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Microbes and Pigments

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Abstract
Colors provide attractive appearance to the marketable products such as food, textiles and pharmaceutical products. There are many artificial synthetic colors which have been used widely in several industries like food, cosmetics, textiles and pharmaceuticals. Although these synthetic colors are reliable and economical as compared to natural colors which are expensive, less stable and possess lower intensity, many of such synthetic colors have also been banned due to their hyper-allergencity, carcinogenicity and other toxicological problems. These issues associated with then adverse effects of synthetic colors have triggered intense research on natural colors and dyes. Microorganism are known as a potential source for bio pigment production due to their advantages as well as their applications in various fields.

Keywords: Microorganisms, pigments, extraction, sources.

Introduction
Color is one of the significant visual properties and is an important attribute of any article. The color determines the acceptance of a product and has paramount influence on human life. Also, colors provide attractive appearance to the marketable products such as food, textiles and pharmaceutical products. There are many artificial synthetic colors which have been used widely in several industries like food, cosmetics, textiles and pharmaceuticals. Moreover, the effluent of synthetic dyes poses series threat to the environment conservation. Consequently, many synthetic colors have been banned due to their toxicological problems. Although these synthetic colors are reliable and economical as compared to natural colors which are expensive, less stable and possess lower intensity, many of such synthetic colors have also been banned due to their hyper-allergencity, carcinogenicity and other toxicological problems. These adverse effects of synthetic colors have triggered intense research on natural colors and dyes (Reyes *et al*. 1996) [10]. With the increasing awareness about the toxic effects of synthetic colors and consumer safety, there is an increasing interest in the development of colors from natural sources (Babu and Shenolikar, 1995) [2]. Recent research efforts have been made to replace synthetic pigments with natural pigments from plant, animals and microorganisms.

Sources of biocolors
Natural colors are generally extracted from fruits, vegetables, roots and microorganisms which are often called as bio-colors due to their biological origin. The utilization of natural pigments in foodstuff, dyestuff, cosmetics and pharmaceutical manufacturing processes has increased in the recent years due to their non toxic nature (Unagal *et al*. 2005) [12]. Moreover, their eco-friendly, antioxidant, anticancer and antimicrobial activities further add to their positive effects. The significant growth in the naturally derived colors has been attributed to their stability and consumer perception. Further the annual growth rate of naturally derived colors has been predicted to be 5-10 per cent in comparison to synthetic colors with a low growth rate of 3-5 per cent (Parmar and Phutela, 2015) [9].
Although there are a number of natural pigments, only a few are available in sufficient quantities to be useful for industry because they are usually extracted from plants. In spite of the availability of variety of pigments from fruits and vegetables, there is an ever growing interest in microbial pigments due to several reasons like their natural character and safety to use, production being independent of seasons and geographical conditions, controllable and predictable yield (Kim *et al*. 1998; Gunasekaran and Poornima, 2008) [8, 4]. The rapid growth of microbes reduces the production time to a matter of days compared to plant and animal sources, the production is flexible and can easily be controlled (Joshi *et al*. 2003) [7].

Biocolors from microbes
The presence of bio pigments has been reported in almost all the microorganisms including bacteria, fungi, yeasts and algae. These micro organisms can produce variety of bio pigments

such as carotenoids, melanins, flavones, quinines, prodigiosin, and monascins (Jiang *et al*. 2005; Dofosse, 2006) [6, 3]. Many yeasts like *Rhodotorula* (pink), *Yarrowia lipolytica* (brown), *Cryptococcus* (red) and *Phaffia rhodozyma* (carotenoids) are good source of microbial pigments. The pigment production by molds of *Monascu*s group especially *Monascus purpureus* and *Monascus anka* for use as a good color is well known (Sharma, 2014) [11]. The algae which produce pigments are *Chlorococcum*, *Chlamydomonas*, *Chlorella*, *Hematococcusi* and *Sporangium*. Another algae namely, *Dunaliella salina* belonging to class chlorophylaceae occur in marine environment and produces β-carotene which can be used as food colorant (Joshi *et al*. 2003) [7]. The pigment produced by algae and fungi may be less accessible for exploitation because of the structural complexity of the pigment bearing tissues and the pigment production at critical points of development within a complex lifecycle.

Advantages of pigment production from microbes

Bacteria are good source of pigments. Bacterial pigment production is one of the emerging fields of research to demonstrate its potential for various industrial applications (Venil and Lakshmanaperumalsamy, 2009) [13]. The advantages of pigment production from bacteria include:

- easy and fast growth in cheap culture medium and faster fermentation for bulk production
- independence from weather conditions
- Avaliability of cultivation technology
- More stable and soluble
- Colours of different shades throught the year
- Easy extraction
- Ecofriendly

Some pigment producing bacteria are *Staphylococcus aureus* for golden yellow, *Serratia marcescens* for red, *Micrococcus lutes* for yellow, *Micrococcus roseus* for pink, *Staphylococcus roseus for* red and *Pseudomonas cynzatha* for yellow pigment (Ahmad *et al.* 2012) [1].

The biocolors are used in food, textile and pharmaceutical industries. The use of non allergic, non toxic and eco-friendly natural dyes in textiles has become a matter of significant importance due to increased environmental awareness. Waste water from printing and dyeing units is often rich in color, containing residue of reactive dyes and chemicals. The toxic effects of dyestuff and other organic compounds, as well as acid and alkaline contaminants in these effluents have reached a stage where they are not treated effectively before their disposal in to environment. Hence, due to harmful effect of chemical dye on environmental pollution a number of countries have issued strict regulations so as to preserve our environment. As a consequence there is a revived interest in the use of natural pigments and dyes, which could be subjected to biodegradation in the environment.

Natural dyes produce very uncommon, soothing and soft shades as compared to synthetic dyes. Although, synthetic colors are widely available at economical price in wider range of colors but these dyes produce skin allergies, less stable and also produce highly toxic wastes that pose a threat to the environment. The color stability under extreme temperature, variable pH, detergents and processing conditions is the pre requisite for industrial application. Therefore, microbial diversity has been a great source for exploration for application of bio pigments.

Table 1: Pigment Producing Microorganisms

Organism	Pigment	Color
Serratia marcescens	Prodigiosin	Red
Corynebacterium insidiosum	Indigoidine	Blue
Monascus roseus	Canthaxanthin	Orange, pink
Staphylococcus aureus	Zeaxanthin	Yellow
Pseudomonas aeruginosa	Pyocyanin blue	Green
Dunaliella salina	β carotene	Orange
Hematococcus pluvialis	Astaxanthin	Red
Bradyrhizobium sp.	Canthaxanthin	Orange / dark red
Alteromonas rubra	Prodigiosin	Red
Flavobacterium sp.	Zeaxanthin	Yellow
Asbhya gossypi	Riboflavin	Yellow
Blakeslea trispora	Lycopene	Rred
Rhodotorula sp.	Torularhodin	Orange-red
Penicillium oxalicum	Anthraquinone	Red
Streptoverticillium rubrireticuli	Prodigiosin	Red
Streptomyces echinoruber	Rubrolone	Red
Janthinobacterium lividum	Violacein	Purple
Haloferax alexandrinus	Canthaxanthin	Dark Red

(Gupta *et al*. 2011) [5]

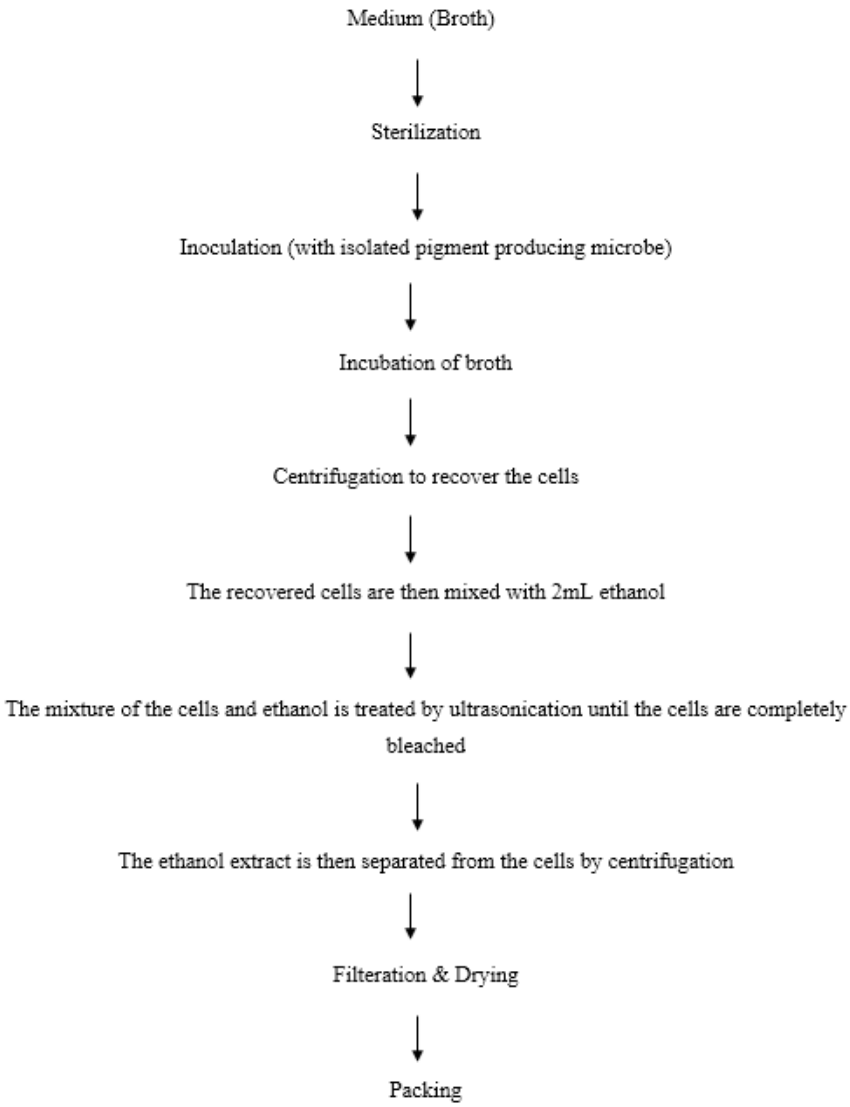

Fig 1: Flow sheet for pigment extraction from microbial cells

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