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Microbial Pigments Production through Agro Industrial Waste as a Substrate using Fermentation Techniques

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ABSTRACT

Waste from agro-industries is widely utilized for the making of microbial pigments using fermentation technique. Production of microbial pigments through the fermentation is a metabolic process that produces chemical changes in organic substrate through the action of enzymes. Production of food grade pigments needs high capital investments. Thus, utilization of agro-industrial waste plays an imperative role in the low cost production of microbial pigments. Agricultural industrial sector generates waste at large scale in the form of seeds, bagasse, whey and molasses etc. Agro-industrial wastes are not only biodegradable but also full of nutrients. Microbial pigment production through agro-industrial waste is an inexpensive and environmental friendly process that has positive impact on the environment. This review paper is aimed to focus on the microbial pigments production through agro-industrial waste as a substrate using fermentation technique. Agro-industrial waste utilization will reduce the environmental pollution as well as can help to produce variety of biological products such as biogases and biopigments etc.

Key words : *Agro-Industrial Waste, Pigments, Microorganisms, Microbial pigments, Natural pigments.*

Introduction

Colors offer marketable goods like fruit, textiles, and pharmaceuticals a more appealing look. We cannot picture a world without colors because colors are the magic of the world. Natural pigments have been available for a long time, and their popularity has grown as a result of the toxicity issues that synthetic pigments have caused. Microbial pigments are a suitable substitute in this case.Many artificial synthetic colorants, which are commonly used in the production of foods, dyes, cosmetics, and pharmaceuticals, have a variety of harmful effects. Synthetic pigments have a number of drawbacks. The precursors utilized in the manufacture of synthetic pigment that have a number of carcinogenic hazards for personnel.The wastes produced during the manufacturing process are also hazardous. They are non-biodegradable and non-environmentally friendly (Solovchenko *et al.,* 2018). There is an improved attention in the creation of pigment processes from natural sources around the world in order to combat the adverse effects of synthetic colorants. A revived concern for the use of comestibles is the potential of different artificial colorants. As a result, the request for (edible) coloring agents, which is naturally occurring, has increased. Microbial pigments have lower production costs associated to equivalent colorants derived from plants or animals. As a consequence, bioprocesses involving

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high-crowded species are expected to be more industrial production capable (Narsing Rao *et al.*, 2017). A range of microbial origins including bacteria, yeasts, molds and algae, are produced from microbial pigments. The ability of microbial pigments to grow on low cost substrates that provide weather resistance, speeded development and inexpensiveness can be additionally improved (De Carvalho *et al.*, 2014). This review article provides an overview of Microbial Pigments Production through Agri Industrial Waste as a Substrate using Fermentation Techniques. This paper will discuss about agro-industrial wastes and its types followed by biological pigment classes. This paper focused on the microbial pigments and its production through the agro-industrial waste and its application.

Agro-Industrial Waste and its Types

Organic wastes comes from agro-commerce are now one of the most significant pollution sources. Organic waste can be found in two forms: (a) agricultural as well as forestry waste, and (b) industrialized waste (Figure 1). Slurry and manure, plant residues and plant waste and the conservation of woodlands are amongst the waste created by farming and forestry operations. Organic waste is created by processing, including by-products of agri-food. Chemical wastes are increasing every day and are thought to be detrimental to the environment; as a result, many countries have enacted legislation to avoid them due to environmental concerns (Singh *et al.*, 2009).

In this respect, the standard applies to leftoveras well as comprises the key concepts and values that regulate leftover management, stressing that the measurement and disposal of waste must be undertaken in an effort to reduce negative impact and to control the utilization of organic leftover as fertilizer in farming without placing water as well as air, land or flora as well as fauna at risk. Clean technologies can be used to reduce industrial pollution by minimizing organic waste by recycling (Madurwar *et al.*,

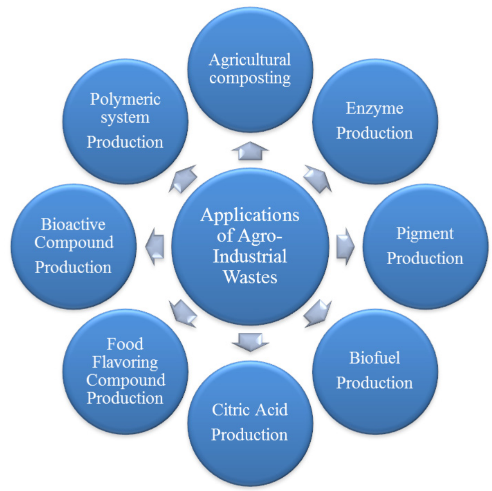

Fig. 2. Schematic illustration of the Potential Applications of the Agro-industrial Wastes.

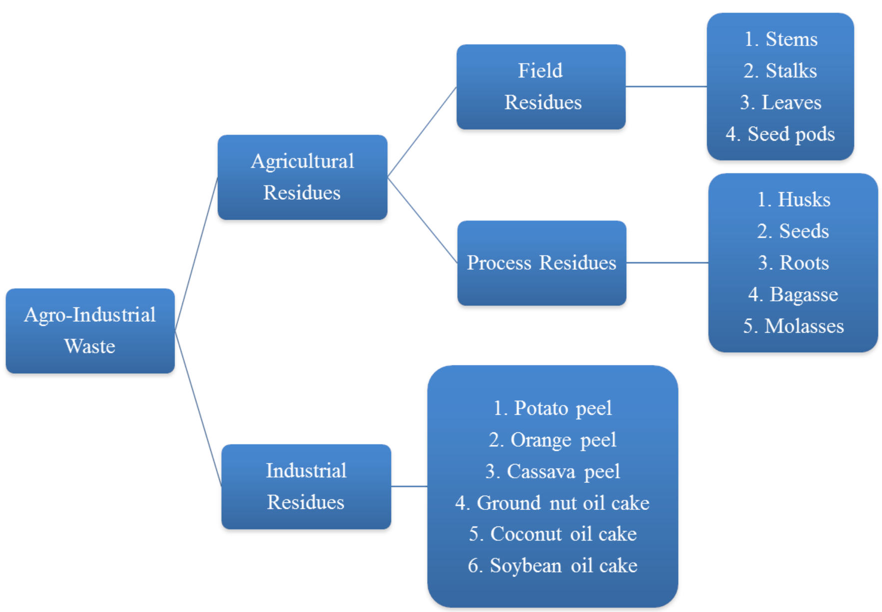

Fig. 1. Schematic Presentation of Different Types of Agro-industrial Waste.

2013). Figure 2 shows a reflection of agro-industrial wastes with recycled value-added applications.

Biological Pigment Classes

The public concern about the use of edible coloring agents has resulted in the ban of a number of synthetic coloring agents with carcinogenic and teratogenic potential. Biological pigments also referred as biochromes or pigments (Pangestuti and Kim, 2011). There are compounds produced in a selective color absorption by living organisms. For several years, synthetic dyes in food have been discussed.

The study of synthetic dyes and the unfavorable view of them by the contemporary market also inspired a strong interest in the substitution of natural colors. There is plenty of color in nature (minerals, seeds, microalgae etc.), with microorgetable pigmentation (fungi, yeasts and bacteria) being abundant. Just any wavelength of light is absorbed by biological pigments (seen in Figure 3). The absorbed light may be utilized to fuel the organism, although the reflected wavelengths of light decide the pigment color. As listed below Table 1: Biological source-based pigments have been classified as:

Classification of Microbial gigments

Biopigments are pigments that are formed by organisms as a result of their secondary metabolism. These biopigments have a wide range of synthetic and commercial uses. For classifying biological pigments, structural affinities and natural occurrences may be used. Table 2 provides several examples of microbial pigments that exist naturally.

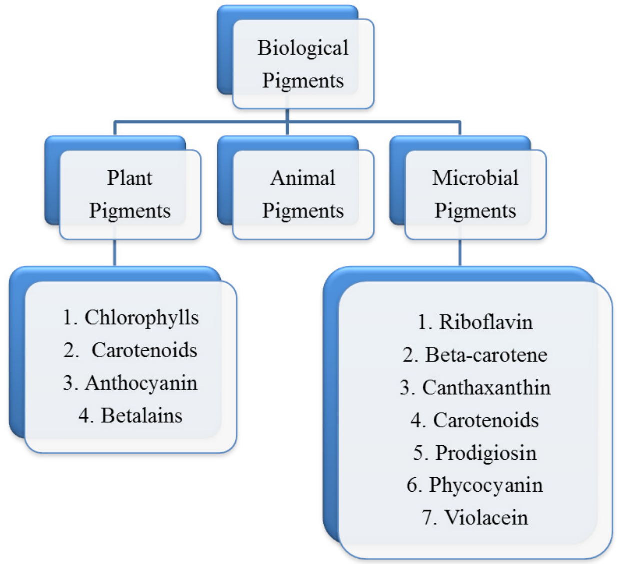

Fig. 3. Schematic Representation of the Classes of the Biological Pigments.

Significance of Microbial Pigments as Natural Colorants

Maximum common species on the planet are microorganisms and they decide life and death. Many of the foods we eat microorganisms are present in and the fermentation of those foods takes place. It can be also utilized as nutrition in the shape of a particular cell, pigmented, amino acid, vitamin, organic acid and enzyme food additives (Rodriguez-Amaya, 2016).

Microorganism pigments are in this case an ac-

Table 1. List of Biological Pigment Classes and Corresponding Details of Different Pigments

Biological Pigment Class	Detail
Plant Pigments	Various firms have definite to stain the food by means of extracts of plants or plant colorants. Plant colorants contain a number of complex molecules that include porphyins, carotenoid, anthocyanin and batalan. These pigments also contribute to pollination by drawing pollinators in plants.
Animal Pigments	Before chemical equivalents were produced, our ancestors were able to acquire a wide variety of pigments from animal sources. The most infrequentas well as difficult to get pigments were symbols of wealth as well as prestige, such as the purple color, which is synonymous with wealth as well as royalty. The ancient purple dye was one of the first pigments discovered in the 13th century. The hypobranchial gland is a mucus-secreting organ found in Murexes drilling snails. The mucus of some mollusks yields a small amount of Tyrian purple.
Microbial Pigments	There are abundant natural colorants, but only a few in adequate amounts are obtainable for commercial use. Micro-organism pigments provide an advantage over other pigments as micro-organisms can rapidly grow, resulting in high product productivity.

ceptable substitute. As a number of pigments are found in microorganisms, they are a potential food colorant source. The most significant natural colorants are carotenoids, tetrapyrroles as well as certain xanthophylls. Generally, widely utilized pigment in the industry is beta-carotene extracted from the microalgae. In the dairy, pharmacy and aquaculture industries astaxanthin is a pigment in red color originating from Phaffia Rohodozoa and pluviais, has been commonly used. The Penicillium Herquei (*Sarcina, penicillin*), *Cryptococcus, Monascus purpureus, Phaffia rhodozyma*, Sp. *Achromobacter, Serratia, Cordyceps, Streptomyces* (Babitha, 2009).

Most of the bacteria as well as fungi have been studied broadly for their impending as food dyes. Natural colorants consist of pro-vitamin A, anticancer properties as well as fundamental characteristics, including consistency of light as well as heat, and the value of pH. The food sector has since been actively concerned in the production of food colors, using microbial technologies. It may also contribute to alleviating consumer anxiety over harm to health from the use of synthetic colors in foods. Furthermore, natural dyes can be useful not only for human health but also for the conservation of wildlife as synthetic dyes may be eliminated when harmful substances are released to the environment. These natural dyes include baby food, cereals as well as sauces, spaghetti, treated cheese, fruit beverages and milk vitamins, and some drive beverages. Natural colors, in addition to being environmentally sustainable, will thus satisfy the twofold requirements for visually pleasant appearance.

Microbial Pigments Production through Agro-Industrial Waste

Depending on the source, different forms of pigment develops in microorganisms including bacteria as well as yeast, and fungi. The future producer of biopigments has been identifying microorganisms of *Monascus* and *Aspergillus* etc. The bacteria that have shown pigment efficient capabilities are only few *Serratia marcescens, Vibrio psychroerythrous, Alteromonas rubra*, and *Streptomyces longisporus*. As a result of its unicellular existence and high rate of growth on low-cost media, leaven cultures are known to be good sources for microbial pigments relative to bacteria as well as fungi. Medium as well as process constraints affect the synthesis of different natural carotenoid colors extracts from yeast. Examples of yeast strain include Rhodotorula glutinis and *Yarrowia lipolytica* etc. (Kumar, *et al.*, 2015). Pigment sources include Phaffia rhodozyma and *Phaffia rhodozyma*. *Monascus purpureus* strains are the most widely used in mold cultures for SSF pigment processing. *Monascus* sp. is a species of *Monascus*. Produces a wide range of azaphilone pigments in a number of colors that can be divided into three classes. Ankaflavins and monascin are natural yellow pigments, orange pigments are produced

Table 2. Classification of Microbial Pigments and Respective Appearing Color (Panesar *et al.*, 2015)

Microorganism(s)	Pigments/Molecule	Color/appearance
	Bacteria	
Agrobacterium aurantiacum	Canthaxanthin	Dark Red
Paracoccus carotinifaciens	Canthaxanthin	Orange yellow
Bradyrhizobium sp.	Astaxanthin	Purple
Brevibacterium sp.	Violacein	Pink-red
Corynebacterium insidiosum	Lycopene	Red
Haloferax alexandrinus	Astaxanthin	Pink-red
Chromobacterium violaceum	Carotenoid like	Dark- red
Algae		
Dunaliella salina	Canthaxanthin	Blue
Chlorococcum sp.	Ankaflavin	Yellow-orange-red
Hematococcus sp.	β -carotene	Orange
Fungi		
Aspergillus sp	Astaxanthin	Cream
Blakeslea trispora	Canthaxanthin	Orange-red
Fusarium sporotrichioides	Indigoidine	Yellow
Haematococcus pluvialis	β–carotene	Orange-pink
Monascus roseus	β-carotene	Red
Monascus sp.	Lutein	Red

from rubropunctatin as well as monascorubin, and red pigments are red rubropntamine as well as monacorubramine. In addition to Monascus, as potential natural pigment producers, microorganisms of *Aspergillus* and *Penicillium* were examined. The utilization of various sources of carbon, the utilization of various sources of nitrogen, the provision of fair rates, tolerances of salt absorption, and temperature resistant, pH-tolerant as well as simple separation of microorganisms for pigment processing should be non-pathogenic in behavior, not harmful in nature.

The microbes generate pigments by the method of fermentation, which might be solid statefermentation (SSF) or it can be submerged fermentation (SmF) as listed in Table 3 (Panesar *et al.,* 2015).

Application of Microbial Pigments

Food industry

Some fermentation-derived pigments are now used in the food industry, such as bcarotene from the fungus Blakesleatrisporain Europe or pigments from Monascus in Asia. Various pigments give the product a pleasing appearance while also providing nutritional and medicinal benefits such as antibiotics and antioxidants. Because of the adverse effects of synthetic chemicals, there is a craze among people to use natural products (pigment). Monascus red pigments, which are commonly manufactured as MFR (Monascus Fermented Rice), for example, enhance the organoleptic characteristics of foods. Monocolins are found in these pigments, which lower LDL cholesterol while raising HDL cholesterol.

Pharmaceutical industry

In their products, the pharmaceutical industry uses a lot of microbial pigments. Many pigmented secondary metabolites of the microorganism have considerable therapeutic promise, and several studies are underway to treat diseases such as cancer, leukemia, and diabetes mellitus.Antibiotics, anticancer, antiploriferative, and immunosuppressive compounds may all be found in these pigments. Anthocyanins are flavonoid pigments that are water soluble. They are convoluted in various biological activities, together with antioxidant activity, cancer risk reduction, and the reduction and modulation of immune response insult. Prodigiosin is a possible

Table 3. Production of Pigments through Fermentation Process (Panesar *et al.,* 2015)

Microbial Source	Media	Type of Pigment
	Submerged Fermentation	
Rhodotorula rubra	Channel based on coconut liquid with whey	Pigment in yellow color
Sporidobolus salmoncolor	Medium based on Yeast-malt	Carotenoids
Rhodosporium paludigenum	Urea KH_2PO_4, $MgSO_4.7H_2O$	Carotenoids
Monascus purpureus	Medium based on Modified Yeast malt broth	Pigment in Red as well as yellow color
Penicillium purpurogneum	Medium based on Czapek DOX	Pigment in red color
Streptomyces sp.	Medium based on Basal	Prodiginines
Serratia marcescens	Medium based on Peptone glycerol broth	Pigment in red color
Pseudomonas aeruginosa	Medium based on Cotton seed meal	Pyocyanin
	Fermentation Based on Solid State Process	
Monascus ruber	1. Medium grounded on broken rice 3. Medium based on seed powder of jack fruit	2. Medium based on the long grain sized rice 1. Red as well as yellow pigment 2. Red pigment 3. Red pigment
Monascus purpureus	1. Medium based on the residue of coconut, meal based on soya, peanut and corn 2. Medium based on the power on corn cob 3. Unpolished rice	1. Red pigment 2. Red and yellow pigment 3. Red pigment

pigment with a variety of pharmacological properties. It shows that *Vibrio psychroerythrus*, *S. marcescens* as well as *Pseudomonas magnesiorubra*, and remaining eubacteria contain a wide range of cytotoxic activity.

Textile industry

During the Indus civilization, dyes were used to stain garments and cloths. Pigments, mainly synthetic ones, are used in large quantities in the textile industry. Artificial dyes stand readily accessible at a low cost as well as fruitage a wide spectrum of shades, but they cause skin allergies and other harm to the body, produce toxicity during the synthesis process, and release unwanted/hazardous/toxic chemicals, among other things. Because of the harmful effects of synthetic pigments, there is a growing consumer demand for natural or microbial pigments (known as natural dying). Natural pigments are non-carcinogenic and environmentally safe in the textile industry. The required and systematic dyeing techniques for that specific fiber usual dye scheme must be followed for effective commercial utilization of natural dyes for that specific fiber. As a result, effective scientific dyeing techniques/procedures must be established in order to achieve newer shades with suitable color fastness behavior and replicable color yield.

Advantages of Microbial Pigments

Microorganism-produced pigments have long been utilized in oriental countries and the focused on concentrated research in recent years because of their potential for wide spectrum of applications. Microbial pigments provide various benefits that are discussed as follows:

- Attractive topic to science due to wide spectrum of activities
- Easy broadcast and extensive strain assortment
- High adaptable as well asfruitful over additional resources
- Fermentation process fundamentallyquicker as well as additional industrious associated to remaining chemical reaction based process
- Genes can be easily manipulate
- Simple as well asquick culturing techniques
- In order to fulfill the industrial needs, the structural complexity is well suited
- Inexpensive substrates utilized for the bulk manufacturing

Discussion

Pigments are compounds with properties that are essential to a wide range of industries. They're utilized as additives, antioxidants as well as color intensifiers, among other things in foodstuff industry. Pigments are available in an extensive spectrum of shades, with some of them being solubility in water. In recent years, the manufacture of colorants from natural elements for food and textiles has piqued interest. Many biocolorants are produced by nature from a variety of sources, including plants and microorganisms, and could be used as replacements to synthetic dyes as well as pigments are currently in use. Recently emphasis on human safety as well as environmental protection has reignited interest in natural color sources. Agro-industrial waste produced on a large scale by industries. Agro-industrial waste is naturally rich in nutrients and promotes microbial growth. Food researchers are looking for ways to use this waste for microbial pigment processing and more biotechnological exploitation in functional foods or value-added goods to reduce the environmental impact. Microbes are important sources of a variety of bioactive molecules, including the processing of microbial pigments by fermentation and/or the utilization of agro-industrial leftover.

Conclusion

In answer to the requirement of environmental protection, sustainable agricultural production, as well as worldwide food security, the global understanding of agro-industrial waste is rapidly evolving. As a result, rather than disposing of waste, it should be recycled as well as reused by suitable technologies for assessment and accumulation. Acceptability, regulatory endorsement, as well as the capital speculation needed to bring a microbial pigment to market all play a role in its success. As a result, using agro-industrial residues to produce microbial pigments can not only minimize the process costs but aid in environmental controlling. Microbial pigments are utilized in a different applications, such food coloring, flavoring, and dying. They are also used in medicine. They've also been used in clinical treatment to reduce blood cholesterol levels, antidiabetic activity, and anti-inflammation, among other things. According to the above review, it has been recommended that agro-industrial waste should be process through the proper disposal protocol so that useful bio-products can be produced.Proper disposal policies will help to solve the problem of disposal of wastes. Microbial pigments production through the agro-industrial waste should be encouraged so that synthetic pigments consumption can be reduced that will be helpful in environment protection.

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Conflict of interest

Authors are requested to disclose interests that are directly or indirectly related to the work submitted for publication.

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