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ADVANCES IN CHEMICAL AND BIOLOGICAL SCIENCES VOLUME I

EDITORS:

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PREFACE

In the boundless realm of scientific exploration, the book you're about to delve into stands as a testament to the ceaseless pursuit of knowledge in the chemical and biological sciences. "Advances in Chemical and Biological Sciences" serves as a compass guiding you through the intricate landscapes of molecules, cells, and the fascinating interplay between the two.

As we embark on this intellectual journey, it's crucial to recognize the collective efforts of brilliant minds whose tireless curiosity has fueled the progress documented within these pages. The preface of this book is not just an introduction; it's an ode to the insatiable human spirit that propels us to unravel the mysteries of the microscopic and the macroscopic.

Within these chapters, you'll witness the marriage of theory and experimentation, the fusion of innovation and tradition, all converging to push the boundaries of our understanding. The frontiers of chemical and biological sciences are not static; they are dynamic, ever-evolving landscapes where each discovery begets new questions, and each answer opens the door to uncharted territories.

As you immerse yourself in the narratives penned by experts in their respective fields, anticipate revelations that spark excitement, challenge preconceptions, and inspire further inquiry. The pages ahead are not just a compilation of facts and figures but a tapestry woven with the threads of intellectual curiosity, persistence, and the joy of unraveling the secrets that nature has carefully guarded.

"Advances in Chemical and Biological Sciences" is not merely a book; it's a rendezvous with the forefront of scientific inquiry. So, let the pages turn, let the words unfold, and may your understanding of the chemical and biological world be forever enriched.

Editors:

Dr. Bassa Satyannarayana

Mr. Mukul Machhindra Barawnt

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A REVIEW OF HISTORICAL BACKGROUND OF ETHNOBOTANY AND CULTURE OF INDIAN TRIBES

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ABSTRACT
India is one of the largest tribal residing countries in the world and having enormous folklore. Tribes are the indications of primitive traits and origin of inhabitants. Based on their knowledge, researchers tried to find out and reported the novel information. Tribes utilise their vicinity to live their life peacefully and associated with nature. Indian tribes differ from each other in culture, religion, residency, language, dressings, food habits and lifestyle. Based on these factors, tribes build their lifestyle. The plants play a crucial role for food, fodder, disease treatments, ornaments, dress, household things, etc. In this study, the importance of plants and knowledge of tribes about those plants were described in various aspects.
KEYWORDS: Tribes, plants, knowledge, culture, disease, treatments.

INTRODUCTION

Nature is the world-wide repository of therapeutic drugs from our days of residence. The interrelation between human and plants were studied in the modern era to find out the noteworthy riches of plant drugs. Man's vital interest in plants, begins as a source of food, shelter and clothing in the beginning of civilization. After years passed by, human found that the plants are the "nature's chemical factories". The chemical substances present in the plants are potentiating to treat human diseases (Mohite and Shingare, 2020). Ethnobotany is a specific field to study the indigenous plants specifically and also their relationship with the native people. These studies explain the importance of plants in native cultures and their benefaction in food, medicine, spiritual therapies, rituals, etc. Especially in therapeutic field, plants secondary metabolites are used alone or in combination to diagnose, treat and prevent diseases (Olowokudejo *et al.,* 2008). Modern ethnobotanists strive to collect all the available plant drugs Data and methodologies to use the plants (Popovi *et al.,* 2016). Now-a-days, the ethnobotany based researches are authenticated and added value to the indigenous plant drug knowledge in drug development (Haq *et al.,* 2011; Ajaib *et al.,* 2016). Ethnobotany plays a crucial role in the fields of Taxonomy, Nomenclature, Veterinary, Mycology, Bryology, Ecology, Pharmacology, Sociology, Cosmetics, Anthropology, etc. The plant derived therapeutic drugs couldn't be developed in medical field without the help of indigenous people. The "People of India Project" has recognized 4,635 communities with about 50 to 60 thousand endogenous groups in India (Gadgil *et al.,* 1998). The astonishing statistical data shows that 10 percentage of Indian population (more than 80 million) comprised of 533 various tribal communities (Lal B.S., 2019). The indigenous people are scheduled according to their unique culture, traditions, rituals, languages, habitat and their life styles, etc.

MAJOR TRIBES IN INDIA

Ethnobotany is related with indigenous people. They have their own language, culture, rituals, food habits and medicinal systems. Tribals are spread throughout the India as separate communities. Tribes

comprise a significant part of the Indian population, and tribal culture is an integral part of our intangible national heritage. Tribes are also known by the name 'Adivasis' in India. Based on the survey of SCSTRTI, 2015 some of the important tribal groups of India in state wise is given below:

S.No	States	Tribal communities
1	Andhra Pradesh	Andh, Sadhu Andh, Bhagata, Bhil, Chenchus (Chenchawar), Gadabas, Gond, Goundu, Jatapus, Kammara, Kattunayakan, Kolawar, Kolam, Konda, Manna Dhora, Pardhan, Rona, Savaras, Dabba Yerukula, Nakkala, Dhulia, Thoti, Sugalis, Banjara, Kondareddis, Koya, Mukha Dhora, Valmiki, Yenadis, Sugalis, Lambadis.
2	Arunachal Pradesh	Apatanis, Abor, Dafla, Galong, Momba, Sherdukpen, Singpho, Nyishi, Mishmi, Idu, Taroan, Tagin, Adi, Monpa, Wancho
3	Assam	Chakma, Chutiya, Dimasa, Hajong, Garos, Khasis, Gangte, Karbi, Boro, Borokachari, Kachari, Sonwal, Miri, Rabha, Garo.
4	Bihar	Asur, Baiga, Birhor, Birjia, Chero, Gond, Parhaiya, Santhals, Savar, Kharwar, Banjara, Oraon, Santal, Tharu
5	Chattisgarh	Agariya, Bhaina, Bhattra, Biar, Khond, Mawasi, Nagasia, Gond, Binjhwar, Halba, Halbi, Kawar, Sawar
6	Goa	Dhodia, Dubia, Naikda, Siddi,Varli, Gawda.
7	Gujarat	Barda, Bamcha, Bhil, Charan, Dhodia, Gamta, Paradhi, Patelia, Dhanka, Dubla, Talavia, Halpati, Kokna, Naikda, Patelia, Rathawa, Siddi.
8	Himachal Pradesh	Gaddis, Gujjars, Khas, Lamba, Lahaulas, Pangwala, Swangla, Beta, Beda Bhot, Bodh.
9	Jammu and Kashmir	Bakarwal, Balti, Beda, Gaddi, Garra, Mon, Purigpa, Sippi, Changpa, Gujjar.
10	Jharkhand	Birhors, Bhumij, Gonds, Kharia, Mundas, Santhals, Savar, Bedia, Ho, Kharwar, Lohra, Mahli, Parhaiya, Santal, Kol, Banjara
11	Karnataka	Adiyan, Barda, Gond, Bhil, Iruliga, Koraga, Patelia, Yerava, Hasalaru, Koli Dhor, Marati, Meda, Naikda, Soligaru.
12	Kerala	Adiyan, Arandan, Eravallan, Kurumbas, Malai arayan, Moplahs, Uralis, Irular, Kanikaran, Kattunayakan, Kurichchan, Muthuvan
13	Madhya Pradesh	Baigas, Bhils, Bharia, Birhors, Gonds, Katkari, kharia, Khond, Kol, Murias, Korku, Mawasi, Pardhan, Sahariya
14	Maharastra	Bhaina, Bhunjia, Dhodia, Katkari, Khond, Rathawa, Warlis, Dhanka, Halba, Kathodi, Kokna, Koli Mahadev, Pardhi, Thakur
15	Manipur	Naga, Kuki, Meitei, Aimol, Angami, Chiru, Maram, Monsang, Paite, Purum, Thadou, Anal, Mao, Tangkhul, Thadou, Poumai Naga
16	Meghalaya	Chakma, Garos, Hajong, Jaintias Khasis, Lakher, Pawai, Raba, Mikir.
17	Mizoram	Chakma, Dimasa, Khasi, Kuki, Lakher, Pawi, Raba, Synteng, Lushai
18	Nagaland	Angami, Garo, Kachari, Kuki, Mikir, Nagas, Sema, Ao, Chakhesang, Konyak, Lotha, Phom, Rengma, Sangtam
19	Odisha	Gadaba, Ghara, Kharia, Khond, Matya, Oraons, Rajuar, Santhals, Bathudi, Bathuri, Bhottada, Bhumij, Gond, Juang, Kisan, Kolha, Kora, Khayara, Koya, Munda, Paroja, Saora, Shabar, Lodha.

20	Rajasthan	Bhils, Damaria, Dhanka, Meenas (Minas), Patelia, Sahariya, Naikda, Nayaka, Kathodi
21	Sikkim	Bhutia, Khas, Lepchas, Limboo, Tamang
22	Tamilnadu	Adiyan, Aranadan, Eravallan, Irular, Kadar, Kanikar, Kotas, Todas, Kurumans, Malayali
23	Telungana	Chenchus
24	Tripura	Bhil, Bhutia, Chaimal, Chakma, Halam, Khasia, Lushai, Mizel, Namte, Mag, Munda, Riang
25	Uttarakhand	Bhotias, Buksa, Jannsari, Khas, Raji, Tharu.
26	Uttar Pradesh	Bhotia, Buksa, Jaunsari, Kol, Raji, Tharu, Gond, Kharwar, Saharya, Parahiya, Baiga, Agariya, Chero
27	West Bengal	Asur, Khond, Hajong, Ho, Parhaiya, Rabha, Santhals, Savar, Bhumij, Bhutia, Chik Baraik, Kisan, Kora, Lodha, Kheria, Khariam, Mahali, Mal Pahariya, Oraon
28	Andaman and Nicobar islands	Oraons, Onges, Sentinelese, Shompens.

HABITAT AND LIFE STYLE

Tribe's lifestyle differs from modern society due to their dwelling places, food habits, dresses and cosmetics. They selected their living places inaccessible and it ranges from plains to hills, forests and valleys. They are ecologically different and have various kinds of geo- climatic conditions. According to their dwellings, they live in mud clay house, rock, caves, leaf shelters and thatched huts, etc. They are living in their own territory. Tribals are living as a nuclear family and they have freedom to choose communities to live. They can independently choose their life partners according to their community rules (Rao BA, 2022). They are living their simple life, independent and straightforward. In Tamilnadu, Irulas tribe follows endogamy method of marriage that is within their group (Ganesh *et al.*, 2021).

RELIGIOUS BELIEFS AND RITUALS

Religion is an integral part of tribe's culture. They believe that the God exists in nature. Therefore, they worship hills, trees, mountains, rivers, streams, animals, agricultural fields, etc. They have separate religions and festivals. For example, "Saridharam" is the Santal tribe's religion and they worship "Singhbonga" (the Sun God) as a deity. Oraons and Mundas belong to "Sarna" religion. They worship old "Sarjom" (Sal) trees. "BadhoJatra" is the festival celebrated for Judgment to the Goddess BhangaramDevi by the tribes of Chattisgarh. An interesting God worshipped by another group of Chattisgarh tribes is "Kaana Doctor". He treated the people who suffered from epidemic small pox and cholera. They have a stout stick for the remembrance of Kaana Doctor (Drolia R, 2022). In Himachal Pradesh, the tribes follow Hinduism, Buddhism, local deities and they celebrate festivals like Flaich Ukhayang Festival, Phagul and Losar. Jukaro is the winter festival to celebrate New year and phoolyatra is an Autumn festival celebrated by Pangi (Himachal Pradesh) tribes. In Odisha, the Jungas believe the supernatural powers and worship the God Dharm deuta (Sun God) and Basuki mata (Earth Goddess). They have mythical ancestors Rusi and Rusiani (Bhagvat D, 2014). In Jharkhand, the tribals celebrate the nature related festivals like Karma, Sarhul, Sakrat, Jatra, etc.

TRIBES AND SACRED GROOVES

Tribes were protecting the medicinal plants in the name of sacred grooves in the forest. They are unknowingly safeguarding the endemic, rare and old aged plant species with their superstitious believes. The forest dwelling tribes are living near the forest fringes. They protect the ethnomedicinal plants on belief of God. Lodhas are the tribes of Jharkhand and Orissa, conserving the local ethnomedicinal plants

in the name of Guptamani (Jatropha gossypifolia, Anthocephalus cadamba), Lohatikri (Strychnos nux-vomica, Aristolochia indica) and Nayagram (Agele marmelos, Alangium salvifolium) (Bhakat R.K *et al.,* 2008). Dhenkanal District in Odisha has 26 tribal communities like Sabara, Saora, Juanga, Saunti, Santal, Pendia, Paraja, Oraon, Munda, Mirdha, Matia, Mankidi, Mahali, Lodha, Koya, Kora, Kolha, Kishan, Kandha, Haria, Ho, Gand, Dharua, Binjhal, Bhumij and Bhuyan. They worship to appease planet by usinig the plants Dalbergia lanceolaria and Ficus hispida, Carrisa spinarum for welfare of family, Polyalthia longifolia for sacrificial fire usage, Acacia catechu, Crataeva nurvula and Emblica officinalis for family welfare, Diospyrosa melanoxylon to avoid evil spirits, Semecarpus anacardium to get success in every work, Streblusasper (Sacred plant) and Withania somnifera to protect from evil eyes of others. (Mohanty N *et al.,* 2011).

PLANTS AS TRIBAL FOOD

Tribes of India prefer the seasonal foods for their cooking. Based on the season and geographical factors they choose their food habits. The forest dwellers prefer millets, greens, mushrooms, tuberous vegetables like potato, yam, bulbs like onion, roots like tapioca, sweet potato, palm root, carrot, beetroot, radish, etc. Sumi tribes of Nagaland collected the plant parts like leaf, bark, stem, fruits, root, seeds, and flowers from the forests and used them as a raw material to prepare their food. The food products are preserved in the form of fermented and sun dried food. The fermented foods prepared from plants are Ahequ (Brassica Campestris leaves), Akuthu (Bambussa tulda shoots) and Axone (Glycine max seeds). The sun-dried foods are Aghanekipki (Brassica campestris leaves), Akhushi (Cyclanthera pedata fruits), Anikiki (Colocasia esculenta leaves), Asutsuna (Allium Chinese bulbs), Yeghitsune (Allium sativum bulbs), Chighusu (Elsholtzia communis inflorescence), Ghajiku (Colocasia esculenta stem), Yeqheye (Hibiscus sabdariffa young leaves and pods), Aghuthi (Chenopodium album seeds), Anau, Ajiu (Zea mays seeds), Kuthi kutsupu (Vigna mungo seeds), Axalothi (Phaseolusvulgaris seeds), Akixi(Vigna luteola), etc. Angothi is a spice prepared from the fruits of Zanthoxylam species. Kighithi is a pickle prepared from Stixis suaveolens fruits (Yeptho L, *et al.,* 2020). Manipur tribes prepare fermented food from soyabean, bamboo shoots and fishes. The Hawaichar is prepared from Soyabean. Soibum, Shoidon and Soijin are prepared from bamboo shoots. They prepare the Madhurjan (Sweet), Sinju (Salad), chak-hao(dessert), Sweetkabok (Snack) and Rice beer (alcoholic beverages) (Devi P and Kumar P.S.,2012). In South India, Muthuans consume Eleusine coracana, Oryza sativa. Ullatans, Uralis and Kanikkars consume tapioca and yam. Kota and Irulas consume millets as a staple food. (Sen Gupta, P.N. 1980).

MEDICINAL PLANTS AND TRIBES

The lives of Tribal's are interconnected with the plants. They believe that the plants have supernatural powers to heal their diseases. Therefore, they treat the plants as a God. Tribes have knowledge to use the plants for treating wounds and curing diseases like rheumatism, diabetes etc. For example, Tharu tribes of Uttarakhand used the leaves of the plant Acalypha indica to treat the ear problems, Aegle marmelos fruit were used to treat cholera, Allium sativum bulbs used in the treatment of diarrhoea, Argemone mexicana seeds were used for digestive diseases, Balioselia retusa used for asthma, Basella rubra used for cough and cold, Bridelia retusa is used for abdominal pain, Cucumis sativus is used for fever. Bhotia tribes use Aconitum heterophyllum to treat abdominal pain, Acorus calamus to relieve sprain, Allium stracheyi to treat wounds, Bergenia ligulata to remove kidney stone, Morus alba fruit juices were used for cough treatment. Jaunsari tribes use Abruspre catorious to treat fever, ashtma, chest pain, tuberculosis, Aconitum atrox to treat rheumatism, paralysis, Berberis chitria is used to treat Jaundice, opthalmia, Centella asiatica for mental disorders, Syzygium cumini for diabetes treatment, etc (Prakash R., 2015). Athumu is prepared from Rhus chinensis to avoid stomach disorders by Sumi tribes (Yeptho L, *et al.,* 2020). In South India, Kotas are skilled healers and they use the herbals for disease treatment. They use Rubus ellipticus for diarrhoea, Mentha piperata for digestive problems, Cynodon dactylon for blood

circulation, Oxalis corniculata for milk production, Sigesbeckia orientalis for psoriasis, Dodoneae viscosa for joint problems, Acorus calamus forsStomach pain, Centella asiatica for body heat, Rubia cordifolia for Jaundice, etc. (Lamuel W and Jeyabalan D, 2015).

COSMETICS AND ORNAMENTS OF INDIAN TRIBES

Cosmetics are not invented in modern era. They are naturally available from 10,000 years ago. Tribes made their own ornaments by using seeds, flowers, feathers, animal teeth, leaves, berries, fruits etc. The ornaments are unique to their culture and it differs from other groups and geographical regions. Tribes also use the plants for their skin care and hair care. Chattisgarh tribes prefer Azadirachta indica to treat pimples, Centella asiatica for strech marks, Helianthus annus oil used for smoothing, Cocus nucifera as moisturizer and softener, Cicer arietinum as cleansing agent. Allium sepa as hair smoother, Eclipta prostrate to improve hair thickness, reduce grey hair, hair fall, Acacia concinna as a shampoo, Lawsonia inermis as a staining agent (Dixit A K., 2022). Tribes use the leaves, seeds, pods, fibers for making ornaments like earrings, bangles, chains, nose pin, etc. In Kerala, tribes use the palm leaves to make earring. The flower necklace is the traditional ornament of bride. In Himachal Pradesh, tribes use local thorn plants to make bangles. The Akas tribes of Arunachal Pradesh use bamboo to make earrings and bangles (Dwivedi J, 2016).

CONCLUSION

Human life depends on nature. Tribes connected the plants as a prime source of livelihood. Tribes are distributed throughout the country in India. They are following their own ancestral lifestyle and culture. They believe the plants are divine being and they are safeguard for their life. Therefore, they protect the plants which are in endangered state. They utilise the plant parts and make it economically useful. Tribal products are marketed now-a-days and they are taking part in Indian economy. Tribal jewels like bangles, chains, studs, nose pin are attracted by modern society. Their natural skin care and hair care products, food, beverages are highly commercialized. They have nutrition value and less food colour. Medicines are derived from the folklore knowledge and used in novel therapeutics production. Tribes produce household things like basket, mat, curtain and home decors with the organic materials. The study about inhabitant people is important to know the value of folklore knowledge and helps to secure the threatened tribal communities, because some minor tribal communities are extinct and some are vulnerable due to the habitat loss and natural calamities. The tribal knowledge also not inherited to their younger generations. In Tamil Nadu, the tribal groups of Todas, Kotas, Kurumbas, Irulas, Paniyas and Katunayakas are at vulnerable stage (Ganesh *et al.,* 2021).

REFERENCES

[1]. Ajaib, M., Z. Khan, N.A.S.R.U.L.L.A.H. Khan and M. Wahab. (2016). Ethnobotanical studies on useful shrubs of district Kotli, Azad jammu and Kashmir, Pakistan. Pakistan Journal of Botany. 42(3): 1407-1415.

[2]. Bhagvat D.(2014).Tribal Gods and Festivals in Central India.Asian Folklore Studies, Vol. 27, No. 2, 1968, pp. 27-106.

[3]. Bhakat, R. K. and Sen, U. K. (2008). Ethnomedicinal plant conservation through sacred groves. Tribes and Tribals (Spl. Vol.). 2: 55-58.

[4]. Devi P and Kumar P.S.(2012). Traditional, ethnic and fermented foods of different tribes of Manipur. Indian Journal of Traditional Knowledge. Vol. 11(1), pp. 70-77

[5]. Dixit A K. (2022).Plants Used by Local and Tribal People of Chhattisgarh with Special Reference to Their Cosmetic and Skin Care Uses: A Review. GIS research Journal, Research gate.

[6]. Drolia R. (2022). Times of India. Cover story.

[7]. Dwivedi J. (2016). Indian Tribal Ornaments; a Hidden Treasure, IOSR Journal of Environmental Science, Toxicology and Food Technology. Volume 10, Issue 3, PP 01-16

[8]. Gadgil, M., Joshi, N.V., Manoharan, S., Patil, S. & Shambu Prasad, U.V. (1998). Peopling of India. In: Balasubramanian, D. & Appaji Rao, N. (Eds.). The Indian Human Heritage, Universities Press, Hyderabad, pp. 100–129.

[9]. Ganesh, Balasubramanian, Rajakumar, Thangarasu; Acharya, Subhendu Kumar; Vasumathy, Sridharan; Sowmya, Sridharan; Kaur, Harpreet. (2021).Particularly Vulnerable Tribal Groups of Tamil Nadu, India. A Sociocultural Anthropological Review. Indian Journal of Public Health 65(4): p 403-409.

[10]. Haq, F., H. Ahmed and M. Alam. (2011). Traditional uses of medicinal plants of Nandiar khuwarr catchment (District Batlagram) Pakistan. Journal of Medicinal Plants Research. 5(1): 39-48.

[11]. Lal B.S. (2019). Tribal Development in India: Some Observations, Serials Publications, New Delhi, pp.1-16.

[12]. Lamuel W and Jeyabalan D. (2015). Ethnomedicinal investigation of tribes Kotas in Kundha Kothagiri village, The Nilgiris, Tamilnadu, India. Global J Res. Med. Plants & Indigen. Med., Volume 5(2): 49–56

[13]. Mohanty N., Das P.K., and Panda T. (2011). Use of plant diversity in household and rituals by tribal people of Dhenkanal district, Odisha, India.Journal of Applied Pharmaceutical Science 01 (04). pp.79-82

[14]. Mohite A. K and Shingare R.M. (2020). Phytochemical analysis and Ethnobotanical study of wild medicinal plants, International Journal of Research and Analytical reviews. Volume 7, Issue 1.

[15]. Olowokudejo, J.D., Kadiri, A.B. and Travih, V.A. (2008). An ethnobotanical survey of herbal markets and medicinal plants in Lagos State of Nigeria. Ethnobotanical. Leaflets 12: 851865

[16]. Popović, Z., Matić, R., Bojović, S., Stefanović, M., & Vidaković, V. (2016). Ethnobotany and herbal medicine in modern complementary and alternative medicine: An overview of publications in the field of I& C medicine 2001–2013. Journal of Ethnopharmacology, 181,182–192.

[17]. Prakash R. (2015). Medicinal Plants Used by Tribal Communities: A Study of Uttarakhand Himalayan Region. International Journal of Humanities and Social Science Invention.

[18]. Rao B.A. (2022). Lifestyle of the tribals in India, EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal, Volume: 8, Issue: 3.

[19]. SCSTRTI, Bhubaneswar. (2015). Research study on Effectiveness measurement of development interventions among PVTGS in the nine PVTG inhabiting states of India: An outcome analysis.

[20]. Sen Gupta, P.N. (1980). Food consumption and nutrition of regional tribes of India, Ecology of Food and Nutrition, 9:2, 93-108.

[21]. Yeptho L., Ajungla T., Kichu A and Singh M.R. (2020). Ethnic food habits of the Sumi tribe, Nagaland, India. Current Science, Vol.119, No.4.

Chapter 2

ORGANIC FARMING - AN INTEGRATED APPROACH FOR ECO-FRIENDLY ENVIRONMENT

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ABSTRACT

Organic farming is a system which excludes all the synthetic off-farm inputs but depends only on biological, farm agronomic and mechanical methods like crop residues, crop rotations, animal manure, organic wastes and also the biological system of nutrient mobilization etc which nurtures and strengthens the biodiversity, biological cycles and the agro-ecosystem health.

KEYWORDS: Organic farming, eco-friendly, biological, biodiversity, health.

INTRODUCTION

Organic farming is the utilization of production system which depends on compost, green manure, biological pest and insect control, crop rotation to produce crops and livestock. The utilization of compost, green manure, animal manure, cover crops, and soil rotation, to control and eliminate the pests and the diseases caused by them, to improve the soil fertility, and to enhance the biological activity are the primary features of organic farming.

As per the definition of FAO on organic farming, "Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs".

Therefore, the objective of organic farming is the production of agricultural products like grains, vegetables, flowers, fruits, foods and animal products like milk, eggs, and meat in the best natural way.

ORGANIC FARMING IN WORLD-WIDE

The recent global survey on certified organic farming is given below:

- The agricultural land of 35 million hectares is managed organically by nearly 1.4 million producers.
- The following regions are having the largest areas of organically managed agricultural land. They are Oceania, Europe and Latin America with 12.1, 8.2 and 8.1 million hectares respectively. Australia, Argentina and China are the countries which has the most organic agricultural land.
- The Falkland Islands the highest shares of organically managed agricultural land which is 36.9 percent, Liechtenstein with 29.8 percent and Austria has 15.9 percent.
- India is the country which has the highest number of producers with 3, 40,000 producers, followed by Uganda with 1, 80,000 and Mexico 1, 30,000.
- On a world-wide level, the organic agricultural land area has been increased in all regions that are around three million hectares.

ORIGIN OF ORGANIC FARMING IN INDIA

Organic farming has made feasible developments during the past decade. It is a combined effect of farmer's and public efforts, Governmental involvement, NGO's work, and market divisions through

which the organic farming in India has reached a place where it can rapidly move to engage prominent space in Indian agriculture.

National Project on Organic Farming (NPOF) and National Horticulture Mission (NHM) scheme of Department of Agriculture and Cooperation has remarkably contributed to the organic farming growth. For quality assurance, the country has internationally acclaimed certification process in place for export, import and domestic markets. The National Programme on Organic Production (NPOP) contributes required support for the policy. At present, there are 16 accredited certification agencies are taking care of the requirement of certification process and the products certified by them are accepted in many countries including European Union and USA.

Fig. 1: Components of Organic farming

STEPS AND COMPONENTS OF ORGANIC FARMING

Organic farming involves the following steps and components:

- Conversion of conventional management land to organic management land. Organic farming initially uses the bacteria which are present in animal waste. These bacteria help to make the land more productive and fertile by increasing the soil nutrients.
- Management of entire surrounding to ensure biodiversity and reliable of the system. Organic farming focuses on reducing the unwanted weed and not completely removing it. The two commonly used weed management techniques are mulching and mowing or cutting.
- Using alternative sources of nutrients like crop rotation, remnant management, organic manures and biological inputs for the crop production. Besides monoculture, recently polyculture has also come in existence through which we could harvest and cultivate varieties of crops.
- Managing weeds and pests by better practices, that is through physical and cultural means and by biological control. We need to control the growth of both useful and harmful organisms which affect the agricultural field by using the natural herbicides and pesticides.
- Maintaining the livestock in collaboration with organic concept and making them an integral part of the entire management system.

PRINCIPLES OF ORGANIC FARMING

The four principles of organic farming are as follows:

1. PRINCIPLE OF HEALTH

Health is the entireness and integrity of all living beings. Organic farming should maintain and increase the health of soil, plants, animals and human beings. Healthy and nutrient rich soils yield healthy crops that strengthen the health of both animals and human.

2. PRINCIPLE OF ECOLOGY

This principle states that the production should be based on the ecological processes and the recycling. Welfare and nourishments are achieved through the ecology of the précised production environment. Organic farming should be adapted to local environment, ecology and culture. The methods of organic farming have to be relevant to the ecological balance and cycle.

3. PRINCIPLE OF FAIRNESS

This principle highlights that those involved in organic agriculture should ensure fairness at all the stages and to all the farmers, traders, distributors, mediators and consumers. It aims to produce an ample supply of fine quality food and other products. Natural and the other environmental resources which are used for production and consumption should be socially and ecologically held in trust for upcoming future generations.

4. PRINCIPLE OF CARE

Organic farming or agriculture should protect the health and as well as the environment. It is a living and energetic system that responds to both the internal and external requirements and conditions. We should practice organic agriculture in a careful way to help the environment and as well as the present and future generations.

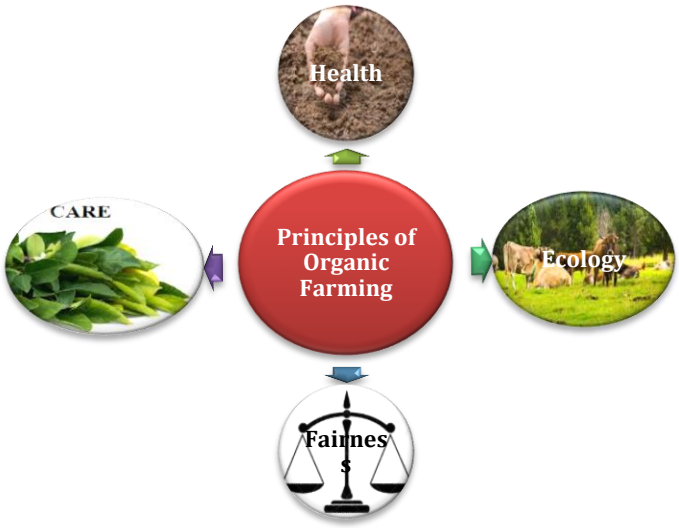

Fig. 2: Principles of Organic farming

ADVANTAGES OF ORGANIC FARMING

1. Nutritional Value: Organic food contains excessive nutrition when compared to conventional agricultural food products because they do not contain any modified ingredients like pesticides, fungicides and herbicides in them. There are reasonably constant results of high value nitrate and low vitamin C in conventional vegetables (Woese *et al.*, 1997). Many researches revealed that more than 10-60% of healthy fatty acids and omega-3 fatty acids are present in organic dairy products (Butler *et al.*, 2008). In several crops, more than 5-90% of vitamin C and more than 10-50% secondary metabolites are present in organic. Also, lower amount of pesticides and antibiotics are present in those products (Huber

and van de Vijver, 2009). Heaton, (2002) revealed that the organic food consists of high minerals, dry matter and 10-50% phytonutrients. Decreased cell proliferation of cancer cells has been observed in the extracts of organic strawberries (Olsson *et al.,* 2006). Staiger, (1988) reported that organic feed leads to increased fertility in animals and it also increased the immune parameters (Finamore *et al.,* 2004).

2. Taste: Food taste is better in organic grown than that of conventionally grown. The taste of vegetables and fruits are directly related to their sugar content, which is a function of the quality of nutrition. The quality of vegetables and fruits could be measured by subjecting their juice to brix analysis which measures its specific gravity. Organically grown plants are grown naturally and also the integrity of their cellular structure is higher than that of the conventionally grown plants.

3. Increases soil nourishment: The damaged soil which was subjected to erosion and salinity were able to feed on micro-nutrients through inter-cropping techniques, crop rotation and the considerable usage of green manure. A holistic, ecological or the biodynamic farms have better soil quality, they were greater in organic matter and microbial activities and due to the presence of more earthworms they have the good soil structure, easier penetrability and the thickest topsoil (Reganold *et al.,* 1993); agricultural productivity increased with soil fertility techniques and the introduction of leguminous plants into the crops (Dobbs and Smolik, 1996; Edwards, 2007).

4. Energy efficiency: Organic rice has more energy efficient than the rice which were grown by conventional method (Mendoza, 2002).

5. Less water pollution: More than 60% nitrates are leached into groundwater over a 5-year period in conventional farms (Drinkwater *et al.,* 1998).

6. Environment-friendly: Neem and compost tea are used as green pesticides which are non-toxic and environment-friendly. They help to identify and remove the diseased plants subsequently which increase the crop defense system. Organic farming reduces soil erosion which was caused by wind and water (Pimentel *et al.,* 1995).

7. A source for productive labour: Agriculture is the main source of income for the people in rural areas. Therefore, organic farming provides not only the employment but also improves their wages and returns on labour.

DISADVANTAGES OF ORGANIC FARMING

1. Time consuming: To grow the crops organically, it requires a lot of patience and commitment. It needs a huge interaction between a farmer and their crops or livestock. The whole process is highly time consuming.

2. Skills: More skills are needed to grow crops or farm organically when compared to mechanical or chemical agriculture.

3. Expensive: Due its great benefits, the organic food products are more expensive than the conventional grown food products. In the markets, organic vegetables and fruits cost more than 20-40% than the non-organic vegetables and fruits.

4. Required more labours: The organic farming focuses on plant and soil health through various processes like regular aeration, drainage, fertility and watering. Therefore, more number of labours is involved in organic farming.

CONCLUSION

Organic farming involves the techniques which were used to achieve proper crop yields without harming the environment or the human beings who work and live in it. Organic farming is a kind of agriculture that provides the consumers fresh, tasty and reliable food products. In addition to this, there are many

environmental benefits for the world. An organic farming maintains the biodiversity and reduces the environmental pollutions like air, water and soil.

REFERENCES

[1]. Butler G, Nielsen JH, Slots T, Seal Ch, Eyre MD, Sanderson R and Leifert C. (2008). Fatty acid and fat-soluble antioxidant concentrations in milk from high- and low-input conventional and organic systems: seasonal variation. J. Sci. Food Agric., 88: 1431–1441.

[2]. Dobbs ThL and Smolik JD. (1996). Productivity and profitability of conventional and alternative farming systems: a long-term on-farm paired comparison. Journal of Sustainable Agriculture, 91(1): 63-79

[3]. Drinkwater LE, Wagoner P and Sarrantonio M.(1998). Legume-based cropping systems have reduced carbon and nitrogen losses. Nature, 396: 262-265.

[4]. Edwards S. (2007). The impact of compost use on crop yields in Tigray, Ethiopia. Institute for Sustainable Development (ISD). Proceedings of the International Conference on Organic Agriculture and Food Security. FAO, Rom.

[5]. Finamore A, Britti MS, Roselli M, Bellovino D, Gaetani S and Mengheri E. (2004). Novel Approach for food safety evaluation. Results of a pilot experiment to evaluate organic and conventional foods. J. Agric. Food Chem.52: 7425-7431.

[6]. Heaton S. (2002). Assessing organic food quality: Is it better for you? In: in Powell J. *et al.,* (eds.) Proceedings of the UK Organic Research 2002 Conference, pp 55-60. Organic Centre Wales, Institute of Rural Studies, University of Wales Aberystwyth.

[7]. Huber M and van de Vijver L. (2009). Overview of research linking organic production methods and health effects in the lab, in animals and in humans. Department of Health Care and Nutrition, Louis Bolk Institute, Netherlands.

[8]. Mendoza TC. (2002). An Evaluation study of plan international sustainable agriculture program in Calapan, Oriental Mindoro. Report submitted to Plan International Philippines, 6th Floor N & M Building Chino Roces Ave. Makati City, Philippines. 123 pp.

[9]. Olsson ME, Andersson CS, Oredsson S, Berglund RH and Gustavsson KE. (2006). Antioxidant levels and inhibition of cancer cell proliferation in vitro by extracts from organically and conventionally cultivated strawberries. J Agric Food Chem., 54: 1248–1255.

[10]. Pimentel D, Harvey C, Resosudarmo P, Sinclair K, Kurz D, McNair M, Crist S, Shpritz L, Fitton L, Saffouri R and Blair R. (1995). Environmental and economic costs of soil erosion and conservation benefits. Science, 267: 1117-1123.

[11]. Reganold JP, Palmer AS, Lockhart JC and Macgregor AN. (1993). Soil quality and financial performance on biodynamic and conventional farms in New Zealand. Science, 260: 344- 349.

[12]. Staiger D. (1988). The nutritional value of foods from conventional and biodynamic agriculture. IFOAM Bulletin No. 4, pg 9-12.

[13]. Woese K, Lange D, Boess C and Bogl KW. (1997). A comparison of organically and conventionally grown foods –Results of a review of the relevant literature. J. Sci. Food Agric., 74: 281-293.

Chapter
3

PHYTOCHEMISTRY

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ABSTRACT

Phytochemistry is the study of the chemicals produced by plants, particularly the secondary metabolites, synthesized as a measure for self-defense against insects, pests, pathogens, herbivores, ultraviolet exposure and environmental hazards. It takes into account the structural compositions of these metabolites, the biosynthetic pathways, functions, mechanisms of actions in the living systems as well as it's medicinal, industrial, and commercial applications. The proper understanding of phytochemical is essential for drug discovery and for the development of novel therapeutic agents against major diseases. This chapter introduces phytochemistry, discusses the history of modern phytochemistry, the relationship of phytochemistry with other sciences and the importance of phytochemistry. It also provides information on the sources and classification of phytochemicals, prospects for phytochemists, the usefulness of computational phytochemistry, biostatistics and the advances in phytochemical research.

KEYWORDS: Phytochemistry, Phytochemicals, metabolites, medicinal property, mechanisms.

INTRODUCTION

The term "phytochemistry" originates from two Greek words: "phyton" meaning "plant" and "chemistry" meaning "the study of chemical substances and their properties." The roots of phytochemistry can be traced back to ancient times when humans first began using plants for medicinal purposes. Early civilizations, such as the Egyptians, Greeks, and Chinese, were already aware of the medicinal properties of certain plants and herbs. The formalization of phytochemistry as a scientific discipline started in the 19th century when advancements in chemistry and analytical techniques allowed scientists to isolate and identify various compounds from plants. The German chemist Friedrich Sertürner is often credited with isolating the first alkaloid, morphine, from the opium poppy in 1804. This discovery laid the foundation for the study of alkaloids and other plant compounds. In the following decades, more and more natural compounds were discovered and characterized from various plants, including alkaloids, terpenes, flavonoids, and phenolics. These compounds were found to have diverse biological activities, such as anti-inflammatory, anticancer, antimicrobial, and antioxidant properties.

Today, phytochemistry is an interdisciplinary field that combines principles of botany, chemistry, biochemistry, pharmacology, and other related disciplines. It plays a crucial role in drug discovery, as many pharmaceutical drugs have been derived from plant compounds or inspired by them. Additionally, phytochemistry continues to shed light on the chemical diversity of plants and their ecological roles.

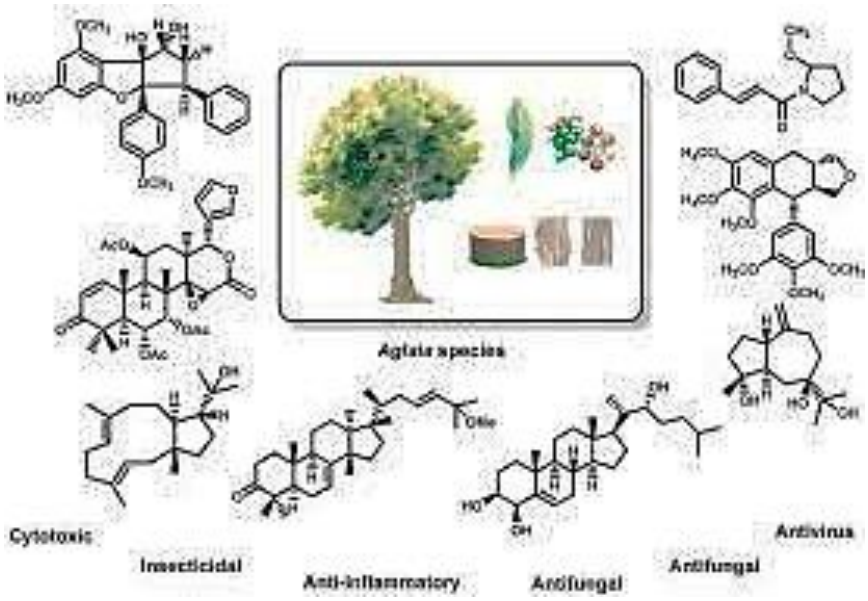


Fig. 1: Biologically Active Compounds

BRIEF HISTORY OF MODERN PHYTOCHEMISTRY

Modern phytochemistry is the scientific study of bioactive compounds found in plants, their chemical properties, structures, and biological activities. It has its roots in ancient herbal medicine practices but evolved into a rigorous scientific discipline over time.

- **Early Herbal Medicine (Ancient Times - middle Ages):** The use of plants for medicinal purposes dates back to ancient civilizations such as the Egyptians, Greeks, and Chinese. Herbal remedies were based on empirical knowledge and folklore. While these practices lacked a deep understanding of the chemical composition of plants, they laid the foundation for the exploration of plant-based therapies.
- **Emergence of Chemical Analysis (16th - 18th Centuries):** The Renaissance period marked the beginning of systematic chemical analysis. Herbalists and alchemists began to extract and isolate compounds from plants. Paracelsus, a Swiss physician, emphasized the importance of the active constituents of plants for therapeutic effects.
- **Isolation of Morphine (19th Century):** Friedrich Sertürner isolated morphine, the first alkaloid compound, from opium poppy in 1805. This marked a significant milestone in modern phytochemistry, as it demonstrated the isolation of a single active compound responsible for a plant's medicinal effects.
- **Discovery of Alkaloids (19th Century):** Alkaloids, nitrogen-containing compounds with diverse pharmacological activities, were discovered in various plants. Notable alkaloids include quinine from cinchona bark and cocaine from coca leaves.
- **Phytochemical screening (20th Century):** The 20th century saw the development of systematic methods for phytochemical screening, which involved testing plant extracts for specific activities. This led to the discovery of compounds with therapeutic potential, such as salicylic acid from willow bark (precursor to aspirin) and artemisinin from sweet wormwood (used to treat malaria).
- **Advances in Analytical Techniques (Mid-20th Century):** The development of advanced analytical techniques, such as chromatography and spectroscopy, revolutionized phytochemical analysis. These methods enabled the identification and structural elucidation of complex plant compounds.

- **Natural Products as Drug Leads (Late 20th Century):** Many modern pharmaceuticals are derived from or inspired by natural products. Taxol (from Pacific yew) and vinblastine (from Madagascar periwinkle) are examples of plant-derived compounds used in cancer treatment.
- **Phytochemical Diversity and Functional Genomics (21st Century):** Advances in genomics, transcriptomics, and metabolomics have provided insights into the biosynthesis of phytochemicals and the genetic basis of their production in plants. This has opened new avenues for engineering plants to produce desired bioactive compounds.
- **Phytochemicals and Human Health (Present):** Research continues on the health benefits of phytochemicals, including antioxidants, flavonoids, polyphenols, and terpenes. Phytochemicals are being explored for their potential roles in preventing chronic diseases, enhancing immune function, and promoting overall well-being.

Modern phytochemistry has come a long way from traditional herbal medicine, evolving into a multidisciplinary field that integrates chemistry, biology, genetics, and pharmacology. It continues to contribute to our understanding of plant-based compounds and their potential applications in medicine and beyond.

PHYTOCHEMICALS

Phytochemicals are naturally occurring chemical compounds found in plants. They are responsible for the plant's color, flavor, aroma, and other characteristics. Phytochemicals are known to have various health benefits and are often associated with the prevention of chronic diseases.

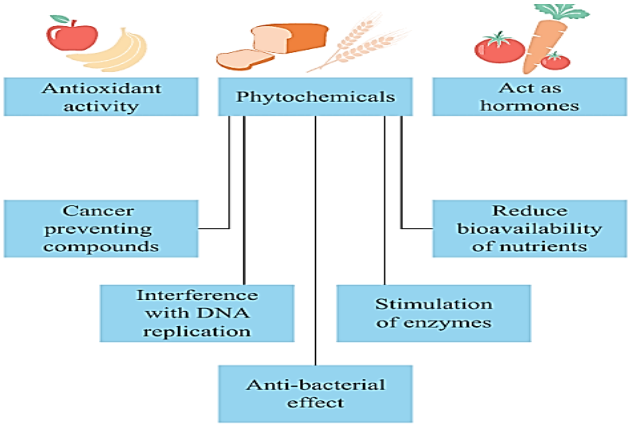


Fig. 2: Importance of Phytochemicals

TYPES OF PHYTOCHEMICALS

Phytochemicals have great antioxidant potential and are of great interest due to their beneficial effects on health of human beings, and they give immense health benefits to the consumers. Epidemiological and animal trials suggest that the regular consumption of fruits and vegetables, and whole grains reduces the risk of various diseases linked with oxidative damage. The natural antioxidants are classified into two categories namely in vitro and in vivo antioxidants. Free radical scavengers act as hydrogen donors, electron donor peroxide decomposer, singlet oxygen quencher, enzyme inhibitor, synergist and metal-chelating agents.

Among the phytochemicals mentioned as potentially providing health benefits are polyphenols, flavonoids, isoflavonoids, anthocyanidins, phytoestrogens, terpenoids, carotenoids, limonoids, phytosterols, glucosinolates, and fibres. These antioxidant-rich phytochemicals are explained as below:

Table 1: Antioxidant-rich Phytochemicals with their food sources and health benefits:

Sl.No	Phytochemicals	Sources	Health benefits	References
1	Carotenoids	Carrots tomatoes, parsley, orange and green leafy vegetables, chenopods, fenugreek, spinach, cabbage, radish and turnips.	Antioxidant protect against uterine, prostate, colorectal, lung and digestive tract cancers.	Agarwal and Rao (2000); Elliott (2005); Britton (1995); Johnson (2002); Prakash *et al.* (2004).
2	Phytosterols	Vegetables, nuts, fruits, seeds	Suppress the growth of diverse tumors cell lines via initiation of apoptosis and concomitant arrest of cells in the GI phase of the cell cycle	John *et al.* (2007); von Bergmann *et al.* (2005), Dillard and German (2000)
3	Limonoids	Citrus fruits	Inhibiting phase 1 enzymes and inducing phase II detoxification enzymes in liver, provide protection to lung tissue. Detoxify enzymes.	Ozaki *et al.* (1995); Lam *et al.* (1994); Willcox *et al.* (2004)
4	Polyphenols Flavonoids Isoflavonoids Anthocyanidins	Fruits, vegetables, cereals, beverages legumes, chocolates, oilseeds.	Action against free radicals, free radicals mediated cellular signaling, inflammation, allegies, platelet aggregation and heptotoxins.	Kaul and Kapoor (2001); Scalbert *et al.* (2005); Ceislik *et al.* (2006); Prakash and Kumar (2011).
5	Glucosinolates	Cruciferous vegetables	Protection against cancer of colon, rectum and stomach.	Conaway *et al.* (2001); Cartea and Velasco (2008); Hayer *et al.* (2008).
6	Phytoestrogen	Legumes, berries, whole grains, cereals, red wine, peanuts, red grapes.	Protection against bone loss and heart disease, cardiovascular diseases, breast and uterine cancers.	Morabito *et al.* (2002); Prakash and Gupta (2011); Sakamoto *et al.* (2010).
7	Terpenoids (Isoprenoids)	Mosses, liverworts, algae, lichens, mushrooms.	Antimicrobial, antiparasitic, antiviral, antiallergic, anti-inflammatory, chemotherapeutic, antihyperglycemic, antispasmodic.	Tholl (2006); Langenheim (1994); Lee *et al.* (2003); Paduch *et al.* (2007).

8	Fibers	Fruits and vegetables (green leafy), oats	Reduces blood cholesterol, cardiovascular diseases.	Narasinga Rao (1988, 2003); Schnecman (1989)
9	Polysaccharides	Fruits and vegetables	Antimicrobial, antiparasitic antiviral, antialergic, anti-inflammatory, lowering serum, enhances defense mechanisms.	Bnouham *et al.* (2006); Lopez (2007); Atherton (2002); Schmidgall *et al.* (2000)
10	Saponins	Oats, leaves, flowers, and green fruits of tomato.	Protection against pathogens, antimicrobial, anti-inflammatory, antiulcer agent.	Hostettmann and Marton (1995); Morrissey and Osbourn (1999); Price *et al.* (1987); Mert-Tunk (2006).

IMPORTANCE OF PHYTOCHEMISTRY

The Knowledge of phytochemistry is essential for:

- **Plant Conservation and Biodiversity:** It contributes the conservation of plant species and biodiversity. By studying the chemical composition of plants, scientists can identify unique chemical profiles associated with specific plant species or populations. This information aids in monitoring and preserving endangered plants, promoting sustainable harvesting practices, and protecting natural habitats.
- **Agricultural Applications:** Phytochemistry plays a role in enhancing crop production and agricultural practices. By studying the phytochemical composition of plants, researchers can identify compounds that contribute to pest resistance, disease tolerance, and stress adaptation. This knowledge can be utilized in breeding programs to develop crop varieties with improved traits, reducing the reliance on synthetic pesticides and fertilizers.
- **Environmental Applications:** It can provide insights into the ecological interactions and roles of plants in the environment. By studying the chemical compounds produced by plants, researchers can understand their roles in attracting pollinators, repelling herbivores, and mediating ecological relationships. This knowledge can be utilized in conservation efforts, restoration projects, and sustainable land management practices.
- Phytochemistry is important for advancing our understanding of the chemical diversity and biological activities of plants. It has practical applications in medicine, agriculture, and environmental sciences, contributing to human health, economic development, and ecological sustainability.

STRUCTURE AND ACTIVITY RELATIONSHIP IN PHYTOCHEMICALS

Structure-Activity Relationship (SAR) is a crucial concept in the field of pharmacology and drug design, including the study of phytochemicals (bioactive compounds derived from plants). SAR explores the relationship between the chemical structure of a molecule and its biological activity. In the context of phytochemicals, SAR helps researchers understand how the structural features of these compounds contribute to their various biological effects, such as antioxidant, anti-inflammatory, anticancer, antimicrobial, and other therapeutic properties.

- **Functional Groups:** The presence and arrangement of specific functional groups (e.g., hydroxyl, carboxyl, amino) on the phytochemical molecule often dictate its interactions with biological targets and enzymes.
- **Stereochemistry:** The spatial arrangement of atoms in a molecule can significantly impact its activity. Isomers (molecules with the same molecular formula but different structural arrangements) can have vastly different biological effects.
- **Substituent Effects:** The type and position of substituents on the molecular backbone can influence the compound's potency, selectivity, and overall activity.
- **Conformational Flexibility:** The ability of a molecule to adopt different conformations (shapes) can influence its interactions with target proteins and receptors. Flexibility can affect binding affinity and biological activity.
- **Binding Affinity:** The strength of interaction between a phytochemical and its biological target is a crucial determinant of its activity. Stronger binding often leads to higher potency.
- **Molecular Size and Shape:** The size and shape of a molecule can affect its ability to fit into binding sites on target proteins or receptors. Complementary shapes often result in better binding and activity.
- **Electrostatic and Hydrophobic Interactions:** Interactions between charged and hydrophobic regions of a phytochemical and its target can play a significant role in determining biological activity.
- **Quantitative Structure-Activity Relationship (QSAR):** This involves the use of mathematical models to quantitatively predict a compound's activity based on its structural features. QSAR models can guide the design of new phytochemical derivatives with desired properties.
- **Metabolism and Bioavailability:** The metabolism of phytochemicals in the body can lead to the formation of active or inactive metabolites. Understanding how the structure of a compound influences its metabolism and bioavailability is critical for optimizing therapeutic effects.
- **Synergistic Effects:** Phytochemicals in plants often work together synergistically, enhancing each other's effects. The presence of multiple bioactive compounds in a plant can lead to complex SAR considerations.

SAR studies provide valuable insights into how the chemical structure of phytochemicals influences their biological activity. This knowledge can guide the design and optimization of phytochemical-based drugs and therapeutics, ultimately contributing to advancements in natural product-based medicine.

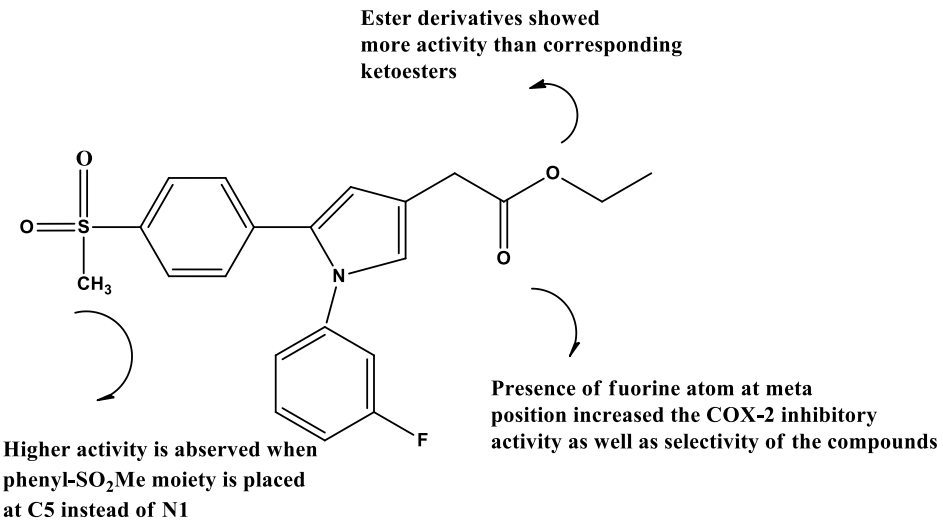


Fig. 3: Chemical structure of phytochemicals influence their biological activity

RELATIONSHIP OF PHYTOCHEMISTRY WITH OTHER SCIENCE FIELDS

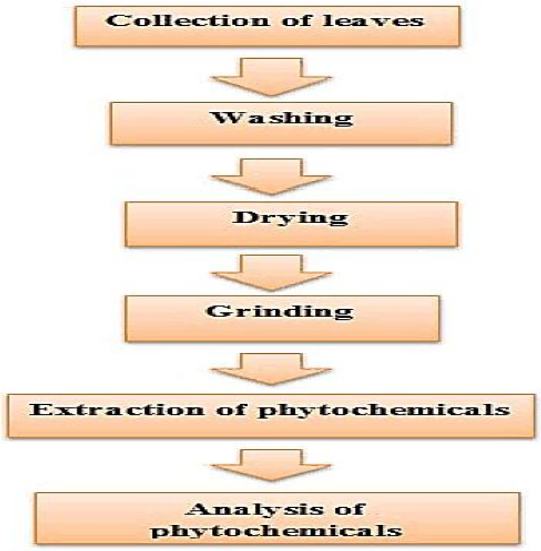
Phytochemistry, the study of bioactive compounds in plants, intersects and collaborates with various other scientific disciplines due to its multidisciplinary nature. Here are some key relationships between phytochemistry and other fields:

- **Chemistry:** Phytochemistry is inherently rooted in chemistry, as it involves the analysis, isolation, and characterization of chemical compounds present in plants. Techniques from analytical, organic, and physical chemistry are used to identify and study phytochemicals' structures, properties, and reactions.
- **Biology:** Phytochemistry has a strong connection with biology, particularly in understanding the biosynthesis of plant compounds and their interactions with living organisms. This includes the study of enzymatic pathways responsible for producing phytochemicals and the effects of these compounds on cellular processes and organisms.
- **Pharmacology:** Phytochemicals often possess pharmacological activities that can impact human health. Collaborations between phytochemists and pharmacologists involve studying how plant compounds interact with receptors, enzymes, and other molecular targets, leading to potential therapeutic applications.
- **Medicinal Chemistry:** The relationship between phytochemistry and medicinal chemistry is crucial for drug discovery and development. Phytochemicals can serve as inspiration for designing new drugs or as lead compounds for developing pharmaceutical agents with improved bioactivity and reduced side effects.
- **Botany:** Phytochemistry intersects with botany by providing insights into the chemical basis of plant physiology, growth, and adaptation. Understanding how plants produce and use phytochemicals contributes to the broader understanding of plant biology.
- **Bioinformatics and Genomics:** The use of bioinformatics and genomics allows researchers to identify genes responsible for the biosynthesis of specific phytochemicals. This information can be used to engineer plants for higher production of desired compounds or to explore the genetic diversity of plant species.
- **Ecology:** Phytochemicals play a role in plant defense against herbivores and pathogens. The study of plant-herbivore interactions, chemical ecology, and allelopathy (the interaction of chemicals between plants) falls within the realm of phytochemistry.
- **Environmental Science:** Phytochemicals can have ecological implications, affecting nutrient cycling, soil microbial activity, and interactions between plants and other organisms. Understanding these dynamics is important for ecosystem health and management.
- **Food Science and Nutrition:** Phytochemicals are essential components of human diets, contributing to the nutritional value and potential health benefits of plant-derived foods. Research in food science explores the impact of phytochemicals on human health, sensory attributes, and food preservation.
- **Analytical Techniques and Instrumentation:** Phytochemical analysis relies on various advanced analytical techniques such as chromatography, mass spectrometry, nuclear magnetic resonance (NMR), and infrared spectroscopy. Developments in these fields enhance the ability to identify and quantify phytochemicals.
- **Ethnobotany and Traditional Medicine:** Phytochemistry collaborates with ethnobotany to understand how traditional knowledge of plant use aligns with the chemical composition and bioactivity of plants. This knowledge informs the development of evidence-based herbal medicines.

The interdisciplinary nature of phytochemistry allows it to contribute insights to these and other fields, and it benefits from their methodologies, approaches, and knowledge to deepen our understanding of plant-derived compounds and their diverse applications.

ANALYSIS OF PHYTOCHEMICALS IN PLANTS

Analyzing the phytochemicals in plants involves several steps and techniques. Some general overview of the process is given below;



- **Sample Preparation:** Start by selecting plant material for analysis, such as leaves, stems, or roots. The chosen plant material should be representative of the species and part of the plant being studied. Clean the material to remove any dirt or debris and dry it if necessary. Grinding or homogenizing the plant material helps increase the surface area for extraction.
- **Extraction:** Phytochemicals are often present in plant material in low concentrations, so extraction is necessary to isolate them. Common extraction methods include maceration, sonication, Soxhlet extraction, and solid-phase extraction. The choice of extraction method depends on the type of phytochemicals being targeted and their solubility properties. Selection of an appropriate solvent is also crucial to ensure maximum extraction efficiency.
- **Fractionation and Purification:** After extraction, the crude extract may contain a mixture of phytochemicals. Fractionation techniques such as liquid-liquid partitioning or solid-phase extraction can be employed to separate the extract into different fractions based on the phytochemicals' properties. This step helps isolate specific groups of compounds for further analysis.
- **Chromatographic Techniques:** Chromatography is widely used to separate, identify, and quantify phytochemicals. Thin-layer chromatography (TLC), high-performance liquid chromatography (HPLC), and gas chromatography (GC) are commonly employed. TLC allows for visualizing different compounds based on their migration on a thin layer of adsorbent material, while HPLC and GC use a mobile phase to separate and detect individual compounds. These techniques often employ various detectors, such as UV-Vis, fluorescence, or mass spectrometry, for compound identification and quantification.
- **Spectroscopic Techniques:** Spectroscopic methods, such as UV-Vis spectroscopy, infrared spectroscopy (IR), and nuclear magnetic resonance (NMR) spectroscopy, provide valuable

information about the structure and functional groups present in phytochemicals. These techniques aid in compound identification and characterization.

- **Mass Spectrometry:** Mass spectrometry (MS) is a powerful technique used to identify and quantify phytochemicals. It provides information about the mass-to-charge ratio (m/z) of compounds, enabling compound identification, structural elucidation, and quantification. Different MS techniques, such as liquid chromatography-mass spectrometry (LC-MS) and gas chromatography-mass spectrometry (GC-MS), can be employed depending on the nature of the compounds being analyzed.
- **Biological Assays:** In addition to chemical analysis, biological assays can be performed to evaluate the bioactivity of phytochemicals. These assays help determine the potential health benefits or therapeutic properties of the compounds, such as antioxidant, antimicrobial, or anticancer activities.

It's important to note that the specific techniques and methods employed for phytochemical analysis can vary depending on the target compounds, available equipment, and the goals of the study. Researchers often combine multiple techniques to obtain comprehensive information about the phytochemical composition of plants.

ADVANTAGES OF PHYTOCHEMISTRY IN RESEARCH FIELD

Phytochemistry in research offers several advantages and benefits in various fields. Some of the key advantages:

- **Discovery of Bioactive Compounds:** Phytochemical analysis allows for the identification and isolation of bioactive compounds from plants. These compounds may have significant pharmacological, therapeutic, or preventive effects. Phytochemical research has led to the discovery of numerous drugs, such as anticancer agents (e.g., taxol from Taxus species), cardiovascular medications (e.g., digoxin from Digitalis purpurea), and antimicrobial agents (e.g., artemisinin from Artemisia annua). Studying phytochemicals expands the repertoire of potential drug candidates and provides a valuable source for new therapeutic agents.
- **Drug Development and Optimization:** Phytochemistry research provides a foundation for drug development. By analyzing the chemical composition of plants and their bioactive compounds, researchers can identify lead compounds for drug development. These lead compounds can be further modified and optimized to enhance their efficacy, bioavailability, and safety profiles. The knowledge gained from phytochemical research guides the development of novel drugs and therapeutic interventions.
- **Herbal Medicine Development:** Phytochemistry plays a crucial role in the development of herbal medicines and traditional remedies. By analyzing the phytochemical composition of medicinal plants, researchers can determine the active constituents responsible for the observed therapeutic effects. This information enables the standardization and quality control of herbal medicines, ensuring their safety, efficacy, and reproducibility. Phytochemical research helps bridge the gap between traditional and modern medicine and supports evidence-based use of herbal remedies.
- **Understanding Mechanisms of Action:** Phytochemical research provides insights into the mechanisms of action of bioactive compounds. By studying the interactions of phytochemicals with biological systems, researchers can elucidate the molecular targets, signaling pathways, and cellular responses involved in their biological activities. This knowledge deepens our understanding of the underlying mechanisms of diseases and potential therapeutic interventions.

- **Nutraceutical and Functional Food Development:** Phytochemical research contributes to the development of nutraceuticals and functional foods. By identifying and quantifying phytochemicals in food sources, researchers can determine their potential health benefits and develop dietary interventions for specific health conditions. Phytochemical-rich foods, such as fruits, vegetables, whole grains, and spices, can be incorporated into functional food formulations, providing natural sources of bioactive compounds with potential preventive and therapeutic effects.
- **Conservation and Sustainable Use of Plant Resources:** Phytochemistry research aids in the conservation and sustainable use of plant resources. By studying the chemical composition of plants, researchers can identify unique chemical profiles associated with specific plant species or populations. This information helps in monitoring endangered species, protecting biodiversity, and promoting sustainable harvesting practices. Phytochemical research contributes to the preservation of plant diversity and ensures the responsible utilization of plant resources.

Overall, phytochemistry research offers significant advantages in drug discovery, herbal medicine development, understanding mechanisms of action, functional food development, and conservation efforts. It harnesses the potential of plant-derived compounds for various applications, benefiting human health, well-being, and environmental sustainability.

CONCLUSION

Today, a huge sector of the population is relying on medicinal plants for their preventive and curative properties. WHO stated that that traditional medicine/ethnomedicine is still being used to treat different ailments. Nearly 70% of the populations rely on these medicinal practices. Phytochemists are seriously embarking on research activities involving the extraction of natural compounds present in plants. Some of these phytochemicals have the ability to suppress the activity of cancer cells by encouraging cell cycle inhibition and apoptosis. There is a lot of demand for natural products of plant origin and these by-products are to replace the synthetic products in view of their side effects on human health. Therefore, a lot of attention is needed toward natural products in which phytochemists plays a key role in this context. Owing to the increasing demand for novel drugs, so many important and vital compounds regularly being manufactured by the industries generate employment opportunities for experts in this field. In addition, the increasing acceptance of the chemical diversity of natural products is well suited to provide the core scaffolds for future drugs.

REFERENCES

[1]. Desi Harneti, Unang Supratman. (2021). Phtochemistry and biological activities of Aglaia species, 18 2021.

[2]. Monika Thakur, RenuKhedkar. (2020). Functional and Preservative properties of phytochemicals, 2020.

[3]. Sherz Khalid, Adil Shahzad, Neelam Basharat, Muhammad Adubakar and Pervaz Anwar. (2018). Journal of Phytochemistry & Biochemistry, 2(1), 2018.

[4]. A.Pandey, STripathi. (2014). Journal of pharmacognosy and Phytochemistry, 8, 2014.

[5]. Saswthi Panigrahi, Uma Shankar Mishra, Prasana Kumar Dixit, Piyusha Ranjan Mishra. (2022). International Journal of Health Science, 6(S2), 2022.

[6]. Ahmad, B.; Hafeez, N.; Bashir, S.; Rauf, A. *et al.* (2017). Phytofabricated Gold Nanoparticles and Their Biomedical Applications. Biomed. Pharmacother. 2017, 89, 414–425.

[7]. Angelova, A.; Garamus, V. M.; Angelov, B.; Tian, Z.; Li, Y.; Zou, A. (2017). Advances in Structural Design of Lipid-Based Nanoparticle Carriers for Delivery of Macromolecular Drugs, Phytochemicals and Anti-Tumor Agents. Adv. Colloid Interface Sci. 2017, 249, 331–345.

[8]. Bahramsoltani, R.; Rahimi, R.; Farzaei, M. H. (2017). Pharmacokinetic Interactions of Curcuminoids with Conventional Drugs: A Review. J. Ethnopharmacol. 2017, 209, 1–12.

[9]. Arens, U. (2018). Authorised EU Health Claim for Carbohydrates and Maintenance of Normal Brain Function. Food Nutr. Food Ingredients Authorised EU Health Claims 2018, 229, 236.

[10]. Basheer, L.; Schultz, K.; Guttman, Y.; Kerem, Z. (2017). In Silico and in Vitro Inhibition of Cyto chrome P450 3A by Synthetic Stilbenoids. Food Chem. 2017, 237, 895–903.

[11]. Chrbolka, P.; Paluch, Z.; Hill, M.; Alusik, S. (2017). Circulating Steroids Negatively Correlate with Tinnitus. Steroids 2017, 123, 37–42.

[12]. David, B.; Jacoby, R. M. Y. (2005). Encyclopedia of Family Health. Third 2005.

[13]. Kurita, N.; Miyaji, M.; Kurane, R.; Takahara, Y. (1981). Antifungal Activity of Components of Essential Oils. Agric. Biol. Chem. 1981, 45, 945–952.

Chapter
4

BIO-ORGANIC CHEMISTRY

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ABSTRACT

Modern globalization concepts have now become a crucial part of interdisciplinary science. Currently, this is a well-known approach and gives new ideas, concepts, and connectivity among different science fields. One of the modern and best-studied multidisciplinary filed is Bio-organic Chemistry, which is thecombinatorial product of biochemistry and organic chemistry. It is defined as the field of natural science that deals with the properties, structure, and mechanism of biological molecules and the technique that can help in understanding them, in the principles of chemistry. This concept emerged once it was observed that organic compounds are also synthesized outside the laboratory, and hence it was suggested that both parts of life science are now studied under one concept. Both of these fields have some common characteristics like transformation, catalysis, and designing of new compounds. This subject has the properties of biochemical aspects of organic molecules and shares some common characteristics with organic compounds. This field is considered a versatile and enriched multidisciplinary approach and hence has a wide spectrum of applications, for instance, the discovery of new drugs candidates, man-made molecules, having part in Nanoscience, help in the deeply understanding of nucleic acid chemistry, and providing a recognition concept in molecular and biosynthetic chemistry. This field has a bright future and thus plenty of research opportunities are available to explore the nature, behavior, and structure of different organic and biomolecules.

KEYWORDS: Bio-Organic Chemistry, Biochemistry, Chemistry, Biomolecules, Nucleic Acids

INTRODUCTION

The modern concept of globalization affects all form of life especially, the interaction of scientific fields with one another. Multidisciplinary approaches in science are well-known and common practices nowadays which on one side connect different science domains, but on the other hand, they give rise to new concepts, ideas, and approaches. To combine these interdisciplinary approaches new fields of science were developed that are focusing on that particular interrelation. One of the recently and relatively new emerged multidisciplinary field is Bioorganic Chemistry, which is the combinatorial product of biochemistry and organic chemistry. Bioorganic chemistry in sample words is the chemistry of biomolecules or it is the biological side of organic molecules. It is the field of natural science that deal with the properties, structure, mechanism, and behavior of biological molecules and the technique that can help in understanding them, in the light and principles of chemistry. The major concept of bioorganic chemistry is to explain and deeply understand all borders of biological processes and their exact nature through the principle and tools of organic chemistry. The scope of this subject lies in the organic characteristics of biomolecules, their significance, their impacts on life processes, and how these molecules are acting in real life.

HISTORY AND DEVELOPMENT OF THE CONCEPT

Bioorganic chemistry was emerged at the time when the well-known concept of organic compounds was changed from 'only synthesized in the laboratory" to those compounds which are composed of carbon and their derivative. At that time both biologists and organic chemists are working in their fields and do not take an interest in their interaction.

Historically, combinatorial bioorganic chemistry was dedicated to their explanation of key biological processes, like enzymes investigation, drug actions, protein synthesis, and biosynthesis of other molecules. Frank H. Westheimer is widely recognized as the father of mechanistic enzymology and one of the earliest authorities in the field of bioorganic chemistry. Initially scientist were studying different aspects of biological processes but soon it was realized that the molecular origin of the biological reactions are very important, as they affect most of the life processes, and consequently, a new field that combined both of these concepts i.e. biological processes and how these reactions occur, were developed. Another importance for its development is that mostly organic chemistry is involved in the synthesis of molecules that are helping in real-life processes, while biochemistry can respond what is the importance of these compounds and how properly execute these, and hence it becomes obvious to develop a new interdisciplinary branch that covers both of these. The development of bioorganic chemistry is not an abrupt process, but this consists of an array of interconnecting events of biochemistry and organic chemistry that finally lead to the birth of this new subject. The major interacting events of organic chemistry and biochemistry that happened in the course of bioorganic chemistry are summarized in Figure 1.

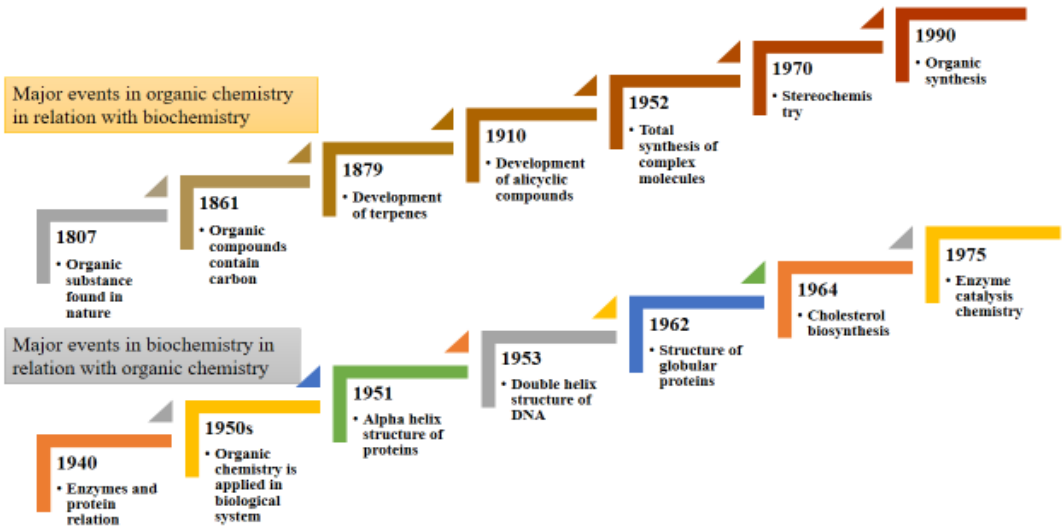

Fig. 1: Illustration of the major events in the timeline history of organic and biochemistry that lead to development of bioorganic chemistry

DEFINITION AND CONCEPTS

As already explained that bioorganic chemistry is the combined field of biochemistry and chemistry and covers a range of disciplines (like, biology, molecular biology, cell biology, medicine, natural product chemistry, medicinal chemistry, etc.) in a single discipline. Bioorganic chemistry is considered a growing field that focuses on the study of biological processes in the light of chemistry. How do the two disciplines come together in a single domain? It can be understood by elaboration of the two fields. For instance, in organic chemistry researcher are developing new methods for the understanding of chemical

compounds mechanism that can lead to the creation of new compounds. But, this synthesis may fail due to the unfamiliarity of their biological analogue. On the other sides, a biochemist can study the life processes by biochemical methods, like enzyme assays, etc. and know what is wrong with the problem and what is the exact molecule required but unable to prepare the required compound in the laboratory. This dilemma required a multidisciplinary approach to be solved, and this is possible in the discipline of bioorganic chemistry which mostly has two parallel laboratories, the biochemistry laboratory and the synthesis laboratory.

The development of such a new discipline can build model-building concepts to study and sort out different biological parameters in a single unit. For instance, the specificity of enzymes in biological systems can help the organic chemist to know and study newly discovered compounds. The roots of bioorganic chemistry are also extended to the pharmacological aspects of chemistry (medicinal chemistry) in which the three, biochemist, organic chemists, and pharmacologists are working side by side with each other and helping each other to understand the exact nature, mechanism, and application of the molecule of interest. It is the beauty of bioorganic chemistry that it not only unite the two discipline (biochemistry and organic chemistry) but can cover a series of concepts and principles in a single field, that give a new shape and properties to the selected processes.

The tools and techniques used in bioorganic chemistry are versatile and may range from basic life processes to complex biological-organic mechanisms. One of the concept/part in this discipline is natural product chemistry which no doubt can explain different drugs or substances that can help in the treatment of different biological diseases, like the development of antibiotics. Another combinatorial process of organic and biological processes is the oxidation-reduction process that happened inside our body and can give energy for body functioning, like development, replication, maintenance, muscular work, signaling, transport, and heat production. The properties that are common in the two disciplines and give birth to bioorganic chemistry are described in Figure 2.

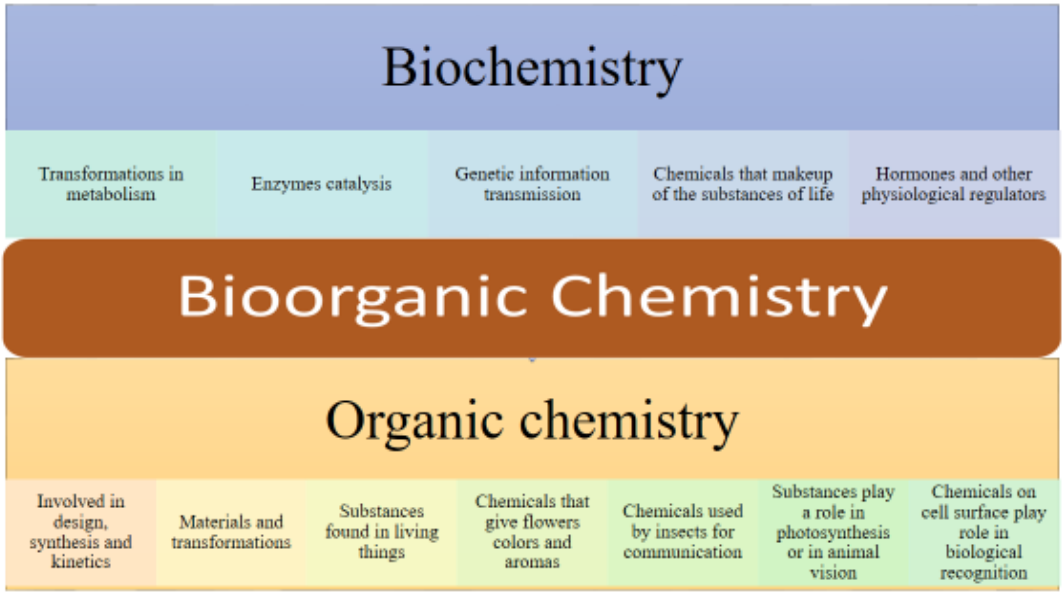

Fig. 2: Characteristics of biochemistry and organic chemistry that is common in bioorganic chemistry

BIOORGANIC CHEMISTRY IS THE NATURAL SCIENCE

As chemistry is considered both natural and unnatural science but bioorganic chemistry is considered pure natural science. For instance, the organic part of bioorganic can explain various phenomena like they explain the substance found in the living systems, chemical substances of plants, chemicals that are

used by insects during communication and substances responsible for seeing, chemicals on the cell surface that are helping in recognition, and substances that show responses to other bacterial species. Similarly, the biochemistry part can help in the understanding and exploration of metabolism, enzyme activities, genetic information transmission, and biomolecule synthesis, etc. Thus, the understanding of such life processes comprised of both organic and biochemistry perception makes bioorganic chemistry is a natural science.

Biochemical aspect of organic chemistry

The biochemical molecules and aspects that are directly or indirectly involved in organic chemistry and inspired the organic chemists include the following;

A) **Natural product chemistry;** in this branch, the organic chemist studies the natural biological substances like terpenoids and alkaloids.

B) **Biomimetic chemistry;** in this area the, organic chemists investigate the structure and functions of biomolecules that help them to make and design such compounds keeping the principle of organic materials.

C) **Pharmacology;** the development and testing of drugs in biochemistry are considered the analogue of organic transition state organic chemistry.

D) **Enzymology;** the concept of enzyme catalysis and reactions are followed in organic synthesis.

Similar properties of biological molecules for chemist and biochemist

The following are some properties that are shared by the molecules of investigation in both organic and biochemistry. These properties also help the two (organic chemist and biochemist) to keep these in consideration while treating such molecules.

i- **Size:** both organic and biological molecules have large size

ii- **Functionality:** both types of molecules have numerous functional groups that impart different properties and characteristics to the molecules.

iii- **Interactions:** intra-molecular and inter-molecular interactions are common features in both biological molecules and organic compounds.

iv- **Mechanism of actions:** molecules in biochemistry and organic chemistry have specific mechanisms of action.

v- **Regulation:** regulation of mechanisms of action is an important aspect of biological molecules that are also shared by organic compounds.

vi- **Catalytic potential:** one of the crucial properties of biomolecules is their catalytic potential that is also found in organic compounds.

APPLICATION OF BIOORGANIC CHEMISTRY

The modern world is following multidisciplinary approaches to assist and reached the in-depth analysis of processes, ranging from a pathway investigation to complex regulatory phenomena. In the present day biologists and chemists are working side by side and helping each other for understanding both biological and chemical processes. For instance, the discovery of new drugs required chemical analysis (structure identification, elucidation, functional group finding, etc.) and biological tests/ assays to identify the complete profile and mechanism of action of that discovered drug. Another example is the chemical analysis of the newly sequenced genome of target sites and the identification of their role in the regulation of signaling systems. The development of man-made molecules is another example in this field that requires cooperation between biologists and chemists.

Scientists are also trying to develop synthetic molecules which are tested and proved by providing some in-vitro biological conditions and different assays that help them to identify the exact binding site in the natural molecules and thus provide a clue what are happening in the actual scenario. The newly emerged nanoparticle area of research is also relying on bioorganic chemistry and using their principles, like the behavior of these materials at the nano scale is studied, which is not possible without the intervention of bioorganic chemistry.

Another area covered by bioorganic chemistry is the deeper understanding of nucleic acid chemistry. With a deeper understanding of DNA scientists are trying to enhance the nucleic acid based supra-molecular assemblies of genetic information and generates new properties by different methods using bioorganic chemistry guidelines. Without the understanding of both biochemistry and organic chemistry, it's almost impossible to develop such new concepts and knowledge.

Finally, the study of the functions of carbohydrates and peptides as well as the advancement of our understanding of processes like molecular recognition and biosynthesis have all been advanced by bioorganic chemistry. The subject of bioorganic chemistry is projected to have further substantial advancements in the years to come, as well as an increase in the number of applications it can be used in.

RESEARCH AREAS

Due to the complex nature of life chemistry, still, there is more work to be done and remain open for further research work. For example, in the natural product chemistry part, plenty of substances are required to be explored for their novel compound identification having good biological activities. Compounds isolation from sea organisms are a bright research area as the sea organisms fight more for their survival so they may develop some potent chemicals that are helping them. Similarly, the chemistry of cognitive functions and memory is also a hot area of research, as it is still unknown that, what are the substances that are involve in the storage of memory.

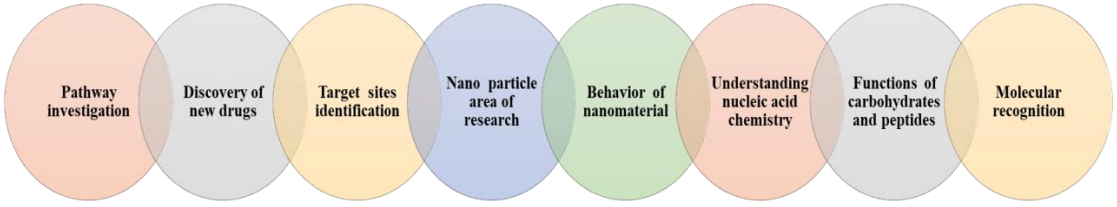

Fig. 3: Future research areas in the subject of bioorganic chemistry

Applications of synthetic and physical organic chemistry to the study of enzymes, metabolic processes, and nucleic acids are among the other research fields. This involves research of coenzyme reactivity, the creation of mechanism-based enzyme inhibitors, and the clarification of enzyme structure and action. Bioorganic chemistry also helps in the sequencing of a gene and helps in the identification of some novel proteins. The interaction of various cell component and their organization affect the life processes, are also in the domain of bioorganic chemistry and much more are remained to be explored.

CONCLUSION

In conclusion, bioorganic chemistry is the combinatorial branch of science that covers both organic chemistry and biochemistry. This concept originated in that most molecules are common to both of these branches and can share numerous characteristics. Bioorganic chemistry makes the understanding of life molecules and organic chemistry easy to apply in various disciplines and identified their functions. This discipline has its roots in a variety of fields that help to understand and use it properly. Its application is

ranging from the chemistry of sample biological molecules to complex reactions and their regulations. Nucleic acid chemistry understanding, sea organism compounds identification, and interaction of molecules in cell signaling, etc. are currently considered hot areas of research in bioorganic chemistry.

REFERENCES

[1]. Johnson, J. A. (2015, March). From Bio-organic Chemistry to Molecular and Synthetic Biology: Fulfilling Emil Fischer's Dream'. In Proceedings of the International Workshop 'Transformation of Chemistry from the 1920s to the 1960s (pp. 2-4).

[2]. Poulter, C. D. (2009). Bioorganic chemistry. A natural reunion of the physical and life sciences. The Journal of organic chemistry, 74(7), 2631-2645.

[3]. Stechenko, O. V. (2019). Competency approach to structuring the curriculum on biological and bioorganic chemistry. Zhytomyr Ivan Franko state university journal. Pedagogical sciences, (3 (98)), 34-42.

[4]. Hilvert, D. (1996). Perspectives on bioorganic chemistry. CHEMISTRY AND BIOLOGY-LONDON-, 3, 727-727.

[5]. Kenyon, G. L., & Gerlt, J. A. (2002). Bioorganic Chemistry: Introduction. Bioorganic Chemistry, 30(1), 1-2.

[6]. Breslow, R. (1998). Bioorganic chemistry: A natural and unnatural science. Journal of chemical education, 75(6), 705.

[7]. Brodesser, S., Sawatzki, P., & Kolter, T. (2003). Bioorganic chemistry of ceramide. European Journal of Organic Chemistry, 2003(11), 2021-2034.

[8]. https://archive.nptel.ac.in/content/storage2/courses/104103018/pdf/mod1.pdf

[9]. https://www.news-medical.net/life-sciences/What-is-Bioorganic-Chemistry.aspx

Chapter 5

PHYTO PHENOLICS, PRECURSOR TO BIOSYNTHESIS, ITS ANTI-OXIDATIVE EXERTION AND POTENCY AS BIOPHARMACEUTICALS

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ABSTRACT

Secondary metabolites (Albrecht Kossel, 1910), a.k.a., specialized metabolites, toxins, and secondary products are organic compounds synthesized exclusively by any living entity, including bacteria, fungi, or plants, which are not directly, appertain in customary growth, and development, or reproduction of the organism. These are idiosyncratic sources for pharmaceuticals, food supplements, flavour enhancers, fine chemicals, and other industrial compounds. Secondary metabolites are synthesized especially by certain types of plants. Organized tissue culture practices, more significantly root cultures can be used in the production of these metabolites from plants avoiding natural capacity or inconveniences. This chapter will provide a lucid interpretation of the different plant secondary metabolites with a special emphasis on Phyto-phenols and polyphenols, their potent antioxidant properties, and emerging biopharmaceutical aspects.

KEYWORDS: Secondary metabolites, polyphenol, antioxidant, reactive oxygen species (ROS), oncology.

INTRODUCTION

The secondary metabolites can be delineated as the specialized Phyto-organic intermediates which are derived biosynthetically from primary metabolic compounds like carbohydrates, fats, amino acids, etc. Kossel, A. [3] [4] was the pioneer to define these metabolites as opposed to primary metabolites. Depending upon their biosynthetic origins, plant secondary metabolites can be categorized into three genres viz., a) flavonoids and phenolic, polyphenolic compounds, b) terpenoids, c) nitrogen-containing alkaloids and sulfur-containing compounds (Crozier, A. *et al.* 2006). The plant produces various secondary substances such as alkaloids, terpenoids, phenols, resins, and tannins, various phytohormones, porphyrins, different co-enzymes, etc. It has been clearly demonstrated that secondary products play a vital role in the adaptation of plants to their environment (Kossel *et al.,* 1891). These possess great commercial as well as social importance for the procreation of dyes [2], fibers, glues, oils, waxes, flavoring agents, drugs, and perfumes, and are also viewed as potential sources of new conventional drugs, antibiotics, micro-biocide, insecticides and herbicides (Croteau *et al.* 2000; Dewick 2002). Moreover, the producer plant also gets benefited from the generation of antibiotics (S.M.) in response to the interaction between the plant and pathogen (Tiwari, R. *et al.,* 2015) committing to the optimum survivability of the host. These serve as, a) symbiotic agents between microbes and plants or nematodes, insects, etc., b) differentiation effectors, etc. c) as metal transporting agents, d) as a competitive tool applied against bacteria, fungi, amoeba, insects, and animals.

Phenolic compounds have been reported in almost every plant at a varied quantity depending upon individuals, that are the main class of secondary or specialized metabolites comprising about 8000 different structures (Carocho, M. *et al.* 2013) (Strack 1997) (Garrido, M. *et al.* 2023) with various effects.

These are divided into, a) phenolic acids and b) polyphenols. Phenolic acids, flavonoids, and tannins are regarded as the main dietary phenolic compounds (King, A. et al.1999). Studies have shown that the synthesis of phenolic compounds in a plant is proportional to its antioxidant potential.

MATERIALS AND METHODS

Among the miscellaneous phyto-organic intermediates, phenolic and polyphenolic compounds were considered as the nucleus for the intensive study.

The methodology proposed to be employed is purely doctrinal. A bibliographic inquisition was executed on all the accessible peer-reviewed literature concerned with the plant phenolic elements via internet search using various authorized literature repositories viz., Google Scholar, Pubmed, SciFinder, Scopus, and Web of Science.

CLASSIFICATION OF PHYTOPHENOLS

Phenols (Phene- benzene; ol- OH) are an important group of secondary plant metabolites and are widely distributed in plants from algae to angiosperms (Waler, 1975). These comprises at least one hydroxyl group attached to an aromatic ring structure (Fig-1). Generally, Phenolic compounds comprise one or more aromatic rings with hydroxyl groups in their structure, regarded as phenolic acid and polyphenols respectively.

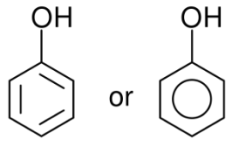

Fig. 1: Structure of phenol

Classification scheme-1: Swain and Bate- Smith in 1962 formulated a classification module of the compounds and grouping them as "common" and "less common" genres [16].

Ribereau-Gayon in 1972 divided the phenols [16] into three main categories as follows:

1) Widely dispersed phenolic compounds
2) Less widely dispersed phenolic compounds
3) Polymeric phenolic constituents

Classification scheme-2: Jeffrey Harborne and Simmonds in 1964 constructed a most pragmatic classification scheme of these compounds based on the number of carbons, published in 1980 [16] [14].

Table 1: Classification scheme formulated by J. Harborne and Simmonds in 1964.

SL No	Skeleton (Structure)	No. of Carbon	Class
1	C_6	6	Simple phenols
2	C_6-C_1	7	Phenolic acid
3	C_6-C_2	8	Phenylacetic acids, Acetophenones
4	C_6-C_3	9	Cinnamic acid, Coumarins
5	C_6-C_4	10	Naphthoguinones
6	C_6-C_1-C_6	13	Xanthonoids
7	C_6-C_2-C_6	14	Anthraquinones
8	C_6-C_3-C_6	15	Flavonoids, Isoflavonoids
9	C_6-C_4-C_6	16	Algal phenolic compound
10	$(C_6$-$C_3)_2$	18	Lignans, Neolignans
11	$(C_6$-C_3-$C_6)_2$	30	Biflavonoids
12	$(C_6$-$C_3)n$ or $(C_6$-C_3-$C_6)n$	N > 12	Lignin, Tannins, polyphenols etc.

The classification module of Harborne and Simmonds was refurbished by various workers based on the number and arrangement of their carbon atoms (Table-1), adjoined to the acids and sugars viz, a) the flavonoids and b) the non-flavonoids.

Classification scheme-3: Depending upon their structural complexity, phyto phenolic compounds may be divided into four groups (Buzarbarua, A. 2000).

1) **Simple phenols:** Which contain one or more hydroxyl groups on the ring and may also contain methyl group [18], e.g. catechol, hydroquinone etc.
2) **Phenol carboxylic acids:** Phenols containing a carboxylic group as a substituent, e.g. p-hydroxybenzoic acid, galic acid etc.
3) **Phenol-propane derivatives:** Phenolic compounds where three carbon atoms of phenyl propane are attached [18], e.g. coumarins, lignins etc.
4) **Flavin derivatives:** These are characterized by having the flavin skeleton with two aromatic rings A and B flanking the central oxygen containing heterocycles [18]. Examples are flavones, anthocyanidins etc.

FLAVONOIDS

Flavonoids are the secondary polyphenolic compounds diversely found in the epidermis of leaves and fruits of plants consisting of C-15, a C-3 bridge associated two aromatic rings. They are the most numerous of the phenolics and are found throughout the plant kingdom (Harborne 1993). Among 8000 phenolic compounds were found where about 4500 flavonoids. Significantly, flavonoids gained importance because of their commercial potential in the field of pharmaceutics, medicines and cosmetics. Operations of phyto-flavonoid entail a) the protection of plants from UV radiation, b) pigmentation and c) disease tolerance to plants. Their anticarcinogenic nature or activity discourages the development of cancer as well as heart disease in mammals. Flavonoids are categorized further as, a) flavones, b) flavonols, c) isoflavones, d) flavan-3-ols, e) flavanones and f) anthocyanidins.

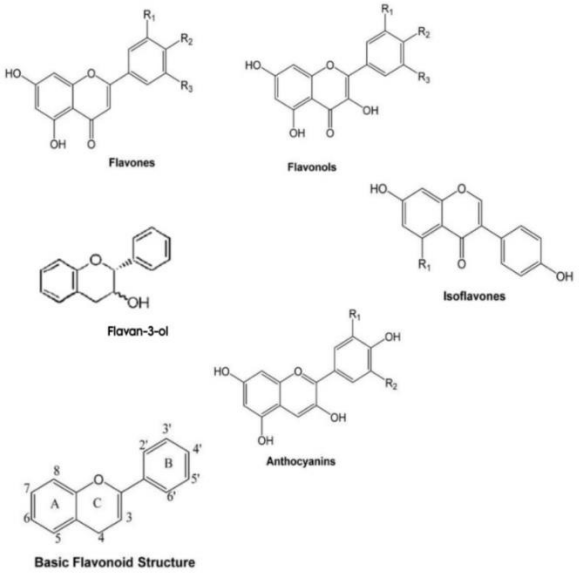

Fig. 2: Structure of the different flavonoids. (Source- Rahman, Md. *et al.* 2021)

FLAVONES

Flavones (latin 'flavus' means 'yellow') are a type of flavonoid, consisting hydrogen at C-3. Glycosylated configuration of the major flavone viz., apigenin as 'isovitexin', 'vitexin', and 'rhifolin' was reported in

plants. A noted flavone i.e. luteolin found in- Piper nigrum L., Daucus carota L., Brassica oleracea L., Chrysanthemum indicum L.etc. The peels of citrus are rich in the polymethoxylated flavones, tageretin, and nobiletin (Manach, C. *et al.* 2004). Structurally, these are akin to flavonols. Although flavones, viz., luteolin and apigenin, retains A- and C-ring substitutions, lacking oxygenation at C-3. A diverse substitution is also possible with flavones viz., hydroxylation, methylation, and glycosylation.

FLAVONOLS

It is a subgroup of flavonoid, diversely occurs only in the plant based foodstuffs, rather in fungi, algae and other sources, consisting the 3-hydroyflavone in the skeleton (IUPAC Name: 3-hydroxy-2-phenylchromen-4-one). It has been reported that, about more than half of the flavonols possess supplementary OH^- radical at the position of 5-7 and are glycosylated. Quercetin, kaempferol [22], fisetin [23], myricetin are common types found in leaves, outer parts and plant foodstuffs.

ISOFLAVONES

Isoflavones are the exclusive subtype of flavonoid, B-ring of which adjoined at the C-3 position with an OH^- in the C-4 and C-7. Significantly, ISF abundant in the Fabaceace family. Leguminous plant viz, Glycine max L., Phaseolus vilgaris L., Medicago sativa L., Trifolium pratense L. contained ISF such as, genistein and daidzein, glycitin etc. Recent epidemiological studies showed that, ISF act as an anti-microbial, anti-inflammatory mediator and are beneficial for patients with cancer, cardiovascular diseases, osteoporosis, postmenopausal [26] [27] [28] [29] etc. Phytoestrogens derived from the Greek word '*phyto' means plant* and '*estrogen'* confined to the sex hormone, that commanded the female fertility in mammals. Depending upon its identical structure can be subdivided into isoflavones (flavonoids) and lignin (non-flavonoids).

FLAVAN-3-OLS

Flavan-3-ols are a complex subtype of flavonoid, consists of 2-phenyl-3, 4-dihydro-2H-chromen-3-ol skeleton, predominantly occurs in the Camellia sinessis (L.) Kuntze, Theobroma cacao L. etc. They are the derivatives of flavones viz, catechin, epicatechin, epigallocatechin, 3-gallate, epicatechin 3-gallate, theaflavin, thearubigins, theaflavin-3, 3-digallate, theaflavin-3-gallate etc. Research has indicated that flavan-3-ols may affect vascular affairs, blood pressure, and blood lipids, only minor effects demonstrated [31] [32].

FLAVANONES

Flavanones are a specialized subtype of flavonoid, abundant in the members of Rutaceae. Citrus flavanones exert interesting pharmacological effects as antioxidant, anti-inflammator, cholesterol-lowering agents (Panche, A. N. *et al.* 2016). Hesperidin, naringenin, eriodictyol are some diversely found glycosidic flavanone which is a constrain intermediary in the biosynthesis of flavonoids. Hesperidin mediates cholesterol lowering, anti-allergic, hypolipidemic, and vasoprotective and anti-aromatase activities. Naringenin is yellowish tinctured flavanone act as antioxidant, radical scavenger, anti-inflammator, immunity system modulator and applied in the treatment of Alzheimer's disease. Eriodictyol is hyaline derivative of flavone found in the leaves of some resinous shrubs used for bitter-masking.

ANTHOCYANIDINS

Anthocyanins, a subtype of flavonoid that are usually water-soluble vacuolar pigments responsible for colorization in plants, flowers and fruits, depends upon the pH and methylation or acylation at the OH^- groups on the A and B rings. They are abundant in hibiscus, red rose, red pineapple sage, red clover, red grapes, merlot grapes, strawberries, blueberries, bilberries and blackberries etc. in the diversified form of

pelargonidin, cyanidin, delphinidin, peonidin, and malvidin etc. They are involved in the protection of plants against excessive light by shading leaf mesophyll cells and also have an important role to play in attracting pollinating insects (Crozier, A. *et al.* 2006).Anthocyanins possess anticancer, anti-inflammatory, antimicrobial, and anti-obesogenic activity, and utilized for prevention of cardiovascular diseases (CVDs) [35].

NON-FLAVONOIDS

In terms of chemical structure, non-flavonoids are generally unembellished, simpler and smaller than flavonoids. This group includes, phenolic acids (C-6, C-1), hydroxycinnamates (C-6, C-3), stilbenes (C-6, C-2, C-6), coumarins, lignans, precursor of hydrolysable tannin i.e., galic acid and conjugated derivatives of hydroxycinnamates etc.

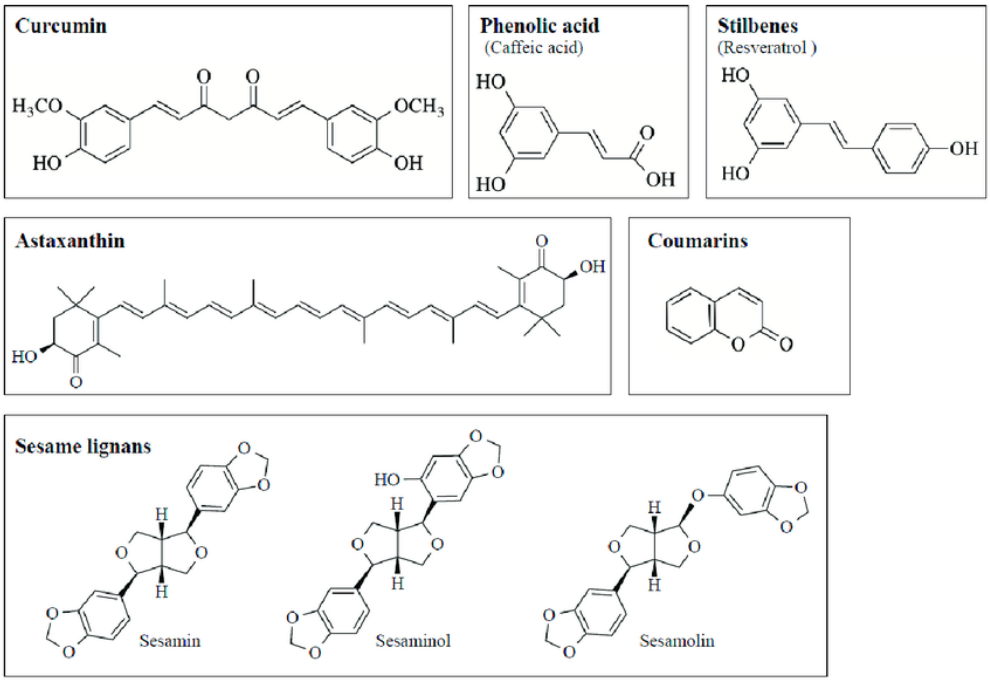

Fig. 3: Structures of different non-flavonoids. (Source- Naoi, M. *et al.* 2019)

PHENOLIC ACIDS

Phenolic acids, a group of phytochemical i.e. polyphenol which is also known as phenol carboxylic acids or hydroxybenzoates, the sole component being gallic acid.The name derives from the French word 'galle', i.e. nodule or swelling in the tissue of a plant after an attack by parasitic insects (Crozier, A. *et al.* 2006). These are aromatic compounds possessing a phenolic ring and an organic carboxylic acid comprising C-6, C-1 skeleton (phenol carboxylic). Collectively, naturally synthesized major phenolic acids can be classified into two types viz, simplest hydroxybenzoic acids with C-6, C-1 skeleton and the most abundant hydroxycinnamic acids with C-6, C-3 skeleton. Galic acid, vanilic acid, salicylic acid are major hydroxybenzoic. These are diversely found in seeds, fruits, endodermis of leaves and natural foodstuff.

STILBENES

Stilbenes, a subtype of non-flavonoid having 14-carbon skeleton (C-6, C-2, C-6), characterized by a 1,2-diphenylethylene backbone, produced in response to protect the organism from the attack of fungal, bacterial and viral pathogens (phytoalexin). These have been identified in at least 72 plant species belonging to 31 genera and 12 families, including Pinaceae, Gnetaceae, Fabaceae, Vitaceae, Moraceae and Polygonaceae [39] [40]. Resveratrol (3,4',5-trihydroxystil-bene), a widely found stilbene reported for its antitumoral and anti-inflammatory activity.

COUMARIN

Coumarins (1, 2-benzopyrone or 2H-1-benzopyran-2-one), which are hyline, crystalline polyphenols, either present as glycosidic or free forms. Vogel in 1820 first isolated these compounds from Dipteryx odorata belonging to Fabaceae. Coumarins and its derivatives are abundant in the families' Rutaceae and Apiaceae, found in the seeds, roots and leaves of oats, spices, olive as coumarin, sculetin, scopoletin etc.

LIGNANS

Lignans are low molecular weight non-flavanoids, generated by the phenylpropanoid pathway. One of the widely found plant lignan is secoisolariciresinol diglucoside. Several epidemiological studies reported that, they possess anti-inflammatory, antitumor capacity and fruitful for the therapeutic of cardiovascular, chronic diseases etc.

PRECURSOR, PATHWAYS OF THE BIOSYNTHESIS OF PHYTOPHENOLS

Most of the phenolic compounds of plants are biosynthesized by three significant pathways viz.

1. The shikimate/succinyl benzoate or chorizmate pathway
2. The mevalonate/acetate pathway
3. The malonate/acetate or polyketide pathway

Phenyl propanoid derivatives (C-1, C-3), quinones, flavonoids, and elongated phenyl propanoids, (C-6, C-3, C-6), monoterpenoids (a chemical compound having a partial terpenoid structure) are biosynthesized by the shikimate/succinyl benzoate or chorizmate pathway, the malonate/acetate or polyketide pathway and the mevalonate/acetate pathway respectively. Deamination, hydroxylation and methylation are the three steps takes place during the biosynthesis process.

THE SHIKIMATE/SUCCINYLBENZOATE OR CHORIZMATE PATHWAY

Shikimic acid was formerly extracted from the highly toxic Illicium anisatum (Vern name -shikimi) in 1885 by Johan Fredrik eykman and named after that so far. In exception to animals, this pathway contributes precursors for the biosynthesis of aroma in fungi, bacteria, and plants. In microbes, this pathway produces aromatic amino acids viz., L-phenylalanine (L-Phe), L-tyrosine (L-Tyr), and L-tryptophan (L-Trp) considered as the molecular building blocks for protein biosynthesis (Weaver *et al.*, 1997) [44] and contributes to the gross development of plants, synthesized various secondary metabolites concretively.

Phenylalanine, an amino acid is the biosynthetic intermediate in the shikimic acid pathway. Aldol condensation of D-erythrose-4-phosphate (DEP) and phosphoenolpyruvate (PEP) takes place, comprising a few consecutive enzyme-mediated phases. DEP and PEP are the intermediates of the pentose phosphate pathway and glycolysis respectively, converted to 3-deoxy-D-arabino-heptulosonic acid 7-phosphate (DAHP). After two successive phases, shikimic acid, NADP+ derived from the DAHP following 3-Dehydroquinic acid (DHQ), 3-Dehydroshikimic acid (DHS) respectively. Shikimic acid converted into Shikimic acid 3-phosphate, ADP, 5- Enol pyruvylshikimate 3-phosphate, eventually synthesizing chorismic acid. Intermediate i.e. Phenylalanine is formed from arogenic acid (non-proteinogenic alpha-amino acid), subsequently from prephenic acid, the derivative of chorismic acid. Phenylalanine ammonia lyase (PAL) (EC 4.3.1.24) catalyzes the transfiguration of phenylalanine into trans-cinnemic acid, biosynthesis of polyphenolic compounds as flavonoids, lignins, and phenylpropanoids, etc occurs.

Some of the paramount cofactors or enzymes that catalyze the subsequent reactions are- 3-deoxy-D-arabino-heptulosonate-7-phosphate synthase (EC 2.5.1.54), 3-dehydroquinate synthase (DHQS; EC 4.2.3.4), 3-dehydroquinate dehydratase/shikimate dehydrogenase (DHQ/SDH; EC 4.2.1.10/EC 1.1.1.25),

shikimate kinase (SK; EC 2.7.1.71), 5-enolpyruvylshikimate 3-phosphate synthase (EPSPS; EC 2.5.1.19), and chorismate synthase (CS; EC 4.2.3.5) (Zhang *et al.,* 2012) [44] [47].

Table 2: Phases of shikimic acid pathway, biosynthesis of phenols with cofactors

Phase	Substrate	Cofactor	Derivative
1	D-erythrose-4-phosphate (DEP), phosphoenolpyruvate (PEP)	3-deoxy-D-arabino-heptulosonate-7-phosphate synthase	3-deoxy-D-arabino-heptulosonic acid 7-phosphate (DAHP)
2	3-deoxy-D-arabino-heptulosonic acid 7-phosphate (DAHP)	3-dehydroquinate synthase	3-Dehydroquinic acid (DHQ)
3	3-Dehydroquinic acid (DHQ)	3-dehydroquinate dehydratase	3-Dehydroshikimic acid (DHS)
4	3-Dehydroshikimic acid (DHS)	Shikimate dehydrogenase	Shikimic acid, $NADP^+$
5	Shikimic acid, ATP	Shikimate kinase	Shikimic acid 3-phosphate, ADP
6	Shikimic acid 3-phosphate, PEP	5-enolpyruvylshikimate 3-phosphate synthase	5-Enolpyruvylshikimate 3-phosphate
7	5-Enolpyruvylshikimate 3-phosphate (EPSP)	Chorismate synthase	Chorismic acid
8	*Chorismic acid	Chorismate mutase	Prephenic acid
9	Prephenic acid	NIL	Arogenic acid
10	Arogenic acid	Hydroxyphenylpyruvate synthase	Phenylalanine
11	Phenylalanine	Phenylalanine ammonia lyase (PAL)	Trans-cinnemic acid

THE MEVALONATE/ACETATE PATHWAY

In the mevalonate/acetate pathway, 5-carbon conjugated two composites viz., isopentenyl pyrophosphate (IPP) and dimethylallyl pyrophosphate (DMAPP) act as the precursors to synthesized isoprenoids, this pathway often regarded as HMG-CoA reductase as well as isoprenoid pathway. Initially, 2 Acetyl CoA converted to acetoacetyl-CoA, catalyzed by the cofactor acetoacetyl-CoA thiolase. Episodically, the condensation takes place as, conversion of acetoacetyl-CoA to 3-hydroxy-3-methyl-glutaryl-CoA (HMG-CoA), catalyzed by HMG-CoA synthase, mevalonate derived from HMG-CoA, catalyzed by HMG-CoA reductase. Successively, mevalonate-5-kinase catalyzed the condensation of mevalonate-5-phosphate from mevalonate and cleavage to form mevalonate pyrophosphate and isopentenyl phosphate, catalyzed by phosphomevalonate kinase and mevalonate-5-phosphate decarboxylase respectively. The 5-C conjugates viz., isopentenyl pyrophosphate (IPP) and dimethylallyl pyrophosphate (DMAPP) synthesized from the aforesaid elements, catalysed by mevalonate pyrophosphate decarboxylase and isopentenyl phosphate kinease respectively. Different terpenes such as, monoterpenes, diterpenes, tertraterpenes, polyterpenes etc., are the intermediates of this pathway into several plant parts.

Table 3: Phases of mevalonate/acetate pathway, biosynthesis of phenols with cofactors

Phase	Substrate	Cofactor	Derivative
1	2 Acetyl CoA	Acetoacetyl-CoA thiolase	Acetoacetyl-CoA
2	Acetoacetyl-CoA	HMG-CoA synthase	3-hydroxy-3-methyl-glutaryl-CoA (HMG-CoA)
3	HMG-CoA	HMG-CoA reductase	Mevalonate
4	Mevalonate	Mevalonate-5-kinase	Mevalonate-5-phosphate
5	Mevalonate-5-phosphate	Phosphomevalonate kinase, mevalonate-5-phosphate decarboxylase	Mevalonate pyrophosphate, isopentenyl phosphate (IPP)
6	Mevalonate pyrophosphate, isopentenyl phosphate (IPP)	Mevalonate pyrophosphate decarboxylase, isopentenyl phosphate kinease	Isopentenyl pyrophosphate (IPP)(5C), dimethylallyl pyrophosphate (DMAPP)(5C)

ANTIOXIDATIVE PROFILE AND THERAPEUTIC EXORDIUM OF PHYTOPHENOLS

Antioxidants are characterized amalgam or elements that retain oxidation. Autoxidation contributes to the deterioration of organic compounds (Klemchuk, Peter P. 2000). Several diseases viz., gastritis, cancer, arthritis, reperfusion injury of many tissues (Kumpulainen and Salonen, 1999), central nervous system injury, human immune-deficiency virus infection(HIV), and acquired immune deficiency syndrome(AIDS) (Cook and Samman, 1996) are pathologically manifested by the free radicals due to environmental pollutants, radiation, chemicals, toxins, stress (Pourmorad, F. et. al, 2005). The rich antioxidative profile or nature of specific plant material protects against such diseases, furthermore, chronic diseases, neurological diseases, cataracts, etc. Antioxidants scrimmage with the free radicals and exert their mode of action by *scavenging the reactive oxygen species (ROS), *protecting the antioxidative defense mechanisms (Umamaheswari, M, 2008). Approx. 4000 types of flavonoids have been reported and recent studies revealed the preventive role of the compounds (flv) and certain phenols in the development of cardiovascular, special types of cancers and subjective to antibacterial, anti-inflammatory, and antiviral effects. They are present in the form of glycosides, whereas found as aglycones. Flavonoids, phenolic acids, tannins opulent dietary substances regulate carbohydrate and lipid metabolism, improve β-cell action viz., the production and secretion of insulin and amylin, advancement of adipose tissue metabolism, and alleviate oxidative stress and stress-hypersensitive signaling mechanisms [58]. Celery and green pepper comprise a flavonoid compound luteolin, rich in anti-oxidative and anti-inflammatory which was reported in previous studies [54]. Luteolin 7-O-rutinoside and luteolin 6, 8-di-C-glucoside abundance in the family Rutaceae, which are the glycosylated forms of luteolin. Phenolics, present in both edible and non-edible parts of the plants, have been considered powerful antioxidants in-vitro and manifested as more potent antioxidants than Vitamin C and E and carotenoids [50] [51] [53]. The involvement of plant polyphenols in the scavenging of hydrogen peroxide (H_2PO_4) in plant cells is reported.

Glycosides are abundant in plants, Salicin and populin are reported in most of the members of the family Salicaceae, glucovanillin in Poaceae (Bartnik *et al.,* 2017), coniferin in conifers, arbutin in Rosaceae,

etc. Studies indicated that plants recurrently produced superficially toxic glycosides and alkaloids viz., Saponin for defensive purposes.

DISCUSSION

In breviary, phyto phenolics have a long chronology of scientific investigation and are confined as the most abundant, most extensively represented category of plant natural products. Erstwhile inquisitorial work of the noble-laureates Emil Fischer, and Robert Robinson viz., chemical components of tannins and plant dyestuffs (anthocyanins, alkaloids) are regarded as substantial, representing the interest from the remote past. Notwithstanding, the various knowledge contributed by the notable workers, further studies need to be carried out on its intracellular transport and activities. Inductions of the metabolites are genetically mediated and most sincere to the environment, dynamic genetical configuration as well as environmental conditions can influence the biosynthesis pattern of these compounds, which demands extensive study. Further studies of these metabolites will provide inkling into their possible biopharmaceutical exploration of antioxidants and oncology.

REFERENCES

[1]. Secondary metabolite. (2022, December 11). In Wikipedia. https://en.wikipedia.org/wiki/Secondary_metabolite

[2]. Crozier, A., Jaganath, I.B. and Clifford, M.N. (2006). Phenols, Polyphenols and Tannins: An Overview. In Plant Secondary Metabolites (eds A. Crozier, M.N. Clifford and H. Ashihara). https://doi.org/10.1002/9780470988558.ch1

[3]. Kossel (1891). "Uber die chemische Zusammensetzung der Zelle‖ Archiv fur Physiologie(1891)181-186

[4]. Tiwari, Ruby & Rana, C. (2015). Plant secondary metabolites: a review. IJERGS. 3. 661-670.

[5]. Marja PK, Anu IH, Heikki JV, Jussi-Pekka R, Kalevi Pihlaja, Tytti SK, *et al.* (1999). Antioxidant Activity of Plant Extracts Containing Phenolic Compounds. J of Agri and Food Chem. 1999; 47():3954-62.

[6]. Boligon AA, De Brum TF, Frolhich JK, Froeder ALF, Athayde ML. (2012). HPLC DAD Profile and Determination of Total Phenolics, Flavonoids, Tannins and Alkaloids Contents of Scutia buxifolia Reissek Stem Bark. Res J of Phytochem. 2012;6(6):84-91.

[7]. Jian Zhaoa,T, Lawrence C. Davisb and Robert Verpoortec. (2005). —Elicitor signal transduction leading to production of plant secondary metabolites‖ Biotechnology Advances, 283–333, 23

[8]. Lin D, Xiao M, Zhao J, Li Z, Xing B, Li X, Kong M, Li L, Zhang Q, Liu Y, Chen H, Qin W, Wu H, Chen S. (2016). An Overview of Plant Phenolic Compounds and Their Importance in Human Nutrition and Management of Type 2 Diabetes. Molecules. 2016 Oct 15; 21(10):1374. Doi: 10.3390/molecules21101374. PMID: 27754463; PMCID: PMC6274266.

[9]. Carocho, M.; Ferreira, I. (2013). The role of phenolic compounds in the fight against cancer—A review. Anticancer Agents Med. Chem. 2013, 13, 1236–1258.

[10]. Garrido, M.; Cosme, P.; Rodriquez, A.; Espino, J. (2023). Plant Phenolics. Encyclopedia. Available online: https://encyclopedia.pub/entry/4542 (accessed on 05 January 2023).

[11]. King A, Young G. (1999). Characteristics and occurrence of phenolic phytochemicals. J Am Diet Assoc. 1999;99:213–218. Doi: 10.1016/S0002-8223 (99)00051-6.

[12]. Reddy CVK, Sreeramulu D, Raghunath M. (2010). Antioxidant activity of fresh and dry fruits commonly consumed in India. Food Res Int. 2010; 43:285–288. doi:http://dx.doi. org/10.1016/j.foodres.2009.10.006.

[13]. Sarawong C, Schoenlechner R, Sekiguchi K, Berghofer E, Ng PKW. (2014). Effect of extrusion cooking on the physicochemical properties, resistant starch, phenolic content and antioxidant capacities of green banana flour. Food Chem. 2014; 143:33–39. Doi: 10.1016/j. foodchem.2013.07.081.

[14]. Naturally occurring phenols. (2023, January 1). In Wikipedia. https://en.wikipedia.org/wiki/Naturally_occurring_phenols

[15]. Tsimogiannis, D., & Oreopoulou, V. (2019). Classification of Phenolic Compounds in Plants. Polyphenols in Plants (Second Edition), 263-284. https://doi.org/10.1016/B978-0-12-813768-0.00026-8

[16]. Harborne, J. B. (1980). "Plant phenolics". In Bell, E. A.; Charlwood, B. V. (eds.). Encyclopedia of Plant Physiology, Volume 8: Secondary Plant Products. Berlin Heidelberg New York: Springer-Verlag. pp. 329–395.

[17]. *Vermerris, Wilfred; Nicholson, Ralph (2007-02-20).* Phenolic Compound Biochemistry. *Springer Science & Business Media.* ISBN*:* 9781402051647

[18]. Buzarbarua Aparna. (2000). A Text book of practical plant chemistry, 2000, ISBN- 9788121919661, S Chand & Co Ltd.

[19]. Panche, A. N., Diwan, A. D., & Chandra, S. R. (2016). Flavonoids: an overview. Journal of Nutritional Science, 5. https://doi.org/10.1017/jns.2016.41

[20]. Soto-Blanco, B. (2022). Herbal glycosides in healthcare. Herbal Biomolecules in Healthcare Applications, 239-282. https://doi.org/10.1016/B978-0-323-85852-6.00021-4

[21]. Manach C, Scalbert A, Morand C, *et al.* (2004). Polyphenols: food sources and bioavailability. Am J Clin Nutr 79, 727–747.

[22]. Pietta, P., Minoggio, M., & Bramati, L. (2003). Plant Polyphenols: Structure, Occurrence and Bioactivity. Studies in Natural Products Chemistry, 28, 257-312. https://doi.org/10.1016/S1572-5995(03)80143-6

[23]. Gonçalves, A. C., Bento, C., Jesus, F., Alves, G., & Silva, L. R. (2018). Sweet Cherry Phenolic Compounds: Identification, Characterization, and Health Benefits. Studies in Natural Products Chemistry, 59, 31-78. https://doi.org/10.1016/B978-0-444-64179-3.00002-5

[24]. Ioannone, F., Miglio, C., Raguzzini, A., & Serafini, M. (2013). Flavonoids and immune function. Diet, Immunity and Inflammation, 379-415. https://doi.org/10.1533/9780857095749.3.379

[25]. Isoflavone. (2022, December 10). In Wikipedia. https://en.wikipedia.org/wiki/Isoflavone

[26]. Conklin, C.M.; Bechberger, J.F.; MacFabe, D.; Guthrie, N.; Kurowska, E.M.; Naus, C.C. (2007). Genistein and quercetin increase connexin43 and suppress growth of breast cancer cells. Carcinogenesis 2007, 28, 93–100.

[27]. Barnes, S. (1998). Evolution of the health benefits of soy isoflavones. Proc. Soc. Exp. Biol. Med. 1998, 217, 386–392.

[28]. Messina, M. (2014). Soy foods, isoflavones, and the health of postmenopausal women. Am. J. Clin. Nutr. 2014, 100, 423S–430S.

[29]. Yu, J.; Bi, X.; Yu, B.; Chen, D. (2016). Isoflavones: Anti-Inflammatory Benefit and Possible Caveats. *Nutrients* 2016, *8*, 361. https://doi.org/10.3390/nu8060361

[30]. Flavan-3-ol. (2022, December 5). In Wikipedia. https://en.wikipedia.org/wiki/Flavan-3-ol

[31]. Ried K, Fakler P, Stocks NP, *et al.* (Cochrane Hypertension Group) (April 2017). "Effect of cocoa on blood pressure". The Cochrane Database of Systematic Reviews. 4 (5):CD008893. doi:10.1002/14651858.CD008893.pub3. PMC 6478304. PMID 28439881

[32]. Raman G, Avendano EE, Chen S, Wang J, Matson J, Gayer B, *et al.* (November 2019). "Dietary intakes of flavan-3-ols and cardiometabolic health: systematic review and meta-analysis of randomized trials and prospective cohort studies". The American Journal of Clinical Nutrition. 110 (5): 1067–1078. Doi:10.1093/ajcn/nqz178. PMC 6821550. PMID 31504087

[33]. Brahmachari, Goutam. (2008). Naturally Occurring Flavanones: An Overview. Natural product communications. 3. 1337-1354. 10.1177/1934578X0800300820.

[34]. Khoo, H. E., Azlan, A., Tang, S. T., & Lim, S. M. (2017). Anthocyanidins and anthocyanins: colored pigments as food, pharmaceutical ingredients, and the potential health benefits. Food & Nutrition Research, 61(1). https://doi.org/10.1080/16546628.2017.1361779

[35]. He K, Li X, Chen X, *et al.* (2011). Evaluation of antidiabetic potential of selected traditional Chinese medicines in STZ-induced diabetic mice. J Ethnopharmacol. 2011; 137(3):1135–1142.

[36]. Kumar, N., & Goel, N. (2019). Phenolic acids: Natural versatile molecules with promising therapeutic applications. Biotechnology Reports, 24. https://doi.org/10.1016/j.btre.2019.e00370

[37]. Heleno, Sandrina A.; Martins, Anabela; Queiroz, Maria João R. P.; Ferreira, Isabel C. F. R. (2015-04-15). "Bioactivity of phenolic acids: metabolites versus parent compounds: a review" (PDF). Food Chemistry. 173: 501–513. doi:10.1016/j.foodchem.2014.10.057. hdl:1822/39808. ISSN 0308-8146. PMID 25466052

[38]. Carocho, M.; Ferreira, I. (2013). The role of phenolic compounds in the fight against cancer-A review. Anticancer Agents Med. Chem. 2013, 13, 1236–1258.

[39]. Rivière, C.; Pawlus, A.D.; Merillon, J.M. (2012). Natural stilbenoids: Distribution in the plant kingdom and chemotaxonomic interest in Vitaceae. Prod. Rep. 2012, 29, 1317–1333.

[40]. Dubrovina, A.S.; Kiselev, K.V. (2017). Regulation of stilbene biosynthesis in plants. Planta 2017, 246, 597–623.

[41]. Valletta, A.; Iozia, L.M.; Leonelli, F. (2021). Impact of Environmental Factors on Stilbene Biosynthesis. *Plants* 2021, *10*, 90. https://doi.org/10.3390/plants10010090

[42]. Morales, Miurel & Barcelo, A. & Pedreño, Maria. (2000). Plant stilbenes: Recent advances in their chemistry and biology. Adv. Plant Physiol. 3. 39-70.

[43]. Akkol, E. K., Genç, Y., Karpuz, B., Sobarzo-Sánchez, E., & Capasso, R. (2020). Coumarins and Coumarin-Related Compounds in Pharmacotherapy of Cancer. Cancers, 12(7). https://doi.org/10.3390/cancers12071959

[44]. Francenia Santos-Sánchez, N., Salas-Coronado, R., Hernández-Carlos, B., & Villanueva-Cañongo, C. (2019). Shikimic Acid Pathway in Biosynthesis of Phenolic Compounds. Plant Physiological Aspects of Phenolic Compounds. doi: 10.5772/intechopen.83815

[45]. Weaver LM, Herrmann KM. (1997). Dynamic of the shikimate pathway. Trends in Plant Science. 1997;9:346-351

[46]. Tzin V, Galili G. (2010). Amino acids biosynthesis pathways in plants. Molecular Plant. 2010; 3:956-972. DOI: 10.1093/mp/ssq048

[47]. Zhang Z-Z, Li X-X, Chu Y-N, Zhang M-X, Wen Y-Q, Duan C-Q, *et al.* (2012). Three types of ultraviolet irradiation differentially promote expression of shikimate pathway genes and production of anthocyanins in grape berries. Plant Physiology and Biochemistry. 2012; 57:74-83. DOI: 10.1016/j.plaphy.2012.05.005

[48]. *Klemchuk, Peter P. (2000). "Antioxidants". Ullmann's Encyclopedia of Industrial Chemistry. Doi;10.1002/14356007.a03_091. ISBN-3527306730*

[49]. Pourmorad, F. & Hosseinimehr, Seyed Jalal & Shahabimajd, N. (2005). Antioxidant activity of phenol and flavonoid contents of some Iranian medicinal plants. African Journal of Biotechnology (ISSN: 1684-5315) Vol 5 Num 11. 5.

[50]. Rice-Evans, C.A.; Miller, N.J.; Bolwell, P.G.; Bramley, P.M.; Pridham, J.B. (1995). The relative antioxidant activities of plant-derived polyphenolic flavonoids. Free Radic. Res. 1995, 22, 375–383.

[51]. Rice-Evans, C.A.; Miller, N.J.; Paganga, G. (1996). Structure-antioxidant activity relationships of flavonoids and phenolic acids. Free Radic. Biol. Med. 1996, 20, 933–956.

[52]. Dai J, Mumper RJ. (2010). Plant Phenolics: Extraction, Analysis and Their Antioxidant and Anticancer Properties. *Molecules*. 2010; 15(10):7313-7352. https://doi.org/10.3390/molecules15107313

[53]. Catherine Rice-Evans, Nicholas Miller, George Paganga. (1997). Antioxidant properties of phenolic compounds, Trends in Plant Science, Vol-2, Issue 4,1997, Pages 152-159, ISSN 1360-1385, https://doi.org/10.1016/S1360-1385(97)01018-2.

[54]. Park, C. M., & Song, S. (2013). Luteolin and luteolin-7-O-glucoside inhibit lipopolysaccharide-induced inflammatory responses through modulation of NF-κB/AP-1/PI3K-Akt signaling cascades in RAW 264.7 cells. Nutrition Research and Practice, 7(6), 423-429. https://doi.org/10.4162/nrp.2013.7.6.423

[55]. M. Bartnik, P.C. Facey. (2017). Chapter 8 - Glycosides, Editor(s): Simone Badal, Rupika Delgoda, Pharmacognosy, Academic Press, 2017, Pages 101-161, ISBN 9780128021040,https://doi.org/10.1016/B978-0-12-802104-0.00008-1.

[56]. Umamaheswari M, Chatterjee TK. (2008). In vitro antioxidant activities of the fractions of Coccinnia grandis L. leaf extract. Afr J Trad Compl Altern Med. 2008, 5: 61-73.

[57]. Saeed, N., Khan, M.R. & Shabbir, M.(2012). Antioxidant activity, total phenolic and total flavonoid contents of whole plant extracts Torilis leptophylla L. BMC Complement Altern Med 12, 221. https://doi.org/10.1186/1472-6882-12-221

[58]. Lin D, Xiao M, Zhao J, Li Z, Xing B, Li X, Kong M, Li L, Zhang Q, Liu Y, Chen H, Qin W, Wu H, Chen S. (2016). An Overview of Plant Phenolic Compounds and Their Importance in Human Nutrition and Management of Type 2 Diabetes. Molecules. 2016 Oct 15; 21(10):1374. Doi: 10.3390/molecules21101374. PMID: 27754463; PMCID: PMC6274266.

[59]. Véronique Cheynier, Gilles Comte, Kevin M. Davies, Vincenzo Lattanzio, Stefan Martens. (2013). Plant phenolics: Recent advances on their biosynthesis, genetics, and Eco physiology, Plant Physiology and Biochemistry, Vol-72, 2013, Pages 1-20, ISSN 0981-9428, https://doi.org/10.1016/j.plaphy.2013.05.009.

[60]. Lattanzio, Vincenzo. "Phenolic compounds: introduction 50." Nat. Prod (2013): 1543-1580.

[61]. Rahman, Md & Rahaman, Md Saidur & Islam, Md. Rezaul & Rahman, Firoza & Mannan Mithi, Faria & Alqahtani, Taha & Almikhlafi, Mohannad & Alghamdi, Samia & Alruwaili, Abdullah & Hossain, Md & Ahmed, Muniruddin & Das, Rajib & Emran, Talha & Uddin, Md. (2021). Role of Phenolic Compounds in Human Disease: Current Knowledge and Future Prospects. Molecules. 27. 233. 10.3390/molecules27010233.

[62]. Naoi, Makoto & Wu, Yuqiu & Shamoto-Nagai, Masayo & Maruyama, Wakako. (2019). Mitochondria in Neuroprotection by Phytochemicals: Bioactive Polyphenols Modulate Mitochondrial Apoptosis System, Function and Structure. International Journal of Molecular Sciences. 20. 2451. 10.3390/ijms20102451.

Chapter 6

CARBON DOTS: SYNTHESIS, PROPERTIES, AND MULTIFACETED APPLICATIONS

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ABSTRACT

this chapter provides an in-depth exploration of carbon dots (cds), nanoscale carbon-based materials renowned for their unique properties. the chapter covers cds' synthesis methods, structural attributes, and diverse applications across catalysis, bioimaging, drug delivery, and more. it highlights their role in addressing challenges like microbial resistance and environmental cleanup, as well as their potential contributions to solar energy conversion and advanced batteries. the abstract emphasizes the significance of cds' biocompatibility, eco-friendliness, and wide-ranging applications. challenges related to uniform synthesis and toxicity assessment IS acknowledged. this narrative underscores the imperative of ongoing research to fully unlock cds' potential across evolving trends in nanotechnology and beyond, as their adaptable core-shell structure and tunable optical properties promise transformative advancements.

KEYWORDS: Carbon Dot, Catalysis, Drug Delivery, Bioimaging, Biocompatibility, Core-Shell

INTRODUCTION

Nanotechnology, particularly in the form of nanoscale materials called nanoparticles (NPs), has significantly impacted fields such as medicine, research, and environmental cleanup. While metal and metal oxide nanoparticles have been widely utilized in various scientific areas, they come with drawbacks like non-biodegradability and toxicity. Surface-functionalization of these nanoparticles enhances their acceptance and utility. In medicine, modified nanoparticles are used to create biocompatible nano-pharmaceuticals with improved solubility and immunity. Nanoparticles have also been explored for microbial control, replacing conventional pesticides and antibiotics. However, antimicrobial nanomaterials face challenges like microbial resistance and particle degradation. Carbon dots (CDs), a type of carbon nanoparticle, have gained attention due to their biocompatibility, easy surface functionalization, and low toxicity. CDs exhibit fluorescence, tunable color emissions, and strong antibacterial properties. Their potential applications include bioimaging, bio sensing, and chemical warfare agent detection. This chapter covers synthesis methods and applications of CDs in fields like chemical warfare agents, medicine, and environmental cleanup.

STRUCTURE AND CHEMICAL PROPERTIES OF CARBON DOTS

Carbon dots exhibit a core-shell structure. This core-shell can be either amorphous or graphitic crystalline. Amorphous structures consist of carbon with mixed sp^2/sp^3 hybridization, while graphitic crystalline structures contain carbon with sp^2 hybridization. The core size is 2-3nm, which is very small, and it displays a characteristic lattice spacing of about 0.2nm. The specific characteristics of the core depend on the synthesis method, precursors used, and other factors such as pH and temperature.

Graphitic cores are obtained at reaction temperatures above 300°C, while amorphous cores form at lower temperatures.

Carbon dots can have their optical characteristics altered through surface functionalization, surface passivation, and heteroatom doping. Surface passivation enhances fluorescence and optical activity, shifting absorbance towards longer wavelengths and increasing quantum yield. As the size of the carbon dot increases, the absorption wavelength also increases. Surface functionalization improves stability, biocompatibility, photo reversibility, and reduces the toxicity of carbon dots. Doping alters optical properties by adjusting the band gap. The electronic characteristics of carbon dots depend on electronic transitions within the band gap. A decrease in size leads to an increase in the band gap, requiring higher excitation energy.

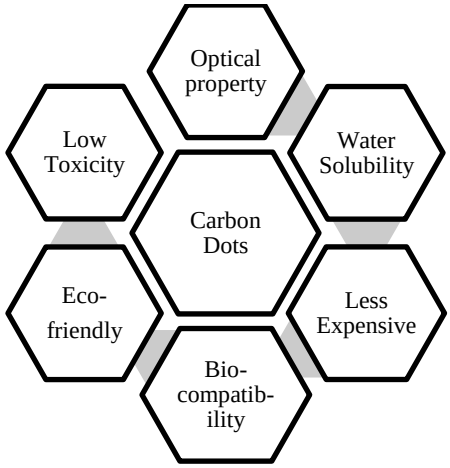

Fig. 1: Showing the features of Carbon Dots

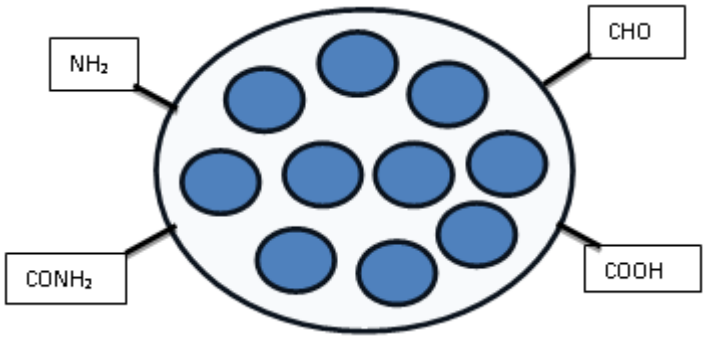

Fig. 2: Showing the core structure of Carbon Dots

SYNTHESIS OF CARBON DOTS

Since the groundbreaking discovery of CDs by Xu and fellow researchers in 2004, a sequence of techniques has emerged for the production of these carbon dots. These approaches can be broadly categorized as "top-down" and "bottom-up" strategies. Carbon dots (C-dots) synthesis has garnered significant attention due to their unique properties and promising applications in various fields. C-dots are luminescent carbon nanomaterials with excellent biocompatibility and low toxicity, making them particularly appealing for biomedicine, environmental pollution control, and other advanced applications. C-dots can be synthesized using two main approaches: top-down and bottom-up methods;

Larger carbon structures including graphite, graphene, carbon nanotubes, and activated carbon are broken down into smaller, fluorescent C-dots using top-down techniques. This method makes use of methods like laser ablation, arc discharge, chemical oxidation, and electrochemical oxidation. These

methods offer advantages such as the ability to produce C-dots with uniform size and high purity. However, they may require expensive equipment and involve complex procedures, which can limit their practicality for large-scale production.

On the other hand, bottom-up methods involve building up C-dots from molecular precursors. This approach includes processes like pyrolysis, carbonization, hydrothermal synthesis, and microwave-assisted synthesis. By using small-molecule precursors derived from sources like organic acids, carbohydrates, and waste materials, these methods offer more control over the resulting C-dots' size, shape, and properties. Hydrothermal synthesis, for instance, has been explored extensively. It allows the controlled growth of C-dots from precursors in a sealed container under high pressure and temperature, producing C-dots with desirable water solubility and high quantum yields. While bottom-up methods can provide abundant and inexpensive precursors, environmentally friendly conditions, and simpler synthesis processes, they may result in C-dots with heterogeneous sizes and structures.

Despite the promise of C-dots, several challenges and limitations are associated with their synthesis. There are benefits and drawbacks to both top-down and bottom-up approaches. For example, top-down methods can yield uniform C-dots, but they may involve complex procedures and require specialized equipment. Bottom-up methods offer more control and flexibility, but they can result in heterogeneous products and may require careful optimization of synthesis conditions. The optimization of size control and uniformity, tuning of surface properties for solubility and applications, and development of large-scale production methods are some of the key challenges in C-dot synthesis that researchers are actively addressing.

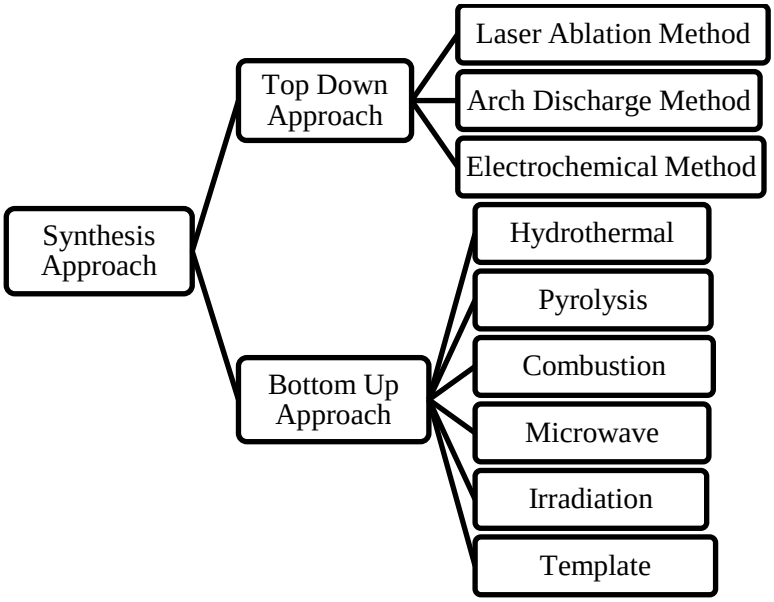

Fig. 3: Showing the synthesis approach of Carbon Dots

PROPERTIES OF CARBON DOTS

Carbon dots (CDs) are nanoscale carbon-based materials that possess a plethora of intriguing properties, rendering them highly sought-after for applications spanning biomedicine, electronics, and sensing. Summarizing the provided information, we can delve into their properties:

ABSORPTION PROPERTIES

1. CDs exhibit robust optical absorption in the ultraviolet (UV) region, extending into the visible spectrum.

2. Distinct absorption behaviors arise from factors such as preparation methods and oxygen content variation.
3. Absorption peaks are attributed to specific transitions, including $\pi-\pi^*$ transitions of C=C bonds and $n-\pi^*$ transitions of C=O bonds.
4. Notably, variations in carbon sources and synthetic routes induce different absorption behaviors.

PHOTOLUMINESCENCE (PL)

1. CDs radiate photoluminescence across a diverse range of colors encompassing UV, blue, green, yellow, red, and near-infrared (NIR).
2. PL emanates from intrinsic and defect state emissions, though the precise mechanism remains a subject of ongoing investigation.
3. The PL characteristics of CDs are primarily influenced by surface groups, π-conjugated domain size, and oxygen/nitrogen content.
4. Quantum yield (QY), which quantifies the efficiency of light emission, varies based on fabrication methods and surface chemistry.

PL DEPENDENCE ON SIZE AND D EXCITATION

1. A noteworthy property of CDs is their susceptibility to shifts in PL emission with alternating excitation wavelengths, facilitating multicolor bioimaging.
2. Notably, diverse CDs, despite disparities in morphology or surface groups, consistently exhibit excitation-dependent emission.
3. Significantly, CDs exhibiting narrow bandwidth emissions, an attribute crucial for applications in bioimaging and optoelectronic devices, have been successfully developed.
4. These advanced CDs, boasting full width at half maximum (FWHM) as narrow as 20−40nm, or even 20nm, have demonstrated potential utility in targeted applications.

ROOM TEMPERATURE AND PHOSPHORESCENCE (RTP)

1. The emerging field of room temperature phosphorescence (RTP) is notable in CDs due to the interplay of intersystem crossing (ISC) and radioactive transitions.
2. Noteworthy contributors to RTP include C=O and C=N moieties, along with heteroatom doping.
3. CDs exhibiting covalent frameworks, polymer chains, and supramolecular interactions present a unique property: the capacity for RTP.
4. The implications for RTP applications span diverse domains, from advanced security measures to enhanced bioimaging techniques.

ELECTROCHEMICAL PROPERTIES

1. Capitalizing on their unique electrochemical attributes, CDs have been harnessed for an array of applications.
2. Electrochemical behavior is influenced by factors such as size, functionalities, and heteroatom doping.
3. CDs have demonstrated the capacity to enhance supercapacitors electrodes and catalytic processes, contributing to advancements in energy storage and electro catalysis technologies.

FLUORESCENT PROPERTIES

1. Fluorescence is a defining property of CDs, grounded in mechanisms including the quantum size effect, surface defect states, and molecular states.
2. CDs manifest properties such as excitation-dependent and pH-dependent fluorescence, enabling versatile applications in fields like multicolor imaging and pH sensing.

3. Notably, CDs exhibit remarkable stability in solutions, defying chemical degradation over extended periods.
4. Additionally, their resistance to Photobleaching under ultraviolet (UV) light further solidifies their status as robust and reliable tools for scientific exploration and technological innovation.

In essence, the captivating properties of carbon dots, encompassing absorption, photoluminescence, electrochemical behavior, and fluorescence, have been meticulously scrutinized and fine-tuned to accommodate a diverse spectrum of applications. Their intrinsic stability, steadfast resistance to Photobleaching, and ability to unveil distinct attributes under varying conditions amplify their potential utility, whether in the realms of bioimaging, electrochemical devices, or photonics.

APPLICATION OF CARBON DOTS

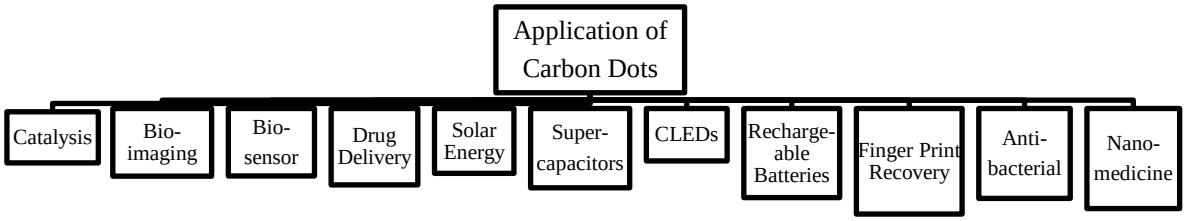

Fig. 4: Showing the applications of Carbon Dots

CATALYSIS

Due to their unique properties, carbon dots (CDs) have demonstrated promising applications in catalysis and photocatalysis. CDs with sizes below 10nm have shown efficient catalytic and photocatalytic capabilities. Their surface modifications allow them to absorb light across various wavelengths, making them suitable for photocatalytic applications. For instance, CDs have been used to modify TiO_2 composites, enhancing the photocatalytic hydrogen evolution under UV-Vis irradiation by improving the separation efficiency of electron-hole pairs. CDs also act as effective catalysts in various reactions. Kang and Li found that small-sized CDs (1-4nm) can catalyze the oxidation of benzyl alcohol to benzaldehyde under NIR light, benefiting from their photo-induced electron transfer ability. Larger CDs (5-10nm) have been demonstrated to generate protons under visible light, enabling catalysis of organic reactions like esterification, Beckmann rearrangement, and aldol condensation. Moreover, CDs functionalized with metal coatings, like gold or platinum, have been employed as photocatalysts for CO2 reduction and water splitting. The versatile nature of CDs makes them attractive candidates for harnessing solar energy for various catalytic processes, showing potential in environmental remediation and energy conversion applications.

BIOIMAGING

Bioimaging is a technique that enables real-time observation of biological processes without interfering with the specimen. Carbon quantum dots (CQDs) have gained attention for bioimaging due to their biocompatibility and fluorescence properties. They are used as fluorescent probes for various applications, including disease diagnosis and cellular imaging. CQDs offer advantages such as high photo stability, resistance to Photobleaching, and non-toxic behavior. The use of CQDs holds promise for advancing bioimaging techniques and improving our understanding of complex biological processes.

BIOSENSORS

Carbon quantum dots (CQDs) have found applications as versatile biosensors due to their unique properties, including excitation-dependent emission, high photo stability, low cytotoxicity, and strong

aqueous solubility. They are used for detecting various biological molecules and intracellular metal ions by monitoring changes in their fluorescence intensity. CQDs have been employed in bio sensing for substances like H_2O_2, Fe^{3+}, glucose, and more. Their fluorescence can be altered through different mechanisms such as resonance energy transfer and photo-induced charge transfer. For example, CQDs derived from different carbon sources, like glutamic acid or lactose, have been utilized to sense hydrogen peroxide (H_2O_2), iron ions (Fe^{3+}), glucose, and other compounds.

DRUG DELIVERY

Carbon quantum dots (CQDs) have demonstrated significant potential in drug delivery applications due to their biocompatibility, low toxicity, and small size. They serve as carriers for drug molecules, providing a nontoxic and biocompatible delivery platform. CQDs have been utilized for the delivery of various drugs, including anticancer agents like doxorubicin (DOX) and SN38. The advantage of using CQDs for drug delivery lies in their ability to be rapidly taken up by cells due to their small size and enhanced surface area. This facilitates efficient drug delivery with minimal adverse effects on the carrier molecule.

C-DOTS FOR SOLAR ENERGY

Carbon dots (C-dots) have garnered interest for their potential as photosensitizers in solar cells. They have been integrated into various types of solar cells, showing promise for enhanced photoelectric conversion efficiency. In dye-sensitized solar cells (DSSCs), C-dots act as co-sensitizers alongside dyes, facilitating energy level alignment and promoting charge separation and collection. C-dots have been employed in organic/inorganic hybrid solar cells, metal oxide-based solar cells, and perovskite solar cells, effectively enhancing light absorption, charge conduction, and electron extraction.

APPLICATION IN SUPERCAPACITORS AND LITHIUM-ION BATTERIES

C-dots have found application in supercapacitors and lithium-ion batteries (LIBs) due to their unique properties. In supercapacitors, C-dots integrated with aligned carbon nanotubes exhibit a capacitance improvement of over 200% through the formation of micropores that enhance ion transport and storage. C-dots combined with graphene and aerogel structures also achieve significant capacitance enhancement due to their high specific surface area. In micro-supercapacitors, C-dots decorated electrodes show exceptional rate capability and stability. In LIBs, C-dots coated on tri-axial nanowire arrays and VO_2 structures demonstrate improved Columbic efficiency, capability retention, and cycling stability.

CDS-BASED LIGHT-EMITTING DIODES (CLEDS).

Carbon dots (CDs) have gained attention as potential replacements for rare-earth phosphors and toxic metal-based quantum dots in LEDs. In phosphor-based LEDs, CDs are dispersed in matrix materials to prevent aggregation-induced quenching. For electroluminescent LEDs, CDs function as active emission layers. Significant progress has been made in multicolor and white LEDs using high-performance CDs.

RECHARGEABLE BATTERIES

In rechargeable batteries like Li, Na, or K ion batteries, carbon dots (CDs) play a crucial role in enhancing performance. CDs create favorable interfaces, increase active sites for ion insertion/extraction, improve stability, and enhance electron/ion transfer. Oxygen-functionalized CDs attract metal cations, leading to uniform solid electrolyte interphases in electrodes.

FINGER PRINT RECOVERY

Carbon quantum dots (CQDs) offer advantages in latent fingerprint visualization due to their small size and reactivity. CQDs can bind effectively to fingerprint ridges, unaffected by the aging of organic and

inorganic content. Methods involving CQDs embedded in polyvinyl alcohol (PVA) films or mixed with liquid PVA show detailed fingerprint images under UV light (395–400nm).

ANTIBACTERIAL

Carbon dots (CDs) exhibit promising antibacterial activity against viruses and bacteria. Amino-acid or boronic-acid-conjugated CDs hinder viral entry, while phenylboronic-acid-conjugated CDs combat highly infectious viruses like coronaviruses. CDs are effective against bacterial pathogens like E. coli, P. aeruginosa, and S. aureus. Fluorescently labeled CDs interact with bacterial cells, leading to fluorescence emission and cell wall destruction.

NANOMEDICINE

Carbon dots (CDs) exhibit therapeutic properties such as antibacterial, anticancer, antiviral, and antioxidant activities. Drug-CDPs, derived from drug molecules (e.g., metronidazole, gentamicin sulfate), retain pharmacophores and often outperform pristine drugs. They offer improved biocompatibility, solubility, and fluorescence, serving as bioimaging probes for theranostics.

CONCLUSION

Carbon dots, also referred to as Carbon Quantum dots, consist of a carbon network. These dots exhibit either amorphous or graphitic structures, incorporating diverse functional groups. Carbon dots are synthesized through two methods: the Top-down Approach and the Bottom-up Approach. Among these, the Bottom-up Approach is more cost-effective and environmentally friendly. Both chemical and biological materials serve as precursors in the synthesis of carbon dots. Due to their versatile optical properties, low toxicity, water solubility, biocompatibility, eco-friendliness, and straightforward and cost-effective synthesis route, carbon dots find applications in bio sensing, bioimaging, drug delivery, nanomedicine, light-emitting diodes, solar cells, and more. Carbon dots hold numerous other potential applications that remain unexplored. Therefore, further research is essential to unveil their potential applications.

REFERENCES

[1]. Jin Gao, Mengmeng Zhu, Hui Huang, Yang Liu and Zhenhui Kang (2017). Advances, Challenges and Promises of Carbon Dots, Inorganic Chemistry Frontiers, 1-17.

[2]. Caicheng Longa, Zixin Jianga, Jingfang Shangguanb, Taiping Qinga, Peng Zhanga, Bo Fenga, (2021). Applications of carbon dots in environmental pollution control: A review, Chemical Engineering Journal, 1-16.

[3]. Jumana Abdul Jaleel, K. Pramod, (2018). Artful and multifaceted applications of carbon dot in biomedicine, Journal of Controlled Release, 304-318.

[4]. Boyang Wang, Haoqiang Song, Xiaoli Qu, Junbiao Chang, Bai Yang, Siyu Lu (2021). Carbon dots as a new class of nanomedicines: Opportunities and challenges, Coordination Chemistry Reviews, 2-5.

[5]. Junjun Liu, Rui Li, and Bai Yang (2020). Carbon Dots: A New Type of Carbon-Based Nanomaterial with Wide Applications, ACS Central Science, 2180-2189.

[6]. Xingbo Shi, Wei, Zhaodi Fu, Wenli Gao, Chunyan Zhang, Qian Zhao, Fangming Deng, Xiangyang Lu (2018). Review on Carbon Dots in Food Safety Applications, Talanta, 5-10.

[7]. Derya Ozyurt, Mohammad Al Kobaisi, Rosalie K. Hocking, Bronwyn Fox (2023). Properties, synthesis, and applications of carbon dots: A review, Carbon Trends, 1-4.

[8]. Areeba Khayal, Vinars Dawane, Mohammed A. Amin, Vineet Tirth, Virendra Kumar Yadav, Ali Algahtani, Samreen Heena Khan, Saiful Islam, Krishna Kumar Yadav and Byong-Hun Jeon, (2021).

Advances in the Methods for the Synthesis of Carbon Dots and Their Emerging Applications, Polymers, 1-19.

[9]. Kuan-Wu Chu, Sher Ling Lee, Chi-Jung Chang, and Lingyun Liu, (2019). Recent Progress of Carbon Dot Precursors and Photocatalysis Applications, Polymers, 1-14.

[10]. Anirudh Sharma and Joydeep Das (2009). Small molecules derived carbon dots: synthesis and applications in sensing, catalysis, imaging, and biomedicine, Journal of Nanobiotechnology, 1-18.

[11]. Ingbo Shi, Wei, Zhaodi Fu, Wenli Gao, Chunyan Zhang, Qian Zhao, Fangming Deng, Xiangyang Lu (2018). Review on Carbon Dots in Food Safety Applications, Talanta, 14-16.

[12]. Derya Ozyurt, Mohammad Al Kobaisi, Rosalie K. Hocking, Bronwyn Fox (2023). Properties, synthesis, and applications of carbon dots: A review, Carbon Trends, 19-21.

[13]. Xiangcao Li, Shaojing Zhao, Baoling Li, Ke Yang, Minhuan Lan, Lintao Zeng,(2020). Advances and perspectives in carbon dot-based fluorescent probes: Mechanism, and application, Coordination Chemistry Reviews, 1-3.

[14]. Yadav, P.K., Chandra, S. Kumar, V; Kumar, D. Hasan, S.H. (2023). Carbon Quantum Dots Synthesis, Structure, Properties, and Catalytic Applications for Organic Synthesis. Catalysts 2023, 13, 422., 1-9.

Chapter 7

REVOLUTIONIZING MDR-ESBL TREATMENT: UNVEILING BREAKTHROUGH DRUG MARVELS

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ABSTRACT

Penicillin was first discovered by Alexander Fleming in 1945 laid the foundation for antibiotic therapy but also predicted the risk of antibiotic resistance. ESBLs, produced by certain bacteria, challenge antibiotic efficacy. Predictions came true with antibiotic misuse accelerating resistance. ESBLs, found in Enterobacteriaceae, pose severe clinical consequences. Combating ESBLs requires a multifaceted approach, including surveillance, stewardship, and new antibiotics. Breakthrough combinations like ceftazidime-avibactam, meropenem-vaborbactam, and aztreonam-avibactam offer hope. Nonetheless, continuous research and collaboration remain essential in this ever-evolving battle.

KEYWORDS: Penicillin, Enterobacteriaceae, ESBLs, Drug Marvels.

INTRODUCTION

In 1945 December, during his acceptance address for the Nobel Prize in Medicine, Alexander Fleming, the discoverer of penicillin, mentioned the risk of antibiotic resistance, stating that it is an expected occurrence that has already been demonstrated in lab settings:

"it's not difficult to make microbes resistant to penicillin in the laboratory by exposing them to concentrations not sufficient to kill them... there is the danger that the ignorant man may easily under-dose himself and, by exposing his microbes to non-lethal quantities of the drug, make them resistant." (A. Fleming, Penicillin, Nobel Lecture, 11 December 1945)

The forecast made by Fleming came true: Antibiotic misuse, and even outright abuse, accelerates the Bacterial emergence and distribution that are resistant to them (Terreni *et al.,* 2021)

Extended-Spectrum Beta-Lactamases (ESBLs) are bacteria-produced enzymes that give resistance to a wide spectrum of beta-lactam antibiotics, including penicillins, cephalosporins, and monobactams. These enzymes can hydrolyze the beta-lactam ring present in these antibiotics, rendering them ineffective against the bacteria that produce ESBLs.

ESBLs are often found in bacteria belonging to the Enterobacteriaceae family, which includes Escherichia coli and Klebsiella pneumoniae, among others. The production of ESBLs by these bacteria is a significant concern in healthcare settings because it can lead to infections that are difficult to treat due to antibiotic resistance (Mukherjee *et al.,* 2013)

In hospital settings where these bacteria might infect sensitive patients, like those in intensive care units, the effects of ESBL-mediated resistance are particularly disturbing. Other antibiotics, combination therapy, or stronger drugs like carbapenems may be the only effective treatments for ESBL-producing bacteria. Even still, bacteria that are resistant to carbapenem have appeared, necessitating additional study and the creation of novel antimicrobial strategies.

Numerous illnesses are brought on by these bacteria, including bloodstream infections, pneumonia infections at surgical sites, infections of the abdomen, endocarditis, infections in newborns, infections linked to catheter use, and infections in long-term care facilities. Due to their potential to resist antibiotics, the spread of ESBL-producing bacteria is a worry, highlighting the necessity of solid infection control procedures and judicious antibiotic usage (Ouchar Mahamat *et al.,* 2019)

IMPACT ON ANTIBIOTICS

ESBLs pose a formidable challenge to multiple classes of antibiotics. The antibiotics most affected by ESBLs include:

1. **PENICILLINS:** ESBLs can hydrolyze penicillins, such as ampicillin and amoxicillin, reducing their efficacy in treating infections caused by ESBL-producing bacteria.
2. **CEPHALOSPORINS:** Third-generation cephalosporins, like ceftriaxone and ceftazidime, are often inactivated by ESBLs, limiting treatment options for serious infections.
3. **MONOBACTAMS:** Aztreonam, a monobactam antibiotic, is typically unaffected by many beta-lactamases. However, ESBLs can hydrolyze aztreonam, rendering it ineffective against ESBL-producing bacteria.
4. **BETA-LACTAM/B-LACTAMASE INHIBITOR COMBINATIONS:** Some antibiotics combine a beta-lactam with a beta-lactamase inhibitor to overcome resistance. However, ESBLs can still outpace the inhibitor's action, leading to treatment failure (Pitout *et al.,* 2008)

CLINICAL IMPLICATIONS: The spread of ESBL-producing bacteria in healthcare settings and the community has significant clinical implications. Infections caused by these bacteria are associated with longer hospital stays, higher healthcare costs, and increased mortality rates. Moreover, the limited availability of effective antibiotics against ESBLs contributes to the overuse of broad-spectrum antibiotics, accelerating the development of further antibiotic resistance.

ADDRESSING THE THREAT POSED BY ESBLS REQUIRES A MULTIFACETED APPROACH:

1. Surveillance and Infection Control: Monitoring the prevalence of ESBLs and implementing strict infection control measures can help prevent their spread.
2. Antibiotic Stewardship: Responsible antibiotic use can help slow the development of ESBLs by minimizing the selection pressure for resistant strains.
3. New Antibiotics: Research and development of novel antibiotics with alternative mechanisms of action are crucial to counter the resistance developed by ESBL-producing bacteria.
4. Combination Therapy: Combining antibiotics with non-beta-lactam agents or other strategies can enhance treatment efficacy against ESBL-producing infections.

DETECTIONS METHODS USED:

CLINICAL MICROBIOLOGY TECHNIQUES:

- Several clinical microbiology procedures, including disc diffusion tests and dilution tests, are used to detect ESBLs.
- Disc diffusion tests entail the use of Disc diffusion method modifications, which are interpreted by expert clinical microbiologists.
- Dilution tests can be performed with or without an expanded-spectrum cephalosporin, clavulanic acid, or another -lactamase inhibitor.
- The NCCLS advises a first screening using a broth medium containing one of five extended-spectrums -lactam antibiotics, followed by a phenotypic confirmatory test to identify ceftazidime or cefotaxime MICs (Bradford 2001).

MOLECULAR DETECTION METHODS:

- Molecular methods, such as PCR with specific oligonucleotide primers, can be used to detect the presence of β-lactamase genes.
- The use of DNA probes, but notes that PCR is the easiest and most common molecular method.
- However, PCR may not discriminate between TEM and SHV-lactamases in various variants.
- Other molecular methods, such as the oligotyping method and additional oligonucleotide probes, have been developed to detect specific mutations within β-lactamase genes (Bradford., 2001).

DRUGS EFFECTIVE AGAINST ESBLS

Carbapenems, such as imipenem, meropenem, and ertapenem, have the most consistent anti-ESBL action. They are the medications of choice for severe infections caused by ESBLs. Cephamycins, such as cefoxitin and cephamycin, are likewise resistant to ESBL hydrolysis and can be used to treat ESBL producers. As long as there is no in vitro resistance, quinolones, such ciprofloxacin, can be beneficial for complex urinary tract infections caused by ESBL-producing pathogens. However, ESBL makers' rising in vitro resistance to quinolones may restrict their future relevance in therapy (Paterson *et al.,* 2005)

COMMON METHODS TO PREVENT SPREAD OF ESBL ASSOCIATED INFECTIONS:

1. **Hand Hygiene**: Regular hand hygiene practises, such as washing hands with soap and water or using alcohol-based hand sanitizers, are critical in limiting the spread of ESBL-producing bacteria. To avoid the transmission of illnesses, healthcare personnel and patients should be educated on the necessity of hand cleanliness (Allegranzi *et al.,* 2009)
2. **Contact Precautions**: Implementing contact precautions for patients colonized or infected with ESBL-producing bacteria is essential to prevent their spread within healthcare settings. This involves using gloves and gowns during patient care and ensuring proper disinfection of equipment and surfaces (Siegel *et al.,* 2007)
3. **Environmental Cleaning and Disinfection**: Cleaning and disinfecting patient care locations, equipment, and surfaces on a regular and thorough basis is critical to preventing the persistence and spread of ESBL-producing bacteria (Donskey, C, J., 2013)
4. **Antimicrobial Stewardship**: Antimicrobial stewardship programmes can help prevent antibiotic overuse and incorrect usage, which contribute to the development and spread of ESBL infections (Dellit *et al.,* 2007)
5. **Surveillance and Screening**: Routine surveillance and screening for ESBL colonisation in patients can aid in the identification of carriers and the implementation of suitable infection control measures to prevent the spread of ESBL-producing bacteria (Tacconelli *et al.,* 2009)

BREAKTHROUGH DRUG COMBINATIONS IN TREATMENT OF MDR-ESBL INFECTIONS

Ceftazidime-Avibactam: Ceftazidime-avibactam is a combination of a third-generation cephalosporin (ceftazidime) and a beta-lactamase inhibitor (avibactam). It has shown promise against MDR-ESBL-producing bacteria, particularly Enterobacteriaceae. Ceftazidime-avibactam is effective against a wide range of beta-lactamase enzymes, including some ESBLs (Livermore *et al.,* 2011)

Meropenem-Vaborbactam: Meropenem-vaborbactam is a combination of a carbapenem (meropenem) and a beta-lactamase inhibitor (vaborbactam). It is effective against certain ESBL-producing Enterobacteriaceae and some carbapenemase-producing bacteria (Motsch *et al.,* 2018)

Aztreonam-Avibactam: Aztreonam- Avibactam is a blend of antibiotics of the monobactam aztreonam and the beta-lactamase inhibitor avibactam. It has shown potential in the treatment of infections caused

by MDR-ESBL-producing bacteria, particularly those that co-produce other resistance mechanisms (Karlowsky *et al.*, 2018)

CONCLUSION

In the realm of combating Extended-Spectrum Beta-Lactamase with Multi-Drug Resistance (MDR-ESBL) infections, breakthrough drug combinations stand as remarkable innovations. These infections, marked by their resistance to conventional treatments, have spurred a quest for novel solutions. The synergy between established antibiotics and potent beta-lactamase inhibitors, exemplified by drugs like ceftazidime-avibactam, meropenem-vaborbactam, and aztreonam-avibactam, presents a beacon of hope. By targeting the mechanisms of antibiotic resistance, these pioneering combinations offer a renewed chance to tackle these formidable infections. Still, the dynamic nature of bacterial resistance necessitates ongoing research and collaboration across medical disciplines to adapt and refine these approaches. As science progresses, the emergence of such breakthroughs illuminates the path towards a future where MDR-ESBL infections might no longer pose insurmountable challenges, fostering optimism for patients and healthcare providers alike.

REFERENCES

[1]. Allegranzi, B., & Pittet, D. (2009). Role of hand hygiene in healthcare-associated infection prevention. The Journal of hospital infection, 73(4), 305–315. https://doi.org/10.1016/j.jhin.2009.04.019

[2]. Bradford, P. A. (2001). Extended-spectrum β-lactamases in the 21st century: characterization, epidemiology, and detection of this important resistance threat. Clinical Microbiology Reviews, 14(4), 933-951.

[3]. Dellit, T. H., Owens, R. C., McGowan Jr, J. E., Gerding, D. N., Weinstein, R. A., Burke, J. P. (2007). Infectious Diseases Society of America, and the Society for Healthcare Epidemiology of America.. Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clinical Infectious Diseases, 44(2), 159-177.

[4]. Donskey C. J. (2013). Does improving surface cleaning and disinfection reduce health care-associated infections? American journal of infection control, 41(5 Suppl), S12–S19. https://doi.org/10.1016/j.ajic.2012.12.010

[5]. Karlowsky, J. A., Lob, S. H., Kazmierczak, K. M., Badal, R. E., Young, K., Motyl, M. R., & Sahm, D. F. (2018). In vitro activity of aztreonam-avibactam against an international collection of carbapenem-resistant Enterobacteriaceae and Pseudomonas aeruginosa from 2012 to 2016. Antimicrobial Agents and Chemotherapy, 62(9), e01706-17.

[6]. Livermore, D. M., Mushtaq, S., Warner, M., Vickers, A., Woodford, N. (2011). Activity of aminoglycosides, including ACHN-490, against carbapenem-resistant Enterobacteriaceae isolates. Journal of Antimicrobial Chemotherapy, 66(1), 48-53.

[7]. Motsch, J., Murta de Oliveira, C., Stus, V., Köksal, I., Lyulko, O., Boucher, H. W., & Lob, S. H. (2018). RESTORE-IMI 1: a multicenter, randomized, double-blind trial comparing efficacy and safety of imipenem/relebactam vs colistin plus imipenem in patients with imipenem-nonsusceptible bacterial infections. Clinical Infectious Diseases, 66(2), 163-171.

[8]. Mukherjee, M., Basu, S., Mukherjee, S. K., & Majumder, M. (2013). Multidrug-Resistance and Extended Spectrum Beta-Lactamase Production in Uropathogenic E. Coli which were Isolated from

Hospitalized Patients in Kolkata, India. Journal of clinical and diagnostic research: JCDR, 7(3), 449–453. https://doi.org/10.7860/JCDR/2013/4990.2796

[9]. Ouchar Mahamat, O., Lounnas, M., Hide, M., Dumont, Y., Tidjani, A., Kamougam, K., Abderrahmane, M., Benavides, J., Solassol, J., Bañuls, A. L., jean-Pierre, H., Carrière, C., & Godreuil, S. (2019, February 28). High prevalence and characterization of extended-spectrum ß-lactamase producing Enterobacteriaceae in Chadian hospitals. BMC Infectious Diseases, 19(1). https://doi.org/10.1186/s12879-019-3838-1

[10]. Paterson, D. L., & Bonomo, R. A. (2005). Extended-spectrum β-lactamases: a clinical update. Clinical Microbiology Reviews, 18(4), 657-686.

[11]. Pitout, J. D., & Laupland, K. B. (2008). Extended-spectrum β-lactamase-producing Enterobacteriaceae: an emerging public-health concern. The Lancet Infectious Diseases, 8(3), 159–166. doi:10.1016/s1473-3099(08)70041-0

[12]. Siegel, J. D., Rhinehart, E., Jackson, M., Chiarello, L., & Healthcare Infection Control Practices Advisory Committee. (2007). 2007 Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. American Journal of Infection Control, 35(10 Suppl 2), S65-S164.

[13]. Tacconelli, E., Cataldo, M. A. (2009). Vancomycin Group of the European Society of Clinical Microbiology and Infectious Diseases. Infection control and antimicrobial stewardship to limit transmission of resistant Gram-negative microorganisms in hospitals. Clinical Microbiology and Infection, 15(1), 14-19.

[14]. Terreni, M., Taccani, M., & Pregnolato, M. (2021). New Antibiotics for Multidrug-Resistant Bacterial Strains: Latest Research Developments and Future Perspectives. Molecules, 26(9), 2671. https://doi.org/10.3390/molecules26092671

Chapter

8

STORAGE PRACTICES AND MYCOTOXIN PREVENTION IN BAKERY PRODUCTS

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ABSTRACT

Mycotoxins are toxic compounds produced by certain molds and fungi that can grow on various types of crops and food products, including bakery items. This chapter provides information on storage practices and mycotoxin prevention in bakery products. It discusses the assessment of storage areas, storage requirements for different bakery products, temperature and humidity control, airtight packaging, cleaning and sanitation, pest control, and emerging technologies for mycotoxin prevention. It also highlights the importance of temperature control, freezing, refrigeration, and packaging materials in maintaining the quality and safety of bakery items. The information emphasizes the need for proper storage practices to prevent mold growth, mycotoxin contamination, spoilage, and other issues that can affect product integrity. Emerging technologies for mycotoxin prevention in bakery products include smart sensors and IoT devices for real-time monitoring, block chain and traceability solutions for transparent tracking, rapid detection kits for quick mycotoxin level detection, high-resolution imaging and machine vision for identifying contamination, predictive analytics and AI for proactive measures, and atmosphere modification techniques like modified atmosphere packaging.

KEYWORDS: Mycotoxins, Storage practices, Prevention.

INTRODUCTION

Mycotoxins are toxic compounds produced by certain molds and fungi that can grow on various types of crops and food products, including bakery items. These toxic substances pose significant health risks to both humans and animals when consumed in even small amounts. Mycotoxins can contaminate raw ingredients used in bakery products during cultivation, harvest, transportation, and storage, leading to potential health hazards. Mycotoxins are produced by molds such as Aspergillus, Penicillium, and Fusarium species. These molds thrive in conditions of high humidity, warmth, and inadequate storage practices. Mycotoxin production is influenced by factors like temperature, moisture content, and exposure to light. In the context of bakery products, several mycotoxins are of particular concern:

AFLATOXINS: Produced primarily by Aspergillus species, aflatoxins are highly potent carcinogens. They can contaminate grains, nuts, and other raw ingredients used in bakery goods.

OCHRATOXIN A: Produced by various Penicillium and Aspergillus species, this mycotoxin is associated with kidney damage and is found in cereal-based products like bread.

DEOXYNIVALENOL (DON): Also known as vomitoxin, DON is produced by Fusarium molds and can contaminate grains like wheat, affecting the quality of flour and baked goods.

ZEARALENONE: Another mycotoxin produced by Fusarium species, zearalenone can affect reproduction and is sometimes found in grain-based products.

FUMONISINS: These mycotoxins are produced by Fusarium molds and can contaminate maize (corn) products used in baking. They are associated with various health issues.

Mycotoxin Contamination in Bakery Products

Several common mycotoxins can be found in bakery items, originating from various sources, including raw ingredients, processing, and storage. Understanding these mycotoxins and their sources is essential for effective mycotoxin management in bakery products. For example,

Aflatoxins are primarily produced by Aspergillus species, including Aspergillus flavus and Aspergillus parasiticus. They commonly grow on nuts, such as peanuts and tree nuts, which are often used in bakery products like pastries and cakes. Aflatoxins are potent carcinogens and can also cause acute health effects. They are heat-stable and can persist in baked goods if the raw ingredients are contaminated.

Ochratoxin A is produced by molds like Aspergillus and Penicillium. It can contaminate cereal grains, including wheat and barley, which are used in bread and other baked goods. Ochratoxin A is associated with kidney damage and has been found in various cereal-based products, including bread.

DON is produced by Fusarium molds, commonly found on cereal crops such as wheat, barley, and corn. These grains are used to make flours for bakery products. DON can cause vomiting, reduced feed intake in animals, and can lead to economic losses due to reduced grain quality.

Zearalenone is also produced by Fusarium molds and can contaminate grains like wheat, barley, and corn. Zearalenone can have estrogenic effects and affect reproduction in animals. While not as well-studied as other mycotoxins, its presence in bakery ingredients is a concern.

Fumonisins are produced by Fusarium molds, commonly found in corn (maize) and corn-based products. Cornmeal and corn-based flours are used in various bakery products. Fumonisins are associated with various health effects, including neural tube defects in animals. They are heat-stable and can persist through baking.

Patulin is produced by Penicillium and Aspergillus molds. It can be found in fruits, particularly apples, and can end up in bakery products containing apple ingredients, such as pies and pastries. Patulin can have adverse effects on the respiratory and immune systems, but its impact on human health is still being studied.

It's important to note that mycotoxin contamination in bakery products can vary widely based on factors such as geographic location, weather conditions, storage practices, and more. Manufacturers of bakery items need to be aware of potential mycotoxin sources in their ingredients and implement appropriate measures to minimize contamination, ensuring the safety and quality of their products.

Fungal growth and mycotoxin production are heavily influenced by specific environmental conditions. Molds that produce mycotoxins thrive in conditions that provide them with the necessary nutrients, temperature, humidity, and other factors for growth and toxin production. The key environmental conditions that favor fungal growth and mycotoxin production are temperature, humidity, substrate availability, oxygen availability, pH level, light exposure, air flow and ventilation, Nutrient availability.

Packaging materials play a significant role in moisture control for bakery products and other food items. The right packaging can help maintain optimal moisture levels, extend shelf life, and prevent mold growth and mycotoxin formation.

STORAGE PRACTICES IN THE BAKERY INDUSTRY

Storage practices in the bakery sector are crucial for maintaining the quality, safety, and freshness of baked goods. Proper storage helps prevent mold growth, mycotoxin formation, spoilage, and other issues that can affect product integrity. Here's an overview of common storage practices employed in the bakery

sector:

- **Temperature Control:**
  Temperature is a critical factor in preventing microbial growth and maintaining product quality. Baked goods are often stored in cool, dry areas to minimize the risk of mold development and extend shelf life.
- **Freezing:**
  Freezing is a widely used method to extend the shelf life of bakery products. Properly packaged and sealed items can be frozen and later thawed for consumption without significant loss of quality.
- **Refrigeration:**
  Refrigeration is suitable for bakery items with shorter shelf lives. It helps slow down microbial growth and delays staleness. However, some products, like bread, can lose moisture and become stale in refrigerated conditions.
- **Humidity Control:**
  Maintaining proper humidity levels is crucial to prevent moisture-related issues. Excessive humidity can lead to mold growth, while low humidity can cause baked goods to become dry and lose quality.
- **Airtight Packaging:**
  Airtight packaging prevents moisture from entering the product and helps maintain freshness. It is essential for preventing mold growth and mycotoxin contamination.
- **Hygiene and Cleanliness:**
  Storage areas should be clean and free from contaminants. Regular cleaning prevents cross-contamination and reduces the risk of mold and bacterial growth.
- **Rotation and First-In-First-Out (FIFO):**
  Adopting FIFO principles ensure that older products are used or sold first, reducing the risk of products becoming stale or expired.
- **Separation and Organization:**
  Properly organizing and separating products prevents physical contamination and helps maintain product quality. Baked goods should be stored away from cleaning chemicals, raw ingredients, and other potential contaminants.
- **Product Packaging:**
  Proper packaging prevents exposure to air, moisture, and light. Packaging materials with suitable barrier properties contribute to product freshness and quality.
- **Storage Duration:**
  Each baked product has a recommended shelf life based on its composition and preservation methods. Monitoring and adhering to these guidelines is essential for maintaining safety and quality.
- **Quality Checks:**
  Regular inspections of stored bakery items help identify any signs of spoilage, mold growth, or other issues that could affect the quality of the products.
- **Temperature and Humidity Monitoring:**
  Using temperature and humidity monitoring devices in storage areas helps maintain optimal conditions and alerts staff if conditions become unfavorable.
- **Pest Control:**
  Effective pest control practices, such as sealing entry points and regular pest inspections, prevent infestations that can contaminate bakery products.

- **Training and Education:**
  Proper training for staff on storage protocols, hygiene practices, and product handling is essential for maintaining product quality and safety.

By implementing these common storage practices, bakeries can ensure that their products remain fresh, safe, and of high quality, reducing the risk of issues such as mycotoxin contamination and mold growth.

BEST PRACTICES FOR MYCOTOXIN PREVENTION

Implementing effective storage practices in a bakery involves a systematic approach to ensure the quality, safety, and shelf life of baked goods. Here are step-by-step guidelines for implementing such practices:

- **Assessment of storage area**: Evaluate the storage area's layout, capacity, ventilation, temperature control, and proximity to potential contaminants.
- **Identify storage requirements**: Determine the storage needs for different types of bakery products, considering factors like temperature sensitivity, shelf life, and packaging requirements.
- **Segregation and organization**: Categorize baked goods based on type, shelf life, and packaging. Store items in a well-organized manner to facilitate easy access and rotation.
- **Temperature and humidity control**: Set optimal temperature and humidity ranges for the storage area based on the bakery items being stored.
- **Airtight Packaging**: Package bakery items in suitable, airtight containers or packaging materials to prevent moisture ingress, which can lead to mold growth.
- **Cleaning and sanitation:** Establish regular cleaning schedules to maintain a clean and hygienic storage environment. Remove crumbs, debris, and spills promptly to prevent pest attraction and mold growth.
- **Pest control**: Implement effective pest control measures, including sealing entry points, using traps, and conducting regular inspections.

EMERGING TECHNOLOGIES FOR MYCOTOXIN PREVENTION

Emerging technologies are playing a significant role in advancing mycotoxin prevention strategies in the food industry, including bakery products. These technologies offer innovative ways to detect, monitor, and mitigate mycotoxin contamination risks. Here are some emerging technologies for mycotoxin prevention:

- **Smart Sensors and Internet of Things (IoT) Devices:**
  Smart sensors and IoT devices can be integrated into storage areas and packaging to monitor temperature, humidity, and other environmental factors in real time. Alerts can be sent to operators if conditions deviate from safe ranges, allowing for immediate corrective actions.
- **Block chain and Traceability Solutions:**
  Block chain technology can enhance traceability along the supply chain, allowing for transparent tracking of ingredients' journey from farm to bakery. This can help identify and address potential mycotoxin contamination sources more effectively.
- **Rapid Detection Kits:**
  Rapid detection kits based on advanced immunoassay or biosensor technologies can quickly detect mycotoxin levels in raw ingredients and finished products. These kits provide on-the-spot results, enabling timely decisions to be made.
- **High-Resolution Imaging and Machine Vision:**
  High-resolution imaging and machine vision technologies can be used to identify mold growth or signs of contamination on bakery products. These systems can catch issues that might not be visible to

the naked eye.

- **Predictive Analytics and Artificial Intelligence (AI):**
  AI algorithms can analyze various data inputs, such as environmental conditions, storage practices, and historical data, to predict the likelihood of mycotoxin contamination. This allows for proactive measures to be taken before issues arise.
- **Atmosphere Modification Techniques:**
  Modified atmosphere packaging (MAP) involves altering the composition of gases within packaging to control microbial growth. It can be effective in reducing mold growth and mycotoxin production in bakery products.

CONCLUSION

In conclusion, mycotoxin contamination poses serious risks to the safety and quality of bakery products. Understanding the sources, impacts, and prevention strategies associated with mycotoxins is crucial for ensuring the production of safe and wholesome bakery products.

REFERENCES

[1]. Abdel-Wahhab MA, Abdel-Galil MM, El-Lithey M. (2005). Melatonin counteracts oxidative stress in rats fed an ochratoxin A contaminated diet. J. Pineal Res. 38:130–135.

[2]. Abrunhosa L, Ines A, Rodrigues AI, Guimaraes A, Pereira VL, Parpot P, Venancio A. (2014). Biodegradation of ochratoxin A by Pediococcus parvulus isolated from Douro wines. Int. J. Food Microbio. 188: 45–52.

[3]. Abrunhosa L, Paterson RR, Venancio A. (2010). Biodegradation of ochratoxin A for food and feed decontamination. Toxins. 2:1078–1099.

[4]. Alberts JF, Gelderblom WCA, Botha A, van Zyl WH. (2009). Degradation of aflatoxin B1 by fungal laccase enzymes. Int J Food Microbiol. 135:47–52.

[5]. Ananthi V, Subramanian RS, Arun A. (2016). Detoxification of Aflatoxin B1 using Lactic acid bacteria. Int. J. Biosci. Technol. 9:40.

[6]. Assaf J C, Nahle S, Chokr A, Louka N, Atoui A, El Khoury A. (2019). Assorted methods for decontamination of aflatoxin M1 in Milk using microbial adsorbents. Toxins. 11:304

[7]. Ashiq S. (2015). Natural occurrence of mycotoxins in food and feed: Pakistan perspective. Compr. Rev. Food Sci. Food Saf. 14:159–175.

[8]. Assaf CEH, De Clercq N, Van Poucke C, Vlaemynck G, Van Coillie E, Van Pamel E. (2019). Effects of ascorbic acid on patulin in aqueous solution and in cloudy apple juice. Mycotoxin Res. 35:341–351.

[9]. Belal J, Muhialdin, Nazamid saari, Anis Shobirin Meor Hussin. (2020). Review on the Biological Detoxification of Mycotoxins Using Lactic Acid Bacteria to Enhance the Sustainability of Foods Supply. Molecules. 25:1-12.

[10]. Ben Taheur F, Kouidhi B, Al Qurashi YMA, Ben Salah-Abbes J, Chaieb K. (2019). Review: biotechnology of mycotoxins detoxification using microorganisms and enzymes. Toxicon. 160:12–22.

[11]. Bennett JW, Klich M. (2003). Mycotoxins. Clin. Microbiol. Rev. 16:497–516.

[12]. Boevre M, Mavungu JD, Landshchoot S, Audenaert K, Eeckhout M, Maene P. (2012). Natural occurrence of mycotoxins and their masked forms in food and feed products. World Mycotoxin J. 5:207–219.

[13]. Corassin CH, Bovo F, Rosim RE, Oliveira CAFF. (2013). Efficiency of Saccharomyces cerevisiae and lactic acid bacteria strains to bind aflatoxin M1 in UHT skim milk. Food Control. 31:80–83.

[14]. Chapot-Chartier MP, Kulakauskas S. (2014). Cell wall structure and function in lactic acid bacteria. Microb. Cell Fact.13: S9.

[15]. Dimosthenis Kizis, Aikaterini-Eleni Vichou, Pantelis I, Natskoulis. (2021). Recent Advances in Mycotoxin Analysis and Detection of Mycotoxigenic Fungi in Grapes and Derived Products. Sustainability. 13:1-26.

[16]. El-Nezami H, Kankaanpaa P, Salminen S, Ahokas J. (1998). Ability of dairy strains of lactic acid bacteria to bind a common food carcinogen, aflatoxin B1. Food Chem. Toxicol. 36:321–326.

[17]. Elsanhoty RM, Salam SA, Ramadan MF, Badr FH. (2014). Detoxification of aflatoxin M1 in yoghurt using probiotics and lactic acid bacteria. Food Control. 43:129–134.

[18]. Fandohan P, Zoumenou D, Hounhouigan DJ, Marasas WFO, Wingfeld MJ, Hell K. (2005). Fate of aflatoxins and fumonisins during the processing of maize into food products in Benin. Int J Food Microbiol. 98:249– 259.

[19]. Franco TS, Garcia S, Hirooka EY, Ono YS, Dos Santos JS. (2011). Lactic acid bacteria in the inhibition of Fusarium graminearum and deoxynivalenol detoxification. J. Appl. Microbiol. 111:739–748.

[20]. Fuchs S, Sontag G, Stidl R, Ehrlich V, Kundi M, Knasmuller S. (2008). Detoxification of patulin and ochratoxin A, two abundant mycotoxins, by lactic acid bacteria. Food Chem. Toxicol. 46:1398–1407.

[21]. Gomaa EZ, Abdelall MF, El-Mahdy OM. (2018). Detoxification of aflatoxin B1 by antifungal compounds from *Lactobacillus brevis* and *Lactobacillus paracasei*, isolated from dairy products. Probiotics Antimicrob. Proteins. 10:201–209.

[22]. Gruber-Dorninger C, Faas J, Doupovec B, Aleschko M, Stoiber C, Hobartner-Gußl A. (2021). Metabolism of Zearalenone in the rumen of dairy cows with and without application of a Zearalenone-degrading enzyme. Toxins. 13:1–18.

[23]. Guan S, Yin Y, Zhou T, Xie M, Ruan Z, Young JC. (2011). Microbial strategies to control aflatoxins in food and feed. World Mycotoxin J. 4:413-24.

[24]. Guan Y, Chen J, Nepovimova E, Long M, Wu W, Kuca K. (2021). Aflatoxin detoxification using microorganisms and enzymes. Toxins. 13:1–17.

[25]. Hahn I, Kunz-Vekiru E, Twaruzek M, Grajewski J, Krska R, Berthiller F. (2015). Aerobic and anaerobic in vitro testing of feed additives claiming to detoxify deoxynivalenol and zearalenone. Food Addit Contam - Part A Chem Anal Control Expo Risk Assess.32:922–933.

[26]. Harrison M A, (1989). Presence and stability of patulin in apple products: A review. J. Food Saf. 9: 147–153.

[27]. Hatab S, Yue T, Mohamad O. (2012). Removal of patulin from apple juice using inactivated lactic acid bacteria. J. Appl. Microbiol. 112:892–899.

[28]. Hathout AS, Aly SE. (2014). Biological detoxifcation of mycotoxins: A review. Ann Microbiol. 64:905–919.

[29]. He JW., Bondy GS, Zhou T, Caldwell D, Boland GJ, Scott P M. (2015). Toxicology of 3-epi-deoxynivalenol, a deoxynivalenol-transformation product by Devosia mutans 17–2-E-8. Food Chem. Toxicol. 84:250–259.

[30]. Heinl S, Hartinger D, Thamhesl M, Schatzmayr G, Moll W D, Grabherr R. (2011). An aminotransferase from bacterium ATCC 55552 deaminates hydrolyzed fumonisin B1. Biodegradation. 22:25–30.

Chapter 9

ACTINOMYCETES AS PRODUCERS OF NOVEL ANTIBIOTICS

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ABSTRACT

Actinomycetes have long been recognized as prolific producers of novel antibiotics, revolutionizing medicine and microbiology. This chapter provides an overview of the traditional and modern methods employed in the discovery of these antibiotics from actinomycetes. Traditional methods involve the isolation and cultivation of actinomycete strains, followed by screening for antimicrobial activity, bioassay-guided fractionation, and structure determination. Modern methods, on the other hand, utilize advanced techniques such as genome mining, metagenomics, high-throughput screening, expression of silent gene clusters, and synthetic biology and metabolic engineering. These methods enable the identification and characterization of bioactive compounds, leading to the discovery of new antibiotics. The combination of traditional and modern approaches offers promising avenues for combating antibiotic resistance and addressing contemporary challenges in the field.

KEYWORDS: Actinomycetes, Antibiotics, discovery, Bioassay-guided fractionation, Structure determination, Genome mining, Metagenomics, High-throughput screening, Expression of silent gene clusters, Synthetic biology, Metabolic engineering, Bioactive compounds, Antibiotic resistance.

INTRODUCTION

Actinomycetes, a diverse group of filamentous bacteria, have been a prolific source of antibiotics that have revolutionized medicine and shaped the field of microbiology. This comprehensive review explores the fascinating world of actinomycetes as producers of novel antibiotics. We delve into their historical significance, the discovery of iconic antibiotics, their unique physiological and genetic characteristics, and their potential to address contemporary challenges in antibiotic resistance. These microorganisms have garnered significant attention due to their prolific contribution to the field of medicine and their role in shaping our understanding of microbial ecology and secondary metabolite production. The significance of actinomycetes in antibiotic discovery dates back to the early 20th century. In 1928, Alexander Fleming's discovery of penicillin from the mold Penicillium marked the beginning of the antibiotic era. However, it was later realized that a substantial number of antibiotics with diverse chemical structures and biological activities were produced by actinomycetes.

Actinomycetes are widely distributed in various terrestrial and aquatic environments, but they are particularly abundant in soil. This diversity of habitats has led to the discovery of a plethora of actinomycete species, each potentially capable of producing unique bioactive compounds. Actinomycetes have been the primary source of many antibiotics that have transformed medicine. Notable examples include streptomycin, tetracycline, erythromycin, chloramphenicol, Vancomycin, and neomycin, among others. These antibiotics have been instrumental in treating bacterial infections, extending human life expectancy, and revolutionizing medical practices. Actinomycetes produce antibiotics and other bioactive

compounds as part of their secondary metabolism. These metabolites often have roles in competition, defense, and communication within their ecological niches. The remarkable diversity of these metabolites has led to the exploration of actinomycetes for potential therapeutic applications. The physiological characteristics of actinomycetes contribute to their ability to produce antibiotics. They exhibit a complex life cycle, transitioning from vegetative growth to sporulation, during which they often produce antibiotics. The filamentous growth pattern, coupled with the formation of aerial mycelia and spore-bearing structures, provides a conducive environment for secondary metabolite synthesis. The antibiotics derived from actinomycetes have not only been crucial in treating bacterial infections but also served as lead compounds for the development of semisynthetic derivatives and entirely new classes of drugs. Their impact extends to agriculture, where some antibiotics are used as crop protection agents.

FACTORS INFLUENCING THE DIVERSITY AND DISTRIBUTION OF ANTIBIOTIC-PRODUCING ACTINOMYCETES

The diversity and distribution of antibiotic-producing actinomycetes are influenced by a combination of ecological, environmental, genetic, and physiological factors. Understanding these factors can provide insights into the complex interactions that shape the microbial communities and their potential for producing bioactive compounds.

HABITAT AND MICROBIAL ECOLOGY

Different habitats, such as soil, marine environments, and extreme habitats, have distinct physicochemical conditions that influence the types of actinomycetes present.

Microbial interactions, including competition and cooperation, play a role in shaping actinomycete communities. Competition for resources may influence the production of antibiotics as a means of ecological defense.

- **Soil Type and Composition:**

Soil characteristics, such as pH, organic matter content, moisture, and nutrient availability, impact the types of actinomycetes that can thrive. Certain actinomycetes are adapted to specific soil conditions.

Soil biodiversity and the presence of other microorganisms can affect actinomycete populations. Complex microbial interactions can influence antibiotic production.

- **Climate and Geographic Location:**

Climate factors such as temperature and humidity influence microbial communities. Actinomycete diversity can vary across different geographical regions and climatic zones.

Specific geographical locations may harbor unique actinomycete species due to isolation and local adaptation.

- **Host-Microbe Interactions:**

Actinomycetes can have symbiotic relationships with plants, insects, and other organisms. These interactions can influence antibiotic production and diversity.

The presence of actinomycetes in the micro biomes of animals and humans can impact host health and contribute to antibiotic resistance dynamics.

- **Nutrient Availability and Competition:**

Actinomycetes often produce antibiotics as a competitive strategy to gain an advantage in resource utilization. Nutrient availability and competition influence the need for antibiotic production.

Competition with other microorganisms for nutrients and space can drive the evolution of antibiotic production in actinomycetes.

- **Sampling and Detection Methods:**

The methods used to sample and detect actinomycetes can influence the perception of their diversity and distribution. Some species might be overlooked due to limitations in sampling techniques.

Understanding these factors requires a multidisciplinary approach that combines microbial ecology, genetics, physiology, and environmental science. Research in this area not only sheds light on the fundamental aspects of microbial life but also has implications for biotechnology, drug discovery, and ecosystem health.

Screening techniques, culture optimization, and isolation of rare strains are crucial steps in the process of discovering novel antibiotics from actinomycetes. These steps help researchers identify strains with unique bioactive compounds and optimize their production for further study. Here's an overview of these aspects:

SCREENING TECHNIQUES

- **Primary Screening:**

Test crude extracts or culture supernatants against panels of pathogenic bacteria, fungi, or other microorganisms using agar diffusion or well diffusion assays. Observe zones of inhibition to identify strains with antimicrobial activity.

- **Secondary Screening:**

Further characterize active strains using more specific assays to determine the spectrum of activity, minimum inhibitory concentrations (MICs), and potential mechanisms of action. Assess the selectivity of the compounds against different strains.

- **High-Throughput Screening (HTS):**

Automate the screening process to quickly assess large libraries of strains or compounds for antimicrobial activity. Use robotics and micro plate readers to streamline the process.

- **Bioassay-Guided Fractionation:**

Isolate active compounds through successive fractionation steps. Perform repeated bioassays to guide the purification process and isolate the active component.

- **Culture Optimization:**

- **Medium Composition:**

Design culture media that mimic natural conditions to induce antibiotic production. Modify nutrient composition, pH, and growth factors to optimize secondary metabolite production.

- **Co-Culturing:**

Encourage interactions between actinomycetes and other microorganisms to induce secondary metabolite production. Mimic natural ecological relationships that might enhance antibiotic production.

- **Stress Induction:**

Manipulate environmental conditions, such as nutrient limitation, temperature shifts, or oxidative stress, to stimulate antibiotic production. Stress-induced responses often trigger secondary metabolite biosynthesis.

- **Fermentation Strategies:**

Optimize fermentation parameters such as agitation, aeration, and temperature to enhance biomass and antibiotic yield. Use batch, fed-batch, or continuous fermentation approaches.

ISOLATION OF RARE STRAINS:

- **Selective Isolation Techniques:**

Use selective media containing specific nutrients, pH levels, or antibiotics to isolate rare or slow-growing actinomycetes. These techniques promote the growth of target strains while inhibiting the growth of others.

- **Single-Spore Isolation:**

Isolate individual spores from sporulated cultures to obtain pure cultures of rare strains. Single-spore isolation ensures genetic and phenotypic uniformity.

- **Genomic Screening:**

Use genomic information to identify strains with unique biosynthetic gene clusters. Target strains that harbor unexplored genetic potential for antibiotic production.

TRADITIONAL AND MODERN METHODS FOR DISCOVERING NOVEL ANTIBIOTICS FROM ACTINOMYCETES

The discovery of novel antibiotics from actinomycetes involves a combination of traditional and modern methods, each contributing to the identification and characterization of bioactive compounds. These methods encompass various stages, from sample collection to compound isolation and characterization.

TRADITIONAL METHODS:

- **Isolation and Cultivation:**

Collect soil or environmental samples rich in actinomycetes. Isolate individual actinomycete strains using selective media. Culture strains under various conditions to induce antibiotic production.

- **Screening:**

Extract secondary metabolites from culture broth using organic solvents. Test crude extracts against panels of pathogenic bacteria, fungi, or other microorganisms. Identify strains that exhibit antimicrobial activity.

- **Bioassay-Guided Fractionation:**

Isolate active fractions from crude extracts using chromatographic techniques.
Perform repeated bioassays to narrow down and purify the active compounds.

- **Structure Determination:**

Characterize the purified compound's chemical structure using techniques like NMR, mass spectrometry, and X-ray crystallography. Relate the compound's structure to its bioactivity.

MODERN METHODS:

- **Genome Mining:**

Sequence the genomes of actinomycete strains to identify potential biosynthetic gene clusters responsible for antibiotic production.
Use bioinformatics tools to predict the types of compounds these clusters might produce.

- **Metagenomics:**

Extract DNA directly from environmental samples to access the genetic potential of unculturable actinomycetes. Analyze metagenomic data to identify biosynthetic gene clusters and predict novel compounds.

- **High-Throughput Screening (HTS):**

Automate the process of culturing, extracting, and testing actinomycete strains for antimicrobial activity. Screen large libraries of compounds for bioactivity against various pathogens.

- **Expression of Silent Gene Clusters:**

Manipulate actinomycete cultures or genomes to activate silent biosynthetic gene clusters. Identify and characterize novel compounds produced by these activated clusters.

- **Synthetic Biology and Metabolic Engineering:**

Engineer actinomycetes to enhance production of known antibiotics or to produce new compounds. Introduce foreign genes or modify regulatory elements to optimize production pathways.

- **Omics Technologies:**

Employ transcriptomics, proteomics, and metabolomics to understand gene expression and metabolic changes during antibiotic production. Identify potential regulatory elements and pathways related to antibiotic synthesis.

- **Bioinformatics and Machine Learning:**

Predict antibiotic potential by analyzing genetic and chemical data. Utilize machine learning algorithms to predict novel bioactive compounds based on existing data.

The combination of traditional and modern methods accelerates the discovery process, allowing researchers to explore the vast diversity of actinomycetes and their potential for producing antibiotics. These methods contribute to the identification of new bioactive compounds, the optimization of production, and the development of solutions to combat antibiotic resistance.

CONCLUSION

Actinomycetes stand as remarkable producers of novel antibiotics, playing a pivotal role in reshaping medicine, microbiology, and biotechnology. The extensive contributions of these filamentous bacteria have led to groundbreaking discoveries that have saved countless lives, paved the way for new therapeutic strategies, and expanded our understanding of microbial ecology and secondary metabolite production. Through their historical significance, actinomycetes have sparked the antibiotic era with the discovery of iconic compounds such as streptomycin, tetracycline, and erythromycin. These antibiotics have not only transformed the treatment of bacterial infections but have also spurred advances in various scientific disciplines.

The rich diversity and habitats of actinomycetes have unveiled a treasure trove of bioactive compounds. From the soil to extreme environments, these microorganisms have thrived in diverse niches, yielding antibiotics with potent antimicrobial properties. The interplay between ecological factors, genetics, and environmental conditions has contributed to the complexity of the secondary metabolite landscape.

Advances in genomics, metagenomics, and synthetic biology have revolutionized the way we explore actinomycetes' potential. Genome mining techniques enable the discovery of silent gene clusters, leading to the identification of previously unexplored antibiotics. Moreover, metabolic engineering and synthetic biology approaches allow researchers to optimize antibiotic production and even engineer strains to produce entirely new compounds.

In an era of antibiotic resistance, actinomycetes continue to offer hope. Their ability to produce novel antibiotics, some with distinct modes of action, holds promise for combating multidrug-resistant pathogens. These compounds may provide alternatives when traditional antibiotics falter.

However, challenges persist. The rediscovery of known compounds, the cultivation of previously unculturable strains, and the sustainable use of natural resources demand ongoing attention. Ethical considerations, responsible antibiotic stewardship, and conservation efforts are integral components of harnessing actinomycetes potential.

REFERENCES

[1]. Abdelmohsen, U. R., Bayer, K., & Hentschel, U. (2014). Diversity, abundance and natural products of marine sponge-associated actinomycetes. Natural product reports, 31(3), 381-399.

[2]. Al-Shaibani, M. M., Radin Mohamed, R. M. S., Sidik, N. M., Enshasy, H. A. E., Al-Gheethi, A., Noman, E. & Zin, N. M. (2021). Biodiversity of secondary metabolites compounds isolated from phylum actinobacteria and its therapeutic applications. Molecules, 26(15), 4504.

[3]. Amin, D. H., Abdallah, N. A., Abolmaaty, A., Tolba, S., & Wellington, E. M. (2020). Microbiological and molecular insights on rare Actinobacteria harboring bioactive prospective. Bulletin of the National Research Centre, 44(1), 1-12.

[4]. Balachandran, C., Duraipandiyan, V., Emi, N., & Ignacimuthu, S. (2015). Antimicrobial and cytotoxic properties of Streptomyces sp. (ERINLG-51) isolated from Southern Western Ghats. South Indian J. Biol. Sci, 1(714), 5.

[5]. Berdy, J. (2005). Bioactive microbial metabolites. The Journal of antibiotics, 58(1), 1-26.

[6]. Bull, A. T., Stach, J. E., Ward, A. C., & Goodfellow, M. (2005). Marine actinobacteria: perspectives, challenges, future directions. Antonie Van Leeuwenhoek, 87, 65-79.

[7]. Chakraborty, B., Kumar, R. S., Almansour, A. I., Gunasekaran, P., & Nayaka, S. (2022). Bioprospection and secondary metabolites profiling of marine Streptomyces levis strain KS46. Saudi Journal of Biological Sciences, 29(2), 667-679.

[8]. Dhakal, D., Pokhrel, A. R., Shrestha, B., & Sohng, J. K. (2017). Marine rare actinobacteria: isolation, characterization, and strategies for harnessing bioactive compounds. Frontiers in Microbiology, 8, 1106.

[9]. Farrelly, V., Rainey, F. A., & Stackebrandt, E. (1995). Effect of genome size and rrn gene copy number on PCR amplification of 16S rRNA genes from a mixture of bacterial species. Applied and environmental microbiology, 61(7), 2798-2801.

[10]. Feling, R. H., Buchanan, G. O., Mincer, T. J., Kauffman, C. A., Jensen, P. R., & Fenical, W. (2003). Salinosporamide A: a highly cytotoxic proteasome inhibitor from a novel microbial source, a marine bacterium of the new genus Salinospora. Angewandte Chemie International Edition, 42(3), 355-357.

[11]. Fenical, W., & Jensen, P. R. (2006). Developing a new resource for drug discovery: marine actinomycete bacteria. Nature chemical biology, 2(12), 666-673.

[12]. Goodfellow, M., & Haynes, J. A. (1984). Actinomycetes in marine sediments. Biological, biochemical and biomedical aspects of actinomycetes, 453-472.

[13]. Han, S. K., Nedashkovskaya, O. I., Mikhailov, V. V., Kim, S. B., & Bae, K. S. (2003). Salinibacterium amurskyense gen. nov., sp. nov., a novel genus of the family Microbacteriaceae from the marine environment. International journal of systematic and evolutionary microbiology, 53(6), 2061-2066.

[14]. Heald, S. C., Brandão, P. F., Hardicre, R., & Bull, A. T. (2001). Physiology, biochemistry and taxonomy of deep-sea nitrile metabolising Rhodococcus strains. Antonie van Leeuwenhoek, 80, 169-183.

[15]. Helmke, E., & Weyland, H. (1984). Rhodococcus marinonascens sp. nov., an actinomycete from the sea. International Journal of Systematic and Evolutionary Microbiology, 34(2), 127-138.

[16]. Jensen, P. R., Mincer, T. J., Williams, P. G., & Fenical, W. (2005). Marine actinomycete diversity and natural product discovery. Antonie Van Leeuwenhoek, 87, 43-48.

[17]. Karuppiah, P., & Mustaffa, M. (2013). Antibacterial and antioxidant activities of Musa sp. leaf extracts against multidrug resistant clinical pathogens causing nosocomial infection. Asian Pacific journal of tropical biomedicine, 3(9), 737-742.

[18]. Lam, K. S. (2006). Discovery of novel metabolites from marine actinomycetes. Current opinion in microbiology, 9(3), 245-251.

[19]. Miethke, M., Pieroni, M., Weber, T., Bronstrup, M., Hammann, P., Halby, L. & Müller, R. (2021). Towards the sustainable discovery and development of new antibiotics. Nature Reviews Chemistry, 5(10), 726-749.

[20]. Nesterenko, O. A., Nogina, T. M., Kasumova, S. A., Kvasnikov, E. I., & Batrakov, S. G. (1982). Rhodococcus luteus nom. nov. and Rhodococcus maris nom. nov. International Journal of Systematic and Evolutionary Microbiology, 32(1), 1-14.

[21]. Rainey, F. A., Burghardt, J., Kroppenstedt, R. M., Klatte, S., & Stackebrandt, E. (1995). Phylogenetic analysis of the genera Rbodococcus and Nocardia and evidence for the evolutionary origin of the genus Nocardia from within the radiation of Rbodococcus species. Microbiology, 141(2), 523-528.

[22]. Rashad, F. M., Fathy, H. M., El-Zayat, A. S., & Elghonaimy, A. M. (2015). Isolation and characterization of multifunctional Streptomyces species with antimicrobial, nematicidal and phytohormone activities from marine environments in Egypt. Microbiological research, 175, 34-47.

[23]. Rifaat, H. M. (2003). The biodiversity of actinomycetes in the river Nile exhibiting antifungal activity. Journal of Mediterranean Ecology, 4, 5-8.

Chapter 10

NUTRITIVE STATUS OF MEDICINAL PLANTS

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ABSTRACT

Plants are the good source of medicines and play an important role in the lives of rural people, especially in the remote parts of developing countries providing health benefits as well as an income generating source. Plants are the local heritage with global significance. Whole world is furnished with a rich wealth of plants.A large number of plants have been provide essential nutritional value, medicinal properties and a remarkable effect to human life for thousands of years. This chapter includes qualitative and quantitative analysis of nutrients present in vegetables, pulses, cereals & millets and fruits. All above mentioned vegetables, pulses, cereals & millets and fruits are traditionally edible in most of the countries of the world. As all these are the richest source of nutrients like carbohydrates, proteins, fat. Minerals and vitamins. A large number of phytochemicals, antioxidants, phytonutrients are also found in these vegetables, pulses, cereals & millets and fruits, which have been shown to reduce the risk of cancer, heart diseases, stoke, diabetes, Alzheimer's and Parkinson's disease. Hence, daily consumption of these fruits and vegetables may pose little to no health risk because all of them content high medicinal properties. Here we want to motivate the people towards herbal medicines as already these are meet us in our daily diet.

KEYWORDS: Medicines, local heritage, nutritional value, phytochemicals, antioxidants, phytonutrients, Alzheimer's and Parkinson 's disease.

INTRODUCTION

Plants are the good source of medicines and play an important role in the lives of rural people, especially in the remote parts of developing countries providing health benefits as well as an income generating source. Plants are the local heritage with global significance. Whole world is furnished with a rich wealth of plants. A large number of plants have been providing essential nutritional value, medicinal properties and a remarkable effect to human life for thousands of years. Even today 80% people still rely mainly on traditional medicines such as herbs. Herbal medicines are currently in demand and their popularity increase day by day.

WHAT IS MEDICINAL PLANT?

A medicinal plant is any plant which contains substances that can be used for therapeutic purposes. Medicinal plants are plants used with the intention health maintenance, to be administered for a few specific conditions, or both, whether in traditional medicine or in modern medicine (Ahn, 2017; Smith-Hall *et al.,* 2012). Food and Agriculture Organization (2002) of theUN estimated that more than 50,000 medicinal plants are used all over the world (Schippmann *et al.,* 2002). The Royal Botanic Gardens, Kew (2016) estimated that 17,810 plant species have medicinal use.

TRADITIONAL SYSTEMS OF MEDICINES:

The fact cannot be denied the traditional system of medicines have served the humanity for the treatment and management of diseases as well as maintenance of good health. The traditional Chinese medicine in

China, Ayurveda system in India, Unani system in Greece, Amachi in Tibet or more recently Homeopathy in Germany are the systems of medicines which were once practiced only in the respective areas or sub-continent of the world, but now a days these are popularly practiced all over the world. In all above traditional system of medicines the medicinal plants or medicinal herbs play crucial role in the traditional medicines. It is said that India has a rich heritage of traditional medicine and the traditional healthcare system have been flourishing for many centuries. Over the centuries, ayurvedic practitioners developed a large number of medicinal preparations and surgical procedures for the treatment of various ailments and diseases.

WHAT IS NUTRITION?

Nutrition is the process of taking in food and converting it into energy and other important nutrients essential for life. Nutrients are the type of substances that provide the necessary energy and biomolecules for performing various types of functions in our body. Each and every organism on the earth needs sufficient amount of nutrients for growth and development, but they show difference how they fulfill their demand. Some of the animals feed on organic compounds to fulfill their need of nutrient while others depend on complex compounds.

There are forty different kinds of nutrients in food and they can generally classified into seven groups such as carbohydrates, proteins, fats, vitamins, minerals, dietary fibers and water. All these nutrients perform different kinds of functions in our body. They are all essential because they work together and contribute to our better health. The main functions of these nutrients are given below:

CARBOHYDRATES:

Carbohydrates are a major source of energy of our body, and they come mainly from grains, such as wheat, rice, sorghum, pearl millet, coconut, noodles, etc.

PROTEINS:

Besides meat, fish, seafood, eggs, dairy products, peanuts, mustard, lentils dry beans and bean products are also a good source of protein. Its major functions include building, repairing and maintaining healthy body tissues.

FATS:

Fats can be found in foods such as meat, fish, seafood, dairy products, nuts, seeds and oils. Fats serve as an energy source. They prevent heat loss in extreme cold weather and protect organs against shock. They are responsible for making up part of our body cells and transporting fat-soluble vitamins such as vitamin A, D, E and K.

VITAMINS:

There are many kinds of vitamins from various food groups and they participate in different body metabolism such as maintaining healthy skin and hair, building bones and releasing and utilizing energy from foods. Vitamins can be classified into water-soluble and fat-soluble vitamins.

MINERALS:

Minerals are a group of essential nutrients which regulate many body functions such as fluid balance, muscle contraction and transmission of nerve impulses. Some minerals also contribute to body structure and build strong and healthy bones, such as calcium, iron and potassium.

DIETARY FIBER:

Dietary fiber is the indigestible part found in plant. It helps to maintain blood sugar, promote gastrointestinal health and prevent constipation. Dietary fiber can be classified into soluble and insoluble fiber.

WATER:

Water is the most abundant substance in human body and is also an essential nutrient to maintain our health. The major functions of water include regulation of body temperature, production of body fluids, transportation of nutrients and removal of waste products.

NUTRITIVE MEDICINAL PLANTS:

Plants are very essential for human's daily life requirements such as, food, shelter, clothe and therapeutic purposes. People in rural areas have mostly preferred herbal medicines for the treatments of various diseases, because these medicines are widely available in that regions and having no or less side effects. The majority of the people in the rural areas took interest in natural medications derived from plants and their use. Natural plant derived products are widely used in medications, nutritional supplements and a variety of healthcare products. Medicinal plant possesses essential food components such as carbohydrates, proteins and fats. These components play an important role in different physiological, metabolic and various morphological activities. Besides these components, medicinal plants include a variety of physiologically active compounds such as nutrients, minerals, vitamins, phytochemicals, etc. These phytochemicals are natural, bioactive substances found in plant foods, act as a natural defense system.

According to ayurvedic medicine, there are numerous herbs which have been used historically for treating the numerous ailments. There is no such sharp difference between food and medicines in Ayurveda and many herbs are taken as a part of our meal. The nutritive values of some vegetables, fruits, pulses and cereals and millets are given below, which vary from variety to variety. A general analysis is mentioned below.

Table1. Qualitative and quantitative analysis of nutrients present in different Vegetables

Sr. No.	Common Name	Botanical Name	Family	Quantitative Analysis (per 100g of edible portion)			Qualitative Analysis	
				Total Carbohydrates	Proteins	Total Fats	Minerals	Vitamins
1	Alfalfa sprout	*Medicago sativa*	Fabaceae	2.1g	3.99mg	0.69mg	Mn,Cu,P,Mg,Zn,Fe	Vit.A,Vit.B_1,B_2,B_9,Vit.C,Vit.K
2	Asparagus	*Asparagus officinalis*	Liliaceae	3.88g	2.2g	0.12g	K,P,Fe,Mg,Na	Vit.A,Vit.B_9,Vit.C,Vit.E,Vit.K
3	Basil	*Ocimum basilicum*	Lamiaceae	2.7g	3.2g	0.6g	Fe,Mg,Ca,Na,K,Mn	Vit.A,Vit.B_6Vit.C,Vit.D,Vit.K
4	Beet	*Beta vulgaris*	Amaranthaceae	9.56g	1.61g	0.17g	Ca,Fe,Mg,P,K,Na,Zn,Cu,Mn	Vit.B_3,B_5,B_6,B_9,Vit.C
4	Bell peppers	*Capsicum annum*	Solanaceae	4.64g	0.86g	0.17g	K,Fe,Mg,Na	Vit.AVit.B_6,B_9,Vit.C,Vit.E,Vit.K
5	Black Mustard	*Brassica nigra*	Brassicaceae	29g	26g	36g	Ca,Fe,Mg,P,Na,Zn	Vit.A,Vit.B_1,B_2,B_3,B_6,B_9,Vit.C, Vit.E,Vit.K

6	Bitter Gourd	*Momordicac harantia*	Cucurbitaceae	7g	3.6g	0.2g	Na,K,Fe,Ca,Cu,Mg, Mn,Zn	Vit.A,Vit.B_1,B_2,B_3,B_6,B_9,Vit.C,
7	Bottle Gourd	*Lagenaria siceraria*	Cucurbitaceae	2.5g	0.2g	0.1g	Ca,Fe,Mg,K,P,Na,Zn	Vit.B_1,B_2,B_3,B_6, Vit.C,
8	Broccoli	*Brassica oleracea*	Brassicaceae	3.2g	4.3g	0.6g	Ca,Fe,Mg,K,P,Na,Zn	Vit.A,Vit.B_1,B_2,B_3,B_6,B_9,Vit.C,Vit.D,Vit.E,Vit.K
9	Carrot	*Daucus carota*	Apiaceae	9.6g	0.9g	0.2g	Mg,K,Ca,P,Mg,Zn,Mn	Vit.A, Vit.B_1, B_2,B_3, B_5,B6,B_9,Vit.C, Vit.E,Vit.K
10	Cauliflower	*Brassica oleraceavar.botrytis*	Brassicaceae	4.97g	1.92g	0.28g	Ca,Fe,Mg,K,P,Na,Zn	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C,Vit.E,Vit.K
11	Cucumber	*Cucumis sativa*	Cucurbitaceae	3.63g	0.65g	0.11g	Na,Mg,K,Ca,P,Mg,Zn,Mn,Fe	Vit.A,Vit.B_1,B_2,B_3,B_6,Vit.C,Vit.D,Vit.E,Vit.K
12	Drumstick	*Moringa oleifera*	Moringaceae	8.53g	2.1g	0.2g	Fe,Na,K,Ca,Cu,Mg, Mn,Se,Zn,	Vit.A,Vit.B_1,B_2,B_3, B_5,B_6,B_9, B_{12},Vit.C,Vit.D
13	Garlic	*Allium sativum*	Amaryllidaceae	33.06g	6.36g	0.5g	Ca,Cu,Fe,Mg,P,K,Se, Zn	Vit.A,Vit.B_1,B_2,B_3,B_6, B_9,Vit.C,
14	Green pea	*Pisum sativum*	Fabaceae	15.6g	5.42g	0.2g	Ca,Co,Fe,Mg,Mn,Se, Zn	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C,Vit.E,Vit.K
15	Lady's Finger	*Abeimoschus esculentus*	Malvaceae	7.45g	1.93g	0.19g	Ca,Fe,P,K,Na,Mg	Vit.B_1,B_2,B_6,B_9,Vit.C,
16	Onion	*Allium cepa*	Amaryllidaceae	9g	1.1g	0g	K,Ca,Mg,P,Fe	Vit.B_6,B_9,Vit.C,Vit.E
17	Peanut	*Arachis hypogaea*	Fabaceae	16g	26g	49g	Co,Mg.Mn,P,	Vit.B_1,B_3,B_7,B_9,Vit.E,
18	Potato	*Solanum tuberosum*	Solanaceae	17.49g	2.05g	0.09g	Ca,Fe, Mg,P, K,Na,Mn	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C,Vit.K
19	Pumpkin	*Cucurbita moschata*	Cucurbitaceae	3.4g	1.2g	0.2g	Fe,Mg, P,K,Na, Mn,Zn	Vit.A,Vit.B_1,B_2,B_3,B_6,B_9,Vit.C, Vit.E,
20	Radish	*Raphanus sativus*	Cruciferae	3.4g	0.68g	0.1g	Ca,Fe, Mg,P, K,Na	Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C
21	Seaweeds	*Ulva lactuca*	Ulvaceae	64.2g	12.9g	1.2g	Na,ca,pVit.K,Fe,Mn, Zn,co	Vit.A,Vit.B_1,B_2, B_3

22	Spinach	*Spenacia oleracea*	Amaranthaceae	3.6g	2.9g	0.4g	Fe,Ca,Mg,Na,Zn,K,P ,Mn,Cu	Vit.A, Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C,Vit.E,Vit.K
23	Sweet potato	*Ipomoea batatas*	Convolvulacea e	20g	1.6g	0.1g	K,Fe,Ca,Mg,P,Na,Se	Vit.A, Vit. B_9,Vit.C, Vit.K
24	Tomato	*Solanum lycopersicum*	Solanaceae	3.9g	0.9g	0.2g	Ca,P,Cu,Mn,Fe,Na,	Vit.A,Vit.B_1,B_2,B_3, B_6,B_9,Vit.C,Vit.E,Vit.K
25	Turnip	*Brassica rapa L.*	Brassicaceae	6g	0.9g	0.1g	Mn,Ca,K,Cu,Mg,SeZ n	Vit.A, it.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C,Vit.K

Table 2: Qualitative and quantitative analysis of nutrients present in different Pulses

Sr. No.	Common Name	Botanical Name	Family	Quantitative Analysis (per 100g of edible portion)			Qualitative Analysis	
				Total Carbohydrates	Proteins	Total Fats	Minerals	Vitamins
1	Bambara beans	*Vigna subterranea*	Fabaceae	21.8g	7.4g	2.4g	Mn,K,F,Mg,Ca,P,Z n,Fe,Cu	Vit.B_3, B_9,Vit.C,Vit.D
2	Black gram	*Vigna mungo*	Fabaceae	58.99g	25.21g	1.64g	Ca,Cu,Fe,Mg,P,Zn	Vit.A, Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C
3	Chick peas	*Cicer arietinum*	Fabaceae	27.4g	8.9g	2.6g	Ca,Fe,Mg,P,K,Na,Z n,Cu,Mn,Se	Vit.A,Vit.B_1,B_2,B_3,B_6,B_9,Vit.C,Vi t.D,Vit.E,Vit.K
4	Cowpeas	*Vigna unguiculata*	Fabaceae	20.8g	7.7g	0.5g	Ca,Fe,Mg,P,K,Na,S e,Zn	Vit.A, Vit.B_1,B_2,B_3,B_6,Vit.C,Vit.E
5	Dry beans	*Phaseolus vulgaris*	Fabaceae	13.33g	4.07g	0.29g	Ca,Fe,Mg,P,K,Na,S e,Zn	Vit.B_1, B_6,B_9,Vit.C,Vit.K
6	Fava beans	*Vicia faba*	Fabaceae	19.7g	7.6g	0.4g	Ca,Fe,Mg,P,Na,K,N a,Zn	Vit.A,Vit.B_3,B_9,Vit.C,Vit.K
7	Green gram	*Vigna radiata*	Fabaceae	5.9g	3g	0.2g	Mn,Mg,P,Fe,Cu,K, Zn	Vit.A,Vit.B_1,B_5,Vit.C,
8	Pigeon peas	*Cajanus cajan*	Fabaceae	23.2g	6.8g	0.4g	Na,K,Ca,Cu,P,Se,Z n,Fe	Vit.A, Vit.B_1,B_2,B_3,B_6,B_9,Vit.C

Table 3: Qualitative and quantitative analysis of nutrients present in different Cereals and Millets

Sr. No.	Common Name	Botanical Name	Family	Quantitative Analysis (per 100g of edible portion)			Qualitative Analysis	
				Total Carbohydrates	Proteins	Total Fats	Minerals	Vitamins
1	Barley	*Hordeum vulgare*	Poaceae	28.2g	2.3g	0.4g	Fe,Ca,Na,K,Se,Zn	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.E,Vit.K
2	Corn	*Zea mays*	Poaceae	41g	5.4g	2.1g	Fe,Mg,P,K,Zn,Cu, Mn,Se	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.E
3	Oat	*Avena sativa*	Poaceae	60g	16.9g	6.9g	Fe,Mg, Ca,Mn,P,S,Co,Se	Vit.B_1,B_3,B_5,B_6,B_9,
4	Pearl millet	*Pennisetum glaucum*	Poaceae	61.78g	10.96g	5.43g	Ca,Mg,Fe,P,K,Na,Zn	Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.K
5	Quinoa	*Chenopodium quinoa Wild.*	Amaranthaceae	21g	4g	2g	Ca,K,Se,Mg,P,Mn,Zn,Cu	Vit.A,Vit.B_1,B_2,B_3,B_9,Vit.E,Vit.K
6	Rice	*Oryza sativa*	Poaceae	79g	7.13g	0.66g	Fe,Ca,PK,Mn	Vit.B_1,B_2,B_5,B_6,B_9,
7	Sorghum	*Sorghum bicolor*	Poaceae	72g	11g	3.5g	Ca,Fe,Zn,Mn,Na,P, K	Vit.A,Vit.B_1,B_2,B_3,B_9,Vit.C,
8	Wheat	*Triticum aestivum*	Poaceae	74.1g	12g	1.3g	Cu,Ca,F,Fe,Mg,Mn, P,K,Se,na,zn	Vit.A,Vit.B_1,B_2,B_3,B_5,Vit.E,Vit.K

Table 4: Qualitative and quantitative analysis of nutrients present in different Fruits

Sr. No.	Common Name	Botanical Name	Family	Quantitative Analysis (per 100g of edible portion)			Qualitative Analysis	
				Total Carbohydrates	Proteins	Total Fats	Minerals	Vitamins
1	Acid lime	*Citrus aurantifolia*	Rutaceae	9g	1.1g	0.3g	Ca,Fe,Mg,K,P,Na,Zn,Cu,Mn,Se	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,B_{12}, Vit.C,Vit.D,Vit.E,Vit.K
2	Amla	*Phyllanthus emblica*	Phyllanthaceae	10.18g	0.88g	0.58g	Ca,Fe,Mg,Mn,P,K,Na,Zn	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C,Vit.E
3	Apple	*Malus domestica*	Rosaceae	13.84g	0.3g	0.2g	Na,Fe,Ca,P,K	Vit.B_9,Vit.C,
4	Apricot	*Prunus armeniaca*	Rosaceae	11g	1.4g	0.49g	Na,Ca,Fe,Mg,Mn,K,P,Se,Zn	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,Vit.C,Vit.D,Vit.E,Vit.K
5	Banana	*Musa paradisiaca*	Musaceae	22.8g	1.1g	0.3g	K,Mn,Ca,Fe,Mg,Cu,Na,Zn	Vit.A,Vit.B_5,B_6,B_9,Vit.E
6	Black Berry	*Rubus frutisosus*	Rosaceae	11.24g	0.87g	0.54g	Mn,Mg,K,Ca,Fe,Cu,Se,Zn	Vit.A,Vit.B_1,B_3,B_5,B_6,B_9,Vit.C, Vit.E,Vit.K
7	Cherry	*Prunus Savium*	Rosaceae	12g	1g	0.3g	Ca,K,P,Mg,Fe	Vit.A, Vit.C,Vit.K
8	Coconut	*Cocos nucifera*	Arecaceae	92.6g	1.62g	0g	Ca,K,P,Na,Fe,Cu,Mn,Se	Vit.A, Vit.B_1,B_2,B_3,B_5,B_6,B_9, Vit.C,Vit.E,Vit.K
9	Custard Apple	*Annona squamosa*	Annonaceae	23.6g	2.1g	0g	Ca,P,Fe,Mg,Na	Vit.A, Vit.B_1,B_2,B_3,Vit.C,
10	Date	*Phoenix dactylifera*	Arecaceae	74.97g	1.81g	0.15g	Ca,Cu,Fe,Mg,Mn,Zn,P.K	Vit.B_1,B_2,B_3,B_5,B_6,B_9, Vit.C,
11	Fig	*Ficus carica*	Moraceae	66.16g	3.14g	0.52g	Na,K,Ca,Fe	Vit.A, Vit.B_3,B_6, Vit.C,
12	Grapes	*Vitis vinifera*	Vitaceae	17.39g	0.72g	0.72g	Mn,K,Ca,P,Fe,Mg	Vit.B_1,B_2,Vit.C,Vit.K

13	Guava	*Psidium guajava L.*	Myrtaceae	14.32g	2.55g	0.95g	Mg,K,P,Mn	VitB_3,B_5,B_6,B_{12},Vit.C
14	Kiwifruit	*Actinidia deliciosa*	Actinidiaceae	15g	1.1g	0.5g	Na,K,Ca,Cu,Fe, Mg,MnP,Se,Zn	Vit.A,Vit.B_1,B_2,B_3,B_5,B_6,B_9,B_{12}, Vit.C,Vit.D,Vit.E,Vit.K
15	Litchi	*Litchi chinensis Sonn.*	Sapindaceae	16.53g	0.83g	0.44g	Na,K,Ca,Cu,Fe, Mg,MnP,Se,Zn	Vit.B_1,B_2,B_3,B5,B_6,B_9,Vit.C,Vit .E,Vit.K
16	Mango	*Mangifera indica*	Anacardiaceae	16.9g	0.6g	0.4g	Cu,K,Na,P,Ca,F e,	Vit.A,Vit.B_6, Vit.C,Vit.E,Vit.K
17	Muskmelon	*Cucumis melo*	Cucurbitaceae	8.2g	0.8g	0.2g	Fe,Mn,K,Na	Vit.B_6,Vit.C,
18	Orange	*Citrus sinensis*	Rutaceae	11.7g	0.9g	0.1g	Ca,K,Fe,Mg	Vit.B_9,Vit.C,
19	Papaya	*Carica papaya*	Caricaceae	7.2g	0.61g	0.14g	Ca, Mg, K	Vit.A,Vit.B_5,B_9,Vit.C,Vit.E
20	Peach	*Prunus persica L.*	Rosaceae	9.9g	0.9g	0.3g	Na,K,Fe,Ca,	Vit.C,Vit.K
21	Pear	*Pyrus communis L.*	Rosaceae	11g	0g	0g	Ca,K,P,Fe, Mg,Mn,Zn,Cu	Vit.A,Vit.B_1,B_2,B_3,B_6, B_9,Vit.C,Vit.D,Vit.E,Vit.K
22	Pineapple	*Ananas comosus*	Bromeliaceae	13.1g	0.5g	0.1g	Mg,Mn,K,Cu,Ca ,Zn,Cr,Cl,Fe	Vit.A,Vit.B_1,B_2,B_3,B_7,B_9,B_{12},Vi t.C,Vit.D,Vit.E,Vit.K
23	Pomegranate	*Punica granatum*	Lythraceae	18.70g	1.67g	1.17g	Mg,Fe,Ca,K,Na	Vit.B_6, B12,Vit.C,Vit.D
24	Strawberry	*Fragaria ananassa*	Rosaceae	7.68g	0.67g	0.3g	Na,K,Ca,P,Fe,M n	VitB_3,B_6,B_9,Vit.C
25	Watermelon	*Citrullus lanatus*	Cucurbitaceae	7.6g	0.61g	0.15g	Na,K,Ca,Cu,Fe, Mg,Mn,Zn	Vit.A,Vit.B_1,B_2,B_3,B_6,B_{12},Vit.C ,Vit.D,Vit.E,Vit.K

CONCLUSION

All above mentioned vegetables, pulses, cereals & millets and friuts are traditionally edible in most of the countries of the world. As all these are the richest soutce of nutriets like carbohydrates, proteins, fat. s, minerals and vitamins. A large number of phtochemicals, antioxidants, phytonutrients are also found in these vegetables, pulses, cereals & millets and friuts, which have been shown to reduce the risk of cancer, heart diseases, stoke, diabetes, Alzheimer's and parkinson's disease. Hence, daily consumption of these fruits and vegetables may pose little to no health risk brcause all of them content high medicinal properties. Here we want to motivate the people towards herbal medicines as alreadty these are meet us in our daoly diet.

REFERENCES

[1]. Anonymous (1987) "Medicinal Plants of India" Vol. 2 ICMR, New Delhi, India.

[2]. Ahn, K. (2017). "The worldwide trend of using botanical drugs and strategies for developing global drugs". BMB Reports. 50 (3): 111–116. doi:10.5483/BMBRep.2017.50.3.221.

[3]. Awuchi, Godswill C. (2019) "Medicinal Plants: The Medical Food and Nutritional Biochemistry and Uses", Int. Jou. Advanced Academic Rese. Science, Technology, Engineering. ISSN No. 2488 9849

[4]. Bharti P. K., Khan A. A., Rathoure A. K. (2018) "Nutraceuticals and Pharmaceuticals from Medicinal plants" by Discovery Publishing house Pvt. Ltd., India. ISBN. 978-93-86841-55-1

[5]. Bhaskar P. (2011) "Encyclopedia of Ayurvedic Medicinal Plants" by Mangalam Publications, Delhi. ISBN. 978-93-81142-04-2

[6]. Choudhary B. (1983) "Vegetable" by National Book Trust, India. ISBN. 81-237-1677-X

[7]. Dev S. (2006) "A Selection of Prime Ayurvedic Plant Drugs Ancient-Modern Concordance" by Manish Sejwal for Anamaya Publishers New Delhi, India. ISBN. 81-88342-35-1

[8]. Nehra N. (2013) "Medicinal Plants - Chemistry and Properties" Avishkar Publishers, Distributors, Jaipur, Rajasthan, India. ISBN. 978-81-7910-439-2

[9]. Prakash J. (2017) "Medicinal and Aromatic plants Multitherapeutic Uses" Swastik Publications, New Delhi, India. ISBN. 978-93-83762-29-3

[10]. Solowara A., Oganbodede E., Onayade A. (2013) "The Role and Place of Medicinal Plants in the Strategies for Disease Prevention" African Jou. of Traditional, Complementary and Alternative Med. 10(5) 210-229.

[11]. Smith-Hall, C.; Larsen, H.O.; Pouliot, M. (2012). "People, plants and health: a conceptual framework for assessing changes in medicinal plant consumption". J EthnobiolEthnomed. 8: 43. Doi: 10.1186/1746-4269-8-43.

[12]. Schippmann, Uwe; Leeman, Danna J.; Cunningham, A. B. (2002). "Impact of Cultivation and

[13]. Gathering of Medicinal Plants on Inter-Departmental Working Group on Biological Diversity for Food and Agriculture. Rome. Food and Agriculture Organization.

Chapter 11

A PROMISING APPROACH OF ZINC OXIDE NANOPARTICLES IN WATER TREATMENT

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ABSTRACT

The biological synthesis of nanoparticles (NP) has attracted over traditional physical and chemical synthesis process. The metal and metal oxide nanoparticles are synthesized effectively using biological entities such as bacteria, algae, fungi. The biological method is eco-friendly. The zinc oxide (ZnO) nanoparticles show great interest due to its unique characteristics. ZnO is recognized as a best antibacterial agent owing to its stability under unfavorable conditions and it's safe for humans. In this present study the ZnO nanoparticles is synthesized using bacteria isolated from stagnant water. The isolated organism is identified as Staphylococcus aureus, followed by the zinc oxide nanoparticles is synthesized using the bacteria cell supernatant. The synthesized ZnO NP is used to treat the sewage water. The ZnO NP is efficient in the removal bacteria in the sewage water, thus ZnO NP shows promising tool for water purification.

KEYWORDS: Zinc Oxide, Nanoparticles, Sewage water, Water treatment.

INTRODUCTION

The contamination of water bodies is known as water pollution due to human activities that leads to unusable water. There are different types of water pollution including surface water and ground water pollution. The water pollution leads to serious problem including the degradation of aquatic ecosystem and causing water borne diseases when people consumed polluted water (Von Sperling, 2007; Eckenfelder, 2000; Harvard, 2013). Recently, the water pollution is a serious issue in India, the sources of pollutant is untreated sewage and runoff from agriculture and various industries. Around 80% of water bodies are extremely pollutes in India (Samudranil, 2016). Life is not possible without water, the pollution free, pure water is an important for healthy life of human. The water pollution is not only serious threat to the present-day even it causes severe effect to future. The natural and many human activities are the causes of the water pollution. Sewage is the main cause of water pollution; sewage is the garbage landfill of waste water produced by domestic activity and industries. The main source of water borne diseases is sewage thus the treatment of sewage is essential to prevent the water borne diseases (Kumar *et al.,* 2017; Premkumar, 2018). There is several tradition processes to treat polluted water, the tradition methods have low efficiency thus there is a great need of technology that can able to monitor, detect and treat the water. In recent times, the development in nanotechnology provides efficient and improved technique to remove the contaminant form water (Yunus *et al.,* 2012).

Nanotechnology can able to fabricate materials at nanoscale with specific properties and functions. The unique characteristics of nanomaterial is small in size in the range of 1 nm-100 nm and it has large surface

area to volume ratio thus it is used to identify very sensitive contaminants. The environmental applications of nanotechnology are classified into three major applications including remediation and purification of contaminated material, pollution detection and prevention of pollution (Yunus *et al.,* 2012). The use of nanomaterial as adsorbents involves in the water remediation, the nanomaterials show high efficiency due to its properties such as large surface area, reactivity, high adsorption ability and its simplicity. Nano-adsorbent is efficient in removing the organic content of the waste water. The nanomaterials including carbon- based nanomaterials, oxide nanomaterials, metal nanomaterials, silica nanomaterials, polymer based nanomaterials, zeolites and nanocomposites are used as nano-absorbents for water remediation process (Hairom *et al.,* 2021).

This work is aimed on the fabrication of Zinc oxide (ZnO) nanoparticles using biogenic method. The synthesized ZnO nanoparticles are used for the treatment of sewage water collected.

MATERIALS AND METHODS

COLLECTION OF SAMPLE

The stagnant water samples were collected from the campus of Sadakathullah Appa College, Tirunelveli.

ISOLATION OF BACTERIA

One way to enumerate the number of bacteria present in a stagnant water sample is to utilize dilution and plating methodology. This methodology utilizes agar as a medium of bacterial growth a process termed "culturable technology". Keep ready and arrange all materials required for the serial dilution in the laminar flow chamber. Arrange test tubes and label them appropriately (1:100… … 1:1000000000 or 10^8). Add 1ml of the sample from 1:10 or stock to 1:100 diluents. Make up further dilutions up 10^{-8}. Nutrient agar is used as general purpose medium for the growth or wide variety of non-fastidious microorganism. It consists of peptone, beef extract and agar. Nutrient agar is dissolving the dehydrated medium in the appropriate volume of distilled water. Then add agar-agar for correct volume, sterile the medium by autoclaving (121℃ for 15 minutes). Media was poured onto the petri plate at room temperature and allows the medium for solidified. Perform plating from the appropriate dilution by spread plate method. Add 0.1 ml of diluted sample to the agar plates and spread the sample using L-rod. Incubate all the plates at appropriate temperature. Observe plates for growth and record the results. The isolated colonies were then inoculated into nutrient broth for further use.

Calculation the number of colonies per ml by the following formula,

$$\text{Calculation the number of colonies per ml by} = \frac{\text{Number of colonies} \times \text{dilution factors}}{\text{1ml of the sample}}$$

IDENTIFICATION OF ISOLATED ORGANISM

The isolated colonies were identified using gram staining, motility and various biochemical reactions includes Indole, Methyl red, Voges-proskaur test, Catalase test, Citrate utilization test and Oxidase test.

PREPARATION OF ZINC OXIDE NANOPARTICLES

The isolated Staphylococcus aureus was used to prepare ZnO nanoparticles. The fresh 24hours broth culture of Staphylococcus aureus was centrifuged at 10,000rpm for 15 minutes. The supernatant was collected followed by adding Zinc oxide (0.1 M) to the culture supernatant and incubate at 28℃ with agitation for 24 hours. After the incubation, collect the ZnO nanoparticle by centrifugation (Saravanan *et al.,* 2018).

WATER PURIFICATION

The sewage water is collected from canteen located at sadakathullah Appa College campus. The collected water brought into microbiology laboratory. The filter paper was placed in a funnel. The ZnO (0.1g) nanoparticles added onto the filter paper. Then the contaminated water poured over ZnO nanoparticles. The contaminated water was filtered through the funnel as pure water. The non-filtered and filtered water was plated to check the microbial population by spread plate technique (Spoiala *et al.*, 2021).

RESULTS AND DISCUSSION

CULTURAL CHARACTERISTICS OF ISOLATED ORGANISMS

By performing serial dilution and spread plate method on nutrient agar medium from stagnant water sample. Staphylococcus aureus was identified by the presence of round, smooth, convex, opaque and forms golden yellow colonies. The gram staining shows the purple grape like culture cells under 40 x magnifications (Figure 1). The morphological and physiological characteristics of isolated bacteria (Staphylococcus aureus) were observed through microscopy and biochemical tests. The results obtained are tabulated (Table: 1).

COLLECTION OF ZINC OXIDE NANOPARTICLES

The zinc oxide nanoparticles are collected after 24 hours of reaction by centrifugation at 6,000 rpm for 15 mins. The collected pellet is washed with distilled water then dried at 60º C in hot air oven.

Table 1: Result of Microscopic Examination and Biochemical Test for Isolated Organism

Microscopic Examination & Biochemical Test	**Result of Isolated Organism**
Motility	Non-motile
Gram staining	Gram positive cocci
Indole test	-
Methyl red test	+
Voges proskauer test	+
Citrate test	+
Oxidase test	-
Catalase test	+

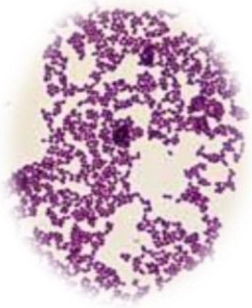


Fig. 1: Gram Staining (+ve cocci)

A **B** **C**

Fig. 2: Culture Supernatant (A), ZnO added to culture supernatant (B) ZnO nanoparticles Collected and dried (C)

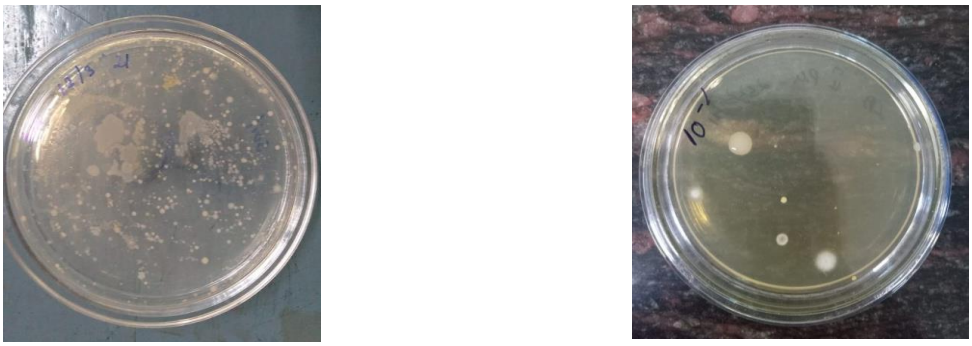
PURIFICATION OF CONTAMINATED WATER

The microbial analysis of the sewage water and treated water is checked by spreading plate technique. Figure 3 shows the untreated sewage, ZnO nanoparticles and clear treated water. The total colonies were

counted through the colony counter. The TNTC colonies were observed from the dilution 10^{-7} in the untreated water and treated water have very less number of bacterial colonies. The ZnO nanoparticles can able to inhibit bacteria from sewage water (Raghavendra *et al.,* 2022) thus the result indicates that the ZnO nanoparticles are acted well to treat water sample. Figure 4 shows the plating of untreated and treated water.

A **B** **C** **D**

Fig. 3: Untreated Sewage water (A), ZnO Nanoparticles (B), Sewage water passed through filter containing zinc oxide (C), Treated water (D)



A **B**

Fig. 4: Untreated water microbial count (A), Treated water count (B)

CONCLUSION

Bacteria mediated synthesized ZnO nanoparticles were used to purify the contaminated water. ZnO nanoparticles to be used in water and waste water disinfection. It has the benefits of addressing the limitations of conventional water treatment methods. This water treatment method includes adsorption/absorption and microbial disinfection. The ZnO nanoparticles were filtered the sewage water into screened water. The comparison of microbial population between sewage and screened water were checked it. The microbial count in the untreated sample shows too numerous to count (TNTC) and too loo too count (TLTC) of microbial colonies were observed in the treated water. The ZnO nanoparticles show promising approach for the treatment of water.

REFERENCES

[1]. Eckenfelder, W.W (2000). Kirk-Othmer Encyclopedia of Chemical Technology. John Wiley & Sons. ISBN 978-0-471-48494-3.

[2]. Hairom, N.H.H., Soon, C.F., Radin Mohamed, R.M.S., Morsin, M., Zainal, N., Nayan, N., Zulkifli, C. Z., Harun, N.H (2021). A review of nanotechnological applications to detect and control surface water pollution. Environmental technology & innovation. 24:102032, ttps://doi.org/10.1016/j.eti.2021.102032.

[3]. Harvard T.H (2013).Water Pollution. Environmental Health Education Program. Cambridge, MA: Chan School of Public Health.

[4]. Ian Sofian Yunus, Harwin, Adi Kurniawan, Dendy Adityawarman & Antonius Indarto (2012). Nanotechnologies in water and air pollution treatment, Environmental Technology Reviews, 1:1, 136-148, DOI: 10.1080/21622515.2012.733966.

[5]. Kumar, S. Meena, H.M. Verma, K (2017). Water pollution in India: Its impact on the human health: Causes and remedies. International Journal of Applied Environmental Sciences.12:2, 275-279.

[6]. Raghavendra, V.B. Shankar, S. Govindappa, M. Pugazhendhi, A. Sharma, M. Nayaka, S.C (2022). Green Synthesis of Zinc Oxide Nanoparticles for effective degradation of dye, polyethylene and antibacterial performance in waste water treatment. Journal of inorganic and organometallic polymers and materials. 32:1, 614-630.

[7]. Samudranil (2016). Water pollution in India: Causes, effects and solutions. My India.

[8]. Saravanan, M., Gopinath, V., Chaurasia, M. K., Syed, A., Ameen, F., & Purushothaman, N. (2018). Green synthesis of anisotropic zinc oxide nanoparticles with antibacterial and cytofriendly properties. Microbial pathogenesis, 115, 57-63.

[9]. Sopiala, A. Loana llie, C. Doina Trusca, R. Cristian Opera, O. Surdu, V.A. Vasile, B.S> Ficai, A. Ficai, D. Andronescu, E. Ditu, L.M (2021). Materials. 14:16, doi: 10.3390/ma14164747

[10]. Von Sperling, M (2007).Wastewater Characteristics, Treatment and Disposal". IWA Publishing. 6. ISBN 978-1-78040-208-6.

[11]. Williams, R.E. Premkumar, A. Vinoth, T (2018). Water pollution in India – an overview. Shanlax International Journal of Commerce.6:5, 94-96.

Chapter
12

NEW AGE TECHNOLOGIES FOR SOLID WASTE AND ENVIRONMENTAL CARE

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ABSTRACT

As societies grapple with the challenges of urbanization and rising consumption rates, the management of solid waste has become a critical issue in safeguarding the environment. This paper explores the paradigm shift in solid waste management brought about by the integration of innovative technologies. The advent of new age technologies has introduced transformative approaches that not only address waste disposal but also contribute to environmental conservation. From advanced recycling methods to smart waste collection systems, these technologies are redefining waste management practices. This paper focuses into key technological interventions, their implications for environmental care, and the potential for creating sustainable ecosystems where waste is seen not as a burden, but as a resource. By embracing these cutting-edge solutions, communities can effectively manage solid waste while promoting a greener and more sustainable future.

KEYWORDS: Solid waste management, environmental care, new age technologies, waste recycling, smart waste collection, sustainable ecosystems, innovative solutions, waste-to-resource, environmental conservation, urbanization

INTRODUCTION

In an increasingly urbanized world, the issue of solid waste management has emerged as a critical global concern. The rapid growth of urban areas, coupled with soaring population rates and evolving consumption patterns, has placed immense pressure on waste management systems. As a consequence, we face a host of challenges including environmental degradation, threats to public health, and the depletion of precious resources. The heart of these challenges lies in the outdated and unsustainable methods of waste disposal that have long been employed. Traditional approaches, such as landfilling and incineration, have proven to be woefully inadequate and counterproductive to the goals of environmental preservation and human well-being. The interconnectedness between solid waste production and the contamination of the air, soil, and water is undeniable (Brunner, 2013). The gravity of the situation is underscored by disconcerting figures from the 2014 UN Climate Summit, ranking municipal solid waste (MSW) and landfills as the third-largest anthropogenic source of global CH4 emissions. Additionally, the annual emission of roughly 800 tons of CO2 from solid waste exacerbates the environmental challenges we face (Lee *et al.*, 2016). Beyond the realm of environmental impact, the unchecked proliferation of solid waste poses substantial risks to human health (De and Debnath, 2016). The implications are stark and necessitate a paradigm shift towards sustainable solutions in the realm of solid waste management. This shift calls for a departure from the traditional linear model of "take, make, dispose," and encourages the adoption of a circular economy approach. In this new paradigm, waste is not treated as a mere castaway,

but rather as a valuable resource that can be efficiently managed, repurposed, and integrated back into the production cycle.

EMERGENCE OF SMART WASTE SEPARATION AND COLLECTION SYSTEMS

A. Optical Sorting: Optical sorting systems utilize sensors and cameras to identify and categorize materials based on their visual attributes, such as colour, shape, and size. This technology is widely applied in segregating various materials like plastics, paper, and metals from mixed waste streams. It has also found extensive utility in classifying mining residues. For instance, the innovative optical mechanism developed at Comex, an optical sorting platform, exemplifies this trend. This mechanism facilitates the recognition and separation of diverse mineral particles based on their colour properties (Kolacz, 2012). In the paper industry, optical waste paper sorting techniques are employed to separate fibers from waste paper. The recycling of paper fibers can be accomplished six to seven times, as demonstrated by studies such as Villanueva and Wenzel (2007). This practice of repurposing solid materials like paper, glass, and plastics not only mitigates waste but also converts discarded items into valuable resources, thus contributing significantly to the establishment of a sustainable ecosystem (Zaman, 2010; Chen *et al.,* 2010). Municipal solid waste presents a complex waste category, distinct from the relatively homogeneous waste originating from industrial or agricultural activities. This waste stream exhibits substantial diversity across municipalities and even varies significantly from one country to another. Moreover, its composition undergoes marked changes over time. Addressing this intricate waste landscape, optical sorting systems emerge as a fitting solution (Ligus G, 2012; Troschinetz A M and Mihelcic J R, 2009; Dahél L and Lagerkvist A, 2010).

B. Magnet-Based Separation: Magnet-based separation stands as a method to differentiate between ferrous and non-ferrous components. It operates through the application of robust magnetic fields that entice and segregate ferrous materials, notably encompassing iron and steel, from their non-ferrous counterparts. This technique streamlines the extraction of precious metals, amplifying its significance. Its versatile implementation extends to various environmental spheres, spanning tasks such as the decontamination of wastewater and the isolation of perilous substances (Oka T *et al.,* 2010; Zhao Y *et al.,* 2012; Xiong J *et al.,* 2008; Ha D W *et al.,* 2010).

C. Eddy Current Separation for E-Waste: Within the spectrum of solid waste, electronic waste (e-waste) represents a significant category comprising discarded electronic and electrical equipment. E-waste poses a formidable global pollution challenge, primarily stemming from the absence of effective recovery methodologies. Addressing this concern, eddy current separators (ECS) emerge as a valuable solution. These separators use magnetic fields to induce electric currents in non-ferrous metals, notably materials like aluminium and copper. This induction leads to the repulsion and subsequent separation of these metals from other waste constituents (Y.R. Smith *et al.,* 2019). Eddy current separation (ECS) has been identified as the optimal technique for reclaiming non-ferrous metals from e-waste. Despite this recognition, the existing body of literature specifically focusing on ECS for e-waste reclamation remains limited (Jujun R *et al.,* 2014). Initially, rudimentary methods like acid-washing and open incineration (Ruan and Xu, 2012a, b; Ilgin and Gupta, 2010a, b) inflicted substantial environmental contamination due to the hazardous elements present in e-waste (Duan *et al.,* 2011; Huo *et al.,* 2007; Leung *et al.,* 2008). In response, a more sophisticated approach that prioritizes both environmental integrity and efficient non-metal retrieval has emerged. This evolved strategy encompasses various processes such as crushing, screen separation, shape sorting, jigging, magnetic separation, air current separation, corona-electrostatic

separation, and ECS (Zhou and Xu, 2012; Cui and Forssberg, 2003). Among these techniques, ECS emerges as the most suitable option for large-scale e-waste reclamation.

D. Near-Infrared (NIR) Spectroscopy: The technology of near-infrared (NIR) spectroscopy stands as a powerful tool for material identification and sorting, operating on the principle of distinctive spectral signatures. It excels particularly in discerning various plastics and materials characterized by unique molecular structures. The near-infrared (NIR) spectrum encompasses wavelengths from 800 nm to 2500 nm (Siesler *et al.,* 2002). This technology has found wide-ranging application in the domain of plastic detection and characterization (Matsumoto T *et al.,* 2000; Kamagai M *et al.,* 2002), earning its reputation as a globally advancing analytical methodology (W.F. McClure, 1994). The accumulation of waste electrical and electronic equipment (WEEE) significantly contributes to the proliferation of plastic waste, encompassing more than 21 diverse plastic types (Martinho *et al.,* 2012). In 2017, China effectively processed 79.947 million units of WEEE through 101 recycling companies subsidized by the Ministry of Ecology and Environment. Notably, within the retrieved materials, plastics constitute 20.9% by weight (Ministry of Ecology and Environment, 2018). The plastics reclaimed from electronic waste comprise polypropylene (PP), polystyrene (PS), acrylonitrile butadiene styrene (ABS), flame-retardant ABS (FR ABS), and the ABS/PC blend (acrylonitrile butadiene styrene/polycarbonate) (Wu X *et al.,* 2019). This spectrum of plastic types underscores the significance of NIR spectroscopy as an invaluable tool in effectively managing and recycling complex plastic waste streams.

E. Air Classification: Air classifiers leverage air currents to effectively segregate lightweight materials from their heavier counterparts. This method finds particular utility in separating materials such as paper, plastic films, and other low-density waste items from heavier substances like glass and metals. Despite the apparent simplicity of the separation principle, the process of air-based classification involves the careful consideration of multiple parameters. These parameters encompass factors like particle density, morphological attributes, and morphometric characteristics. The interplay of these factors with the terminal velocity of individual polymers assumes a critical role in determining both the separation efficiency and the optimal operational configuration of the air classification process (Shapiro and Galperin, 2005). This underscores the nuanced complexity underlying what might seem like a straightforward technique, highlighting the need for a comprehensive understanding of these variables to achieve effective and efficient waste separation.

By embracing these smart waste separation and collection systems we can achieve remarkable recycling rates, minimize contamination, and recover valuable materials from waste streams, amplifying the efficacy of modern waste management practices.

EXPLORING INNOVATIVE RECYCLING TECHNIQUES FOR SUSTAINABILITY

a. Bioremediation: Bioremediation stands as a dynamic waste management technique that harnesses the power of living organisms to combat hazardous substances and pollutants found in waste and contaminated sites. This innovative approach employs the intrinsic abilities of microorganisms, including bacteria, fungi, and plants, to break down or transform harmful compounds into less toxic or non-toxic forms. By leveraging the natural processes of these biological agents, bioremediation offers a sustainable solution to mitigate the impact of pollutants in various waste types, ranging from contaminated soils to industrial waste and wastewater.

Microbial Heroes of Bioremediation:

The diverse cast of microorganisms central to bioremediation includes Acromabacter, Arthrobacter, Alkali genes, Bacillus, Corynebacterium, Pseudomonas, Flavobacterium, Mycobacterium, Nitrosomonas,

Xanthobacter, and more (Singh R, 2014). These microbial heroes exhibit exceptional capabilities to metabolize and transform contaminants, unlocking the potential for waste materials to be remediated and restored.

***In Situ* Bioremediation:**

In this method, hazardous sites are treated directly without relocation. Microorganisms are introduced to the affected area, capitalizing on their natural abilities to gradually degrade pollutants. This technique further branches into two categories: intrinsic and engineered bioremediation. Intrinsic restoration unfolds as a naturally occurring process, requiring no external intervention. Engineered bioremediation, on the other hand, introduces genetically engineered organisms into the contaminated site, propelling the remediation process.

***Ex Situ* Bioremediation:**

The second major approach, "Ex Situ Bioremediation," involves the physical removal of contaminated materials or soil to a dedicated treatment facility. Within this controlled environment, bioremediation processes are employed to effectively detoxify the waste. Following treatment, the remediated waste can be safely returned to its original location or disposed of responsibly.

b. Gasification: With fossil fuel reliance soaring, biomass utilization has waned, primarily serving rural households (Cortez LAB *et al.,* 2006). Biomass encompasses various sources, from forestry products to agro-industrial waste (Garg and Datta, 1998). Escalating energy demands necessitate sustainable alternatives (Pereira EG *et al.,* 2012). Gasification, a thermochemical process, converts biomass into syngas—a blend of CO, H_2, CH_4, CnHm, CO_2, and H_2O—offering a greener energy solution. By replacing fossil fuels, gasification generates heat, electricity, and chemicals, while advancing sustainability, regional economies, and environmental goals (Dermibas AH and Dermibas I, 2007). Gasification outperforms incineration, efficiently converting biomass to a combustible gas. It's a crucial technology, generating heat, hydrogen, ethanol, and power. Globally, 686 gasification plants produce 83 MWh energy collectively (Das S *et al.,* 2019). Gasification stands as a beacon, linking biomass's potential with the imperative for sustainable energy.

TRANSFORMING WASTE INTO ENERGY AND ENVIRONMENTAL CARE

Incineration: Incineration, an advanced waste management technique, entails the controlled combustion of waste at high temperatures. This process not only reduces waste volume but also make use of the generated heat to produce steam, subsequently driving turbines for electricity generation. Incineration presents a dual benefit of waste reduction and energy recovery, significantly curbing methane emissions that would otherwise arise from landfills. Nevertheless, careful management is vital to mitigate the potential for air pollution and the release of harmful emissions.

The importance of incineration lies in its waste-to-energy (WtE) capability. By converting waste into usable energy, incineration plants contribute substantially to electricity, heating, and industrial steam supplies. This symbiotic relationship between waste management and energy generation plays a pivotal role in addressing both waste disposal challenges and energy demands. In the European Union, WtE plants cater to the energy needs of around 18 million households and contribute 2.4 percent to the EU's total energy supply. A prime example is Germany, home to approximately 100 waste incineration facilities, each playing a distinct role in the country's waste management and energy landscape. The Cologne plant, the largest among them, processes a staggering 780,000 tons of residual waste, while even smaller plants like Ludwigslust, with a capacity of 50,000 tonnes, make notable contributions (Hockenos P, 2021). According to Abramov S *et al.* (2018), the thermal efficiency of solid waste incineration enables

the extraction of a substantial 65 to 80% of the heat energy present in the waste materials. This efficient energy recovery not only minimizes wastage but also underscores the environmentally responsible aspect of incineration. By utilizing this heat energy to generate electricity and heat, incineration transforms waste into a valuable resource, bolstering sustainability efforts.

Pyrolysis: Pyrolysis is a thermal decomposition process that converts organic waste into biochar, bio-oil, and syngas in the absence of oxygen. Biochar can be used as a soil amendment, while bio-oil and syngas can be used for energy production or refined into valuable products. Czajczynska *et al.,* (2017) reported that pyrolysis oil exhibits a favourable calorific value of 23 megajoules per kilogram (MJ/kg), making it a suitable additive for enhancing conventional diesel.

CONCLUSION

In conclusion, it can be said that the convergence of these new age technologies is shaping a future where waste is no longer a burden but a resource waiting to be unlocked. By embracing these innovations, societies can mitigate environmental degradation, promote circular economies, and build a greener and more sustainable world where waste is transformed into a catalyst for positive change. This chapter sheds light on the path forward, where technological advancements and environmental consciousness converge to redefine the relationship between waste and the environment.

REFERENCES

[1]. Abramov, S., He, J., Wimmer, D., Lemloh, M. L., Muehe, E. M., Gann, B., & Kappler, A. (2018). Heavy metal mobility and valuable contents of processed municipal solid waste incineration residues from Southwestern Germany. Waste management, 79, 735-743.

[2]. Brunner, P. H. (2013). Cycles, spirals and linear flows. Waste Management & Research, 31(10_suppl), 1-2.

[3]. Chen, H. W., Yu, R. F., Liaw, S. L., & Huang, W. C. (2010).Information policy and management framework for environmental protection organization with ecosystem conception. International Journal of Environmental Science & Technology, 7, 313-326.

[4]. Cortez LAB, Lora ES, Ayarza JAC. (2006). Biomassa para Energia. Sao Paulo: ~ Unicamp; 2006.

[5]. Cui, J., & Forssberg, E. (2003). Mechanical recycling of waste electric and electronic equipment: a review. Journal of hazardous materials, 99(3), 243-263.

[6]. Czajczyńska, D., Anguilano, L., Ghazal, H., Krzyżyńska, R., Reynolds, A. J., Spencer, N., & Jouhara, H. (2017). Potential of pyrolysis processes in the waste management sector. Thermal science and engineering progress, 3, 171-197.

[7]. Dahlén, L., & Lagerkvist, A. (2010). Evaluation of recycling programmes in household waste collection systems. Waste Management & Research, 28(7), 577-586.

[8]. Das, S., Lee, S. H., Kumar, P., Kim, K. H., Lee, S. S., & Bhattacharya, S. S. (2019). Solid waste management: Scope and the challenge of sustainability. Journal of cleaner production, 228, 658-678.

[9]. De, S., & Debnath, B. (2016). Prevalence of health hazards associated with solid waste disposal-A case study of kolkata, India. Procedia Environmental Sciences, 35, 201-208.

[10]. Demirbas, A. H., & Demirbas, I. (2007).Importance of rural bioenergy for developing countries. Energy Conversion and Management, 48(8), 2386-2398.

[11]. Duan, H., Li, J., Liu, Y., Yamazaki, N., & Jiang, W. (2011). Characterization and inventory of PCDD/Fs and PBDD/Fs emissions from the incineration of waste printed circuit board. Environmental science & technology, 45(15), 6322-6328.

[12]. Ha, D. W., Kim, T. H., Sohn, M. H., Kwon, J. M., Baik, S. K., Ko, R. K.,...& Ha, T. W. (2010). Purification of wastewater from paper factory by superconducting magnetic separation. IEEE Transactions on Applied Superconductivity, 20(3), 933-936.

[13]. Hokenons P, (2021). EU climate ambitions spell trouble for electricity from burning waste. Clean energy wire

[14]. Huo, X., Peng, L., Xu, X., Zheng, L., Qiu, B., Qi, Z., & Piao, Z. (2007). Elevated blood lead levels of children in Guiyu, an electronic waste recycling town in China. Environmental health perspectives, 115(7), 1113-1117.

[15]. Ilgin, M. A., & Gupta, S. M. (2010) a. environmentally conscious manufacturing and product recovery (ECMPRO): A review of the state of the art. Journal of environmental management, 91(3), 563-591.

[16]. Ilgin, M. A., & Gupta, S. M. (2010) b. Comparison of economic benefits of sensor embedded products and conventional products in a multi-product disassembly line. Computers & Industrial Engineering, 59(4), 748-763.

[17]. Jujun, R., Yiming, Q., & Zhenming, X. (2014). Environment-friendly technology for recovering nonferrous metals from e-waste: Eddy current separation. Resources, conservation and recycling, 87, 109-116.

[18]. Kakihara, Y., Fukunishi, T., Takeda, S., Nishijima, S., & Nakahira, A. (2004).Superconducting high gradient magnetic separation for purification of wastewater from paper factory. IEEE Transactions on Applied superconductivity, 14(2), 1565-1567.

[19]. Kim, T. H., Ha, D. W., Kwon, J. M., Sohn, M. H., Baik, S. K., Oh, S. S., & Park, S. K. (2010). Purification of the coolant for hot roller by superconducting magnetic separation. IEEE Transactions on Applied Superconductivity, 20(3), 965-968.

[20]. Kolacz, J. (2012). Advanced sorting technologies and its potential in mineral processing. AGH Journal of Mining and Geoengineering, 36(4), 39-48.

[21]. Kumagai, M., Suyama, H., Sato, T., Amano, T., & Ogawa, N. (2002).Discrimination of plastics using a portable near infrared spectrometer. Journal of near infrared spectroscopy, 10(4), 247-255.

[22]. Lee, S., Kim, J., & Chong, W. K. (2016). The causes of the municipal solid waste and the greenhouse gas emissions from the waste sector in the United States. Waste management, 56, 593-599.

[23]. Leung, A. O., Duzgoren-Aydin, N. S., Cheung, K. C., & Wong, M. H. (2008). Heavy metals concentrations of surface dust from e-waste recycling and its human health implications in southeast China. Environmental science & technology, 42(7), 2674-2680.

[24]. Ligus, G. (2012). Municipal waste management model with the use of optical sorting elements. Opole University of Technology, Faculty of Mechanical Engineering,11,1229-1234

[25]. Martinho, G., Pires, A., Saraiva, L., & Ribeiro, R. (2012).Composition of plastics from waste electrical and electronic equipment (WEEE) by direct sampling. Waste Management, 32(6), 1213-1217.

[26]. Matsumoto, T., Tanabe, K., & Kakurata, K. (2000).Rapid discrimination between biodegradable and non-biodegradable plastic by combining near-infrared spectra measurement and chemometrics analysis. Chem. Softw., 22.

[27]. McClure, W. F. (1994). Near-infrared spectroscopy the giant is running strong. Analytical chemistry, 66(1), 42A-53A.

[28]. McCollough, J., Bayramoglu, M. F., & He, M. (2018).Transitioning into a 'throwaway planet'. International Journal of Consumer Studies, 42(1), 131-140.

[29]. Ministry of Ecology and Environment, (2018). Annual Report on Pollution Prevention and Control of Solid Wastes in Large and Medium Cities in China (in Chinese), 18-19.

[30]. Oka, T., Tanaka, K., Kimura, T., Mimura, D., Fukui, S., Ogawa, J., & Yamaguchi, M. (2010). Magnetic separation technique for environmental water purification by strong magnetic field generator loading HTS bulk magnets. Physica C: Superconductivity and its applications, 470(20), 1799-1803.

[31]. Pereira, E. G., Da Silva, J. N., de Oliveira, J. L., & Machado, C. S. (2012). Sustainable energy: a review of gasification technologies. Renewable and sustainable energy reviews, 16(7), 4753-4762.

[32]. Ruan, J., & Xu, Z. (2012) a. Approaches to improve separation efficiency of eddy current separation for recovering aluminum from waste toner cartridges. Environmental science & technology, 46(11), 6214-6221.

[33]. Ruan, J., Xue, M., & Xu, Z. (2012) b. Risks in the physical recovery system of waste refrigerator cabinets and the controlling measure. Environmental science & technology, 46(24), 13386-13392.

[34]. Sharma, I. (2020). Bioremediation techniques for polluted environment: concept, advantages, limitations, and prospects. In Trace metals in the environment-new approaches and recent advances.IntechOpen.

[35]. Siesler, H. W., Kawata, S., Heise, H. M., & Ozaki, Y. (Eds.). (2008). Near-infrared spectroscopy: principles, instruments, applications. John Wiley & Sons.

[36]. Singh, R. (2014). Microorganism as a tool of bioremediation technology for cleaning environment: a review. Proceedings of the International Academy of Ecology and Environmental Sciences, 4(1), 1.

[37]. Sverige, A. (2011). Förebygga avfall med kretsloppsparker. Rapport u2011, 2.

[38]. Tezer, Ö., Karabağ, N., Öngen, A., Çolpan, C. Ö., & Ayol, A. (2022). Biomass gasification for sustainable energy production: A review. International Journal of Hydrogen Energy, 47(34), 15419-15433.

[39]. Troschinetz, A. M., & Mihelcic, J. R. (2009).Sustainable recycling of municipal solid waste in developing countries. Waste management, 29(2), 915-923.

[40]. Villanueva, A., & Wenzel, H. (2007).Paper waste–recycling, incineration or landfilling? A review of existing life cycle assessments. Waste management, 27(8), S29-S46.

[41]. Wu, X., Li, J., Yao, L., & Xu, Z. (2020). Auto-sorting commonly recovered plastics from waste household appliances and electronics using near-infrared spectroscopy. Journal of Cleaner Production, 246, 118732.

[42]. Xiong, J., He, Z., Mahmood, Q., Liu, D., Yang, X., & Islam, E. (2008).Phosphate removal from solution using steel slag through magnetic separation. Journal of hazardous materials, 152(1), 211-215.

[43]. Zaman, A. U. (2010).Comparative study of municipal solid waste treatment technologies using life cycle assessment method. International Journal of Environmental Science & Technology, 7, 225-234.

[44]. Zhao, Y., Xi, B., Li, Y., Wang, M., Zhu, Z., Xia, X., & Luan, Z. (2012). Removal of phosphate from wastewater by using open gradient superconducting magnetic separation as pretreatment for high gradient superconducting magnetic separation. Separation and Purification Technology, 86, 255-261.

[45]. Zhou, L., & Xu, Z. (2012). Response to waste electrical and electronic equipment's in China: legislation, recycling system, and advanced integrated process. Environmental Science & Technology, 46(9), 4713-4724.

Chapter 13

BIOFERTILIZERS FOR ORGANIC FARMING

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ABSTRACT

India is the fourth largest user of chemical fertilizers (12.3 mm of NPK nutrients in the world. On the positive side application of these fertilizers has rendered India sell- sufficient interfood requent or an ever-increasing population. On the negative side, the indu ase application has deteriorated sods in terms of and pH salinity and physics-chemical texture, leading to reduced/grated agro-production polted underground water bod dering water and for human consumption Thi onther pounded by the furgen ments of natural resources conservation and cycling, which led to depletion organic matter in soil and decline in whahi loving mates of wall (Pharke, 2001, 2001b) To address these problem

KEYWORDS: Organic Farming, Biofertilizer, P[H] Salinity.

INTRODUCTION

BIOFERTILIZERS

India is the fourth largest user of chemical fertilizers (12.3 mm of NPK nutrients in the world. On the positive side application of these fertilizers has rendered India sell- sufficient interfood requent or an ever-increasing population. On the negative side, the indu ase application has deteriorated sods in terms of and pH salinity and physics-chemical texture, leading to reduced/grated agro-production polted underground water bod dering water and for human consumption Thi onther pounded by the furgen ments of natural resources conservation and cycling, which led to depletion organic matter in soil and decline in 1 whahi loving mates of wall (Pharke, 2001, 2001b) To address these problem

Fig.1: Biofertilizers

BIOFERTILIZERS AND SOIL CONDITIONER FOR ORGANIC FARMING

Use of Biofertilizers provides a pragmatic, cost-effective, eco-friendly and sustainable approach in the following ways:

I) Biofertilizers are efficient, live or latent cells, which render multiple plant nutrients uptake in easily, accelerated and assimilable form for promoting plant growth (Subba Rao, 1997).

II) Biofertilizers are rhizospheric organisms adapted to local micro-environs, which facilitate through well-established mechanism(s) sustained availability of nutrients and plant protectants from soil to plant. In return, photo- assimilates necessary for the sustenance of Biofertilizers is provided by the plants (Patil *et al*., 2005a; 2005b).

TYPES OF BIOFERTILIZERS

Fig. 2: Organic Biofertilizers

To implement IPNM concept in practice, various types of Biofertilizers are available in the market. Their profiles are summarized in Table

ROLE OF BIOFERTILIZERS

Non- symbiotic NFB for non-legumes (e.g. Azotobacter. Azospirillum, Azolla, BGA: Symbiotic NFB for legumes (e.g Rhizobium, Bradyrhizobium, Azorhizobium, Sinorhizobium). Phosphate solubilizers (e.g. Bacillus, Pseudomonas, Aspergillus

Phosphate mobilizers

Schwaniomyces, Actinomyces, Streptomyces, Cyanobacteria. Phosphate absorbers (e.g. VA Mycorrhizal fungi and Sulphur oxidizers

ectomycorrhizae) Heterotrophic (eg. Pseudomonas, Aspergillus); Autotrophic (eg.

Thiobacillus sp).

Moisture arresters

Ecto- and endo-mycorrhizae

Lignino - Cellulolytics

Ligninolytic organisms (e.g. Phanerocheate, Pleurotus,

Cellulomonas, Trichoderma, Arthrobacter, Volvariella)

NFB Nitrogen fixing bacteria; BGA = Blue green algae.

AZOTOBACTER CHROOCOCCUM

Among the 4 known species of Azotobacter (viz. A. chroococcum, A. beijerinckii, A. vinelandii and A. agilis), *A. chroococcum* was purposefully chosen due to its particular characteristics as accounted below (Tilak, 1998).

MORPHOLOGY

A. chroococcum occurs extensively in top 3 layers of neutral and alkaline soils, with its population decreasing as a function of soil depth (Rangaswamy and Sadasivam, 1964). It is Gram negative, non-spore forming, small rods with round ends, characterized by unique extra-cellular slime. In vegetative state, they are highly motile with peritrichous flagella and produce an insoluble black brown pigment (Tilak, 1998). They also multiply in micro- aerophillic condition. They produce specialized spherical resting cells (cysts), which impart them an ability to withstand adverse conditions (such as desiccation, sonic waves and UV- radiation), which are hardly tolerated by their vegetative cells.

OPTIMUM CONDITIONS FOR GROWTH

Their requirement for are resembles to that of higher plants and need for continuous oxygen supply for 2000 Q sespiratory activity (Jenson, 1954) c. Interaction(s) with other rhizospheric microbes Abate species propagate and function mutualistically with other groups of therospheric organisms, including phosphate solubilizing microbes (PSM), actinomycetes vesicular arbuscular mycorrhizae (VAM) saprophytes futerotrophs and autotrophs. This has been evident from enhanced Abatohu ter population by co-inoculation of PSMs in the higher (Ocampo *et al.* 1975), () maintenance of Azabacter population in larger numbers around mycorrhizal plants than noin mycorrhizal plants (Ea *et al.* 1981100 synergistic effect on plant growth (Bagyaraj, 1997) and (v) significant increase in the cop ield after single inoculation and pronouncet effect after co-inoculation in the presence of farmyard manure iFYM) or soil conditioner (SC) (Kunde and Gaur, 1980).

Fig. 3: Garden food organic biofertilizers

Beneficiary effects on soil quality The amount of atmospheric nitrogen fixed biologically on earth is estimated to be 180 ml per annum (Uonum 1994). With resultant increased soil fertility, beneficial effects al Atobarter inoculation on germination, shoot growth flowering, and biocontrol functiona appear to be

reproducible and attributable to (i) secretion of growth-promoting plant hormones (heteroauxins and gibberellins) and secondary metabolites (nicotinic acid. pantothenic acid and beati (Brown, 1962: Mishustin and Shilinkova, 1972, Lakshmi- Kumari *et al.* 1972), (u) improved post honest send quality in terms of germination (Pandey and Shinde, 19911 and it induction of antifungal/fungi static antibiotics against and Alternarie (Tilak, 1998). It appears that benefits derived from Autower application far outweigh in incremental cost of production and application required for sustainable

FERTILIZER BY AZOTOBACTER

Mishistin and Naumova (1962) and Jackson *et al.* (1964) found that inoculation with Aibacter accelerated the shoot growth, shortened the time of bad appearance and prolonged petal fall in tomatoes Rovira (1965) too observed bustering of flowering in what Stilarly, Boown and Warlingham (1968) reported comparable effects of gibberellin treatment

und Anetteter inoculation on tomato seeds Banerjee (1976) and Shende *et al.* (1977) al reported enhanced seed germination due to Autolueter inoculation Dilut *et al.* (1906) have concluded that fresh inossila of Autobacter @20L/ho have compensated nitrogen equivalent to 30 g per plant in Gant Cavendish and favoured banana development wills mcreased itachistas Several studies have indicated that large population of Azotobuferis found near or on the rout, catalyzing non-symbiotic nitrogen isation, whereby it augments strogen supply to an extent of 20-50 kg/ha (Venkataraman and Tilak, 1990: Varma and Bhattacharya, 1992: Deshmukh, 1996)

SIGNIFICANCE OF VAMs IN NEMETODE CONTROL

It is apparent from plant-pathogen interactions that VAMs usually (though not always deter or reduce the severity of disease caused by sod-borne pathogens (Krishna and Bagyar 1981 Sampang and Bagyaraj, 1989) VAhls increased banana plant tolerance to namatode, Radoleda similis and killing effect on soil-bome pathogens (Knight *et al.,* 1989, Serallu, 1991). In Raine Yaul and Jim Tehuli, banana crop was found to be attacked by Rallus sp, apparently due to lack of proper myeonhical management (Patil, 1996). Therefore, proper management of native VAM population appeared to afford more uptake of nutrition/msture and robust banana plant growth Mycorhizae have attributes of penetrating along with the ramification of root sys and thereby, providing an incised absorptive surface, enhanced nutrient uptake form the rhizosphere and theory spared the healthy plants from nematode attack (Vanna and Hock, 1995) Furthermore, increased VAM spare density and decreased nematode population in PNM has shown that it is compatible with NM in spite of such infection being spread in the neighbouring farms (Phirke, 2001a, 2001h). A considerable decrease in the nematode population found in IPNM plots is worth noting: This multiple effers (more nutrition, better disease combating and alleviation of P/Kratin resulted in an increased plant survival and enhanced growth in IPNM system. These functions seem to have made a substantial impact, since VAMs are reported to occur in banana cropping eco-vystems, although only 4 few experiments have been conducted to date (Rohmi *et al.* 1958 Phirk*et al.* 2002 Vasane and Kothari, 2006)

VAMlS COLONIZATION FOR HORMONES LIKE EFFECT

Allen *et al.* (1996) have illustrated that VAM directly affects the levels of cylin and gibberellin like substances in the soil. Anatomical and physiological studies have brought out that mycorrhizal plants exhibit change in their root exudation and altered hizospheric microbial population, which affects plant growth (Varms and Hock, 1997) They have (0 more number of chloroplasts, mitochondria, xylem vessels and motor cells (0) increased rate of photosynthesis and respiration and (ii) increased pool of sugar.

STABILIZATION OF BIOFERTILIZERS

One of the main reasons as to why histerilizers application by farmers tus not heen picked up is drastic reduction (fren x 10 to Tx 10) in the number of their live/ latent cells/sporm upon storage for 36 months. Charcoal puder dust or fine sand hardly constitute an ideal matrix for their stabilizations due is their usherent chemical composition, lacking food and moisture for the survival of duers Meage mumber of biofertiler live cells cannot inercome the constraint of mambers against outbed local micro-flora and local geo-climatic conditions, new them resulting into apparently negative/stagnated effect on productivity To be effective, then stabilisation doing storage needs a matris/carrier, which could provide sustained release of moisture and nutrients to stain original number of live cells (belare packaging) for 6 months (after packaging) during

ESSENTIAL CHARACTERISTICS OF DESIRED CARRIER

Carrier is the most important ingredient in commercial biofertilizer formulations since its nature determines actice shelf life of biotities it carries and maintains live microorganisms to function as biofertiluers. According to is specification, the carrier should be in powder form and 190-212 in size (72-100 mesh 5 sieve). To quality as a god carrier, it should also:

i. Be non-toxic and life supporting to microorganisms
ii. Provide sustained release of nutrients for the maximum survival of microbes for minimum 6 month
iii. Possess good moisture holding capacity and ease of pulverizing, mixing sieving and packaging
iv. Be compatible for sterilization, preferably by autoclaving OD adhesive nature to seeds/seedlings/plantlets.

CONCLUSION

Organic agriculture also generally prohibits the use of synthetic fertilizers. These fertilizers are concentrated sources of chemical elements, such as nitrogen and phosphorus. Why would a farmer want to add these elements to their crops? Both nitrogen and phosphorus are nutrients that plants need to produce organic compounds. In fact, nitrogen is a limiting factor on plant growth in most terrestrial ecosystems. Therefore, adding these elements can increase plant growth and crop yield.

Chapter
14

ANTICOAGULANT POTENTIAL OF AQUEOUS EXTRACT OF *TURBINARIA DECURRENS*

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ABSTRACT

The blood coagulation pathway plays a major role in atherosclerosis, a cardiovascular disease, which is divided into an intrinsic and extrinsic pathway. Anticoagulation occurs mainly due to the inhibition of serine proteases, thrombin, and factor Xa because of the activity of serine protease inhibitor, antithrombin III. The commercial anticoagulant (heparin) has several side effects such as bleeding, chemical in homogeneity, variability of its physiological activities, development of thrombocytopenia, hemorrhagic effect, ineffectiveness in congenital or acquired antithrombin deficiencies, incapacity to inhibit thrombin bound to fibrin, and more (Pereira *et al.,* 2002). Therefore, there is a necessity for discovering alternative sources of anticoagulants for safer therapy. Promising activities have been reported in many brown seaweed Turbinaria species. Hence, the present study was investigated to know the bioactive potential of Turbinaria decurrens. The present study employs aqueous extraction of the brown seaweed T. decurrens and its in vitro anticoagulant effects was studied in APTT and PT assay. Anticoagulant potential of aqueous extract was proved in the dose dependent manner.

KEYWORDS: APTT, PT, Turbinaria decurrens, Brown seaweed, Anticoagulant.

INTRODUCTION

The coagulation system can be divided into the extrinsic and intrinsic pathway. Activation of the extrinsic pathway is generally considered to initiate both haemostasis and thrombosis. Haemostasis is initiated when blood is exposed to tissue factor located in the adventitia of blood vessels, and thrombosis is initiated when blood is exposed to tissue factor in the necrotic core of the ruptured atherosclerotic plaques, in the subendothelium of injured vessels and on the surface of activated leucocytes attracted to the damaged vessel (Davie *et al.,* 1991) The prothrombin time test (also known as the pro test or PT test) is a useful screening procedure for the extrinsic coagulation mechanism including the common pathway. It detects deficiencies in factor II, V, VII, and X. The prothrombin time test is frequently used to follow oral anticoagulant therapy that inhibit factors II, VII, IX and X. Thromboplastin activates the extrinsic coagulation system in plasma in the presence of calcium ions. The subsequent clotting time is dependent on the concentration of factors II, V, VII and X. Thus, prolongation indicates a deficiency in one or more of these factors (Davie *et al.,* 1991).

Hemostasis is an interaction process between coagulation and anticoagulants that retains the blood within the injured vascular system during periods of injury. (Sirridge and Shannon, 1993) Hemostasis comprises a complex mechanism that contains three major steps: (1) Vasoconstriction, (2) temporary

blockage of a break by a platelet plug, and (3) blood coagulation, or formation of a fibrin clot. Anticoagulant drugs are needed for the short-term treatment of arterial and venous thrombotic disorders and for the long-term prevention of recurrences. (Pallister and Watson, 2010) Although heparin has been the mainstay of anticoagulant treatment for acute thrombotic disorders for decades, this drug presents some limitations related to its clinical application, such as inefficacy in antithrombin deficient patients, bleeding complications, potential for the development of heparin-induced thrombocytopenia, immunosuppression and osteoporotic effect with long-term application as side effects. (Andrew *et al.,* 2015) So, the search for new substances with anticoagulant and antithrombotic activities is relevant. (Andrew *et al.,* 2015) Medicinal plants have historically been the first source of anticoagulant and antithrombotic molecules. (Moll and Robert 2002)

Seaweeds are marine macro algae and primitive type of plants which grow abundantly in the shallow waters of sea, estuaries and back waters. They flourish in rocky, dead coral or in suitable substratum. Based on the pigmentation, morphological and anatomical characters seaweeds are categorized into three groups namely green (Chlorophytes), brown (Pheophytes) and red (Rhodophytes) algae. They contain more than 60 trace elements, minerals, protein, iodine, bromine, vitamins and several bioactive substances (Krishnamoorthy, 2005). Globally 20,000 species of seaweeds were found to be distributed and in India 850 species were reported (Oza and Zaidi, 2001). The total global seaweed production in the year 2004 was >15 million metric tons of which nearly 15–20% is contributed by Indian Ocean (FAO, 2006). In India dried algae (1, 518 tons - red algae and 2, 285 tons - brown algae) are utilized for the manufacture of agar, algin, carrageenan and liquid fertilizer (Kaliaperumal *et al.,* 2004). Due to their low content in lipids, high concentration in polysaccharides, natural richness in minerals, polyunsaturated fatty acids and vitamins, marine algae are known to be a good source of healthy food. Unlike the terrestrial plants these algae have no roots, leaves or vascular systems; however they nourish themselves through the process of osmosis (Gupta and Abu- Ghannam, 2011). Over the past few decades seaweeds and their compounds have been reported to possess biological activity with potential medicinal value because of their antioxidant property (Heo *et al.,* 2005; Meenakshi *et al.,* 2011; 2014; 2016). Seaweeds have been reported to have bioactive compounds such as Polysaccharides, polyphenols, steroids, diterpenes and phlorotannins (Gupta and Abu- Ghannam, 2011)

Therefore, it is necessity and demand of time to explore alternative anticoagulants. The seaweeds are safer source of medicines hence; we undertook the anticoagulation study of aqueous extracts of the brown seaweed Turbinaria decurrens.

MATERIALS AND METHODS

SAMPLE COLLECTION

Brown alga Turbinaria decurrens was collected from Yervadi region and it was identified and confirmed in our department.

AQUEOUS EXTRACTION

The collected T. decurrens was initially washed with seawater to remove the macroscopic epiphytes and other extraneous matter, and then rinsed in distilled water. The specimen was shade dried and coarsely powdered. 10g of dried seaweed powder was added with 100ml of distilled water over night. Then it was filtered through Whatmann No.3 filter paper. The filterate was centrifuged at 3000 rpm for 10 minutes and supernatant was stored for the study.

ANTICOAGULANT ACTIVITY

Preparation of Plasma: Blood was collected from individual healthy donor through vein puncture without bleeding or thrombosis and then it was mixed with 3.8% tri sodium citrate at 9:1 ratio. Further it was centrifuged for 20 min at 2400×g and the plasma were stored at -40°C until use.

ACTIVATED PARTIAL THROMBOPLASTIN TIME (APTT)

For activated partial Thromboplastin time assay, citrated normal human plasma (90µl) was mixed with aqueous extract of T. decurrens (10µl) in each concentration (25, 50, 100, 150 and 200µg/ml) and incubated for 1 minute at 37°C, followed by APTT reagent (100µl) was added to the mixture and incubated for 5 min at 37°C. Thereafter, the clotting was induced by adding 0.02M calcium chloride (100µl) and clotting time was recorded. (Method followed by Pacific hemostasis kit).

PROTHROMBIN TIME (PT)

In prothrombin time, the citrated normal human plasma (90µl) was mixed with 10µl of aqueous extract of T. decurrens in each concentration (25, 50, 100, 150 and 200µg/ml) and incubated for 10 min. Then, PT reagent (200µl) pre-incubated for 10 min at 37°C was added and clotting time was recorded. (Method followed by Pacific hemostasis kit).

RESULTS

ANTICOAGULANT ACTIVITY OF AQUEOUS EXTRACT OF T. DECURRENS

In this study, the coagulation of both intrinsic and extrinsic pathways of aqueous extract of T. decurrens in different concentration (25, 50, 100, 150 and 200µg/ml) was determined through APTT and PT assays. In APTT, the coagulation time of the control was 23.4s and in aqueous extract of T. decurrens it prolonged to >300s at 150 and 200 µg/ml. In PT, the coagulation time of the control was 9s and in aqueous extract of T. decurrens prolonged to 120s at 200 µg/ml (Table.1).

Table.1: Anticoagulant activity of aqueous extract of T. decurrens using APTT and PT assays

Sample (µg/ml)	APTT*	PT*
25	59.3s	48.4s
50	80.3s	72.9s
100	101.2s	94.7s
150	>300s	107s
200	>300s	125s

*The data are the mean values of two experiments

APTT for control without aqueous extract of T. decurrens: 25.3s

PT for control without aqueous extract of T. decurrens: 9s

DISCUSSION

Evaluation of aqueous extract of the brown alga T. decurrens exhibited remarkable anticoagulant potential and may serve as a prominent source. The observed high clotting time of anticoagulants in APTT is due to the inhibition of the intrinsic and PT is due to the extrinsic pathway. The APTT is a useful screening tool and a quantitative test for the intrinsic coagulation factors. It is a simple and versatile (flexible) test which is sensitive to deficiencies of all plasma clotting factors except factor VII; however, it is mainly used to detect deficiencies in factors VIII, IX, XI and prekallikrein. The PT assay is used to determine the clotting tendency of blood in the measure of warfarin dosage, liver damage, and vitamin K status. It measures the factors I, II, V, VII and X and it is used in conjunction with APTT.

Most of the algal species exert their anticoagulant action through the sulphated polysaccharides (Church *et al.,* 1989) and some of them trigger anticoagulant activity through protein, or glycoprotein-like compounds (Yasuda *et al.,* 2004). In the present study, hot water extraction method showed promising result for anticoagulant activity and it was in good agreement with Shanmugam and Mody, (2000). The molecular weight, chain length, charge density and the three-dimensional structure of the sulfated polysaccharide influence its interactions with the coagulation proteins (Melo *et al.,* 2004). The sulphated polysaccharide (fucoidan) which is used in the present study can be capable of binding with proteins at several levels of specificity and exhibit high affinity for particular proteins (Azevedo *et al.,* 2009). It is generally accepted that the anticoagulant activity of the sulfated polysaccharides partly results from the strong interaction between the negatively charged sulfate groups and some positively charged peptidic sequences. Normally, sulphated polysaccharides (sulphated fucoidan and galactofucans) with 50–100,000Da are considered as potential anticoagulants whereas, the fractions with >850,000Da usually demonstrate low anticoagulant activities (Shanmugam and Mody, 2000).

The fucoidan stimulates tissue-type plasminogen activator-induced plasma clot lysis by protecting plasmin activity from inactivation by ct2-antiplasmin and the biological effects of fucoidan have been found to depend on the degree of sulfation and molecular size of the polysaccharide chains. The maximum anticoagulant and fibrinolytic activities were observed in over sulfated fucoidan fractions of high molecular weight (2100 kDa) (Soeda *et al.,* 1992). In the present study, aqueous extract of T. decurrens showed highest activity in both APTT (>300s) and PT (120s) assays. Similar result (>300s) was observed by Athukorala *et al.,* (2007) in Ultraflo extract of C. fragile and S. hornei in the APTT activity but it was lower in hot water extract of C. fragile (250s). The lower activity was observed in few brown seaweeds such as, S. siliquastrum and S. hornei (170s), Laminaria ochotensis (150s), S. thunbergii (85s), S. fulvellum (75s), S. coreanum (70s), Undaria pinnatifida (48s) and Padina arborescens (37s) (Athukorala *et al.,* 2007), G. verrucosa, G. textoria and Gloiopeltis furcata (38.6s, 49.1s, and 51.7s) (Pushpamali *et al.,* 2008). In fermented brown seaweed S. fulvellum the activity (202s in eighth week and 104s for tenth week) was low (Zoysa *et al.,* 2008). This indicates that the polysaccharides have good activity than the fermented seaweeds. In PT assay, the lower activity from C. fragile (20s), S. hornei (13s) (Athukorala *et al.,* 2007) and G. verrucosa, G. textoria and Gloiopeltis furcata (25.3s, 24.7s, and 31.6s) (Pushpamali *et al.,* 2008) were comparatively lower than the present study. Hence, aqueous extract of T. decurrens will be a better candidate as anticoagulant agent.

CONCLUSION

Results of this study could be a useful indicator for clinical practice towards the possibility of interaction between algae and anticoagulants, although further clinical research is needed taking into consideration the limitations of in vitro studies. These findings also suggest that further research into the action of this alage could be of real clinical value in identifying potential alternative anticoagulant therapies.

REFERENCES

[1]. Andrew, T. Ellinor, K. Roman, J. Tobias, A. and Thomas, R. (2015). Contact System Revisited: An Interface Between Inflammation, Coagulation, And Innate Immunity. Journal of Thrombosis and Haemostasis 14: 427-437. 5.

[2]. Athukorala, Y, Lee, K.W. Kim, S.K. and Jeon, Y.J. (2007). Anticoagulant activity of marine green and brown algae collected from Jeju Island in Korea. Bioresource Technology 98:1711–1716.

[3]. Azevedo, T.C.G. Bezerra, M.E.B. Santos, M.D.G. Souza, L.A.S. Marques, C.T. Beneveides, N.M.B. and Leite, E.L. (2009). Herparinoids algal and their anticoagulant, hemorrhagic activities and platelet aggregation. Biomedicine and Pharmacotheraphy 63:477-483.

[4]. Church, F.C. Meade, J.B. Treanor R.E. and Whinna, H.C. (1989). Antithrombin activity of fucoidan. J. Biol. Chem., 264: 3618-3623.

[5]. Davie, E.W, Fujikawa, K, Kisiel, W. (1991). The coagulation cascade: initiation, maintenance, and regulation. Biochemistry 30(43):10363–10370.

[6]. Gupta, S. and N. Abu-Ghannam, (2011). Bioactive potential and possible health effects of edible brown seaweeds. Trends in Food Science & Technology 22 (6): 315-326.

[7]. Heo, S.J, Park, E.J. Lee K.W. and Jeon, Y.J. (2005). Antioxidant activities of enzymatic extracts from brown seaweeds. Bioresource Technology 96: 1613–1623.

[8]. Kaliaperumal, N, Kalimuthu, S.and Ramalingam, J.R. (2004). Recent scenario of seaweed exploitation and industry in India. Seaweed Res. Utiln., 26:47-54.

[9]. Meenakshi, S. Umayaparvathi, S. Arumugam M. and Balasubramanian, T. (2011). In vitro antioxidant properties and FTIR analysis of two seaweeds of Gulf of Mannar,Asian Pacific Journal of Tropical Biomedicine 1(1): 66-70.

[10]. Meenakshi, S. Umayaparvathi, S. Saravanan, R. Manivasagam T. and Balasubramanian, T. (2014) Hepatoprotective effect of fucoidan isolated from the seaweed Turbinaria decurrens in ethanol intoxicated rats. International Journal of Biological Macromolecule 67: 367–372.

[11]. Meenakshi, S. Umayaparvathi, S. Saravanan, R. Manivasagam, T. and Balasubramanian, T. (2016). Neuroprotective effect of fucoidan from Turbinaria decurrens in MPTP intoxicated Parkinsonic mice. International Journal of Biological Macromolecules 86: 425–433.

[12]. Melo, F.R. Pereira, M.S. Foguel, D.and Mourao, P.A.S. (2004). Antithrombin–mediated anticoagulant activity of sulfated polysaccharides. The Journal of Biological Chemistry 279: 20824–20835.

[13]. Moll, S. and Roberts, H.R. (2002). Overview of Anticoagulant Drugs for the Future. Semin Hematol, 39: 145–157.

[14]. Oza R.M. and Zaidi, S.H. (2001). A revised checklist of Indian marine algae. Central Salt and Marine Chemicals Research Institute, India, 296 pp.

[15]. Pallister, C. J. Watson, M.S. (2010). Haematology. Scion Publishing, 336–347.

[16]. Pereira M. S. and Mulloy, B. (1999). Structure and anticoagulant activity of sulfated fucans. J. of Biol. Chem., 274: 7656-7667.

[17]. Pushpamali, W.A., Nikapitiya, C.M. Zoysa, D. Whang, I. Kim, S.J. and Lee, J. (2008). Isolation and purification of an anticoagulant from fermented red seaweed Lomentaria catenata. Carbohydrate Polymers 73: 274-279.

[18]. Shanmugam, S. and Mody, K.H. (2000). Heparonid active sulphated polysaccharides from marine algae as potential blood coagulant agents. Curr. Sci., 79(12): 1672-1683.

[19]. Sirridge, M.S. and Shannon, R. (1993). Hematology Principles and Procedures. 6th Ed. Philadelphia, PA: Lea and Febiger, 202-78.

[20]. Soeda, S. Sakaguchi, S. Shimeno H.and Nagamatsu, A. (1992). Fibrinolytic and anticoagulant activities of highly sulfated fucoidan. Biochem. Pharmacol., 43: 1853-1858.

[21]. Yasuda, S. Atsumi, T. Ieko, M. and Koike, T. (2004). β_2-glycoprotein I, anti-β_2-glycoprotein I, and fibrinolysis. Thromb. Res., **114:** 461–465.

Chapter 15

ECOLOGICAL REQUIREMENTS FOR MULBERRY CULTIVATION&NUTRITIONAL REQUIREMENTS

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ABSTRACT

Silkworms grow best when fed with fresh mulberry leaves, which are rich in nutrients and moisture. Under tropical conditions, dirge of leaf is faster. Usually, the leaves are harvested twice a day and are preserved for successive feedings, depending on the necessity. During this period, the leaves should be preserved in cool and clean places in order to preserve their succulence. It is batter to preserve leaves in a leaf chamber or bamboo basket which is lined with gunny cloth that can be kept wet by sprinkling water at frequent intervals. Harvested leaves must be sprinkled with water in summer season, if necessary. Alternately, chawki mulberry leaves can be stored in a mud pot, which is placed in the moist sand and mouth of the pot must be covered with wet cloth. Also, chawki mulberry leaves can be stored on a flat moist sand bed covered with wet and clean white cloth. Again after arranging the leaves on the sand bed, they must be covered with wet white cloth.

KEYWORDS: Ecology, mulberry cultivation & Nutritional.

INTRODUCTION

The optimum elevation for mulberry growth is about 710 m above MSL. For cultivation purposes, an elevation of 305 to 910 m above MSL is the optimum range. The ideal temperature is 23 to 27°C and relative humidity is 64 to 81%. Sunshine duration 5 to 12 hours per day. Mulberry cannot sprout below 13°C or above 38°C. A rainfall range from 600 m to 2500 mm per year is considered ideal. During the growth period, mulberry requires about 280 – 400 ml of water to synthesize one gram of dry matter. As mulberry is a perennial, deep -rooted plant, soil structure must be sufficiently porous to supply air and water to the root zone. Soil should be deep, fertile, porous, well drained and with good water holding capacity. Loamy, clayey- loamy or sandy - loamy soils are the best. Slightly acidic soils (6.2 to 6.8pH) free from injurious salts are ideal. Mulberry varieties Irrigated: Kanva 2 (M5), MR 2, S 30, S36, S 54, DD, V1. Semi irrigated: Kanva 2, MR 2. Rain fed: S 13, S 34, RFS, 135, RFS, 175, S 1635.

Selection of planting material: Generally, the mulberry plants are raised from semi-hardwood cuttings. Cuttings are selected from well-established garden of 8-12 months old. Only full grown thick main stems, free from insect and disease damages having a diameter of 10-12mm are chosen for preparation of cuttings. The cuttings should be of 15-20 cm with 3-4 active buds and should have 45o slanting cut at the bottom end. Care should be taken to make a sharp clean cut at both the ends of cuttings without splitting the bark. Manually/power operated mulberry cutter (stem cutting machine) is available for quick cutting of propagation material.

This is the transfer of saplings from the nursery to the main field. Saplings which are about 80-90 days old can be transplanted. While uprooting maximum care should be taken not to damage the root system.

Before uprooting, the nursery should be well watered. Transplanting is done early in the morning, late in the evening or anytime during the day when the weather is cool. The shoots should be trimmed to reduce loss of water by transpiration while the roots should be trimmed to avoid wilting of the sapling from bent roots. Spacing of Mulberry Plantation, There are several spacing practices that have been adopted but mostly determined by the intended use, irrigated or rain-fed plantation. 5ft x 2½ (1.5m x 0.75m) for rain-fed mulberry and 4ft x 2½ (1.2 x 0.75) for irrigated mulberry. This will give a population of 4,000 trees per acre.

DIGGING OF HOLES

the size of the planting hole should be 1½ft x 1½ft (45 x 45 cm). Separate topsoil from subsoil and mix the topsoil with half (½) a debt of well decomposed farmyard manure then put it back into the hole. The soil level should be retained at least 10 cm below ground level to form a basin like structure. Add 50 Gms of D.A.P and mix well with the soil. At the onset of the rains, pull out the saplings and trim the roots and cut off the shoot to avoid loss of water by transpiration. Plant the sapling in the basin formed. When the shoots sprout more soil is added to the soil to encourage the formation of secondary roots. If all uprooted saplings are not planted on that day, store the remaining ones in a damp place. One can dig a hole and place them inside or place them under shade and cover them with grass. Sprinkle water over them to keep them damp.

INTER-CROPPING

Legumes can be planted between the mulberry rows, using the standard cultivation. However climbers or any other legume that requires spraying of chemicals that are harmful to the silkworms should not be intercropped. Inter-cropping with legumes can be done within the first year while the crop is young which leads to additional nitrogen to the garden and income in the first year.

TRAINING OF MULBERRY TREE FOR MAXIMUM LEAF PRODUCTION

Three months after the mulberry has been established in the main field; prune the shoots at the base level. This will allow more shoots to grow from the base. After about 6 months, when these shoots attain a height of 3ft select 3 strong shoots. Prune at 1ft above the ground to establish the pruning/harvesting table.

A) Methods of propagation :

The methods of propagation of mulberry are,

1. Sexual propagation
2. Vegetative propagation
3. Micro propagation.

a) Sexual propagation / seedling propagation

This method is rarely practiced for breeding purposes in research institutes. Here the flowers are protected from cross pollination and only controlled pollination allowed.

b) Vegetative propagation

This is the most popular method used for commercial plantation. Its chief advantages are,

i) The desired hereditary characters can be maintained throughout.

ii) Large number of plants can be raised quickly and economically.

iii) Pest and disease resistant plants can be grown.

c) Propagation of mulberry

- Mulberry is mostly propagated through cuttings.

- Cuttings may be planted straight away in the main field itself or nursery may be raised and the sprouted and rooted saplings may be planted in the main field.
- The latter method is advisable because of its easy establishment in the main field.

d) Selection of planting material

- Generally, the mulberry plants are raised from semi-hardwood cuttings.
- Cuttings are selected from well-established garden of 8-12 months old.
- Only full grown thick main stems, free from insect and disease damages having a diameter of 10-12mm are chosen for preparation of cuttings.
- The cuttings should be of 15-20 cm with 3-4 active buds and should have 45o slanting cut at the bottom end.
- Care should be taken to make a sharp clean cut at both the ends of cuttings without splitting the bark. Manually/power operated mulberry cutter (stem cutting machine) is available for quick

e) Nursery bed preparation

- Select 800 sq.m. Area of red loamy soil near water source for raising saplings for planting one hectare of main field.
- Apply 1600 kg of Farm Yard Manure (FYM) @ 20 t/ha and mix well with the soil.
- Raise nursery beds of 4m x 1.5m size.
- The length may be of convenient size depending upon the slope, irrigation source, etc.
- Provide a drainage channel and avoid shady area.

f) Pre-treatment of cuttings

- Mix one kilogram of Azospirillum culture in 40 liters of water.
- Keep the bottom end of the cuttings for 30 minutes in it before planting. Azospirillum is applied for inducement of early rooting.

g) Nursery planting

- Apply VAM @ 100 g/m2 of nursery area.
- Irrigate the nursery bed. Plant the cuttings in the nursery at 15 cm x 7 cm spacing at an angle of 45o.
- Ensure exposure of one active bud in each cutting.

h) Nursery management

- Irrigate the nursery once in three days.
- Dust one kg of any one of the following chemicals around the nursery bed to avoid termite attack.
- Essential elements used in relatively large amounts, Essential elements used in relative small amounts, mostly from air and water, from soils, Macronutrients, Secondary nutrients

Micronutrients, Carbon (C), Nitrogen (N), Calcium (Ca), Iron (Fe), Hydrogen (H), Phosphorus (P), Magnesium (Mg), Manganese (Mn), Oxygen (O), Potassium (K), Sulphur (S), Boron (B), Molybdenum (Mb), Copper (Cu), Zinc (Zn), Cobalt (Co)

ORGANIC MANURES

Organic content is necessary to build up the micro flora which is involved in nitrogen fixation and the recycling pathways of other minerals. Organic matter can supply the essential micro nutrients and also improve the physical, chemical and biological properties of the soil.

Two types of organic manure are

1. Bulky organic manure. e.g. Farmyard manure, Compost, Green manure
2. Concentrated organic manure. e.g. Oilcakes, Fish meal.

1. **Compost:** It is made by the decomposition of grass or straw or other domestic and agricultural wastes in pits under anaerobic conditions. Lime- milk is added to quicken decomposition.
2. **Farm yard manure (FYM):** This consists of dung, urine and straw that has been used as bedding for cattle. Fresh FYM is harmful to mulberry roots. Decomposed or partially decomposed FYM can be used.
3. **Sericulture wastes:** The wastes used as fertilizers after decomposition include silkworm litter, dead worms, eluvia, pruned leaves, unused leaves, pupal wastes and dead and un used moths.
4. **Poultry manure:** Litter, unfed feed and dropped feathers which are rich in phosphates are used after decomposition.
5. **Oil cakes:** Oilcakes of soya bean, neem and groundnut are used.
6. **Green manures:** Leguminous plants which have nitrogen-fixing root nodule bacteria are grown as intercrops in mulberry fields and after their yield are harvested are mulched and used as green manures. Eg. 1.Sunhemp, Crotalaria juncea, 2.Daincha, Sesbania aculeata, 3. Bersem, Trifolium alexandrinum, 4.Cowpea, Vigna sinensis.
7. **Biogas slurry:** It is also used.
8. **Press mud:** it is an important by product of the sugar industry. Application of 7.5 tons of press mud per hectare is equivalent to 150 kg of P_2O_5 (Single super phosphate).

ADVANTAGES OF ORGANIC MANURES

It increases the water holding capacity of the soil. Improves the physical condition of the soil. Increases the chemical and biological activities of the soil.

CHEMICAL FERTILIZERS

The nutrient requirement of mulberry per hectare per year is the highest compared to any other field crops.

REFERENCES

[1]. Annual Report of Central Seri cultural, Research and Training Institute, Central Silk Board, (2008) Mysore. Indian Silk, Vol. 47(5), 2008.
[2]. Md. Aslam (2008) Adding value. Biotech News, Vol. III (5), p. 9.
[3]. Planning Commission Report, Article by Dr. K. Venkatasubramanian. (2004). Member, Planning Commission. Sericologia, Vol. 44(3), 2004.
[4]. Proceeding of the 20th Conference of the International Sericulture Commission, Bangalore, and December, (2005).
[5]. Sericulture and Silk Industry Statistics, (2003), Central Silk Board, Govt. of India, Bangalore.

Chapter
16

MUSHROOM FARMING

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ABSTRACT

The six processes of mushroom farming are rather arbitrary in their classifications, but they do outline the necessary components of a production system. Phase I composting, Phase II composting, spawning, casing, pinning, and cropping are the six processes. The phases are explained in the order in which they occur naturally, highlighting the important aspects of each step. Mushroom growth requires nutrients, which compost offers. Horse manure mixed with wheat straw is the most common and least expensive of the two materials used to make mushroom compost. While hay and wheat straw are typically used to make synthetic compost, the word is frequently used to describe any mushroom compost in which horse dung is not the main constituent. Compost of any kind needs to have a conditioning agent and nitrogen additions added.

KEYWORDS: Mushroom Farming, Synthetic compost, wheat straw.

INTRODUCTION

MUSHROOM FARMING

The six processes of mushroom farming are rather arbitrary in their classifications, but they do outline the necessary components of a production system. Phase I composting, Phase II composting, spawning, casing, pinning, and cropping are the six processes. The phases are explained in the order in which they occur naturally, highlighting the important aspects of each step. Mushroom growth requires nutrients, which compost offers. Horse manure mixed with wheat straw is the most common and least expensive of the two materials used to make mushroom compost. While hay and wheat straw are typically used to make synthetic compost, the word is frequently used to describe any mushroom compost in which horse dung is not the main constituent. Compost of any kind needs to have a conditioning agent and nitrogen additions added.

The preparation of compost occurs in two steps referred to as Phase I and Phase II composting. The discussion of compost preparation and mushroom production begins with Phase I composting.

1. PHASE I: MAKING MUSHROOM COMPOST

The materials are mixed and moistened while being piled into a rectangular pile with tight edges and a loose center to start phase I composting. The bulk materials are typically turned with a compost turner. As the horse dung or synthetic compost passes through the turner, water is sprayed on it. The turner spreads gypsum and nitrogen additions on top of the bulk components and carefully mixes them. Aerobic fermentation, or composting, is initiated once the pile is wetted and produced by the natural development and reproduction of microbes included in the bulk components. This process releases carbon dioxide, heat, and ammonia as byproducts. The mushroom business has almost entirely adopted

forced aeration, which involves placing compost on a concrete floor, in tunnels, or in bunkers and forcing air to travel through plenums, nozzles, or spigots in the floor (Fig. 1).

Fig. 1: Loose straw ready for incorporation into compost windrow (top left); compost windrow (top right); aerated Phase I compost wharf under roof (note groves in concrete, bottom left); grove showing aeration nozzle (bottom right, arrow)

Compost made from mushrooms is created when heat, certain chemical reactions that release heat, and the activity of microbes change the chemical composition of the raw materials. These occurrences produce a food source that is most suited for the mushroom's growth, to the detriment of other bacteria and fungus. Throughout the process, there must be sufficient amounts of moisture, oxygen, nitrogen, and carbohydrates; otherwise, the process will come to an end. For this reason, while the compost pile passes through the turner, it is periodically aerated and supplemented with water.

The performance of the compost in terms of spawn run and mushroom production is known to be influenced by the very variable quality of raw materials used to manufacture mushroom compost. Compost production may be impacted by the location of the wheat straw supply, the type (spring or winter), and the application of fungicides, plant growth regulators, and nitrogen fertilizer. Before being used to make compost, wheat straw should be kept under cover to prevent the growth of undesirable and perhaps harmful fungi and bacteria.

To reduce the grease that compost typically has, gypsum is added. Some chemicals in the compost are more likely to flocculate when there is gypsum present because they stick to the hay or straw instead of filling the pores (holes) between the straws. This phenomenon has the added benefit of allowing air to more easily enter the pile, which is necessary for the composting process. The absence of air creates an anaerobic (airless) environment where harmful chemical compounds grow and reduce the mushroom compost's suitability for mushroom growth. At the beginning of composting, 40 pounds of gypsum are added for every ton of dry ingredients.

Among the common nitrogen supplements used today are chicken manure, soybean, peanut, or cotton seed meals, and corn distiller's grain. With the use of these supplements, the nitrogen content is intended to be raised to 1.5% for horse manure and 1.7% for synthetic fertilizer, both calculated using dry weight. Ammonium nitrate or urea must be added to synthetic compost at the beginning of the composting

process in order to give the compost microflora a readily available source of nitrogen for growth and reproduction.

The initial compost pile should be as long as needed, and it should measure 5 to 6 feet wide and 5 to 6 feet high. The pile (rick) can be formed using a two-sided box, though some turners come with a "ricker" that eliminates the need for a box. Throughout Phase I composting, the pile's sides should be solid and dense, but the middle should stay loose. During the composting process, the materials become less rigid and compactions can easily occur as the hay or straw softens. An anaerobic environment will arise in the traditional Phase I process if the materials get too compacted, preventing air from passing through the pile. Forced aeration has been a major solution to the compost's anaerobic center core problem.

Watering and turning should be done every two to three days, but only when the pile reaches a temperature of 145° to 170°F. Turning gives you the chance to water, aerate, and combine the ingredients. It also allows you to move the hay or straw from an area inside the pile that is cooler to one that is warmer, outside versus inside. Supplements should be added early in the composting process, but they are also added when the compost is turned. The state of the starting material and the amount of time required for the compost to heat to temperatures above 145°F determine how many turnings and how long to wait between turnings.

Water addition is important because too little can prevent bacteria and fungi from growing and too much will prevent oxygen from entering the pore space. Generally speaking, water is added when the pile is formed and during the initial turning until it starts to leach. After that, either no water is added or very little water is added for the duration of the composting process. Water can be liberally applied during the final turning prior to Phase II composting so that water seeps out of the compost when it is compressed tightly. Water, nutritional value, microbial activity, and temperature are all related, and because they are a chain, when one condition becomes limiting for any one of the factors, the chain as a whole will break down.

Depending on the nature of the material at the beginning and its properties at each stage, phase I composting can take anywhere from 6 to 14 days. Composting is usually accompanied by a sweet, moldy smell, as well as a strong ammonia odor. Ammonia and temperatures above 155°F in the compost cause chemical reactions that produce food that the mushrooms primarily consume. The temperature of the compost rises as a result of heat being released by the chemical reactions. When a desirable level of biological and chemical activity is occurring during the second and third turnings, temperatures in the compost can reach 170° to 180°F. At the end of Phase I the compost should: a) have a chocolate brown color; b) have soft, pliable straws, c) have moisture content of from 68 to 74 percent; and d) have a strong smell of ammonia. When the moisture, temperature, color, and odor described have been reached, Phase I composting is completed.

2. PHASE II: FINISHING THE COMPOST

Phase II composting serves two main goals. Any insects, nematodes, pest fungi, or other pests that might be in the compost must be killed by pasteurization. Furthermore, the compost needs to be condition and the ammonia that developed during Phase I composting needs to be removed. Ammonia must be removed at the end of Phase II if its concentration is higher than 0.07 percent, as it frequently inhibits the growth of mushroom spawn. Ammonia is typically odorous when its concentration is higher than 0.10 percent.

Phase II occurs in one of three locations, contingent upon the production system type. Compost is placed into wooden trays for the zoned growing system. The trays are then stacked six to eight high and placed

inside a Phase II environmental control room. Subsequently, the trays are relocated to designated rooms that are specifically designed to offer the ideal conditions for every stage of the mushroom cultivation procedure. Compost is directly deposited into the beds in a bed or shelf system, which is located in the room where all crop culture processes take place. The most recently introduced system, the bulk system, is one in which the compost is placed in an insulated tunnel with a perforated floor and computer-controlled aeration; this is a room specifically designed for Phase II composting (Fig. 2).

Fig. 2: Phase II tunnels used to pasteurize and condition compost for mushroom production. Left: filling machine in front of closed tunnel, Right: open tunnel ready for filling

Regardless of the method used—beds, trays, or bulk—the compost needs to be packed consistently in terms of depth, density, and compression. Since outside air will replace the ammonia and carbon dioxide in the compost, the density of the material should permit gas exchange.

Composting in phase II is regulated, temperature-sensitive, and ecological. Air is used to keep the compost at a temperature where microorganisms can thrive and proliferate. These heat-loving, or thermophilic, organisms depend on the availability of nitrogen and carbohydrates that can be used for growth, with some nitrogen occurring as ammonia. The mushroom mycelium grows and other organisms do not on the compost because these microorganisms either create nutrients or act as nutrients. In recent years, tunnel Phase II completion has gained popularity. Tunnel composting has the advantage of treating more compost per ft2 compared to more expensive production rooms. Tunnel composting has the benefit of increased uniformity and mechanization when combined with bulk spawn run. In contrast to compost that stays in the same room, moving finished compost from the pasteurization tunnel to the bulk spawn run tunnel may raise the possibility of an infestation of undesirable pathogens and pests. Therefore, compared to in-room composting, tunnel composting may require higher standards of sanitation.

While attempting to ascertain the appropriate procedure and sequence to follow, it is crucial to keep in mind the goals of Phase II. The elimination of undesired ammonia is one goal. 125° to 130°F is the most effective temperature range for this purpose because it promotes the growth of de-ammonifying organisms. Using a pasteurization sequence, Phase II's second goal is to eradicate any pests that may have been present in the compost.

Before spawning, or planting, can start, the compost temperature needs to be lowered to between 75° and 80°F at the conclusion of Phase II. The compost should have a moisture content of between 68 and 72 percent and a nitrogen content of 2.0 to 2.4 percent. Additionally, to achieve profitable mushroom yields at the end of Phase II, 6 to 8 pounds of dry compost should be added per square foot of bed or tray surface. Since it is desired to have as homogenous a material as possible, it is crucial that the compost and the temperature of the compost remain consistent during the Phase II process.

SPAWNING

Millions of tiny spores are produced by mature mushrooms on the gills that line the underside of the mushroom cap. These spores work in a manner akin to that of higher plants' seeds. But mushroom spores germinate erratically, so growers do not 'seed' mushroom compost with them. This is because they are unpredictable. Thankfully, mycelium—thin, thread-like cells—can grow vegetatively from spores that have germinated, and enabling spawn producers to expand the culture for the production of spawn. In order to maintain the purity of the mushroom mycelium, mycelium must be propagated in specialized facilities. Sponge is mycelium that has been vegetatively propagated on different grains or agars; commercial mushroom growers buy spawn from businesses that specialize in producing it.

Spawn makers start the spawn-making process by sterilizing a mixture of millet grain plus water and chalk; rye, wheat, and other small grain may be substituted for millet. Sterilized horse manure formed into blocks was used as the growth medium for spawn up to about 1940, and this was called block or brick spawn, or manure spawn; such spawn is not used today. Once sterilized grain has a bit of mycelium added to it, the grain and mycelium is shaken 3 times at 4-day intervals over a 14-day period of active mycelial growth. Once the grain is colonized by the mycelium, the product is called spawn (Fig. 3). Spawn can be refrigerated for a few months, so spawn is made in advance of a armer's order for spawn.

Fig. 3: Mushroom spawn from open bag (left); close up of millet spawn (right)

After being scattered throughout the compost, spawn is well combined with it. For many years, this was carried out by hand using a small instrument that resembled a rake to spread the spawn across the compost's surface and ruffle it in. However, spawn for the bed system has recently been combined with compost using a unique spawning machine that uses tines or tiny devices that resemble fingers to mix the two materials. Spew is combined with compost in a tray or batch system as the compost travels on a conveyer belt or falls into a tray from a conveyor. The spawning rate is expressed as a unit or quart per so many square feet of bed surface; 1 unit per 5 ft^2 is desirable. The rate is sometimes expressed on the basis of spawn weight versus dry compost weight; a 2 percent spawning rate is desirable.

SUPPLEMENTATION AT SPAWNING

Early in the 1960s, it was discovered that adding protein-and/or lipid-rich materials to compost during the spawning, casing, and subsequent stages increased yields. When tiny amounts of protein supplements were added to the compost during spawning, yield increased by up to 10%. The quantity of supplement and associated benefit that could be obtained was significantly reduced by overheating and encouraging rival molds in the compost. The development of delayed release supplements for mushroom culture was able to get around these restrictions (Carroll and Schisler 1976). By encasing vegetable oil micro droplets in a formaldehyde-denaturing protein coat, the drawbacks of adding non-composted

nutrients to mushroom compost during spawning were mainly mitigated. Increases of as much as 60% were obtained. Today, several commercial supplements are available that can be used at spawning or at casing to stimulate mushroom yield.

Amendment of mushroom substrate with Micromax® is another potential opportunity for growers to improve the yield capacity of their Phase II compost. Micromax® contains a mixture of nine micronutrients including (percentage dry wt basis): Ca (12%), Mg (3%), S (12%), B (0.1%), Cu (1%), Fe (17%), Mn (2.5%), Mo (0.05%), Zn (1%), and inert ingredients (57.35%). Research has shown that approximately 70% of the yield increase observed is due to Mn. Commercial supplement makers have begun to add Mn to their delayed release nutrients for mushroom culture.

After the spawn and supplement have been evenly distributed throughout the compost and the surface has been worked to a level state, the temperature of the compost should be kept between 75 and 80°F, and a high relative humidity should be maintained to prevent drying out the spawn or the compost surface. In these circumstances, the spawn will proliferate and spread its mycelium throughout the compost, resembling a web. A spawned bed of compost is created when the mycelium from a spawn grain spreads out in all directions and eventually unites to form a single biological entity. Once fusion has taken place, the spawn appears as a white to blue-white mass throughout the compost. As the spawn grows it generates heat, and if the compost temperature increases to above 80° to 85°F, depending on the cultivar, the heat may kill or damage the mycelium and eliminate the possibility of maximum crop productivity and/or mushroom quality. At temperatures below 74°F, spawn growth is slowed and the time interval between spawning and harvesting is extended.

PHASE III AND PHASE IV COMPOST

Phase III compost is spawn from Phase II compost that has been run in bulk through a tunnel and is prepared for casing upon removal and delivery to the grower. Phase IV compost is created by casing Phase III compost and allowing spawn to colonize the layer before transferring it to the growing unit or growers. The quality of Phase I and Phase II composts has a major impact on the success of both Phase III and Phase IV compost. Because the fragmentation of the colonized compost tends to improve the initial color and shelf life of the mushrooms, using Phase III compost may also improve the quality of the mushrooms. In recent years, the use of bulk Phase III compost has increased in popularity because it allows an increase in the number of crops a grower can expect from his production rooms. Phase II production on shelves allows an average of about 4.1 crops per year whereas growers using Phase III bulk spawn run compost averages about 7.1 crops per year. An additional gain can be made in the number of crops (10-12 crops per year) when Phase IV is used (Dewhurst 2002; Lemmers 2003; Chang 2006).

MUSHROOM VARIETIES

Three main mushroom cultivars are used by growers in the US: A smooth white hybrid has a smooth cap with a white stalk; an off-white hybrid has a scaly cap with a white stalk; and a brown hybrid has a brown cap with a white stalk. There are multiple isolates within each of the three main groups, giving a grower the option to select up to eight strains per variety. While hybrid cultivars that are white or off-white in color are typically used in processed foods like sauces and soups, all isolates make delicious fresh mushrooms. The brown varieties have seen an increase in consumer preference in recent years. The Crimini variety is similar in appearance to the white mushroom except it is brown and has a richer and earthier flavor. The Portobello variety is a large, open, brown-colored mushroom that can have caps up to 6 inches in diameter. The Portobello offers a rich flavor and meaty texture.

The rate and distribution of spawning, the temperature and moisture of the compost, the addition of compost, and the type or quality of the compost all affect how long it takes for spawn to colonize the compost. Typically, a full spawn run takes 13 to 20 days. The following stage of production begins when the compost has grown completely with spawn.

CASING

Casing is a top dressing that is put to the compost created by spawn run, which is eventually where the mushrooms grow. As casing, a combination of ground limestone and peat moss can be utilized. Since casing serves as both a reservoir for water and a location for the formation of rhizomorphs, it does not require nutrients. Thick strings resembling rhizomorphs are created when the extremely thin mycelium unites. There would be no mushrooms without rhizomorphs because rhizomorphs are where mushroom initials, primordia, or pins form. A firm mushroom requires moisture to develop, so the casing needs to be able to retain moisture. The casing layer serves as a support system for the developing mushrooms, prevents the compost from drying out, supplies water to the mycelium for growth and development, and prevents structural collapse after repeated watering. The highest yield potential can be achieved by giving the casing as much water as possible as soon as possible without leaking into the compost underneath.

For casing, sphagnum peat moss is the most widely utilized material. Sphagnum can be processed differently at the harvest site and can range in color from brown (young, less decomposed, loose textured, surface peat) to black (compact, more decomposed, deep dug). While wet-dug peat is transported in a saturated state, milled peat is partially dried before packaging and transportation. Because wet-dug peat can hold more water than milled peat, some growers prefer it.

Pasteurization is not necessary for peat moss-based casing because the material is devoid of nematodes, weed molds, and pathogens that could lower mushroom yield. When combined with 40 lbs of limestone and water, one 6-ft3 compressed bale can cover approximately 125 ft2 of compost surface at a depth of two inches.

CASING INOCULUM (CI)

Casing inoculum is a sterilized mixture of peat, vermiculite and wheat bran that has been colonized by mushroom mycelium. It is mixed with casing to decrease cropping cycle time, improve uniformity of mushroom distribution over the bed and improve mushroom cleanliness. Mycelium from the CI colonizes the casing layer while it fuses with the underlying mycelium of the compost. This allows more breaks per crop or more crops per year.

Fig. 4: Casing inoculum used to inoculate casing for more rapid mycelial colonization

SUPPLEMENTATION AT CASING

Early in the 1960s, there was an attempt to add nutrients at casing. The findings demonstrated that yield increases were nearly proportionate to the amount added and that significantly larger amounts of nutrients could be added during casing than during spawning. While yield increases of up to 100% are possible, there are certain potential issues and restrictions with supplementation at casing. When supplementing at casing, the compost cannot contain weed molds, nematodes, or pathogens. When the compost is broken up before supplementation, these organisms get scattered throughout and can grow quickly before the mushroom mycelium resumes its growth.

Maintaining the crop after casing necessitates maintaining a high relative humidity level and maintaining the compost temperature at about 75°F for up to five days. The compost should then be cooled by approximately 2°F every day until tiny mushroom initials, or pins, start to form. Water needs to be applied sporadically during the period after casing in order to bring the moisture level up to field capacity prior to the formation of mushroom pins. Applying the right amount, timing, and technique of water to casing is an "art form" that easily distinguishes seasoned growers from novices.

PINNING

Mushroom initials develop after rhizomorphs have formed in the casing. The initials are extremely small but can be seen as outgrowths on a rhizomorph. Once an initial quadruples in size, the structure is a pin. Pins continue to expand and grow larger through the button stage, and ultimately a button enlarges to a mushroom (Fig. 5). Harvestable mushrooms appear 18 to 21 days after casing. Pins develop when the carbon dioxide content of room air is lowered to 0.08 percent or lower, depending on the cultivar, by introducing fresh air into the growing room. Outside air has a carbon dioxide content of about 0.04 percent.

Fig. 5: Mushrooms forming and maturing on the casing - a 2-inch layer of neutralized peat. Both "pins" and young mushrooms are visible

The timing of fresh air introduction is very important and is something learned only through experience. Generally, it is best to ventilate as little as possible until the mycelium has begun to show at the surface of the casing, and to stop watering at the time when pin initials are forming. If the carbon dioxide is lowered too early by airing too soon, the mycelium will stop growing through the casing and mushroom initials form below the surface of the casing. As such mushrooms continue to grow; they push through the casing and are dirty at harvest time. Too little moisture can also result in mushrooms forming below the surface

of the casing. Pinning affects both the potential yield and quality of a crop and is a significant step in the production cycle.

CROPPING

During the cropping cycle, there are recurring 3- to 5-day harvest periods known as flush, break, or bloom. These are separated by a few days during which no mushrooms are ready to be harvested. This cycle is rhythmically repeated, and harvesting can continue for as long as the mushrooms keep growing. The majority of mushroom growers harvest their crop for 35 to 42 days, but some harvest for 60 days, and some harvest for as long as 150 days.

For optimal cropping results, the air temperature should be maintained between 57° and 62°F. In addition to being conducive to the growth of mushrooms, this temperature range can also prolong the life cycles of disease-causing microorganisms and insect pests. Although it may seem strange that pests can harm mushrooms, all crops must contend with other living things in order to be grown. Pests that cause problems with mushrooms have the potential to destroy entire crops, and the degree of pest infestation frequently determines when to harvest a crop. Although pesticides and cultural methods can be used to control these diseases and insects, it is preferable to keep these organisms out of the growing rooms.

The growing rooms' relative humidity should be high enough to prevent the casing from drying out too much, but not so high that the growing mushrooms' cap surfaces become sticky or clammy. In order to prevent water stress from impeding the development of mushrooms, water is applied to the casing; in commercial practice, this entails watering two or three times per week. Depending on the cultivar being grown, how dry the casing is, and how far along the pins, buttons, or mushrooms are in their development, each watering may require more or fewer gallons. The majority of novice growers overwater their plants, which causes the casing's surface to seal and lose its texture. Sealed casing prevents the exchange of gases essential for mushroom pin formation. One can estimate how much water to add after first break has been harvested by realizing that 90 percent of the mushroom is water and a gallon of water weighs 8.3 lb. If 100 lb of mushrooms were harvested, 90 lb of water (11 gal.) were removed from the casing; and this is what must be replaced before second break mushrooms develop.

During the harvest season, outside air is used to regulate the temperature of the compost and the air. The growing mycelium releases carbon dioxide, which is also dispersed by outside air. Since more growth happens early in the crop, more fresh air is required during the first two breaks. The more mycelial growth, the more carbon dioxide produced. The quantity of compost in the growing room, the area of the producing surface, the mushrooms growing, and the state or makeup of the fresh air being introduced all affect how much fresh air is needed. Experience seems to be the best guide regarding the volume of air required, but there is a rule of thumb: $0.3 ft^3/ft^2/min$ when the compost is 8 inches deep, and of this volume 50 to 100 percent must be outside air.

Growing mushrooms requires proper ventilation in addition to temperature and humidity management. Wetting the walls and floors will add moisture to the air, as will using live steam or a cold mist. Increasing the amount of outside air admitted into the growing room, introducing drier air, or moving the same amount of outside air and heating it to a higher temperature—warmer air retains more moisture and reduces relative humidity—are three ways to remove moisture from the growing room. Controlling the temperature in a mushroom growing room is no different from controlling the temperature in your house. Hot water circulating through wall-mounted pipes can produce heat. Venting ducts can be used to blow hot, forced air, and this is a common practice at mushroom farms that were constructed more recently. A few mushroom farms can be found in limestone caves, where, depending on the season, the

rock serves as a heating and cooling surface. Any kind of cave isn't always the best place to grow mushrooms, and abandoned coalmines have too many inherent issues to be a feasible location for a mushroom farm. Before being suitable for mushroom growing, even limestone caves need to undergo extensive renovations and improvements. Additionally, mushroom growing only takes place within the cave, with composting occurring above ground on a wharf.

A 7–10 day cycle is observed in mushroom harvesting; however, this can vary based on temperature, humidity, cultivar, and stage of harvest (Fig. 6). When mature mushrooms are harvested, a growth-inhibiting substance is eliminated, causing the subsequent flush of mushrooms to progress toward maturity. Typically, picking mushrooms occurs when the veil is not too far. North American consumers prefer closed, tight, white or brown (Portobello) mushrooms, while some prefer open, brown (Crimini) mushrooms. A mushroom's level of maturity is determined by how far its veil extends rather than by its size. Thus, mature mushrooms can be big or small, but both growers and consumers like medium-to-large-size mushrooms.

Fig. 6: Harvesting of mushrooms. Each mushroom is hand harvested, the base of the mushroom is trimmed, and the clean, mature mushroom placed in a basket

Farm to farm, picking and packing techniques frequently differ. It is necessary to refrigerate freshly harvested mushrooms between 35° and 45°F. Mushrooms should be allowed to "breathe" after harvest, which is why it's better to store them in non-waxed paper bags rather than plastic ones.

A question frequently arises concerning the need for illumination while the mushrooms grow. Mushrooms do not require light to grow; only green plants require light for photosynthesis. However, growing rooms can be illuminated to facilitate harvesting or cropping practices.

NUTRIENTS

A good source of many different nutrients is mushrooms. This is illustrated with data on Crimini mushrooms in Figure 7. They are good sources of niacin (vitamin B3), pantothenic acid (vitamin B5), potassium, and selenium (containing over 20% of the RDA in a serving), and they are an excellent source of riboflavin (vitamin B2), copper, and selenium (containing over 10% of the RDA in a serving). Additionally, criminis are a great source of zinc, vitamin B6, thiamin (Vitamin B1), protein, fiber, manganese, magnesium, zinc, and folic acid. However, mushrooms are low in calories, fat, and sodium.

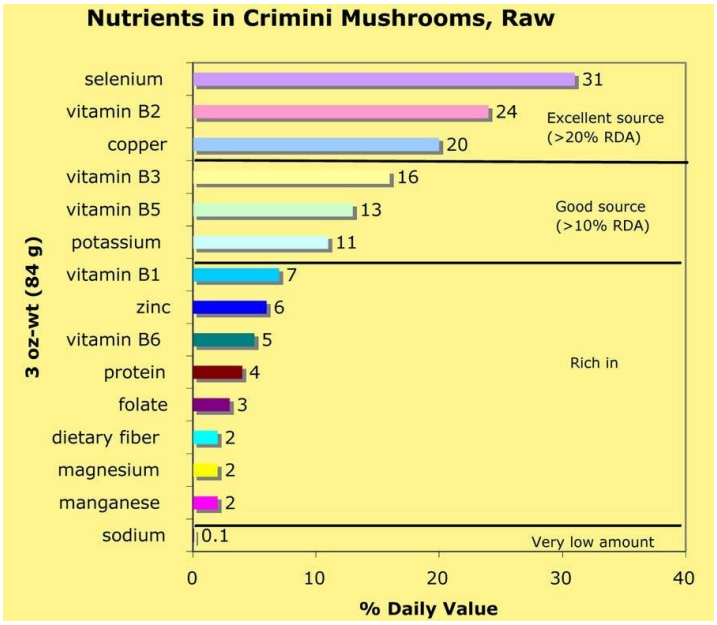

Fig. 7: Nutrients in crimini mushrooms based on FDA reference serving size of 84 g for raw mushrooms. Mushrooms are not a significant source of saturated fat, trans fat, cholesterol, sugars, vitamin A and calcium. Source: Mushroom Council

VITAMIN D

According to recent studies, mushrooms that are exposed to UV light have significantly higher vitamin D2 contents. After harvesting and just five minutes in the sun, a single serving of mushrooms will contain more than 800% of the recommended daily allowance (RDA) of vitamin D2. For those who don't consume milk or fish, this could be a convenient method of getting their recommended daily intake of vitamin D.

DIETARY FIBER (DF)

Many complex carbohydrates, including polysaccharides like glucans and glycogen, mono- and disaccharides, sugar alcohols, and chitin, are found in mushrooms. Since the majority of polysaccharides—including chitin and glucans—are indigestible to humans and form the structural elements of cell walls, they could be categorized as dietary fiber. In wealthy societies, dietary fiber may be helpful in preventing a number of diseases. Compared to white mushrooms, portobello mushrooms have a higher concentration of DF.

SELENIUM

The USDA National Nutrient Database states that three ounces of Crimini mushrooms provides nearly one-third of the recommended daily allowance (RDA) for selenium. Results from the Baltimore Longitudinal Study on Aging indicate that selenium can reduce prostate cancer by over 60%. Prostate cancer was found to be four to five times more common in men with the lowest blood selenium levels than in those with the highest levels, and selenium levels were found to decline with advancing age.

Selenium levels can be reliably increased in mushrooms by adding sodium selenite to mushroom compost. Some commercial supplement makers are now adding this compound to their delayed release nutrients for mushroom culture.

POTASSIUM

Potassium, which is necessary for maintaining the water content of fat and muscle, controlling blood pressure, and ensuring optimal cell function, is present in crimini mushrooms. More potassium can be

found in a 3-ounce Portobello than in an orange or banana. Thus far, efforts to increase the potassium content of mushrooms have yielded only patchy results.

ANTIOXIDANTS

Along with broccoli, carrots, green beans, red peppers, and portobello and Crimini mushrooms are good sources of antioxidants in the diet. They are the best source of L-ergothioneine (ERGO), a powerful antioxidant that is only found in nature and is produced by fungi. They are also rich in polyphenols, which are the main antioxidants in vegetables. Compared to the previously most well-known dietary sources of ERGO, crimini mushrooms have over 15 times the amount of ERGO.

ENVIRONMENTAL CONCERNS

ODORS

Certain mushroom farms face nuisance complaints as a result of preparing mushroom compost in close proximity to residential areas. The main cause of these complaints is the unpleasant smells connected to the process of making mushroom compost. Public attention has been drawn to this issue by suburbanization and the general public's increased sensitivity to environmental issues. Growers have implemented various strategies to mitigate the ecological effects of mushroom cultivation, such as the forced aeration of Phase I compost housed in tunnels or bunkers. Nonetheless, mushroom growers are still under pressure due to the problem of offensive odor generation.

DISPOSAL OF POST-CROP MUSHROOM COMPOST

Once the final batch of mushrooms has been harvested, the growing chamber needs to be sealed off and heated with steam. By destroying any pests that might be in the crop or the growing room's woodwork, this final pasteurization reduces the possibility that the following crop will become infested.

Post-crop mushroom compost (MC) is the material left over after the crop has been terminated (Fig. 8). It has many uses and is a valued product in the horticultural industry. One of the major uses of MC is for suppression of artillery fungi in landscape mulch. The artillery fungi grow rapidly throughout moist landscape mulch, and produce sticky spore masses about the size of a pinhead. These spores are forcibly discharged toward light colored surfaces such as house siding and cars. Once the spores dry they are nearly impossible to remove without leaving an unsightly brown stain on the surface. The incorporation of 20-40% MC into mulch effectively suppress the artillery fungi.

Fig. 8: Post-crop mushroom compost (MC) being loaded onto a truck as it is removed from a mushroom house

CONCLUSION

An entire production cycle, from the beginning of composting to the last steaming off after harvesting is finished, takes about 14 weeks to complete. A mushroom grower can anticipate between 0 and 8 pounds per square foot for this work; in 2006, the national average was 5.92 pounds per square foot. How successfully a grower has monitored and managed the temperature, humidity, pests, and other factors will determine the final yield. When everything is taken into account, the most crucial elements for successful production seem to be experience combined with a sense of intuition about the biological cycles of the commercial mushroom. Once the fundamentals of mushroom growing are understood, the crop's production system can be selected.

Chapter
17

HEAVY METALS IN MUNICIPAL SOLID WASTE DEPOSITS: A REVIEW OF ENVIRONMENTAL IMPACTS AND MANAGEMENT STRATEGIES

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ABSTRACT

The improper disposal and management of municipal solid waste (MSW) have led to significant environmental concerns, especially regarding the presence of heavy metals in waste deposits. Heavy metals, including lead, cadmium, mercury, chromium, and arsenic, are persistent pollutants that pose serious threats to ecosystems and human health. This review aims to provide an overview of the environmental impacts of heavy metals in MSW deposits and explore potential management strategies to mitigate their adverse effects. The accumulation of heavy metals in MSW deposits occurs through various pathways, such as industrial waste, electronic waste, and the disposal of household products containing these toxic elements. Once deposited in landfills or open dumpsites, heavy metals can leach into the surrounding soil and groundwater, leading to contamination of local ecosystems. Additionally, the decomposition of organic matter in waste generates methane gas, further exacerbating the environmental impact by contributing to greenhouse gas emissions and climate change.

To address these concerns, effective management strategies are imperative. Improved waste segregation, recycling, and waste-to-energy technologies can minimize the amount of waste entering landfills. The implementation of advanced leachate treatment systems and engineered barriers can help prevent heavy metal leaching and protect the surrounding environment. Furthermore, the development of remediation techniques, such as phytoremediation and biochar application, offers promising approaches to reduce heavy metal concentrations in MSW deposits. This review compiles existing studies and data on heavy metals in MSW deposits, highlighting the need for comprehensive waste management practices to safeguard public health and environmental integrity. As heavy metal pollution in waste deposits continues to pose a global challenge, interdisciplinary collaborations among policymakers, waste management professionals, environmental scientists, and communities are crucial for sustainable waste management and pollution prevention. By adopting these strategies and promoting public awareness, society can work towards a cleaner and healthier environment for future generations.

KEYWORDS: municipal solid waste (MSW), segregation, recycling, waste-to-energy technologies phytoremediation, sustainable waste management etc.

INTRODUCTION

Municipal Solid Waste (MSW) management is an increasingly pressing global challenge, driven by rapid urbanization and population growth. Improper handling and disposal of MSW can lead to severe environmental repercussions, including the release of heavy metals into the surrounding ecosystems. Heavy metals, known for their toxic and persistent nature, pose significant threats to both environmental integrity and human health. As a result, understanding the environmental impacts of heavy metals in

MSW deposits and implementing effective management strategies has become a crucial priority for sustainable waste management.

The term "heavy metals" encompasses a group of elements, including lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), and arsenic (As), among others. These elements can originate from diverse sources, such as industrial processes, electronic waste, and the disposal of batteries, paints, and chemical products. As these items find their way into municipal waste streams, the potential for heavy metal contamination in waste deposits intensifies.

Fig. 1: Municipality Waste

Once MSW is deposited in landfills or open dumpsites, complex interactions between waste constituents, moisture, and microbial activities can facilitate the leaching of heavy metals into the surrounding soil and groundwater. From there, these toxic elements can enter aquatic systems, disrupt natural ecosystems, and eventually find their way into the food chain, potentially causing harm to both wildlife and humans. Beyond the direct environmental implications, heavy metal contamination in MSW deposits also contributes to greenhouse gas emissions. The decomposition of organic matter in landfills generates methane gas, a potent greenhouse gas that significantly impacts global climate change. To address the challenges posed by heavy metals in MSW deposits, there is an urgent need to explore effective management strategies. Waste segregation at the source, enhanced recycling efforts, and adoption of waste-to-energy technologies are some of the approaches aimed at reducing the amount of waste destined for landfills. Additionally, the implementation of advanced leachate treatment systems and engineered barriers can help minimize heavy metal leaching from waste deposits.

This review paper aims to provide a comprehensive analysis of the environmental impacts associated with heavy metals in MSW deposits. It will explore the various sources and pathways through which heavy metals enter waste streams and examine their behaviour and fate in waste disposal sites. Furthermore, the paper will evaluate existing management strategies and technologies, with a focus on those that show promise in mitigating heavy metal contamination and ensuring long-term environmental sustainability. As societies strive to move towards more sustainable waste management practices, understanding the risks posed by heavy metals in MSW deposits and identifying effective solutions is imperative. This review seeks to contribute to this knowledge by consolidating the current state of research, highlighting the urgency of addressing heavy metal pollution, and promoting informed decision-making for a cleaner and healthier environment for present and future generations.

THE FATE OF HEAVY METALS IN MUNICIPAL SOLID WASTE DEPOSITS

The fate of heavy metals in municipal solid waste (MSW) deposits is a complex process influenced by various factors, including waste composition, environmental conditions, and waste management practices. Understanding the fate of heavy metals is crucial for assessing potential environmental impacts and developing effective strategies to mitigate their release into the environment. The fate of heavy metals in MSW deposits can be summarized as follows:

LEACHING

When MSW is disposed of in landfills or open dumpsites, rainwater and other sources of moisture can percolate through the waste, dissolving and carrying heavy metals with them. This process is known as leaching. Leachate is a liquid that accumulates at the bottom of landfills and can contain high concentrations of heavy metals. If not properly managed, leachate can contaminate groundwater and surface water, posing significant environmental and human health risks.

MIGRATION

Heavy metals, once released from the waste matrix via leaching, can migrate through the landfill or dumpsite's soil layers. This migration can spread heavy metal contamination beyond the boundaries of the disposal site, affecting nearby ecosystems and communities.

BIOACCUMULATION

In some cases, heavy metals leached from MSW deposits may be taken up by plants and microorganisms. These contaminants can then be transferred up the food chain through a process known as bioaccumulation. The accumulation of heavy metals in the tissues of organisms can lead to toxic effects and potential harm to predators, including humans that consume contaminated organisms.

VOLATILIZATION

Certain heavy metals can undergo volatilization under specific environmental conditions. For example, mercury may be released into the atmosphere as a vapor, contributing to air pollution and eventually depositing back into soil or water bodies through deposition processes.

CHEMICAL TRANSFORMATION

Some heavy metals may undergo chemical transformations in the waste environment due to interactions with other compounds present in the waste or the surrounding soil. These transformations can affect the mobility and toxicity of heavy metals, potentially influencing their environmental fate.

LONG-TERM PERSISTENCE

Heavy metals are known for their persistence in the environment. Once deposited in MSW deposits, they can remain a threat for extended periods, continually releasing into the surroundings if not adequately managed.

To mitigate the environmental impact of heavy metals in MSW deposits, various waste management strategies and technologies are employed. These may include waste segregation to remove hazardous components, the implementation of engineered landfill liners to minimize leachate migration, and the establishment of leachate treatment systems to remove heavy metals before they can contaminate water sources. Overall, the fate of heavy metals in MSW deposits is a multifaceted process that demands comprehensive waste management practices and constant monitoring to minimize their adverse effects on the environment and human health.

HEAVY METALS IN AQUATIC ENVIRONMENTS

Heavy metals in aquatic environments are a significant environmental concern due to their toxic nature, persistence, and ability to bioaccumulate in aquatic organisms. These metals can enter water bodies

through natural processes, but human activities, such as industrial discharges, agricultural runoff, and improper waste disposal, have dramatically increased their presence in aquatic ecosystems. Some of the key heavy metals of concern in aquatic environments include lead (Pb), mercury (Hg), cadmium (Cd), chromium (Cr), and arsenic (As).

SOURCES OF HEAVY METALS IN AQUATIC ENVIRONMENTS

INDUSTRIAL ACTIVITIES

Industrial processes and effluents can release heavy metals into nearby water bodies. These metals are often present in industrial wastewater, which, if not adequately treated, can contaminate rivers, lakes, and coastal waters.

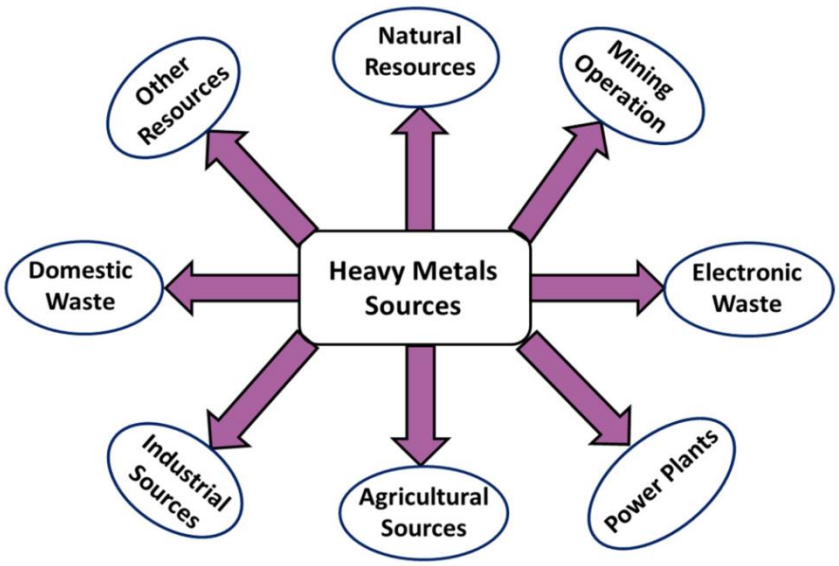

Fig. 2: Sources of Heavy metals

AGRICULTURAL PRACTICES

The use of fertilizers and pesticides in agriculture can introduce heavy metals, such as cadmium and lead, into water systems through runoff and leaching from soil.

MINING OPERATIONS

Mining activities can release substantial amounts of heavy metals into water bodies. These metals can be naturally present in ores or released during ore processing and waste disposal.

URBAN RUNOFF

Urban areas with impervious surfaces, such as roads and pavements, can contribute to the runoff of heavy metals from vehicles, industrial sites, and construction activities into nearby water bodies.

ENVIRONMENTAL IMPACTS OF HEAVY METALS IN AQUATIC ENVIRONMENTS

TOXICITY TO AQUATIC LIFE

Heavy metals are toxic to many aquatic organisms, including fish, invertebrates, and algae. They can impair reproduction, growth, and survival, leading to population declines and disruptions in aquatic ecosystems.

BIOACCUMULATION AND BIOMAGNIFICATION

Heavy metals tend to accumulate in the tissues of aquatic organisms over time. Predators that consume contaminated prey can experience bio magnification, where the concentration of heavy metals increases up the food chain, potentially reaching harmful levels in top predators, including humans.

SEDIMENT CONTAMINATION

Heavy metals can bind to sediment particles in aquatic environments. This contamination can persist for long periods, acting as a source of ongoing pollution and impacting benthic organisms.

DISRUPTION OF WATER QUALITY

Elevated levels of heavy metals can degrade water quality, making it unsuitable for human use and harming aquatic biodiversity.

MANAGEMENT AND MITIGATION

To address heavy metal contamination in aquatic environments, several strategies are employed:

Regulatory Measures

Governments implement regulations and standards to limit heavy metal discharges into water bodies. Industries are required to treat their wastewater to reduce heavy metal levels before release.

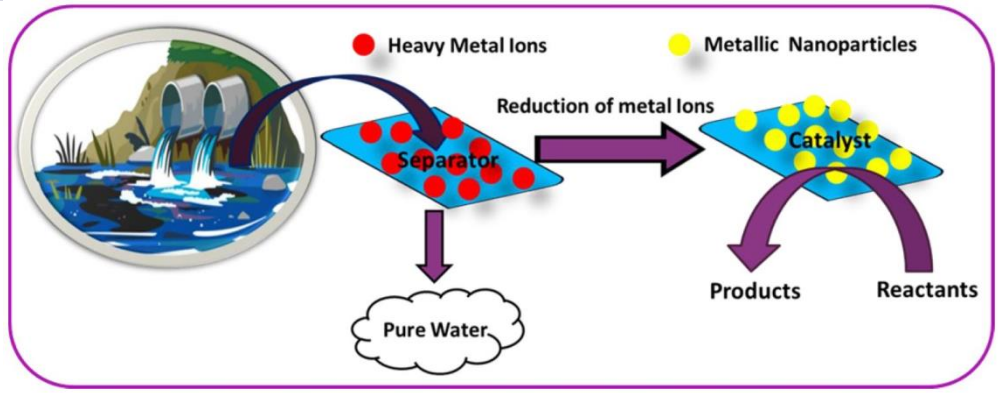

Fig. 3: Heavy metals treatment

Waste Management

Proper management of industrial, agricultural, and urban waste is essential to prevent heavy metal runoff and leaching into water systems.

Water Treatment

Advanced water treatment technologies are employed to remove heavy metals from contaminated water sources before they are supplied for human use.

Environmental Monitoring

Regular monitoring of water quality and the levels of heavy metals helps identify pollution sources and assess the effectiveness of mitigation measures.

Safeguarding aquatic environments from heavy metal contamination requires a collaborative effort between industries, governments, communities, and environmental organizations. By implementing effective management practices and promoting sustainable practices, it is possible to reduce the impact of heavy metals and protect the health and biodiversity of aquatic ecosystems.

MUNICIPAL SOLID WASTE DEGRADATION

Municipal solid waste (MSW) degradation refers to the natural breakdown and transformation of organic and non-organic components present in solid waste over time. This process involves the action of microorganisms, physical factors, and chemical reactions that lead to the decomposition and conversion of waste materials into simpler compounds, gases, and stabilized residues. MSW degradation is a crucial part of waste management, especially for the reduction of waste volume and prevention of environmental pollution.

Key aspects and factors of MSW degradation include:

Biological Decomposition

The organic fraction of MSW, such as food waste, yard trimmings, and paper, undergoes biological degradation. Microorganisms, including bacteria and fungi, play a vital role in breaking down complex organic molecules into simpler substances like water, carbon dioxide, methane, and humus.

Composting

Composting is a controlled, aerobic decomposition process where organic waste is converted into nutrient-rich compost. Composting facilities create conditions favorable to microorganisms, accelerating the degradation of organic matter while producing a valuable soil amendment.

Anaerobic Digestion

In the absence of oxygen, certain microorganisms can carry out anaerobic digestion, leading to the production of biogas (mainly methane) and digestate. Anaerobic digestion is particularly effective for treating food waste and sewage sludge.

Landfills and Landfill Biodegradation

In landfills, the degradation of organic matter occurs in both aerobic (at the surface) and anaerobic (deeper in the landfill) zones. Anaerobic decomposition generates landfill gas (methane and carbon dioxide), which can be captured and used as a renewable energy source.

Physical Factors

Environmental conditions, such as temperature, moisture content, and oxygen availability, significantly influence the rate of MSW degradation. Warm and moist environments support microbial activity and accelerate degradation.

Chemical Reactions

Some non-organic components of MSW can undergo chemical transformations, like metals and certain plastics, although these processes are often slower compared to biological degradation.

Stabilization of Residues

After extensive degradation, the remaining waste materials may undergo stabilization, where potential pollutants are immobilized, reducing their leach ability and environmental impact.

While MSW degradation is essential for waste management, it also has implications for environmental and public health:

LANDFILL GAS AND GREENHOUSE GAS EMISSIONS

The decomposition of organic matter in landfills produces significant amounts of methane, a potent greenhouse gas. Proper landfill gas management can mitigate its release into the atmosphere.

Leachate Generation

As waste degrades, liquid known as leachate is produced, containing dissolved organic and inorganic pollutants. Leachate must be collected and treated to prevent groundwater and surface water contamination.

Odor and Aesthetic Issues

The decomposition of organic waste can produce unpleasant odors, attracting pests and affecting the quality of life for nearby communities.

Efforts to optimize MSW degradation and minimize its environmental impact include waste diversion through recycling and composting, utilizing biodegradable materials, capturing and utilizing landfill gas for energy, and implementing advanced landfill management techniques. By prioritizing waste reduction

and promoting sustainable waste management practices, the overall environmental burden of MSW degradation can be reduced.

HEAVY METAL EXTRACTION METHODS AND MATERIALS

Extraction of heavy metals from various sources, such as ores, industrial waste, and contaminated soil, is a critical process to obtain valuable metals or remediate polluted environments. Several extraction methods and materials are employed for this purpose, depending on the specific application and characteristics of the heavy metal of interest. Here are some common extraction methods and materials used for heavy metal extraction:

1. Hydrometallurgical Methods:

(a) Leaching: Involves using a liquid solvent to dissolve the heavy metals from solid materials. Common leaching agents include acids (e.g., sulfuric acid, hydrochloric acid) and alkalis. Leaching is often used for extracting metals from ores and recovering metals from electronic waste.

(b) Bioleaching: Utilizes microorganisms to extract heavy metals from ores or waste materials. Certain bacteria and fungi can mobilize metals by oxidizing or reducing them, making them accessible for recovery.

2. Pyrometallurgical Methods:

Smelting: Involves the heating of ores or metal-containing materials at high temperatures to separate the metal from the unwanted impurities. Smelting is commonly used for extracting metals like copper, lead, and zinc.

3. Ion Exchange:

Ion Exchange Resins: These resins have a high affinity for specific heavy metal ions. When passed through a solution containing heavy metal ions, the resins selectively adsorb and retain the target metals, facilitating their extraction and subsequent recovery.

4. Solvent Extraction:

Chelating Agents: Organic compounds known as chelating agents can form stable complexes with heavy metal ions. These complexes are then extracted into an organic solvent, allowing for the separation and concentration of heavy metals.

5. Electrochemical Methods:

Electro winning: Utilizes an electric current to reduce metal ions in a solution to their elemental form on a cathode. This process is commonly used for recovering metals like copper and nickel from their solutions.

6. Phytoremediation:

Plants: Certain plant species, known as hyper accumulators, have the ability to take up and accumulate heavy metals from the soil. Phytoremediation involves planting these species in contaminated areas to absorb and store heavy metals, thus remediating the environment.

7. Precipitation and Co-Precipitation:

Chemical Precipitants: Adding chemical reagents to a solution can induce the precipitation of heavy metal ions as insoluble compounds. The precipitated metal compounds can then be separated from the solution.

8. Sorbent Materials:

Activated Carbon: Highly porous activated carbon can adsorb heavy metal ions from liquid solutions, making it a common sorbent material for water treatment and wastewater remediation.

9. Zeolites: These naturally occurring or synthetic materials have a crystalline structure with a high surface area. They can selectively adsorb heavy metal ions from solutions.

10. Biosorbents: Biomass-derived materials, such as agricultural waste, algae, and bacteria, can effectively adsorb heavy metals from aqueous solutions due to their abundant functional groups.

The choice of extraction method and materials depends on factors like the type and concentration of heavy metals, the matrix from which they are to be extracted, environmental considerations, and economic viability. Proper management and disposal of waste generated during the extraction process are crucial to minimize environmental impacts. Additionally, sustainable extraction methods are continually being developed to ensure responsible resource utilization and environmental protection.

THE MECHANISMS OF HEAVY METAL TRANSFORMATION

Transformations of heavy metals in the solid phase refer to various physicochemical processes that occur when heavy metals interact with solid materials, such as soil, sediment, or solid waste. These transformations influence the mobility, bioavailability, and potential toxicity of heavy metals in the environment. Some of the key transformations in the solid phase include:

1. Adsorption:

Heavy metals can adsorb onto the surfaces of solid materials, such as clay minerals, organic matter, and metal oxides. This process involves electrostatic attraction and chemical bonding, leading to the immobilization of heavy metals on the solid surfaces.

2. Desorption:

Desorption is the release of adsorbed heavy metals from solid materials back into the surrounding environment. This process can be influenced by changes in environmental conditions, such as pH, redox potential, and the presence of other competing ions.

3. Complexation:

Heavy metals can form complexes with ligands present in the solid phase, such as organic matter and humic substances. Complexation can affect the solubility and mobility of heavy metals.

4. Precipitation:

Under certain conditions, heavy metal ions can react with other ions or compounds in the solid phase, leading to the formation of insoluble precipitates. This precipitation process can immobilize heavy metals and reduce their mobility. Heavy metal ions can react with other ions or compounds in the environment, leading to the formation of insoluble precipitates or dissolution of existing solid phases. Precipitation can immobilize heavy metals, reducing their mobility, while dissolution can release heavy metals back into the solution.

5. Redox Reactions:

Redox reactions involve the transfer of electrons between different chemical species. For example, some heavy metals can undergo reduction or oxidation reactions in the solid phase, changing their valence states and influencing their mobility and toxicity.

6. Ion Exchange:

In soils and sediments, cation exchange sites on clay minerals can bind heavy metal ions, leading to the exchange of these metals with other cations in the surrounding solution.

7. Transformation by Microorganisms:

Microorganisms in the solid phase, such as bacteria and fungi, can interact with heavy metals through processes like microbial reduction, oxidation, and complexation. These microbial activities can impact the fate and behaviour of heavy metals. Microorganisms play a crucial role in heavy metal transformation.

Some microorganisms can reduce or oxidize heavy metal ions, convert them into less toxic forms, or immobilize them through precipitation or adsorption.

8. Aging and Weathering:

Heavy metals in the solid phase can undergo aging and weathering processes, leading to changes in their speciation and reactivity over time. The transformations of heavy metals in the solid phase are critical in determining their fate and behaviour in the environment. Depending on the specific transformation processes, heavy metals can become more or less available for uptake by plants, aquatic organisms, or other living organisms. Additionally, solid-phase transformations can affect the leaching potential of heavy metals into groundwater, their transport in soil and sediment, and their potential for long-term persistence in the environment. Understanding these transformations is essential for environmental risk assessment and developing effective remediation strategies for contaminated sites. Proper waste management and responsible handling of industrial and agricultural activities can help minimize the release of heavy metals into the solid phase and reduce their potential environmental impacts.

9. pH-Dependent Transformations:

The pH of the environment strongly influences heavy metal speciation and transformation. Changes in pH can impact the solubility of heavy metal compounds and their interactions with other chemical species.

10. Competitive Sorption:

The presence of other chemical species in the environment can compete for sorption sites on solid surfaces. This competitive sorption can affect the sorption and desorption of heavy metals.

Understanding the mechanisms of heavy metal transformation is vital for assessing environmental risks, designing appropriate remediation strategies for contaminated sites, and developing sustainable waste management practices. By considering these mechanisms, scientists and environmental professionals can work towards mitigating the adverse effects of heavy metals on ecosystems and human health.

POLLUTION POTENTIALS AND ENVIRONMENTAL RISKS

Heavy metals pose significant pollution potentials and environmental risks due to their toxic nature, persistence in the environment, and ability to bioaccumulate in organisms. The pollution potentials and environmental risks associated with heavy metals include:

Water Pollution:

Heavy metals can contaminate water bodies through industrial discharges, agricultural runoff, and improper waste disposal. They can leach from landfills, mining sites, and industrial facilities, leading to the pollution of rivers, lakes, and groundwater. Water pollution by heavy metals poses serious risks to aquatic ecosystems and can impact human health if contaminated water is used for drinking or irrigation.

Soil Contamination:

Heavy metals can accumulate in soils due to the deposition of atmospheric emissions, agricultural practices, and the application of metal-containing fertilizers. Contaminated soils can negatively affect plant growth, reduce soil fertility, and potentially transfer heavy metals to crops, posing risks to food safety and agricultural productivity.

Air Pollution:

Some heavy metals, like lead and mercury, can be released into the atmosphere through industrial processes, waste incineration, and vehicle emissions. Inhalation of airborne heavy metal particles can lead to respiratory problems and other health issues.

Ecotoxicity:

Heavy metals are toxic to a wide range of organisms, including aquatic life, soil organisms, and plants. Their presence in the environment can disrupt ecosystems, leading to reduced biodiversity, population declines, and ecological imbalances.

Bioaccumulation and Bio magnification:

Heavy metals can accumulate in the tissues of organisms through the food chain. Predators consuming contaminated prey can experience bio magnification, where heavy metal concentrations increase with each trophic level. This phenomenon leads to higher concentrations of heavy metals in top predators, including humans, with potential health implications.

Human Health Risks:

Exposure to heavy metals through contaminated water, food, air, or occupational settings can lead to various health issues. Heavy metals like lead, mercury, and cadmium are particularly harmful and can cause neurological damage, kidney damage, developmental disorders, and other health problems.

Ecosystem Disruption:

Heavy metal pollution can disrupt ecosystem functions, such as nutrient cycling, decomposition, and primary productivity. This disruption can lead to imbalances in ecological processes and reduce the resilience of ecosystems to environmental stressors.

Long-Term Persistence:

Heavy metals have the potential to persist in the environment for extended periods, leading to long-term contamination issues and challenges in remediation efforts.

To mitigate the pollution potentials and environmental risks associated with heavy metals, various measures are taken, including the implementation of environmental regulations, waste management practices, and pollution control technologies. Sustainable practices such as recycling, proper waste disposal and the use of environmentally friendly products can help minimize heavy metal pollution and protect both ecosystems and human health.

CONCLUSION

In conclusion, the presence of heavy metals in municipal solid waste (MSW) deposits is a significant environmental concern with far-reaching implications. This review has highlighted the environmental impacts and risks associated with heavy metal contamination in waste deposits, as well as key management strategies for mitigating these effects. The environmental significance of heavy metal pollution in MSW deposits cannot be underestimated. Leaching of heavy metals from waste deposits can contaminate soil, groundwater, and surface water, posing risks to ecosystems and human health. As heavy metals persist in the environment, their long-term effects demand urgent attention and effective management.

Waste management practices play a crucial role in reducing heavy metal contamination. Waste segregation, recycling, and waste-to-energy technologies are vital for minimizing the amount of waste destined for landfills. Implementing advanced leachate treatment systems and engineered barriers can help prevent heavy metal leaching and protect the surrounding environment. Incorporating remediation strategies, such as phytoremediation and biochar application, offers promising avenues for reducing heavy metal concentrations in MSW deposits. These eco-friendly techniques show potential in improving environmental outcomes and should be integrated into waste management practices.

Collaborative efforts among policymakers, waste management professionals, environmental scientists, and communities are essential for effective heavy metal management. A multi-disciplinary approach is

required to address the complex challenges associated with heavy metal contamination. Public awareness and education are critical in promoting responsible waste disposal practices and encouraging sustainable consumption habits. By empowering individuals with knowledge, we can foster environmental responsibility and create a collective commitment to address heavy metal pollution. Continuous research is fundamental for advancing our understanding of heavy metal transformations in MSW deposits and identifying emerging pollutants. This knowledge is vital for developing innovative and eco-friendly management techniques.

In conclusion, managing heavy metals in municipal solid waste deposits requires a long-term perspective. Continuous monitoring, stringent regulations, and adaptive management strategies are essential to safeguard the environment, protect public health, and work towards a cleaner and more sustainable future. By adopting sustainable practices, advancing waste treatment technologies, and promoting public awareness, we can collectively address heavy metal pollution in MSW deposits and create a healthier and safer environment for current and future generations.

REFERENCES

[1]. Allison, J., D., Brown, D., S. and Novo-Bradac, K., J. (1991) Minteqa2/Prodefa2, a geochemical assessment model for environmental systems: Version 3.0 user's manual. EPA/600/3-91/021, Environmental research laboratory, Athens, Georgia.

[2]. Baccini, P., Belevi, H. and Lichtensteiger, T. (1992) Die Deponie in einer okologisch orientierten Volkswirtschaft. GAIA, 1(1), 34-49.

[3]. Berner, R., A. (1981) A new geochemical classification of sedimentary environments. Journal of Sedimentary Petrology, 51(2), 0359-0365.

[4]. Brune, M., Ramke, H.G., Collins, H.J. and Hanert, H.H. (1991) Incrustation processes in drainage systems ofsanitary landfills. In Sardinia 91 (Christensen, T. H., Cossu R. and Stegmann R., eds) Proceedings of the Third International Landfill Symposium, Cagliari, Italy, 999-1035.

[5]. Calmano, W. and Forstner, U. (1983) Chemical extraction of heavy metals in polluted river sediments in central Europe. Sci. Total Environ., 28, 77-90.

[6]. Calmano, W. (1989) Schwermetalle in kontaminierten Feststoffen. Verlag TUV Rheinland GmbH, Koln, Germany. Calmano, W., Hong, J. and Forstner, U. (1993) Binding and mobilization of heavy metals in contaminated sediments affected by pH and redox potential. Wat. Sci. Tech., 28(8-9), 53-58.

[7]. Christensen, T.H., Kjeldsen, P., Albrechtsen, H.-J., Heron, G., Nielsen, P.H., Bjerg, P.L. and Holm, P.E. (1994) Attenuation of landfill leachate pollutants in aquifers. Critical Reviews in Environmental Science and Technology, 24(2), 119- 202.

[8]. Christensen, T., H. and Kjeldsen, P. (1995) Landfill emissions and environmental impact: an introduction. In Sardinia 95 (Christensen, T. H., Cossu R. and Stegmann R., eds) Proceedings of the Fifth International Landfill Symposium, Vol. 3, Cagliari, Italy, 3-12.

[9]. Di Toro, D., M., Mahony, J., D., Hansen, D., J., Scott, K., J., Hicks, M., B., Mayr, S., M. and Redmond, M., S. (1990) Toxicity of cadmium in sediments: the role of acid volatile sulfide. Environmental Toxicology and Chemistry, 9,1487-1502.

[10]. Ehrig, U. (1983) Quality and quantity of sanitary landfill leachate. Waste Management & Research, 1, 53-68.

[11]. Farquhar, C.J. & Rovers, F.A. (1973) Gas production during refuse decomposition. Water, Air and Soil Pollution, 2,483-495.

[12]. Finnveden, G. (1996) Solid waste treatment within the framework of life cycle assessment. Int. J. LCA, 1(2), 74-78.

[13]. Flyhammar, P. (1997a) Estimation of heavy metal transformations in municipal solid waste. Sci. Total Environ., 198, 123-133.

[14]. Flyhammar, P. (1997b) Use of sequential extraction on anaerobically degraded municipal solid waste, (submitted)

[15]. Flyhammar, P., Tamaddon, F. and Bengtsson, L. (1997) Heavy metals in a municipal solid waste deposition cell, (accepted for publication)

[16]. Forstner, U. and Salomons, W. (1991) Mobilization of metals from sediments. In Metals and their compounds in the environment. Occurrence, analysis, and biological relevance (Merian, E., ed.). VCH, Weinheim, 379-398.

[17]. Forstner, U. (1993) Metal speciation - general concepts and applications. Intern. J. Environ. Anal. Chem., 51, 5-23.

[18]. Keller, C. and Ve'dy J.-C. (1994) Distribution of copper and cadmium fractions in two forest soils. J. Environ. Qual., 23, 987-999.

[19]. Kim, N., D. and Fergusson, J., E. (1991) Effectiveness of a commonly used sequential extraction technique in determining the speciation of cadmium in soils. Sci. Total Environ., 105, 191-209.

[20]. Persson, B.L. and Rylander, H. (1977) Recirkulation av lakvatten vid avfallsdeponering. Bulletin Serie VA nr 15, Dept, of Water Resources Engineering, Lund University, Sweden, (in Swedish).

[21]. Prudent, P., Domeizel, M. and Massiani, C. (1996) Chemical sequential extraction as decision-making tool: application to municipal solid waste and its individual constituents. Sci. Total Environ., 178, 55-61.

[22]. Stigiliani, W.M. (1991) Chemical time bombs: definition, concepts, and examples. Executive Report 16, International Institute for applied system analysis, Laxenburg, Austria.

[23]. Tessier, A., Campbell, P.G.C. and Bisson, M. (1979) Sequential extraction procedure for the speciation ofparticulate trace metals. Anal. Chem., 51, 844-851.

[24]. Wallman, K., Kersten, M., Gruber. J. and U. Forstner, U. (1993) Artifacts in the determination of trace metal binding forms in anoxic sediments by sequential extraction. Intern. J. Environ. Anal. Chem. 51,187-200.

[25]. Akesson, M. (1997) Biogas generation in landfills. Equilibria, rates and yields. Dissertation, Report No 1018, Department of Water Resources Engineering, Lund University, Sweden

Chapter 18

BIOPESTICIDES

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ABSTRACT

Insects that harm crop plants and products in storage are called pests. They severely reduce crop yields by feeding on the leaves, roots, or sap of the plants. Chemical pesticides were the first to cause this issue. If chemical pesticides are used repeatedly on plants, the ecosystem may suffer and pests may become resistant to the pesticides. Then, in an effort to lessen the negative impact, biopesticides are created as an alternative to chemical insecticides.

But in addition to this benefit, biopesticides have certain drawbacks that must be managed if they are to be sufficiently effective. Biopesticides are pesticides or compounds that are used to control agricultural pests through particular biological effects that come from microbes, plants, animals, or any other biologically available source (including their genes or metabolites).

KEYWORDS: Biopesticides, Chemical Insecticides, Ecosystem.

INTRODUCTION

Insects that harm crop plants and products in storage are called pests. They severely reduce crop yields by feeding on the leaves, roots, or sap of the plants. Chemical pesticides were the first to cause this issue. If chemical pesticides are used repeatedly on plants, the ecosystem may suffer and pests may become resistant to the pesticides. Then, in an effort to lessen the negative impact, biopesticides are created as an alternative to chemical insecticides.

But in addition to this benefit, biopesticides have certain drawbacks that must be managed if they are to be sufficiently effective. Biopesticides are pesticides or compounds that are used to control agricultural pests through particular biological effects that come from microbes, plants, animals, or any other biologically available source (including their genes or metabolites).

They are an important part of Integrated Pest Management (IPM) strategy in controlling the pest.

ADVANTAGES

They do not leave behind hazardous residues and are less hazardous to people and the environment.

Only the targeted pest is impacted.

Because they linger in the environment, they suppress pest populations over an extended period of time.

BIOPESTICIDES ARE CATEGORIZED UNDER THREE DIFFERENT CLASSES

1. Naturally occurring compounds that, through nontoxic mechanisms, can control specific pests.
2. Microbial pesticides, which employ a variety of microbes to suppress certain pests and plant diseases.
3. Plant-incorporated protectants, primarily created by genetically modified plants, are plant-derived insecticides.

BIOPESTICIDES – BACTERIAL, VIRAL AND FUNGAL

Insects that harm crop plants and products in storage are called pests. They severely reduce crop yields by feeding on the leaves, roots, or sap of the plants. Chemical pesticides were the first to cause this issue.

If chemical pesticides are used repeatedly on plants, the ecosystem may suffer and pests may become resistant to the pesticides. Then, in an effort to lessen the negative impact, biopesticides are created as an alternative to chemical insecticides. But in addition to this benefit, biopesticides have certain drawbacks that must be managed if they are to be sufficiently effective.

Pesticides/compounds known as "biopesticides" are those that are used to control agricultural pests through particular biological effects that come from microbes (including their genes or metabolites), plants, animals, or any other biologically available source. They play a significant role in the Integrated Pest Management (IPM) strategy for pest control.

Advantages

They are less toxic to humans and environment and they do not leave harmful residues.

They affect only the target pest.

They cause long term suppression of pest populations since they persist in the environment.

BIOPESTICIDES ARE CATEGORIZED UNDER THREE DIFFERENT CLASSES

1. Naturally occurring substances that can control certain pests by involving in nontoxic mechanisms.

2.Microbial pesticides which include the involvement of several microbes to control plant pathogens and some

Pests.

3.Plant incorporated protectants which are plant-derived pesticides mostly developed by genetically modified plants.

MICROBIAL HERBICIDES

Herbicides, also called weed killers, are used to control the growth of unwanted plants. The last few years have seen a significant advancement in the microbial source of herbicides, which is now serving as a viable substitute for chemical herbicides. Many nations use microbial herbicides because they are a sufficiently effective weed control method.

BACTERIAL INSECTICIDES

Most often, bacteria are linked to illness in both humans and plants. On the other hand, a number of bacteria acts as pathogens to a number of insects. These microorganisms are crucial to the creation of bacterial insecticides. The ability of bacteria to control multiple insects is highly specific to their hosts, which makes them effective enough to replace chemical insecticides. There are different types of bacterial insecticides available commercially; some of those are described as following:

PSEUDOMONAS AS BACTERIAL INSECTICIDE

In addition to stimulating plant growth, a number of Pseudomonas species have been shown to be pathogenic to various insects. There have been reports of Pseudomonas aeruginosa and P. taiwanensis having insecticidal properties. The majority of the toxin complex genes carried by these bacteria are insect-specific. The ability of P. fluorescence to promote plant growth is well known. On the other hand, P. fluorescence uses bacterial antagonists to manage fungal infections. Furthermore, P. cepacia was also noted for its ability to suppress plant-pathogen activity through siderophore secretion.

II. Bacillus as Bacterial Insecticide

a) *Bacillus thuringiensis*

b) Other Bacillus species

B. thuringiensis is one of the bacillus species which is used widely to control insects. However, there are other Bacillus species such as B. papilliae and B. lentimorbus which play an important role in controlling insects such as Japanese beetle.

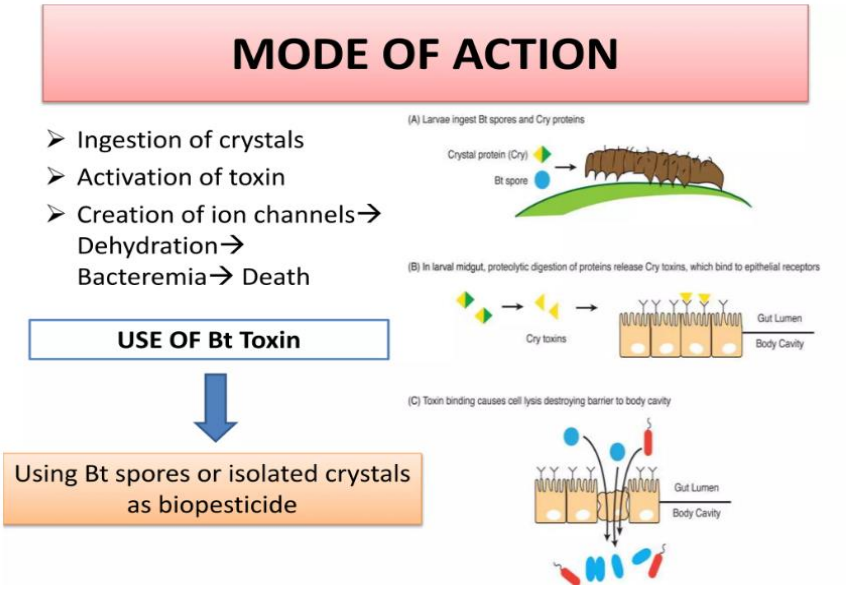


Fig. 1: Bacillus as biopesticides

Disadvantages of Bacterial Insecticides

1. Many bacterial insecticides are specific for a species of pest. In many cases, these insecticides kill only one type of insects and the other type of insects survive and continue to cause damage to the crop.

2.In genetically modified plants such as Bt. The hypersensitive reaction occurred to the animals and humans consumed the plant.

3. Environmental factors such as heat, desiccation, etc. Can affect the viability of the bacteria. Therefore, it is difficult to maintain proper application procedures.

4. Due to the same reason, proper preservation and storage are required for some bacterial insecticides.

VIRUS INSECTICIDES

Like bacterial insecticides, certain viruses are only specific to a particular kind of insect. One well-known example of this class of arthropod-based insecticides is the Baculoviridae family. Baculoviruses, however, only infect a small number of arthropod species. In addition, there are other viruses like NPV, cytoplasmic polyhedrosis virus, granulosis virus, entomopox virus, etc. that have the ability to control insects like sawflies and Lepidoptera.

ENTOMOPATHOGENIC FUNGI

I. *Metarhizium anisopliae*

II. *Beauveria bassiana* and *B. brongriartii*

III. *Verticillium lecanii*

IV. *Hirsutella thompsonii*

MICROBIAL BIOPESTICIDES ARE OF THREE KINDS

1. Bacterial biopesticide
2. Fungal biopesticide
3. Viral biopesticide

1. Bacterial Biopesticide

Bacteria like

Bacillus thuringiensis,

Bacillus papillae

And *Bacillus lentimorbus*

Have the potential to kill certain insect
Pests and are entomopathogenic.

BACILLUS THURINGIENSIS

It is a rod-shaped, spore-forming, gram-positive soil bacterium. The bacteria create insecticidal proteins in the form of parasporal crystals during sporulation. These are also known as Cry proteins or delta endotoxin. Only a small number of insect orders, including Lepidoptera and Coleoptera, are particularly susceptible to the toxicity of cry proteins. Widely used bacilli, B. thuringiensis (Bt), are effective at controlling a variety of insects, including moths, beetles, flies, aphids, butterflies, and some pathogenic fungi like Pythium ultimum.

Bt uses toxins as part of its mechanism to control insects. The endotoxin is a protein that has crystallized and is soluble in alkaline environments. The majority of an insect's gut pH is alkaline, so when the toxin is consumed, it dissolves quickly in the midgut. Subsequently, the toxin is broken down by proteases, resulting in the creation of tiny active fragments. Osmotic equilibrium is disrupted when these active fragments attach to the gut epithelial membrane and form pores. The insects perish as a result of this. The gene that causes Bt to produce toxins has been inserted into a number of agricultural plants through genetic modification; examples of these plants include Bt tomatoes and brentjal.

Mode of action of Bt

The Bt cells sprayed on the leaves has to be ingested by the larval forms of the insects in order to exert its action. This is because the Bt toxin gets activated in the insect gut at a specific pH.

Process

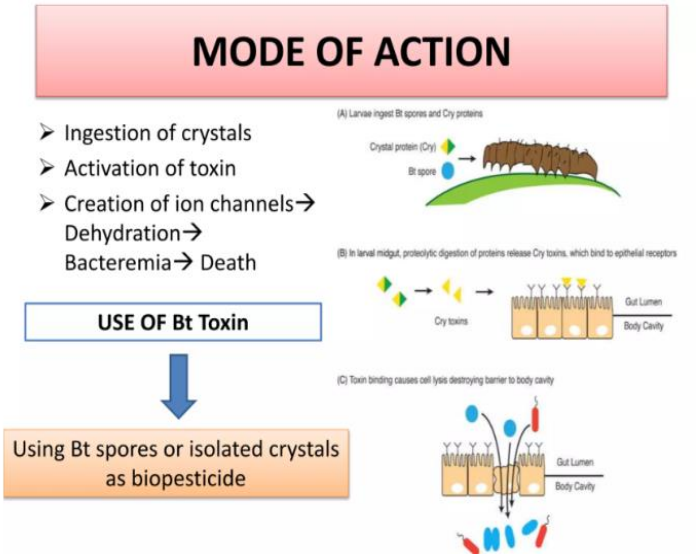


Fig. 2: Bt Toxin as biopesticide

Symptoms

- Larvae stops feeding
- Larvae becomes sluggish and static
- Water oozes out from the body
- Larvae dies and falls off the leaf

Various species of Bt are able to work against cotton boll worm, cabbage worm and gypsy moths.

FUNGAL BIOPESTICIDES

These entomopathogenic fungi attack insects and result in illnesses that ultimately kill the insects. The two well-known fungi that cause white muscardine disease are employed as mycopesticides.

BEAUVERIA BASSIANA

Viral Biopesticides

Insects and other arthropods are attacked by viruses, which act as pesticides. To regulate, viral pesticides are employed. Larvae of lepidopterans such as Spodoptera sp. and Helicoverpa on cotton, corn, sorghum, and tomatoes. The most widely used viral biopesticide is baculovirus. They are extremely small and are composed of double stranded DNA. The genus Baculoviruses contains 3 subgroups.

- Nuclear Polyhedrosis viruses (NPVs)
- Granulosis viruses (GVs)
- Non occluded viruses

MODE OF ACTION OF NPV

Insects consume the virus, which then fuses its membranes to infect the midgut cells. The NPV sheds its coat inside the cell nucleus, passes through the intestinal epithelium, and infects the hemocoel systemically.

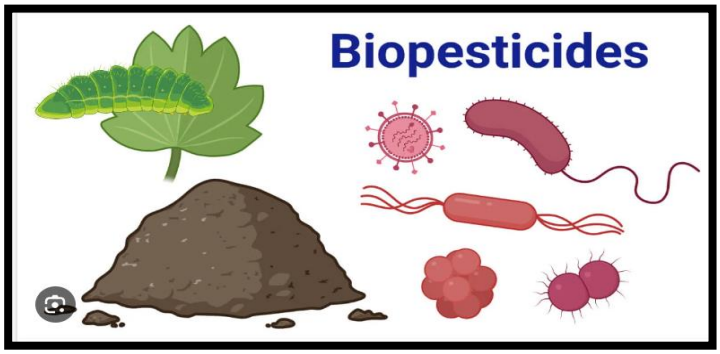
Symptoms

Discoloration (larvae turns brown or yellow)

- Decomposition or softening of larvae
- Lethargy
- Infected larvae hang upside down twigs
- Larvae become swollen with fluid containing virus and eventually die turning black in color.

MASS PRODUCTION OF NPV

In a lab, NPV are mass produced with the right larval hosts. Food contaminated with NPV is fed to larvae in their fifth stage. The dead larvae are gathered and macerated after four to five days. The pellet containing the viruses is suspended in sterile distilled water after the liquid has been centrifuged. In the fields, this viral suspension can be sprayed.



Chapter
19

METAL TARTRATE COMPLEXES: A REVIEW

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ABSTRACT

A variety of metal-ligand complexes were studied in the past for their antimicrobial, mechanical and technological activities.[25] Metals used in these complexes were one or more transition metals and few inner transition metals. This review article focuses on complexes in which tartrate act as a ligand. Synthesis and various applications such as catalyst, medicinal and some other applications of metal tartrate complexes are discussed.

KEYWORDS: Metal Tartarate complex, Metal-Ligand, Catalysis, Inner Transition metals.

INTRODUCTION

Organometallic compounds are compounds having bonds between one or more metal atoms and one or more carbon atoms of an organic ligand. In addition to the traditional metals and metalloids elements such as B, Si, As, and Se are considered to form organometallic compounds. Now day's applications of organometallic compounds are increasing day by day in various fields.

Classification of Organometallic Compounds

Main group organometallic compounds. Transition metal organometallic compounds [1]. Metal tartrates are also one of the promising organometallic complexes having large number of applications. Sodium potassium tartrate shows ferroelectric property [2]. Potassium- chromium tartrate and antimony- barium tartrate have medicinal importance [3][4] Calcium- strontium mixed L- tartrate [5], iron- manganese L-tartrate are also reported. The tartrtes also find applications in science and technology [2] [6] [7] [8] [9]. They are used for transducers and many linear and non-linear mechanical devices [10] [11] [12].

This review article focuses on various mixed Metal Tartarates.

A tartrate is a salt of tartaric acid [13].

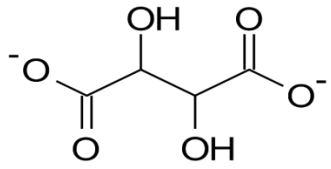

Fig. 1: Structure of tartrate

Tartrate ion act as ligand which combines with varieties of metals to form metal tartrate complexes. [14][15]. Some complexes contain mixed metals while in some Metal Tartarates are found with different ratios[16].

Table 1: Different Metal tartrate complexes and Applications

Metal tartrate complexes	Studied properties /Applications	References
Transition metal(Mn, Fe, Co, Ni, Cu, Zn) and Ca	Synthesis Characterization and microbial activity	Betallu *et al.* (2016) [14]
Transition metal (Mn, Co, Ni, Cu, Zn, Cd)with Fe	Synthesis Characterization and antimicrobial activity	Patil *et al.* (2016) [15]
Fe tartrate nanoparticles	Synthesis and Characterization	Lathiya *et al.* (2018) [19]
Mn, Fe, Co, Ni, Cu, Zn with Ba	Synthesis Characterization and antimicrobial activity	Ubale (2016)[25]
Cu Ni tartrates	Synthesis Characterization and biological activity	Pawar et al.(2014)[28]
Cu Ni tartrates	As catalyst	Pawar *et al.* (2016) [20]
Doped Co Fe tartrates	As catalyst	Walle (2022) [21]
Cu doped Fe tartrates	As catalyst	Walle *et al.* (2021) [23]
Doped Co Fe tartrates	As catalyst	Walle *et al.* (2022) [21]
Ti tartrate complex	As catalyst	Shi *et al.* (2010) [24]
(Mn, Fe, Co, Ni, Cu AND Zn with Ca	Antibiofilm activity	Betallu *et al.* (2017) (17)
Fe(III)–tartrate complexes	Investigation on damage of BSA molecules	Wang *et al.* (2008)(27)
Al tartrates	impact of tartrate on Al speciation in gasto intestinal fluid and blood plasma	Desroches (2000) [29]
Cu Zn Tartrates	precursors to prepare CuO/ ZnO	Weiss *et al.* (2006) [36]
Cu Co tartrates	precursors to prepare CuO/ ZnO	Hernández *et al.* (2012) [37]
Gd tartrate complexes	precursors to prepare Gd_2O_3	Zou *et al.* (2014) [41]
Zn tartrate	As corrosion inhibitor in presence of 2CEPA	Gunasekaran *et al.* (2000) [42]
Fe tartrates	Photo physics	Pozdnyakov (2012) [44]
Fe(III)–tartrate complexes	Photoproduction and determination of hydroxyl radicals in aqueous solutions	Wang *et al.* (2006) [43]
Lanthanum–tartrate complexes	Hydrothermal synthesis and crystal structures	Wang *et al.* (2010) [46]

SYNTHESIS

Tartrate complexes with various metals have found tremendous applications in different fields. In some areas research has been going on synthesis of metal tartrate complexes. Series of tartrates of transition metals with Ca are synthesized Mn Ca $(C_4H_4O_6)_25H_2O$ Fe Ca $(C_4H_4O_6)_210H_2O$ Co Ca $(C_4H_4O_6)_2$ $5H_2O$ Ni Ca $(C_4H_4O_6)_2$ $8H_2O$, Cu Ca $(C_4H_4O_6)_22H_2O$ Zn Ca $(C_4H_4O_6)_25H_2O$. [17]

Mixed transition metal tartrates such as $MnFe_2$ $(C_4H_4O_6)_3 5H_2O$, $CoFe_2$ $(C_4H_4O_6)_3 6H_2O$ NiFe2 $(C_4H_4O_6)_3$ $5H_2O$, $CuFe_2$ $(C_4H_4O_6)_3 6H_2O$, $ZnFe_2(C_4H_4O_6)_3 5H_2O$ and $CdFe_2(C_4H_4O_6)_3 5H_2O$ were prepared. Out of these metal complexes $CoFe_2$ $(C_4H_4O_6)_3 6H_2O$ was prepared by green synthesis principals, as a water-soluble catalyst. This can be recoverable and can be used several times in reactions without losing its efficiency. [15]

Various transition metals form complexes with Ba, $MnBa(C_4H_4O_6)_2 2H_2O$, $FeBa(C_4H_4O_6)_2 8H_2O$, $CoBa(C_4H_4O_6)_2 3H_2O$, $NiBa(C_4H_4O_6)_2 6H_2O$, $CuBa(C_4H_4O_6)_2 2H_2O$ and $ZnBa(C_4H_4O_6)_2 4H_2O$ were synthesised by using co-ppt. method [16]. Pawar *et al.* prepared tartrates of Cu Ni complexes in various ratios [18]. Iron tartrates nanoparticles were prepared by wet method [19].

AS A CATALYST

Heterocyclic compounds like quinolines derivatives and dihydropyridines are increasing demand due to their pharmaceutical and biological properties quinolines derivatives shows anti-cancer, anti-microbial activity. Dihydropyridines are found in natural products. These compounds were synthesised by using Cu Ni tartrate composites. [18]

For synthesis of two medicinally important compounds 3,3-arylidene bis(4-hydroxy coumarin) derivatives and 2-Amino-5-oxo4,5-dihydropyrano[3,2-c]chromene-3-carbonitrile Derivatives doped Cobalt iron tartrate is efficiently used as catalyst[21][22]. Tetrahydro[b]pyran derivatives were prepared by one pot synthesis using Copper doped Iron tartrate [23]. Into the interlayer space of Mg/Al and Zn/Al the titanium tartrate complex was intercalated, it was observed that the catalytic activity was found higher where interaction between titanium tartrate and brucite-like layers was stronger in the asymmetric sulfoxidation reaction [24].

MEDICINAL APPLICATIONS

Tartrates of transition metal with Ca have found biological activity against bacteria Bacillus subtills and Escherichia coli also on fungi Saccharomyces cerevisiae and Aspergillus Niger. These complexes showed enhanced antimicrobial activity as compared to ligands [14].

Study of Mixed transition metal tartrates showed increased effectiveness against Staphylococcus aureus, Pseudomonas, Bacillus Megatherium and Proteus Vulgaris than that of individual ligand. [15].

Ubale *et al.* (2016) studied antibacterial activity of tartrates of various transition metals with Barium against bacteria Bacillus subtilis, Staphylococcus aureus, Proteus vulgaris and E. coli. They observed inhibitory effects of all the metal complexes. [25]

Anti-biofilm activity of tartrates of different transition metals with calcium assessed against Proteus vulgaris, Staphylococcus aureus, E. coli Pseudomonas aeruginosa Klebsiella pneumoniae bacteria. Co Ca $(C_4H_4O_6)_2 5H2O$ and Cu Ca $(C_4H_4O_6)_2 2H2O$ complexes inhibit biofilm activity of all tested bacteria. So, complexes can be used to control infections of pathogenic bacteria at various places. [17]

Interactions of Fe (III)-tartrate complexes with Bovine serum albumin in presences of ultrasonic irradiation were studied. Effect of solution acidity and concentration were observed on damage of BSA. This research clearly reported valuable references for application of Sonodynamic therapy. [27]

Pawar *et al.* (2014) synthesized of Cu and Ni tartrate complexes with various concentrations of copper and Ni.Cu (0.8) -Ni (0.2) $(C_4H_4O_6)$*H2O, Cu(0.6)-Ni(0.4)$(C_4H_4O_6)$*H2O, Cu(0.4)-Ni(0.6) $(C_4H_4O_6)$*H2O. All these complexes showed antibacterial and antifungal activity. But among these complexes Cu (0.0) Ni (1.0) $(C_4H_4O_6)$ H2O showed highest antifungal and antibacterial properties. [28]

Potential implications of aluminium metabolism, its toxicity were studied using tartrate as ligand. Also, the impact of tartrate on aluminium speciation in the gastrointestinal fluid was discussed [29].

AS A PRECURSOR

Co (II)–tartrate complex in carbonate solution is used as precursor for Cobalt oxide-based materials. These Oxides are used to produce magneto resistive devices [30], electro chromic thin films [31] [32] and energy storage systems [33] [34]

The thermolysis in dinuclear complexes is always difficult due to the decomposition of the corresponding anions. Both the metals are kept in one solid phase. To avoid decomposition and to keep metals in one solid phase at moderate temperature Cu/ZnO an active methanol catalyst is used and to prepare this active catalyst Copper and Zinc tartrates are used. [35][36]

Copper oxide and cobalt oxide nanoparticles show antimicrobial and cytotoxic activities. Thus, they have various medical applications. For synthesis of copper oxide and cobalt oxide nanoparticles their respective tartrate complexes are used. The method used for synthesis of this oxide is inexpensive and can be reproducible. [37]

Lanthanide oxide like Gd_2O_3 Lu_2O_3 etc. has various applications in different fields. They are used as magnets, Luminescent materials and as a catalyst. [38, 39, 40] Gd_2O_3 shows good chemical durability and thermal stability. Calcination process is used for conversion of gadolinium tartrate to gadolinium oxide. [41]

OTHER APPLICATIONS

Zinc ions and organophosphonic acid (2-carboxy- ethylphosphonic acid) mixture form porous inhibitor films. When tartrates are added in a particular concentration, the surface completely reduces its porosity. Hence Zn tartrate can be used for protection of steel from corrosion. [42]

Photo physics of Fe (III)–tartrate complex applied to study photo processes in the environment and for water treatment. For generation of OH radicals, H_2O_2 and some organic radicals Fe (III)-Tar complexes are used as they are photo chemically reactive. This activity is important in oxidation of organic compounds in natural waters and in the environment [43, 44].

Lanthanum when complexed with tartrate formed new metal- organic frameworks (MOFs). These new MOFs have found novel magnetic and luminescent properties [45]. These frameworks may be used to construct such new coordination compounds [46].

CONCLUSION

Metal tartrates are mostly synthesized by coprecipitation method. Some tartrates synthesized using green principles. These complexes have found antibacterial and antifungal properties which make them pharmaceutically important compounds. For preparation of some heterocyclic compounds, tartrates are used as catalysts. Some of the tartrates plays important role as a precursor. Besides all these tartrates have other applications like, corrosion resistant water purifier etc.

REFERENCES

[1]. Mehrotra R.C. Singh A. (2000). Organometallic Chemistry Second edition 2000, New age international limited publishers [1-4]

[2]. Valasek, J. (1921). Piezo-electric and allied phenomena in Rochelle salt. Physical review, 17(4), 475.

[3]. Veseleya, I. V., & Gorodyski, V. I. (1975). Voprosy. Onkol, 3, 300.

[4]. http://www.opsi.gov.uklsi/si 1991 1392-en-1.htm#end.

[5]. Parikh, K. D., Parekh, B. B., Dave, D. J., & Joshi, M. J. (2006). Investigations of various growth

[6]. parameters, FTIR and thermal studies of gel grown pure and mixed levo-tartrates of calcium and strontium. Indian Journal of Physics, 80, 719-726.

[7]. W. Taylor, D. J. Lockwood, H.J. Labbe. (1984). Raman spectroscopy and dielectric constants of ferroelectric Rochelle salt and calcium tartarate, J. Phys.C: SOLID state Phys, 1984, 12, 3685-3699.

[8]. Gon, H. B. (1990). Ferroelectricity in calcium tartrate single crystals grown by gel technique. Journal of crystal growth, 102(3), 501-504.

[9]. Sawart, D. K., & Bhavasar, D. S. (2012). Nucleation and growth of barium tartrate crystals in silica gel, Arch. Phys. Res, 3, 8-14.

[10]. E. Sawaguchi, L.E. Cross. (1971). Electromechanical coupling effects on the dielectric properties and ferroelectric phase transition in lithium thallium tartrate, ferroelectrics, 2, 37-46, 1971

[11]. C.C.Desai, A.H.Patel. (1988). Crystal data for ferroelectric RbHC4H4O6 and NH4HC4H4O6 crystals, J. of Mat. Sci. Lett, 1988, 7, 371-373.

[12]. J.Fousek, L.E. Cross, K. Seely. (1970). some properteis of the ferroelectric lithium thallium tartrate ferroelectric, 1970, 1,63-70.

[13]. M.E. Toress, T. Lopez, J. Peraza, J. Stockel, A.C. Yanes, C. Gonzalez-Silgo, C. Ruiz-Perez, P.A. Lorenzo-Luis. (1998). J. Appli.Phys, 1998, 84, 5729.

[14]. "Tartaric Acid - Compound Summary". PubChem

[15]. Betallu, M. A., Tadke, V. B., Pathade, G. R., Sapnar, K. B., & Ubale, M. B. (2016). Synthesis, characterisation and microbial activity of mixed "transition metal-Calcium tartarate" complexes. J Appl Chem, 5(1), 165-178.

[16]. Patil, C. S., Dhavale, N. S., Tadke, V. B., & Pawar, R. P. (2016). Synthesis, characterization of novel mixed metal tartratec omplexes and study of their in vitro antimicrobial activity. International Journal of Pharmaceutical Sciences and Research, 7(4), 1524.

[17]. Ubale, M. B., Betallu, M. A., Tadke, V. B., Vhankate, S. M., & Pathade, G. R. (2016). Synthesis, characterisation and in vitro antimicrobial activity of mixed "transition metal–Barium Tartarate" complexes. World J Pharm Res, 5(6), 1578-1594.

[18]. Betallu, M. A., Tadke, V. B., Vhankate, S. M., Pathade, G. R., Pathade, A. G., & Ubale, M. B. (2017). Anti-biofilm activity of mixed 'transition metal (mn, fe, co, ni, cu and zn)–calcium tartarate'complexes. Int. J. Pharm. Sci. Res, 8, 4745-4749.

[19]. Ubale, M. B., Betallu, M. A., Tadke, V. B., Vhankate, S. M., & Pathade, G. R. (2016). Synthesis, characterisation and in vitro antimicrobial activity of mixed "transition metal–Barium Tartarate" complexes. World J Pharm Res, 5(6), 1578-1594.

[20]. Lathiya, U. M., Vyas, P. M., Jethva, H. O., Joshi, M. J., & Joshi, G. M. (2018). Synthesis and Characterization of Iron Tartrate Nanoparticles. Asian J. Chem, 30, 2754-2760.

[21]. Pawar, S. S., Patil, C. S., Tadke, V. B., Vhankate, S. M., Dhanmane, S. A., & Pawar, R. P. (2016). Copper-nickel tartarates composites: reusable and green catalysts for the synthesis of quinolines and dihydropyrimidines derivatives. Catalyst, 1, A6.

[22]. Walle, M. (2022) Doped Cobalt Iron Tartrates as Efficient Catalyst in Synthesis of 3, 3 Arylindene Bis (4-Hydroxy Coumarin) Derivatives. IJARSCT 2(4),111-113.

[23]. Walle, M., Pansare, D., Khan, T., Pawar, R., Shelke, R., & Ingle, R. (2021). One pot three component synthesis of 2-amino-5-oxo-4, 5-dihydropyrano [3, 2-c] chromene-3-carbonitrile derivatives catalyzed by cobalt doped iron (III) tartarate complex. Lett App Nano Bio Sci, 11(1), 3208-3217.

[24]. Walle, M., Ingle, R., & Pawar, R. (2021). Efficient and One-pot Synthesis of Tetrahydro [b] Pyran Derivatives Catalyzed by Copper Doped Iron Tartarate. Journal of Scientific Research, 65(6).

[25]. Shi, H., Yu, C., & He, J. (2010). On the structure of layered double hydroxides intercalated with titanium tartrate complex for catalytic asymmetric sulfoxidation. The Journal of Physical Chemistry C, 114(41), 17819-17828.

[26]. Ubale, M. B., Betallu, M. A., Tadke, V. B., Vhankate, S. M., & Pathade, G. R. (2016). Synthesis, characterisation and in vitro antimicrobial activity of mixed "transition metal–Barium Tartarate" complexes. World J Pharm Res, 5(6), 1578-1594.

[27]. Arouri, A., Essghaier, B., Dridi, R., & Zid, M. F. (2021). Crystal structure, spectral investigation, thermal properties and evaluation of the antimicrobial behavior of a new 2D polymeric Mn (II):(C6H9N2) 2 [Mn (C2O4) 2]. H2O. Journal of Molecular Structure, 1244, 131251.

[28]. Wang, J., Wang, Y., Gao, J., Hu, P., Guan, H., Zhang, L., & Zhang, X. (2009). Investigation on damage of BSA molecules under irradiation of low frequency ultrasound in the presence of FeIII-tartrate complexes. Ultrasonics sonochemistry, 16(1), 41-49.

[29]. Pawar, S. S., Patil, C. S., Tadke, V. B., Vhankate, S. M., Dhanmane, S. A., Pathade, G. R., & Pawar, R. P. (2014). Synthesis, characterization and biological activity of some tartarates and transition metal complexes. International Journal of Pharmaceutical Sciences and Research, 5(4), 1557.

[30]. Desroches, S., Daydé, S., & Berthon, G. (2000). Aluminum speciation studies in biological fluids: Part 6. Quantitative investigation of aluminum (III)–tartrate complex equilibria and their potential implications for aluminum metabolism and toxicity. Journal of Inorganic Biochemistry, 81(4), 301-312.

[31]. Ueda, Y., Kikuchi, N., Ikeda, S., & Houga, T. (1999). Magnetoresistance and compositional modulation near the layer boundary of Co/Cu multilayers produced by pulse electrodeposition. Journal of magnetism and magnetic materials, 198, 740-742.

[32]. Yoshino, T., & Baba, N. (1995). Characterization and properties of electrochromic cobalt oxide thin film prepared by electrodeposition. Solar energy materials and solar cells, 39(2-4), 391-397.

[33]. Monk, P. M., & Ayub, S. (1997). Solid-state properties of thin film electrochromic cobalt–nickel oxide. Solid State Ionics, 99(1-2), 115-124.

[34]. Hutchins, M. G., Wright, P. J., & Grebenik, P. D. (1987). Comparison of different forms of black cobalt selective solar absorber surfaces. Solar energy materials, 16(1-3), 113-131.

[35]. Barrera, E., González, I., & Viveros, T. (1998). A new cobalt oxide electrodeposit bath for solar absorbers. Solar energy materials and solar cells, 51(1), 69-82.

[36]. Guo, Y., Weiss, R., & Epple, M. (2005). A straightforward route to copper/zinc oxide nanocomposites: the controlled thermolysis of Zn [Cu (CN) 3].3072– 3079.

[37]. Weiss, R., Guo, Y., Vukojević, S., Khodeir, L., Boese, R., Schüth, F., & Epple, M. (2006). Catalytic activity of copper oxide/zinc oxide composites prepared by thermolysis of crystallographically defined bimetallic coordination compounds.

[38]. Palacios-Hernández, T., Hirata-Flores, G. A., Contreras-López, O. E., Mendoza-Sánchez, M. E., Valeriano-Arreola, I., González-Vergara, E., & Méndez-Rojas, M. A. (2012). Synthesis of Cu and Co metal oxide nanoparticles from thermal decomposition of tartrate complexes. Inorganica Chimica Acta, 392, 277-282.

[39]. Zheng, K., Song, W., Lv, C., Liu, Z., & Qin, W. (2014). Controllable synthesis and size-dependent upconversion luminescence properties of Lu 2 O 3: Yb 3+/Er 3+ nanospheres. CrystEngComm, 16(20), 4329-4337.

[40]. Wang, Y., Zhu, Y., Xu, W., Song, H., Xu, S., Wang, J., & Cui, H. (2013). Self-assembly of three-dimensional Lu 2 O 3: Eu 3+ inverse opal photonic crystals, their modified emissions and dual-functional refractive index sensing. Dalton Transactions, 42(38), 14014-14020.

[41]. Gupta, A., Brahme, N., & Bisen, D. P. (2014). Electroluminescence and photoluminescence of rare earth (Eu, Tb) doped Y2O3 nanophosphor. Journal of Luminescence, 155, 112-118.

[42]. Wang, Z., Wang, P., Zhong, J., Liang, H., & Wang, J. (2014). Phase transformation and spectroscopic adjustment of Gd2O3: Eu3+ synthesized by hydrothermal method. Journal of luminescence, 152, 172-175.

[43]. Gunasekaran, G., Natarajan, R., & Palaniswamy, N. (2001). The role of tartrate ions in the phosphonate-based inhibitor system. Corrosion science, 43(9), 1615-1626.

[44]. Wang, L., Zhang, C., Wu, F., & Deng, N. (2006). Photoproduction and determination of hydroxyl radicals in aqueous solutions of Fe (III)–tartrate complexes: a quantitative assessment. Journal of Coordination Chemistry, 59(7), 803-813.

[45]. Pozdnyakov, I. P., Kolomeets, A. V., Plyusnin, V. F., Melnikov, A. A., Kompanets, V. O., Chekalin, S. V., & Lemmetyinen, H. (2012). Photophysics of Fe (III)–tartrate and Fe (III)–citrate complexes in aqueous solutions. Chemical Physics Letters, 530, 45-48.

[46]. Luneau, D., & Rey, P. (2005). Magnetism of metal-nitroxide compounds involving bis-chelating imidazole and benzimidazole substituted nitronyl nitroxide free radicals. Coordination chemistry reviews, 249(23), 2591-2611.

[47]. Wang, Y., Liu, G. X., Chen, Y. C., Wang, K. B., & Meng, S. G. (2010). Two novel lanthanum–tartrate complexes with distinctive new topologies: Hydrothermal synthesis and crystal structures. Inorganica Chimica Acta, 363(11), 2668-2672.

Chapter
20

BIOFERTILIZER: VERMIWASH PREPARATION PROCESS, BENEFITS, COST

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ABSTRACT

Hello farmers and gardeners, today we are back with great information of Vermiwash preparation process, advantages and application of Vermiwash. Vermiwash is a liquid extract obtained from vermicomposting beds and is used as an organic fertilizer for crop plants. Vermiwash is a collection of excretory products and mucus secretions of earthworms along with micronutrients from the soil organic molecules. These are transported to the leaf, shoots and other parts of plants in the natural ecosystem. Vermiwash, if collected accurately, is a clear and transparent, pale yellow colored fluid. Vermiwash is a rich source of vitamins, hormones, macronutrients, and micronutrients when applied to plants to help in effective growth. What are we waiting for? Let's get into the details of preparation process of Vermiwash.

KEYWORDS: Vermicomposting, ecosystem, Biofertilizers, Macro and Micronutrients.

INTRODUCTION

Hello farmers and gardeners, today we are back with great information of Vermiwash preparation process, advantages and application of Vermiwash. Vermiwash is a liquid extract obtained from vermicomposting beds and is used as an organic fertilizer for crop plants. Vermiwash is a collection of excretory products and mucus secretions of earthworms along with micronutrients from the soil organic molecules. These are transported to the leaf, shoots and other parts of plants in the natural ecosystem. Vermiwash, if collected accurately, is a clear and transparent, pale yellow colored fluid. Vermiwash is a rich source of vitamins, hormones, macronutrients, and micronutrients when applied to plants to help in effective growth. What are we waiting for? Let's get into the details of preparation process of Vermiwash.

A GUIDE TO VERMIWASH PREPARATION PROCESS AND BENEFITS

Vermiwash is rich in dissolved nutrients and amino acids which are easily obtainable for plants. It is a non-toxic and eco-friendly compound, which arrests the bacterial growth and forms a protective layer for their survival and growth. Vermiwash at 5 to 10 percent dilution inhibits the mycelial growth of pathogenic fungi. It has the capacity to encounter worms thereby saving the plants and their productivity. As a foliar spray, it was reported to initiate flowering and lasting inflorescence. It can be used as a liquid fertilizer applied to the rhizosphere. No pathogen can survive in this fluid, thus protecting the earthworms from the diseases caused by pathogens. It acts as a plant tonic and thus helps in reducing several plant pathogenic fungi. It increases the rate of photosynthesis in crops or plants. It increases the number of micro-organisms in the soil which helps in decomposing soil organic matter.

The Vermiwash contains necessary plant nutrients, plant growth-promoting hormones (auxin and gibberellins), enzymes (cocktail of protease, amylase urease and phosphatase that acts as antimicrobic symbiotic microbes (nitrogen fixing bacteria such as Azotobacter sp., Agrobacterium sp., and Rhizobium

and some Phosphate Solubilizing Bacteria (PSB)) in addition to the macronutrients and micronutrients. It can be used as a foliar spray as well as soil application whereby it acts as a pesticide and natural fertilizer for the crop plants in sustainable agriculture. Vermiwash is a part of Good Agriculture Practice (GAP)
Vermiwash is a Brown colored liquid fertilizer, which is collected after the water passes by a worm culture column. As a storehouse of nutrients and microorganisms, Vermiwash is mainly used as a foliar spray for crops. Prepare Vermiwash while maintaining high concentrations of micro and macronutrients, plant hormones to ensure the healthy development of crops.

Vermiwash contains; The high amount of enzymes, amino acids
Heterotrophic bacteria, fungi, actinomycetes including nitrogen fixers, phosphate

SOLUBILIZERS

Vitamins and hormones like Cytokinins, auxins, and gibberellins, etc Along with macro and micronutrients, Vermiwash used as a foliar spray Soluble Nitrogen, Phosphorus and Potash

THE BASIC PRINCIPLE OF VERMIWASH PREPARATION PROCESS

The basic principle of Vermiwash preparation is simple and easy. Worm worked soils contain burrows formed by the earthworms. Bacteria richly inhabit these burrows and are also called as the drilospheres. Water passing through these passages washes the nutrients from these burrows to the plant roots to be absorbed by the plants. This principle is applied in the Vermiwash preparation. It can be formed by allowing water to percolate by the tunnels made by the earthworms on the coconut leaf – cow dung substrate kept in a plastic barrel. Then water is allowed to fall drop by drop from a pot hung above the barrel into the vermicomposting system. But barrels are not a must for Vermiwash preparation and Vermiwash units can be set up either in barrels or in buckets or even in small earthen pots.

STEPS OF VERMIWASH PRODUCTION AND PREPARATION PROCESS

The Vermiwash producer can set up the Vermiwash unit in a large container made of the concrete or plastic barrel of a 250-liter capacity. Drill a hole at the bottom of the container and then fix a tap to it. At the bottom of the barrel, fill gravels or broken small pieces of bricks up to a height of 10 to 15 cm or 10 to 15% of the container. Add another layer with coarse sand 10 to 15 cm or 10-15%. Place hay on top of this layer of soil. Pre decomposed organic wastes or cow dung (10 days old) are added and then moistened. Introduce about 1000 to 1500 juvenile or adult earthworms into the Vermiwash container and moisten the Vermiwash unit is every day. To obtain Vermiwash, continuously suspend water from a small bucket with a single hole at its center. Place cotton wicks or bamboo sticks in the holes so the water trickles down. The water gradually percolates to the bottom through the compost carrying with it nutrients through the filter unit. Fill the container with 4 to 5 liters water every day to keep the unit moist.

EFFECT OF VERMIWASH ON SOIL PROPERTY

Organic formulations can be a potent source to move forward soil fertility. Vermicompost and Vermiwash combination recorded a significant influence on the biochemical characteristics of the soil with marked development in soil micronutrients and better qualitative improvement in the physical and chemical properties of the soil. Soil treated with a mixture of and Vermiwash had significantly improved soil Physico-chemical properties comparison to unamended soil.

EXTRACTION OF VERMIWASH

Vermiwash extracted from the Vermiwash collecting device. The drops of water made the upper surface with different layers of sand, dung, and concrete mixture wet and moist. Earthworm started decomposing the dung present in the container and water sprinkled on the upper layer passes through the dung decomposed by the earthworm. The collecting device is made from plastic or metal drum having a capacity of 2 liters and a tap at the bottom of the drum filled with crushed breaks, about 10cm thickened which is followed by a sand layer of 2 to 3cm thickness, lastly filled with Vermicompost with a heavy population of earthworms. Simultaneously added a sufficient amount of freshwater, into the drum and a container kept below the tap of the drum. The watery extract of Vermicompost that means Vermiwash drained out of the drum and collected, drop by drop into the container.

ROLE OF VERMIWASH IN SUSTAINABLE CROP PRODUCTION

Vermiwash can be used as a potent biofertilizer to develop the germination and seedling survival rates in crop plants growing on nutrition depleted soils thus paving the way for sustainable agriculture using organic farming practices. It could be utilized efficiently for sustainable plant production at low input basis green farming. Vermiwash recorded significant growth and productivity in the black gram. Vermiwash is a natural growth supplement for tea, coconut and also horticulture

USE OF VERMIWASH

We have learned the preparation process of Vermiwash, now let's see how we can use this on crops or plants.

Dilute with water (10%) before spraying effectively on the plant.

Vermiwash must be diluted 5 to 10 times with water and then applied.

BENEFITS OF VERMIWASH

Vermiwash acts as a plant tonic and helps to reduce several plant diseases.

A mixture of 1litre Vermiwash with 1litre cow urine in 10 liters of water acts as biopesticide and liquid manure.

REFERENCES

[1]. Ansari AA, Ismail SA. (2001). A case study on organic farming in Uttar Pradesh.J Soil Biol. Ecol. 2001; 27:25-27.

[2]. Ansari AA, Sukhraj K. (2010). Effect of Vermiwash and vermicompost on soil parameters and productivity of okra (Abelmoschus esculents) in Gu Biermann Yana. African Journal of Agricultural Research. 2010; 5(14):1794-1798.

[3]. 3. Arancon NQ, Edwards CA, P. (2006). Influences of vermin composts on field strawberries: Part 2. Effect on soil microbiological and chemical properties. Bioresource Technology. 2006; 97:831-840.

[4]. Balaam SB. (2000). Studies on bio pesticide effect of Vermiwash in control of some foliar pathogens. M.Sc. (Ag) thesis submitted to Dr. Balasaheb Sewant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnangi, Maharashtra, 2000.

[5]. Bucker field JC, Flavel T, Lee KE, Web Ster KA. (1999). Vermicompost soil and liquid form as plant growth promoter. Pedobio logia.1999; 42:753-759.

[6]. Chaoui HI, Zibilske LM, Ohno T. (2003). Effects of earthworm casts and compost on soil microbial activity and plant nutrient availability. Soil Biology and Biochemistry. 2003; 35:295-302.

[7]. Chattopadhyay A. (2015). Effect of Vermiwash of Eugenia foetida produced by different methods on seed germination of green mung, Vigna radiate. International Journal of Recycling of Organic Waste in Agriculture. 2015; 4(4):233-237.

[8]. Edwards CA, Dominguez J, Arancon NQ. The influence of vermin composts on plant growth and pest incidence. In, S.H Shakir and W.Z.A. Mikhail, (Eds. Soil Zoology for Sustainable Development in the 21st

Chapter
21

BIOLOGY AND BIOCHEMISTRY OF MUSHROOMS AND ITS IMPORTANCE

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ABSTRACT

Mushrooms are the fleshy fruiting body of some fungi arising from the group of mycelium, mushroom use as food and medicine since time immemorial. Traditional and folk medicine practitioners are using mushrooms for their healing and cleansing properties. These have been considered as the Delicacy, in the nutrition point of view mushrooms are placed between meat and vegetables and also called as vegetable meat. All varieties of mushrooms are low in calories and fat, and contain modest amounts of fiber and various nutrients. Mushrooms constitute both a nutritionally functional food as well as a source of physiologically advantageous medicine. Mushroom consumption is increasing rapidly worldwide due to their rich source of bioactive compounds such as functional protein, vitamins, minerals and dietary fibers etc. due to that considering it as precious, and functional food ingredient as food, as tonic, and as medicine to remedy and to treat numerous dangerous illnesses around the world. Mushrooms can serve as agents for promoting equitable economic growth in society. Good resource to a non-green revolution in less developed countries, and in the world at large. Mushrooms are also an important and integral component to create a clean the ecosystem.

KEYWORDS: Bioactive Compounds, Ecosystem, Food, Medicine, Mushroom, Mycelium, Nutrition.

INTRODUCTION

Mushrooms are a group of fleshy macroscopic fungi. They lack chlorophyll having heterotrophic mode of nutrition. The word mushroom is used through world to express the different species of fungus belongs to the order of Basidomyecets or Ascomycetes. Chang and Miles (1992) defined mushroom as a "macro fungus with a distinctive fruiting body which can be either epigeous or hypogenous and large enough to be seen with the naked eye and can be picked with hand." Mushrooms can be found everywhere in soils rich in organic matter and humus, moist wood, animals waste after heavy rain or a sudden change of temperature and soon after a few hours or day's they disappear, leaving no sign except mycelium. Mushrooms can serve as food, as tonic, and as medicine. A regular intake of mushrooms can make you healthier, fitter, and happier. They can make you live longer, and always look younger. Mushroom consumption is increasing rapidly worldwide due to their rich source of bioactive compounds such as functional protein, vitamins, minerals, low in calories, carbohydrates, growth promoting substances and high dietary fibers etc due to that considering it as precious, and functional food ingredient. Mushrooms can serve as agents for promoting equitable economic growth in society. Good resource to a non-green revolution in less developed countries, and in the world at large. It has great potential for generating a great socio-economic impact in human welfare, at local, national and regional levels.

BIOLOGY OF MUSHROOMS

Mushroom biology is the branch of mycology that deals with mushrooms. It is concerned with any aspect of the scientific study of mushrooms, such as: taxonomy; physiology; genetics; etc.

Applied mushroom biology is concerned with all aspects of the application of mushroom biology. It consists of three main components: mushroom science; mushroom biotechnology; and mushroom mycorestoration. Mushrooms are seasonal fungi with fleshy, spore bearing fruiting body, typically produces above the ground of the soil or on its food source as a saprophytic fungus that grows on dead and decaying organic matter. Due to the absence of chlorophyll, it is unable to synthesize its own food and hence is dependent upon the organic matter/substrate for food. Which occupy diverse niches in nature in the forest ecosystem they predominantly occur during the rainy season and also during spring. There are about 50,000 known species of fungi and about 10,000 are considered as edible ones. Of which, about 180 mushrooms can be tried for artificial cultivation and 70 are widely accepted as food. Worldwide accepted edible mushrooms are Button Mushroom Agaricus bisporus, Straw Mushroom Volvariella volvacea, Oyster Mushroom Pleurotus ostreatus, Milky Mushrooms Calocybe indica, Cremini Mushroom Agaricus bisporus Shiitake Mushroom Lentinula edodes, Portobello Mushroom Agaricus, Enokitake mushrooms Flammulina velutipes, Morel Mushrooms Morchella esculenta, Lentinula edodes, Oyster Mushrooms-Pleurotus ostreatus, King Oyster Mushroom -Pleurotus eryngii, Lion's Mane Mushrooms Hericium erinaceus, Enoki Mushrooms - Flammulina velutipes, Porcini Mushrooms -Boletus edulis, Maitake Grifola frondosa, Matsutake Mushroom - Tricholoma matsutake, Reishi Mushroom - Ganoderma lingzhi, Giant Puffball Calvatia gigantean, Buna Shimeji Mushroom Hypsizygus tessellates, Pepeao Jaws Ear Mushroom Auricularia auricula-judae, Straw Mushroom - Volvariella colvacea, Chanterelle Mushrooms Cantharellus cibarius and Other important edible mushrooms are Calocybe, Coprinus, Boletus, Flammulina and Termitomyces etc. Not all mushrooms are edible, wild mushrooms with white gills or a ring around the stem are considered poisonous. Some other inedible mushrooms look like edible mushrooms, also are there i.e Amanita phalloides(Death Cap), Amanita muscaria, Amanita virosa (Distroying Angel), Clitocybe sp. Cortinarius smithi, Gyromitra sp., Paxillus involutus, Tricholoma muscarium etc (Figure-1).

Fig. 1: Some Edible and Poisonous Mushrooms

BIOCHEMICAL'S OF MUSHROOM

Mushrooms contain moisture 85–95%, Carbohydrates 35–70%, includes starches, pentoses, hexoses, disaccharides, amino sugars, sugar alcohols, and sugar acids. Glycogen -α-glucans.β-glucans, Protein 15–34.7 protein content ranges are from 17 g to 42 g per 100 g of dried fruit bodies, significant amino acids i.e leucine, aspartic acid, valine, glutamine, and glutamic acid are found, Lipids little fat (4–6%) without cholesterol, important fatty acids linoleic acid, oleic acid, and palmitic acid are included, minerals 6–

10.9% mostly potassium, calcium, iron, manganese, magnesium, copper, selenium, zinc etc, nucleic acids 3–8%, and large amount of vitamins such as thiamine 1.4–2.2 mg, riboflavin 6.7–9.0 mg, niacin 60.6–73.3 mg, biotin, ascorbic acid 92–144 mg, pentatonic acid 21.1–33.3 mg, and folic acid 1.2–1.4 mg/100 g in dry weight. The fruiting body contains approximately 100 different bioactive compounds such as functional protein glucans, laccase, proteoglycan (ubiquinone-9, nebrodeolysin, and lycoprotein), proteoglycans, pleuran (β-1, 3-glucan with galactose, and mannose), pleurostrin (peptide), and phenolic compounds include phenolic acids, flavonoids, hydroxycinnamic acids, hydroxybenzoic acids, lignans, tannins, stilbenes, oxidized polyphenols and dietary fibers. The fruiting bodies are high in antioxidants and anti-aging components like ergothioneine, phenolic compounds, and indole compounds like melatonin, serotonin, and selenium, and found 55 fragrance compounds in mycelium, namely, 27 esters, 9 ketones, 7 thiols, 5 alcohols, 4 terpenoids, 2 phenols, and 1 aldehyde, and also have ash, glycosides, volatile oils, tocopherols, flavonoids, carotenoids, folates, organic acids, etc (Table-1 & 2).

Table 1: Nutrients content in Mushrooms

Nutrient	**Average in 100gram of mushrooms**
Protein (g)	3.0
Carbohydrate (g)	5.1, including 1.9 g of sugar
Energy (calories)	28
Dietary Fibre	2.2 gm
Total Omega -2 fatty Acids	1.0mg
Total Omega -6 fatty Acids	190 mg
Calcium (mg)	6.9
Iron (mg)	1.5
Magnesium (mg)	12
Phosphorus (mg)	85.6
Potassium (mg)	356
Sodium (mg)	2.3
Zinc (mg)	0.9
Copper (mcg)	0.5
Manganese	0.1mg
Selenium (mcg)	11.9
Vitamin C (mg)	4.0
Vitamin D (mg)	21 IU
Thiamin	0.1mg
Riboflavin	0.3mg
Folate (mcg DFE)	18
Choline (mg)	19.6
Niacin (mg)	4.5
Pantathenic Acid	2.2mg

Table 2: Nutritional Value of few most widely Cultivated and Edible Mushrooms

Mushroom	Carbohydrate	Protein	Fat	Fiber	Vit-D (IU/g)	Ash	Energy (Kcal)
Agaricus bisporous	46.19	33.38	3.10	20.80	985	5.80	489
Pleurotus sajor-caju	63.40	20.13	2.70	48.60	496	6.36	426
Pleurotus ostreatus	57.60	30.40	2.30	8.70	484	9.80	275
Volvarella volvaceae	54.80	37.60	2.60	5.60	463	1.20	306
Lentinula edodes	47.60	33.23	3.75	28.90	415	5.20	395
Calocybe indiaca	64.36	17.89	4.10	3.40	486	7.45	393
Auricularia auricula	82.80	4.30	8.30	20.10	438	4.60	358
Flammulina velutipes	73.10	17.50	1.90	3.60	316	7.40	374

Mushrooms have a long association with humankind and provide profound biological and economic impact. From ancient times, man has consumed wild mushrooms with delicacy probably, for their taste and pleasing flavor. Mushrooms constitute both a nutritionally functional food as well as a source of physiologically advantageous medicine. Mushrooms are famous, precious and considered functional food ingredients for the structural and functional activities of any living being. Mushroom consumption is increasing rapidly worldwide due to their rich source of bioactive compounds, functional protein, fibers, cholesterol-free and low in calories, excellent source of vitamins, microelements, indoles, polyphenols, carotenoids, tocopherols, nine essential amino acids which required for human growth, complex carbohydrates strengthen the immune system, to increase the protein content in their diet helps lower cholesterol, Niacin can be another good supplement for vegetarians, Ergosterol performs the same function as cholesterol and Vitamin D precursor good Non Animal dietary source. as a powerhouse of minerals, copper help the body to absorb oxygen and create red blood cells, contain more selenium than any other form of produce, it acts as antioxidant to neutralize free radicals, potassium is an extremely important mineral that regulates blood pressure and keeps cells functioning properly. ergothioneine antioxidant for the protection against cardio vascular diseases, chronic inflammatory conditions, ultraviolet radiation damages, and neuronal injuries. Alkaloids like Cordycepin, Lectins, Lovastatin for various body functions. high significant amino acids, low fat contents, polyunsaturated fatty acids and small amounts of saturated fatty acids are almost ideal for a nutrition program aimed to prevent hypercholesterolemia, cardiovascular diseases, reduction of total blood cholesterol, lipoprotein cholesterol and antioxidant activities, in the regulation of blood lipid levels and reduction of blood glucose levels also used as therapeutic foods to check diseases such as hyper-diabetes, hypertension, atherosclerosis and cancer mainly due to their chemical profile. Antioxidants in mushrooms help in prevent lung, prostate, breast, and other types of cancer, choline help in muscle movement, learning, and memory, transmission of nerve impulses, reduce the risk of some types of cancer, Dietary fiber, Beta-glucans may help manage type 2 diabetes, reduce blood glucose, potassium can help regulate blood pressure, and this may decrease the risk of hypertension and cardiovascular disease (Table-3).

Table 3: Medicinal value of few edible Mushrooms

Mushroom	Compounds	Medicinal properties
Agaricus bisporus	Gallic acid, protocatechuic acid, catechin, caffeic acid, ferulic acid and myricetin, Lectine	Antioxidant activity
		Immune system enhancer
		Anticancer
		Enhance Insulin Secretion
Pleurotus ostreatus	Lovastatin: inhibitor of 3-hydroxy-3-methylglutaryl coenzyme A reductase Pleurotus ostreatus	Reduction of cholesterol
	Oyster mushroom concentrate	Anti-inflammatory activity
Pleurotus eryngii	Acidic glycosphingolipids	Antitumour activity; immune system enhancer; antibacterial activity
Lyophyllum shimeji	A novel fibrinolytic enzyme: α-chymotrypsin	Blood anticoagulant
Lentinula edodes	Polysaccharides, Eritadenine, Lentinan	Antioxidant, Anticancer, Lower Cholesterol
Auricularia auricula	Acidic Polysaccharides	Decrease Blood Glucose
Ganodermalucidum	Ganoderic acid, Beta Glucan	Liver Protection, Augments immune System, Inhibit Cholesterol Synthesis, Antibiotic Properties
Ganoderma frandosa	Polysaccharides, Lectins	Increase Insulin secretion, decrease blood glucose
Crucibulum leave	A new salfredin-type metabolites (DSM 1653 and DSM 8519	Inhibition of the enzyme aldose reductase
Cordyceps sinensis	Cordycepin	Cure Lungs Infection, Hypoglycemic activity, Anti-depressant Activity, Cellular Health Properties
Phallus indusiatus	A β-D-glucan called T-5-N	Anti-inflammatory properties
		Antioxidant capability
Flammulina velutipes	Ergotheoneine, Proflamine	Antioxidant, Anti-Cancer activity
Hericium erinaceus	Glycoprotein HEG-5	Hemaglutinating activity
	Polysaccharides (HEPs)	Antibacterial activity against Helicobacter pylori
	Glycoprotein HEG-5	Anticancer potential against human gastrointestinal cancers

Mushroom	Compounds	Medicinal properties
Hydnellum peckii	(2,5-dihydroxy-3,6-bis (4-hydroxyphenyl)-1,4-benzoquinone)	Anticoagulant
		Antibacterial activity atromentin and leucomelone
Trametes versicolor	Polysaccharide -K	Decrease Immune system Depression

Mushrooms have more medicinal properties it help to control many human ailments include anti-oxidant, anti-inflammatory, anti-carcinogenic, anti-microbial, antibacterial, anti-fungal, anti-diabetic, anti-angiogenic, immunemodulatory, hepatoprotective, hypoglycemic, anti-viral, anti-tumor, anti-hypercholesterolemic, anti-hypertensive, protecting the liver, promoting general fitness, anti-asthmatic, anti-obesity, anti-atherosclerotic, and anti-ulcer, due to that fact Increased interest in consuming mushrooms as food, as tonic, and as medicine to remedy and to treat numerous dangerous illnesses around the world (Figure-2).

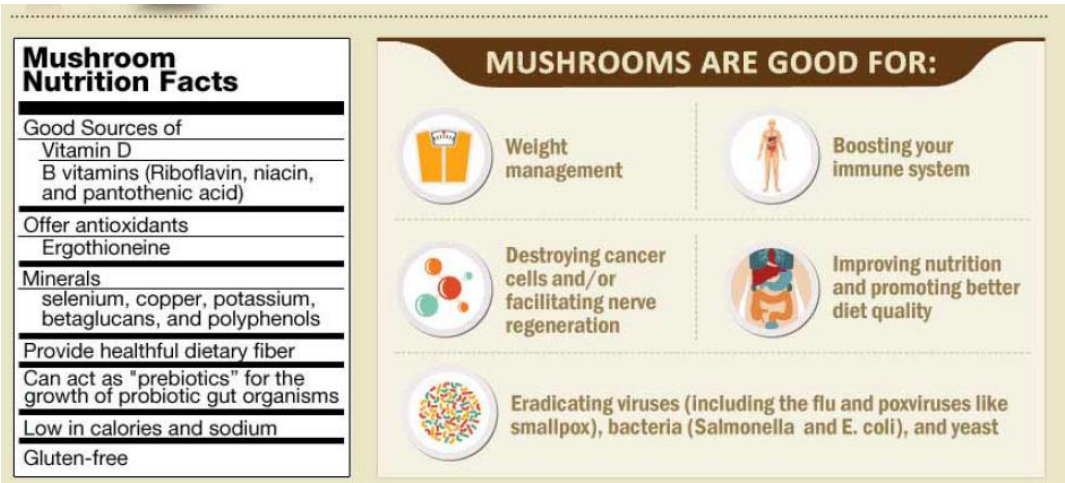

Fig. 2: Biochemicals of Mushroom and its importance for human beings

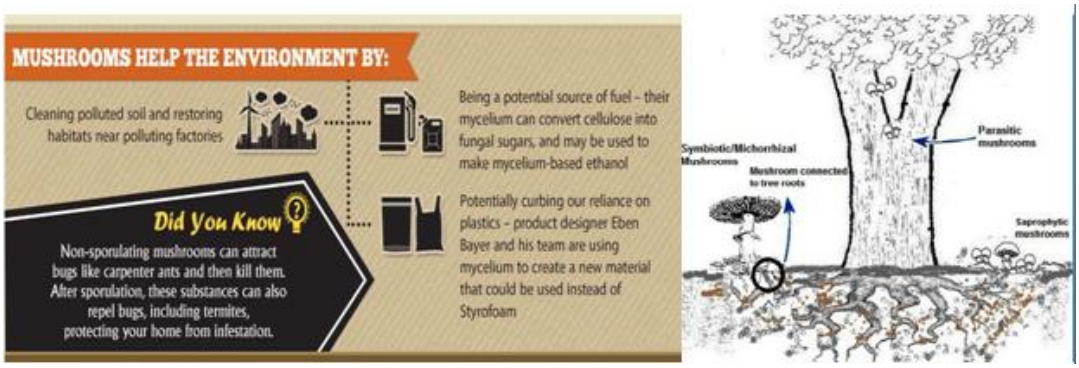

Fig. 3: Mushrooms in Environmental protection

Mushrooms are an important and integral component of the ecosystem. Mushrooms are seasonal fungi, which occupy diverse niches in nature in the forest ecosystem they predominantly occur during the rainy season and also during spring. Mushroom mycelia can produce a group of complex extracellular enzymes which can degrade and utilize the lignocellulosic wastes in order to reduce pollution. Mushroom mycelia can play a significant role in the restoration of damaged environments. Saprotrophic, endophytic, mycorrhizal, and even parasitic fungi/mushrooms can be used in mycorestoration, as like mycofiltration (using mycelia to filter water), mycoforestry (using mycelia to restore forests), mycoremediation (using mycelia to eliminate toxic waste), and mycopesticides (using mycelia to control

insect pests). These are the potential to create a clean ecosystem, where no damage will be left after fungal implementation (Figure-3)

CONCLUSION

Mushroom is a general term used mainly for the fruiting body of macro fungi (Ascomycota and Basidiomycota). The edible fungi in addition to mushrooms are also known as morels, truffles, puff-balls, tudstools, morels truffles widely used as food since time immemorial. Mushrooms have a long association with humankind and provide profound biological and economic impact. Mushrooms can serve as a functional food, tonic, as medicine to control many human ailments, including antioxidant, anti-inflammatory, anti-carcinogenic, anti-viral, anti-fungal, anti-bacterial, anti-diabetic, anti-angiogenic, immuno-modulatory, hypoglycemic, and hepatoprotective. Mushrooms are the rich source of all needed material for our life. A regular intake of mushrooms can make you healthier, fitter, and happier. They can make you live longer, and always look younger. Mushrooms can serve as agents for promoting equitable economic growth in society. Mushrooms are taking part in non-green revolution in less developed countries, and in the world at large. These are great potential for generating a great socio-economic impact in human welfare and in the restoration of damaged environments.

REFERENCES

[1]. Anmut Assemie and Galana Abaya (2022). The Effect of Edible Mushroom on Health and Their Biochemistry. International Journal of Microbiology. https://doi.org/10.1155/2022/8744788

[2]. Bhambri A, Srivastava M, Mahale VG, Mahale S and Karn SK (2022). Mushrooms as Potential ources of Active Metabolites and Medicines. Front. Microbiol.doi: 10.3389/fmicb.2022.837266

[3]. Gloria A. Martinez-Medina a, M´onica L. Ch´avez-Gonz´alez a,, Deepak Kumar Verma b, L. Arely Prado-Barrag´an c, Jose L. Martínez-Hern´andez a, Adriana C. Flores-Gallegos a, Mamta Thakur d, Prem Prakash Srivastav b, Crist´obal N. Aguilara, (2021). Bio-functional components in mushrooms, a health opportunity: Ergothionine and huitlacohe as recent trends. Journal of Functional Foods 77

[4]. Girma W, Tasisa T. (2018). Application of Mushroom as Food and Medicine. Adv Biotech & Micro. 11(4): 555817. DOI: 10.19080/AIBM.2018.11.555817.

[5]. Kaisun Nesa Lesa *et al.* (2022). Nutritional Value, Medicinal Importance, and Health-Promoting Effects of Dietary Mushroom (Pleurotus ostreatus). Journal of Food Quality.1-9 pp.

[6]. Nagaraju D. (2022). Mushroom Culture Technology. Textbook for B.Sc by Kasthuri Publications pp.56

[7]. Robin Rijal, Meenakshi Rana, Seweta Srivastava. (2021). Biochemical Composition, Nutritional Values and Medicinal Properties of Some Edible Mushrooms: A Review. Environment and Ecology 39 (2): 358—369.

[8]. Romi Singh (2017). A Review on Different Benefits of Mushroom.IOSR Journal of Pharmacy and Biological Sciences. 12(1) II: 107-111.

[9]. Sanjay Mishra, S.K. Chauhan and Priyanka Nayak (2021). Physiological, Biochemical, Biotechnological and Food Technological Applications of Mushroom: An Overview. IOSR Journal of Biotechnology and Biochemistry 7(1), PP 39-46.

[10]. Shubhra Shukla and A. K. Jaitly (2011). Morphological and Biochemical Characterization of Different Oyster Mushroom (Pleurotus spp.). Journal of Phytology 3(8): 18-20.

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