pest attacks. The current review provides the basic idea of all those research studies about impact of vermicomposting on plants growth in an institution in which continuous progress of the college is monitored through an annual external academic audit conducted by the IQAC. Vermicomposting is in practice in the institution since past years.

Keywords – vermicomposting, aeration, bulk density, water retention, granular manure, biomass, excrete, growth hormones.

Introduction

Vermicomposting is the scientific method of making compost, by using earthworms. They are commonly found living in soil, feeding on biomass and excreting it in a digested form. Vermicomposting is a simple biotechnological process of composting, in which certain species of earthworms are used to enhance the process of waste conversion and produce a better product. The institute has a provision for vermicomposting. Dry leaves, green waste and wet waste is collected and dumped in the Vermin-compost pit. After the collected waste goes through the process of composting.

Interested students of college and staff can create and sustain pollution free environment for the present generation and posterity. The facility in our college for converting fallen leaves and solid waste of our campus into vermicompost is an old practice. The facility was established in the year 2010 with financial support of UGC . It helps us to maintain our campus free from litter and keep our campus neat and tidy.

Vermicomposting Material

Decomposable organic wastes in a Institute such as laboratory waste, paper waste, animal excreta, Canteen waste, kitchen waste, garden and farm residue and forest litter are commonly used as composting materials. Mixture of leguminous and non-leguminous crop residue enriches the quality of vermicompost, *Mall(2004)*.

Most worm farms raise two main types of earthworm: *Eisenia foetida* and *Lumbricus*



rubellis. These worms are commonly used to produce vermicompost, as well as for fish bait. Both are referred to by a variety of common names, including red worms, red wigglers, tiger worms, brandling worms, and manure worms, *Mehta et.al(2014)*.

Vermicomposting turns the kitchen-canteen waste and other green waste into dark, nutrient-rich soil. Due to the presence of microorganisms, it maintains healthy soil. It is an eco-friendly process that recycles organic waste into compost and produces valuable nutrients. Vermicomposting converts institutional and household waste into compost within 30 days, reduces the C:N ratio and retains more N than the traditional methods of preparing composts, *Gandhi(1997)*.

Types of Vermicomposting Method

There are two major types of vermicomposting method

- Vermicomposting in bin : Vermicomposting in pile

• Vermicompos
The bin techniqu
in institution it
from numerous
bins, owing to
vermicompost b
over thirty cm.
executive.Period
fertilizer vermic



Organic
Worm
(catt
Ear
Coarse

• **Vermicomposting in Bin**

The bin technique is ready to use in little scale like home composting, in room or garage and in institution it is being performed for making organic fertilizer. The bin is manufactured from numerous materials, however wood and plastic ones square measure in style. Plastic vermicompost bin could also be in numerous sizes and shapes, however its height must be over thirty cm. bins with a height of 30-50 cm, and not therefore over it, square measure executive. Period of 2-3 month is required for the proper conversion of the foliage into bio-fertilizer vermicomposting depending on population of the worms.

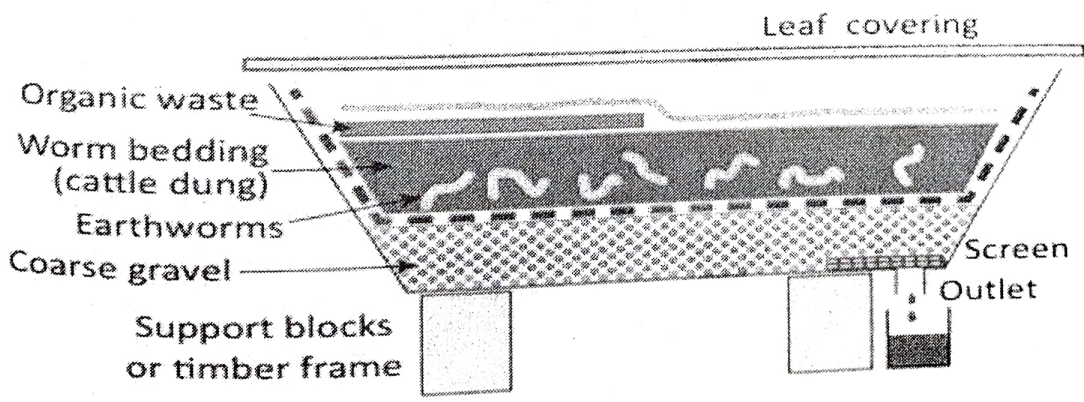


Figure 7.30 Vermicomposting bin

• Vermicomposting in Bin

The bin technique is ready to use in little scale like home composting. in room or garage and in institution it is being performed for making organic fertilizer. The bin is manufactured from numerous materials, however wood and plastic ones square measure in style. Plastic bins, owing to lightness, square measure a lot of most popular in home composting. A vermicompost bin could also be in numerous sizes and shapes, however its height most be over thirty cm. bins with a height of 30-50 cm, and not therefore over it. square measure executive. Period of 2-3 month is required for the proper conversion of the foliage into bio-fertilizer vermicomposting depending on population of the worms.

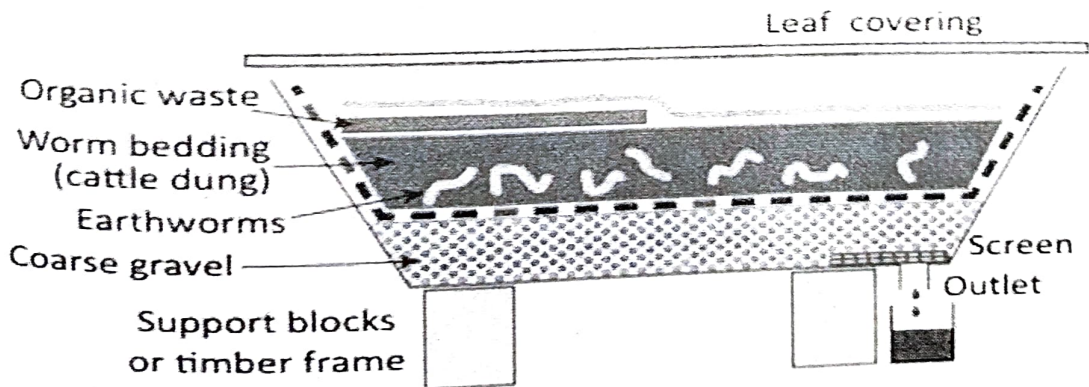


Figure 7.30 Vermicomposting bin

• Vermicomposting in Pile

Pile method mostly is used for vermicomposting in larger scale rather than bin method Rostani(2011). Where the vermicompost is the chosen way to processing a large amount of wastes, application of piles is cost beneficial. The piles can be made in porch place like greenhouse or in a floor with some facilities for drainage in warm climates.

• Benefits of Vermicompost for Plants and Soil

Benefits of vermicomposting include pathogen suppression in which some cases compost-mediated disease suppression can be explained by interaction that occur on the surface of germinating seeds within short times frame so exploring the relationships in the immediate infection area in different pathosystem may be fruitful with any analysis of bulk media.

In vermicomposting nutrient delivery is rich with many nutrients like nitrogen, potassium, and phosphorus micro nutrients are beneficial for soil and also contain plant growth hormones and enzymes. The speciality of water retention it stabilise the soil pH, detoxify chemicals and heavy metals in the soil. The ability to retain water and its beneficial contents of Nitrogen (N), Phosphorus (P), Potassium (K) and microbial nutrients increase and improve germination rate and growth rate.

Vermicompost have higher content of macro and micro nutrients like nitrogen, phosphorus, potassium, calcium, sodium, magnesium and micronutrients namely iron, copper, zinc and manganese which play a major role in solid waste management. In vermicomposting pest suppression products have been proved to be efficient as organic fertilizers and biological control agents providing suppression on many plant diseases incidences caused by soil-borne/foliar plant pathogens and pests. Plant growth regulation and higher yields, polluted soil remediation, wrapping it up are also some points that can be added as benefits of vermicomposting.

• Disadvantages of Vermicomposting.

It is a time-consuming process and takes as long as six months to convert the organic matter into usable forms it releases a very foul odour. Vermicomposting has high maintenance as we perform such activity in our institute under care so that it should not get too wet or too dry. The feed has to be added periodically and care should be taken that the worms are not flooded with too much to eat. The moisture levels need to be monitored periodically. They nurture the growth of pests and pathogens such as fruit flies, centipede and flies.

• Applications of Vermicomposting

Vermicomposting is an organic and biological process in which earthworm species are primarily used to convert organic matter or biodegradable wastes into manure (*Byjus*). The produced vermicompost are rich in nutrition and thus, they are widely used as bio fertilizers in organic farming and sewage treatment plants. Vermicomposting is environmental friendly

and is widely used in agriculture. These organic wastes contain organic carbon and plant nutrients in appreciable amounts. Vermicomposting can also be used as a technique for domestic wastewater management it can be used in organic farming and small scale sustainable farming hence it is also used by in our surrounding to keep the institute campus healthy by making the use of organic waste. Adding vermicompost, which is rich in organic compounds, to the soil, plays a fundamental role in improving productivity and can also be used as a growth regulator as it contains all essential plant nutrients in appropriate proportions. Thus, it is complete and balanced plant food. Composting is high in proteins and other essential nutrients. Therefore, it is also used as an alternative in aquaculture feed. Regular use of vermicompost extract promotes plant growth, keeps plants healthier and fights plant diseases.

Conclusion

Vermicomposting is in practice in the institution since past years. The campus area of the college is full of greenery with wild, ornamental and medicinal plants. Vermicomposting enhances plant growth, suppresses disease in plants, increases porosity and microbial activity in soil, and improves water retention and aeration. Vermicompost also benefits the environment by reducing the need for chemical fertilizers and decreasing the amount of waste going to landfills. No pollution is caused if done properly. Produced vermicompost is used as a bio-fertilizer for campus plantation and at the same time students are also provided knowledge about the project and guided to use such type of project in the farming also. Specifically in Institutions audit is conducted on the basis of criteria wise as suggested by the NAAC , to evolve and develop eco friendly and novel technologies for restoration and improvement of soil health through vermibiotechnology. This is an attempt to minimize the pollution and to create environmental awareness among the students and other staffs.

Reference

- Gandhi M, Sangwan V, Kapoor KK, Dilbaghi N. (1997). Composting of household wastes with and without earthworms. *Eco Environments.*;15(2):272–279.
- <https://byjus.com/biology/application-of-vermicompost/>
- Mall, A.K., Dubey, A. and Prasad, S. (2005) Vermicompost: an inevitable tool of organic farming for sustainable agriculture. *Agrobios Newsletter*, 3(8):10-12.
- Mehali J. Mehta (2014) Composting Organic Kitchen Waste with Worms for Sustainable Kitchen Waste Management *Int. Journal of Engineering Research and Applications* Vol. 4, Issue 3(Version 5), pp.28-31.
- Roohalah Rostami , Vermicomposting, Book 2010 Published: August 23rd, 2011

A Brief Review on Bacterial Pigments

Delna N S*, Dr. Renu Mishra, Dr. Anil Prakash

Abstract

Pigments produced from micro-organisms are highly demandable in both industrial and pharmaceutical fields because of its safe, non-toxic, and biodegradable characteristics. Use of bacteria for pigment production has several advantages such as short life cycle and easy for genetic modification. Among all other sources, many studies pointed out soil bacteria contribute a significant role in the production of colored pigments as their secondary metabolites. Bacterial pigments are famous for their antimicrobial, antioxidant, and anti-cancer properties. Hence it opened new therapeutic insights for the development of novel drugs. However, compared with fungal pigments, most of bacterial pigments are still at the platform of research and development, therefor work on bacterial pigment production should be intensified to make them readily available on the market in low cost for various purpose. This review article can be spread light on bacterial pigments along with their various applications based on the data available in the previous literatures.

Key words: *Bacterial pigments, Secondary metabolites, Antimicrobial property, Antibiotics, Antibiotic resistance.*

Introduction

Apart from colorant, Bacterial pigments have many medicinal properties such as antioxidant, anti-inflammatory, UV protector, antimicrobial and anticancer activity. Bacteria provide a readily available source of naturally derived pigments and have wide range of applications with enormous advantage over plant and fungal pigments, including easy and rapid growth in low cost medium, easy processing, and growth that is independent of weather and geographic conditions (Usmanet *al.*, 2017)

Numerous reports on microbial secondary metabolites have been published in recent years. "our understanding to enhance the production of bioactive secondary metabolites are still limited" denoted by researchers in Mizoram University, Aizawl, India in the topic of "Microbial Secondary Metabolites: Recent Developments and Technological Challenges" (Singh *et al.*, 2019). In their article they comprised 25 studies covering important aspects on biodiversity, exploitation and utilization of microbial resources for the production of secondary metabolites together with their biological functions. They were also described that Bacterial secondary metabolites are an important source of antimicrobial and cytostatic drugs.

Pigment Producing Bacteria

Many bacterial strains have proved their potential in pigment production. According to the study of Narsing *et al.*, (2017) Various genera of *actinomycetes* such as *Streptomyces*, *Nocardia*, *Micromonospora*, *Thermomonospora*, *Actinoplanes*, *Microbispora*, *Streptosporangium*, *Actinomadura*, *Rhodococcus*, and *Kitasatospora* produce a wide variety of pigments. As per the results of this study, the genus *Streptomyces* was reported for highest pigment production. Many species of this genus, like *Streptomyces griseus*, *Streptomyces griseoviridis*, *Streptomyces coelicolor*, *Streptomyces cyaneus*, *Streptomyces vietnamensis*, *Streptomyces peucetius*, *Streptomyces echinoruber*, *Streptomyces shaanxiensis*, and *Streptomyces caeruleatus* were reported to produce pigments.

Venil *et al.*, (2013) reported that, Pigments such as pyocyanin and pyorubin obtained from *Pseudomonas aeruginosa*, pigments from *Micrococcus luteus* and *Monascus ruber*, prodigiosin pigment produced from *Vibrio sp.*, pigment of an endophyte fungal species *Monodictys castaneae*, shows good antibacterial property on various bacterial pathogens. In their study, Pigment obtained from *Streptomyces hygrosopicus*, even showed good antimicrobial activity against drug resistant pathogens such as methicillin and vancomycin resistant strains of *Staphylococcus aureus* and β -lactamase producing strains of *Escherichia coli*, *Pseudomonas aeruginosa*, and *Klebsiella sp.*

Soil: A Rich Source of Pigmented Bacteria

Pigment producing bacteria are present in various ecological regions such as rhizosphere soil, desert sand, fresh water, and marine samples and were reported in low and high temperature regions, can persist in salt regions, and even as endophytes (Malik, *et al.*,2012). Historically, most of the antibiotic molecules have come from soil bacteria which can be isolated and grown in the laboratory, but there is still vast majority of soil bacteria cannot be isolated with proper information. These understudied soil bacteria offer a wealth of potential for the discovery of new compounds (Sharrar, *et al.*,2020).

The study of Singh *et al.*, (2016) says that “India has a unique asset of biodiversity, which can be used as a treasure for the search of novel isolates. With the variation of type of soil, according to the geographical changes, soil provide very complex habitat to the microbes residing in it. Due to this intricate environment, the soil microbes play an important role in the isolation of novel drugs”. For their study they were collected the soil samples from six diverse habitats of India (Lucknow, Uttar Pradesh: 26.7°N, 80.9°E; Badrinath, Uttarakhand: 30.7440°N, 79.4930°E; Delhi, New Delhi: 28.6100°N, 77.2300°E; Bhatinda, Punjab: 30.2300° N, 74.9519° E; Haryana: 28.04°N 76.11°E; Thinmala range, Kerala: 8.5074°N, 76.9730°E) for the isolation of microbes. These habitats included rhizosphere of the plants, agricultural soil, hospital surroundings, river mud, and preserved areas of forest soils.

Parmar *et al.*, (2016) has conducted a study in ITM University, Gwalior, Madhya Pradesh, India., their objective was to isolate, characterize, and study the biological activity of pigment-producing *actinomycetes*. For their research they were collected the samples from rhizosphere soil of Chambal territory and other parts of Madhya Pradesh regions. According to the results of the study *Streptomyces* isolate has also shown notable antimicrobial activities against various pathogens, and Chambal territory region of Madhya Pradesh has great ability to produce potent *actinomycetes*, which possess pigment-production and antimicrobial activities.

Important Applications of Bacterial Pigments

In Drug Industries

Antimicrobial, anticancer, cytotoxic and remarkable antioxidant properties of bacterial pigments make them popular in drug industries. Owing to the medicinal properties of bacterial pigments it was considered as a best choice for novel drugs (Numan *et al.*, 2018). Most of the studies in antimicrobial resistance concluded with the need of an urgent novel antimicrobial agent. "Never has the threat of antimicrobial resistance been more immediate and the need for solutions more urgent", said WHO Director-General Tedros Adhanom Ghebreyesus to The UN News in 2020. Marathe *et al.*, (2019) and D'Andrea *et al.*, (2019) has clearly described in their articles that the rise in antibiotic resistance is a serious growing problem for human health, hence they hope this extreme antimicrobial property of bacterial pigments can shed light as a solution to compete against antibiotic resistance.

Waghela and Khan (2019) in Mumbai India, conducted a study in antibacterial property of bacterial pigments isolated from food samples, they were aimed to isolate the microorganisms from different food samples capable of producing pigments with antimicrobial activity. Antimicrobial activity of the pigments they were tested against four human pathogens such as *Escherichia coli*, *Pseudomonas*, *Staphylococcus aureus*, and *Streptococcus species*, by well diffusion method on nutrient agar plates. The results of their study showed that all the three pigments 1 yellow and 2 orange pigments from the isolates were found to inhibit the growth of both Gram-positive as well as Gram-negative bacteria and thus these pigments could be designated as broad-spectrum antimicrobial agents.

In Food Industries

Digging for Natural sources of food colors are increasing since some of the artificial color additives have demonstrated detrimental effect on public health. Due to the shortage of availability of natural sources of colors, Non-hazardous behavior of microbial pigments make them demandable in food industry (Sánchez *et al.*, 2020). Bacterial pigments play significant role as food coloring agent, because of its easy production process such as easier extraction, higher yields through strain improvement by gene modification. This naturally

obtained colors can be readily replace synthetic colors thus protects humans and environment from harmful effect of this synthetic dyes (Aberoumand 2011)

In Textile and Cosmetic Industries

Textile industries are the largest consumer of natural dyes. Bacterial pigments are a very good natural colorant in cosmetics and textile industries. Even though microbial pigments remain so costly, the value of this pigments are exponentially increasing in International market of color world. This organic dyes are widely used as printing inks, paints, and coating agents. (Narsing *et al.*, 2017). The study of Choksiet *al.*, in 2020 has suggested that bioactive pigment's antioxidant and sun-protective properties can be further develop and should be used as a main ingredient in cosmeceuticals.

Modern Therapeutic aspects of Bacterial Pigments

The Nano medicine technology and recombinant DNA technology offering another research opportunity of bacterial pigments in therapeutic purpose. Thus indicating growing interest of bacterial pigments in modern medicines (Soliev *et al.*, 2011)

Nano medicine is the application of nanotechnology in health care, and it is one of the most promising and worldwide technology. Nano medicine offers numerous promising possibilities to significantly improve medical diagnosis and therapy, leading to affordable higher-quality health care. (Bernardi *et al.*, 2018).

Rahul, *et al.*, (2015) were extracted and purified Bioactive pigments from cultures of *Serratia marcescens* and *Chromobacterium violaceum*. These bioactive pigments, prodigiosin, violacein and their combinations with photosynthesized silver and gold nanoparticles were studied for the growth inhibition of *Plasmodium falciparum* and *Trypanosoma brucei gambiense*. Prodigiosin was found to be more effective than violacein for inhibition of both parasites in vitro. Specifically, combinations of the microbial pigment prodigiosin with metal nanoparticles showed a significant reduction of both parasites without increase of cytotoxicity upon mammalian cells. The data may be useful for the microbial pigment based drug designing said by the authors at the conclusion of their article. Charkoudian *et al.*, (2010) Cultured *Streptomyces* and extracted their pigments then they modified the genomes and used Engineered bacteria to make new pigments. The study proved that the metabolic engineering of microbial systems can Scaling up the production of bacterial metabolites by using large scale bioprocessing techniques such as recombinant DNA technology.

Conclusion

The demand for bacterial pigments are increasing day by day due to its non-adverse effects in environment and on human health. Apart from the industrial uses in food, textiles and cosmetics, their specific characteristics such as antimicrobial, antioxidants, and anti-cancer,

make them famous in medical drug designing. As per the compendium of all the reviewed articles, bacterial pigment production is now one of the promising and emerging field of research to reveal its potential various usage and a best choice for drug designing. Yet unexpected functions of known secondary metabolites are continuously being unrevealed, and are fulfilling some of the gap in present-day research on medicinal use of bacterial pigments can contribute great promise for the future microbiology.

References

- Aberoumand, A. A review article on edible pigments properties and sources as natural biocolorants in foodstuff and food industry. *World Journal of Dairy & Food Sciences*,6(1), 71-78.2011
- Bernardi J C, Marangoni VS, Besson JC, Cancino ME, Natali MR, Zucolotto V. Gold-based nanospheres and nanorods particles used as theranostic agents: An in vitro and in vivo toxicology studies. *Chemosphere*.213:41-52.2018.
- Charkoudian LK, Fitzgerald JT, Khosla C, Champlin A. In living color: bacterial pigments as an untapped resource in the classroom and beyond. *PLoS biology*. 2010 Oct 5;8(10):e1000510.
- Choksi J, Vora J, Shrivastava N. Bioactive pigments from isolated Bacteria and its antibacterial, antioxidant and sun protective application useful for cosmetic products. *Indian journal of microbiology*. 60(3):379-82. 2020.
- D'Andrea, M. M., Fraziano, M., Thaller, M. C., & Rossolini, G. M. The Urgent Need for Novel Antimicrobial Agents and Strategies to Fight Antibiotic Resistance: *NCBI, PubMed central* 254.2019.
- Malik K, Tokkas J, Goyal S. Microbial pigments: a review. *Int J Microbial Res Technol*. (4):361-5.2012.
- Marathe NP, Berglund F, Razavi M, Pal C, Dröge J, Samant S, Kristiansson E, Larsson DJ. Sewage effluent from an Indian hospital harbors novel carbapenemases and integron-borne antibiotic resistance genes. *Microbiome*. (1):1-1, 2019 Dec7.
- Narsing Rao MP, Xiao M, Li WJ. Fungal and bacterial pigments: secondary metabolites with wide applications. *Frontiers in microbiology*,8:1113, 2017 Jun 22.
- Numan M, Bashir S, Mumtaz R, Tayyab S, Rehman NU, Khan AL, Shinwari ZK, Al-Harrasi A. Therapeutic applications of bacterial pigments: a review of current status and future opportunities. *3 Biotech*. (4):1-5, 2018 Apr;8.
- Parmar RS, Singh C, Saini P, Kumar A. isolation and screening of antimicrobial and extracellular pigment-producing actinomycetes from chambal territory of madya pradesh region, INDIA. *Asian J Pharm Clin Res*. 9(1):157-60, 2016.
- Rahul, Suryawanshi, Patil Chandrashekhar, Borase Hemant, Salunke Bipinchandra, Elisabeth Mouray, Philippe Grellier, and Patil Satish. "In vitro antiparasitic activity of microbial pigments and their combination with phytosynthesized metal nanoparticles." *Parasitology international* 64, no. 5: 353-356. 2015.

- Sánchez-Muñoz, Salvador, Gilda Mariano-Silva, Marcela O. Leite, Fabiana B. Mura, Madan L. Verma, Silvio S. da Silva, and Anuj K. Chandel. "Production of fungal and bacterial pigments and their applications." In *Biotechnological production of bioactive compounds*, pp. 327-361. Elsevier, 2020.
- Sharrar, A. M., Crits-Christoph, A., Méheust, R., Diamond, S., Starr, E. P., & Banfield, J. F. Bacterial secondary metabolite biosynthetic potential in soil varies with phylum, depth, and vegetation type. *American Society for Microbiology, Mbio*, 11(3).2020.
- Singh BP, Rateb ME, Rodriguez-Couto S, Polizeli MD, Li WJ. Microbial secondary metabolites: recent developments and technological challenges. *Frontiers in Microbiology*. 2019 Apr 26;10:914.
- Singh V, Haque S, Singh H, Verma J, Vibha K, Singh R, Jawed A, Tripathi CK. Isolation, screening, and identification of novel isolates of *actinomycetes* from India for antimicrobial applications. *Frontiers in microbiology*. 7:1921.2016.
- Soliev AB, Hosokawa K, Enomoto K. Bioactive pigments from marine bacteria: applications and physiological roles. Evidence-based Complementary and Alternative Medicine: *ECAM*. 2011;2011.
- UN News: "Urgent need for 'immediate' solutions to combat drug resistant infections warns WHO". 2020
- Usman HM, Abdulkadir N, Gani M, Maiturare HM. Bacterial pigments and its significance. *MOJ Bioequiv Availab*. 4(3):00073.2017.
- Venil CK, Zakaria ZA, Ahmad WA. Bacterial pigments and their applications. *Process Biochemistry*.;48(7):1065-79, 2013 Jul 1.
- Waghela M, Khan S. Isolation, Characterization of Pigment Producing Bacteria from various food samples and testing of antimicrobial activity of bacterial Pigments. *DAV International Journal of Science*.;7(1).2277- 5536, 2018.