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**Review Article**

# ECO-FRIENDLY UTILIZATION OF BANANA PLANT EXTRACT FOR DYEING OF TEXTILE MATERIALS AND RELATED PURPOSES: A REVIEW

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**ABSTRACT**

With the consumer's increased awareness of eco-safety, there has been an increasing tendency towards the use of eco-friendly sustainable materials. Consequently considerable attention has been given to green products from plants, for various utilizations in industries notably in the textile industry. Among these plants banana is selected for this review, since it is the second largest produced fruit after citrus, contributing about 16% of the world's total fruit production. This review provides literature information about classification of techniques of natural dyes, dyeing principles and mechanisms, and some important evaluation tests methods. The study also aims to overview the recent researches on banana utilization, application, characterization, and testing of banana extract applied into textiles for coloration purposes, discoloration, and other important applications around the world for producing more appealing and highly functional value-added textiles such as dyes, binders, pigments, and other biologically active compounds.

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## INTRODUCTION

Dyeing was known as early as in the Indus Valley period (2600-1900 BC); this knowledge has been substantiated by findings of colored garments of cloth and traces of madder dye in the ruins of the Indus Valley Civilization at Mohenjodaro and Harappa. Natural dyes, dyestuff and dyeing are as old as textiles themselves. Man has always been interested in colors; the art of dyeing has a long past and many of the dyes go back into prehistory. It was practiced during the Bronze Age in Europe. The earliest written record of the use of natural dyes was found in China dated 2600 BC. Mansour,(2013).

The modern lifestyle creates today the situation in which the actual aim of textile materials is changing from traditional simple protection to the necessary functionality and added-value (Paul, 2015). The consumers' demands has increased and diversified concerning certain functional properties and high performance, in addition to usual properties such as comfort, handle, easy care, aesthetic appeal, etc (Mariana, *et al*., 2010). The textile industry is constantly striving for innovative production techniques to improve products, quality, and it is also important that these products are developed in an environmentally friendly way (Paul, 2015). In this new millenniums, maintenance of a safe environmental balance will become a necessary requirement. According to Khaleque A(2016), there are 10,000 types of commercially available textile synthetic dyes. Most of the dyes are not only based on toxic raw materials and intermediates, 10-25% of textile dyes are lost during the dyeing process, their use in textile wet processing also produce effluent estimated, 2-20% according to K. Kalaiarasi,(2012),and to the World Bank (20%) of the global industrial water pollution ,which causes environmental pollution. Natural dyes are free from such problems. It has been estimated that, and 2-20% of such dyes are directly released as aqueous effluents in various environmental constituents,(B. H. Patel, 2011).

Historically, plants have been used for the extraction of natural products. Various plants are cited as sources of natural dyes such as Teak, Mahogany, Ketapang, Tamarind, Mangosteen, Mango, Suji, Pandan, Indigofera, Guava, Banana and Onion, (Nurizza,2015), (Ado, A.,2015) .Various plant parts including roots, leaves, twigs, stems, heartwood, bark, wood shavings, flowers, fruits, rinds, hulls, husks, and the like serve as natural dye sources. (Sujata and Raja, 2014).

Up to the end of the 19th century natural dyes were the main colorants for textiles. The introduction of synthetic dyes led to an almost complete replacement of natural dyes, due to favorable application properties of synthetic dyes. Besides a wide range of available colors, higher reproducibility and improved quality of dyeing could be achieved at lower specific cost, (Jihad, 2014). Since 1956, synthetic colorants became

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more important, consequently, natural colorants were increasingly replaced by synthetic ones. Almost all the synthetic colorants which are being synthesized from petrochemical sources through hazardous chemical processes, pose threats towards the environmental and human body health, (Tushar K. *et al*.2014), (Kasir and Safapour, 2015), (Renu Singh and Sangita Srivastava, 2017). The application of such dyes causes serious health hazards and influences negatively the eco-balance nature. In this situation, a higher demand is put towards the greener alternatives of agricultural residues. As a result, natural dyes are among the promising options for developing a greener textile dyeing process, and such interest is reflected to the increased number of recent publications (Gias, 2015). Recently, interest in the use of natural dyes has been growing rapidly due to the result of stringent environmental standards imposed by many countries in response to toxic and allergic reactions associated with synthetic dyes. With the world becoming more conscious towards ecology and environment, there is a greater need today to revive the tradition of natural dyes and dyeing techniques as an alternative of hazardous synthetic dyes is extremely crude. Now-a-days natural dyes are commonly used for textile industries, due to their harmless effects and harmful consequences of synthetic dyes, (Jihad 2014), (Iqbal and Ansari, 2014). In recent years, there has been increasing interest and demand for natural dyes all over the world on account of increasing public awareness of ecological and environmental problems related to the production and usage of synthetic dyes. The specialists around the world are attempting to build up a cleaner innovation and ecologically supporting methods of cotton coloring for conforming to continuously requesting ecological regulation and to save water, energy and time, (Kumar *et al* (2012). Sustainable textile coloration is possible either by using green ingredients or zero discharge of wastewater, Ali *et al*, (2007).

Natural dyes are eco-friendly, safe, cheap, need no special care, uncommon and soothing shades, wonderful and rich in tones, act as health cure, have no disposal problems, non-carcinogenic, non-allergic, non-toxic, easily biodegradable, require simple dye house to apply on matrix and mild reactions conditions are involved in their extraction and application, (Sasmita *et al*, 2013), (Salah, 2013). Natural dyes have been receiving more and more attention for applications in textile dyeing because of their renewability and biodegradability. Presently, it has been reported that a variety of natural dyes extracted from henna leaves, acalypha wilkesiana leaves, rhubarb, helichrysum bracteatum, etc., have been successfully applied for textile dyeing**, (**Ghouila, *et al*, 2012), (Sinha, *et al*, 2012), (Ado, A. 2014). Some plants are found to give dyeing effect and antimicrobial activity, (Teli MD, *et al* 2014). Recently, a number of commercial dyers and small textile export houses have started looking at the possibilities of using natural dyes for regular basis dyeing and printing of textiles to overcome environmental pollution caused by the synthetic dyes, (Tassew and Zenebesh 2014).

***Classification Systems for Natural Dyes***

The origins of dyeing are uncertain, but it is believed that coloured fabrics found in the ancient tombs of Egypt were in existence before 2500 BC. It is likely that the ancient art of dyeing originally spread westwards from India, and it may well have been accidental staining from berries and fruit juices that initially stimulated its development (K. Hunger 2003). Dyes may be classified according to chemical structure or by their usage or application methods. The former approach is adopted by practicing dye chemists, who use terms such as azo dyes, anthraquinone dyes, and phthalocyanine dyes. The latter approach is used predominantly by the dye user, the dye technologist, who speaks of reactive dyes for cotton and disperses dyes for polyester. Dyes may also be divided according to their nature into two categories, namely: synthetic and natural dyes. The first synthetic dye, Mauveine, was discovered by Perkin in 1856, (Hunger, 2003).

Natural dyes can be classified into different groups based on their application, chemical composition and color (hue). They can be classified into three major types based on their application: 1- Substantive dyes. 2- Vat dyes. 3- Mordant dyes. Natural colors cover a wide range of chemical classes, they are: Indigoid, Carotenoids, and Flavonoids, Anthocyanidins, Di-hydropyrans, αnaphthoquinones, Anthraquinones. Natural colors cover a wide range of hues, from blue to, orange, yellow, green, red, purple and black. Natural dyes may be divided into three groups according to the source of dye namely: plant, animal, and mineral dyes. (Jihad, 2014).

Natural dyes come from plant parts (roots, stems, leaves, flowers, fruit, seeds and lichens), other sources of natural dyes are the outer, inner bark and heart wood of trees. The existence over 1000 sources of plants based dyes that were used across the word until the early 1900s included in these vast arrays of dyes yielding plants are the following. Henna (orange-red) - from leave of henna plants, Carechu (brown)- from resin, (sticky substance from plant of acacia tree, Fustic (yellow)- from the wood of the fustic tree, Indigo (blue)-from leaves and stems of the indigo plant, Logwood (black)- from the core (heart) of the log wood tree, Turmeric (violet) -from the roots the turmeric plant and Saffron (yellow) - from stigmas of the common crocus are the common ones, (Tassew and Zenebesh, 2014).

***Animal sources:*** the major source of animal dyes comes from the secretion of insects and dried insect bodies. For example shell-fish provides the coloring matter.

***Mineral source:*** As minerals are used for fixing or improving the fastness of vegetable dye, the name natural dye is more appropriate which covers all the dyes derived from natural resources including vegetable dyes as well as minerals. And some minerals are also used to give a coloring matter. For example seru, cow urine, cow dung, and egg albumin.

***Banana utilization and composition***

Banana and banana parts serve as a unique ideal and low cost food source in developing countries. Most of the populations depend upon taking cheaper rate nutrition fruits, Barhanpurkar, (2015). Banana is the second largest produced fruit after citrus, contributing about 16% of the world's total fruit production, (FAO, 2009). Banana production is estimated around 72.5 million metric tonnes,V. Ramesh,(2017).

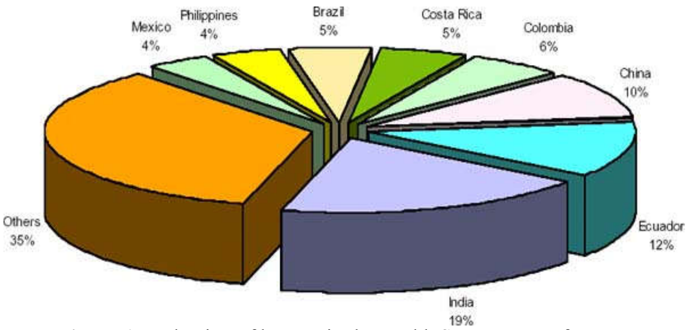


**Figure 1** production of banana in the world, Source: www.fao.org

Musaceae is a family of flowering plants composed of three genera with ca 91 known species, placed in the order Zingiberales. The family is native to the tropics of Africa and Asia. The plants have a large herbaceous growth habit with leaves with overlapping basal sheaths that form a pseudostem making some members appear to be woody trees. In most treatments, the family has three genera, Musella, Musa and Ensete. Cultivated bananas are commercially important members of the family, and many others are grown as ornamental plants. (Byng, 2016).The chemical composition of banana fibre is cellulose (50-60%), hemicelluloses (25-30 ,(% pectin (3-5%), lignin (12-18%), water soluble materials (2-3%), fat and wax (3-5 %) and ash (1-1.5%), Mukhopadhay, *et al*, ( 2008). Banana sap consists of different chemical constituents like carbohydrates, cellulose, lignin, ash, coloring matter and portentous material. Presently, the banana pseudostem is hazardous waste, it has been used in several countries to develop important bio-products such as fibre to make yarn, fabric, apparel as well as fertilizers, fish feed, bio-chemicals, paper, handicrafts, pickles, candy,(Mohiuddin, 2014). Banana extract may be used for dyeing and printing of textiles. The banana peel has been used as bio-adsorbent of soluble contaminants, such as dyes, metals, and phenolic compounds. In addition, its use in the production of pectin and ethanol, as well as for production of biomass and metabolites of biotechnological interest, has also been reported (Younsook Shint,*et al*.,2013). Banana leaf and pseudo stem sap mixed another natural dye had used for cotton coloration, (Reazuddinm, 2016), (Paul V, 2013), (Shuaibing, 2013).

### *Methods of Extraction of Dyes*

### *Extraction technology*

A typical extraction process may contain the following steps:

1. Collection and authentication of plant material and shed drying
2. Size reduction (into small pieces or powder)
3. Extraction by distilled water and/or solvents (Methanol, Ethanol, ethyl acetate,… etc.), using conventional methods (Hydro distillation and Soxhlet apparatus are still considered as reference methods to compare success of newly developed methodology) and/or non-conventional methods (ultrasound, pulsed electric field, enzyme digestion, microwave heating), which are more environmental friendly due to decreased use of synthetic and organic chemicals, reduced operational time, and better yield and quality of extract). For liquids extractions squeezing rollers will be used .The techniques of extraction are shown in figure-2

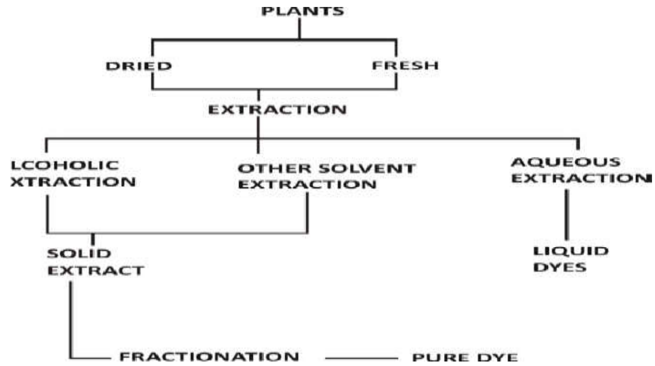


**Figure 2** Different Types of Extraction Techniques

The extraction efficiency of colorants component present in natural plant, animal, mineral, sources depends on the media type like aqueous, organic solvent, acid, alkali, PH of the media and condition of extraction, such as temperature, time, and material to liquor ratio particle size of the substrate **(**J. Lee,2013), (S. S. Handa, *et al*, 2008).

### *Characterization of natural dyes*

Spectroscopic (UV-Vis and FT-IR) and chromatographic (PY-GC/MS) techniques were employed in order to characterize some of the chemical properties of natural dyes. Analytical pyrolysis coupled to gas chromatography/mass spectrometry (PY-GC/MS), is a chromatographic variant used to analyze organic matter in short time and minimum sample preparation (Y. Espinosa *et al*, 2012).

Ultraviolet/Visible absorption (UV/VIS) and Fourier Transformed–Infrared (FT-IR) spectroscopies can be used as qualitative tool to identify and characterize molecular species or some of their properties like molecular structures and characteristic absorption spectra that at least constitute their characteristic fingerprints, (Y. Espinosa *et al*,2012), (J. Reyes, 2004), **(**F. Shadkami, *et al*, 2007). FTIR (Fourier transform, infrared spectroscopy, NMR, (nuclear magnetic resonance), AAS (atomic absorption spectrometric), TGA (thermo gravimetric analysis) and elemental analysis of natural dyes /colorants to study the chemical functional nature, presence of different elements to understand the chemistry of natural dyes components (Z. Lauresen, 2005), **(**Tassew A., Zenebesh T.,2014).

Fourier transform infrared spectra offer the possibilities to measure different types of inter atomic bond vibrations at different frequencies. Especially in organic chemistry the analysis of IR absorption spectra shows what types of bonds are present in the sample. It is also an important method for analyzing polymers and constituents like fillers, pigments and plasticizers. The FT-IR microscope combines microscopy with IR spectroscopy to provide a versatile instrument for molecular microanalysis. The technique has really taken off in the last decade and has embraced a wide range of applications. Nowadays, developments in PC and software products allow for instruments with remote control (including focusing) of microscopes, (Y. Espinosa 2012), (L. Morselli, 1997).

Ultraviolet - visible spectra. A total of 1.0 g natural dyes is dissolved in 99.0 g water, and the pH of the solutions is adjusted to 2.5, 3.5, 5.5, 7.0, 9.0, 10.0 and 11.0 by acetic acid, sodium carbonate and sodium hydroxide solutions. Their absorbencies in range of 400–800nm will be measured by a UV-2100 spectrophotometer (Beckman, USA).

High-performance liquid chromatography (mass spectrometry analysis).

Chromatography is very important in chemistry. It is used to analyze unknown compound. Thin layer chromatography (TLC) is applicable to identify different color components in natural dyes to be applied on textiles. Dyes detected were insect dyes, and vegetable dyes. Non-destructive –identifying faded dyes on fabrics through examination of their emission and absorption spectra and analyzed quantitatively the red dyes, such as alizarin, purpurin carminic acid, etc.. (Chunxia, 2016).

The HPTLC analyses of the banana peel extracts characterize the pigment compound Luteolin, which exists in the banana peel crude alkaline extract. The structure of this compound is shown in Figure 3. Mansour, (2012)

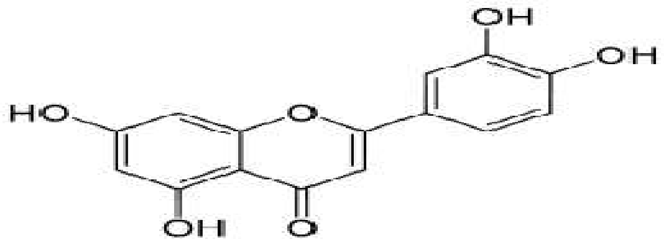


**Figure 3** Structure of the banana peel crude alkaline extracted compound

***Natural Dyeing Principles***

Application of natural dyes in today's scenario makes use of modern science and technology not only to revive the traditional technique but also to improve its rate of production, cost effectiveness and consistency in shades. It therefore, requires some special measures to ensure even-ness in dyeing. Many factors have to be accounted for when one works with natural dyes. They are: nature of Material to be dyed, measurements of mordants and dyestuffs, temperature, agitation, natural dyes are unpredictable, wet fibers look darker and rinsing, (Redwan Jihad, 2014).

***Mechanism of dyeing***

Natural dyes work best with natural fibers such as cotton, linen, wool, silk, jute, and sisal. Amongst this wool is by far the easiest to take up dyes followed by cotton, linen, silk and then the coarse fibers such as sisal and jute. Nearly every plant will yield some of color whether we use leaves, bark, wood, roots or fruits. Nearly all require or are enhanced by, some sort of mordant. The trick then is to determine which plants or which part of the plants will give not only beautiful tones but also colorfast shades as well. A coloring material that has the strength to bind itself to a fiber and remain there by staining the fiber is considered to be the best. The fabric to be dyed is first soaked into mordant solution of the metallic salt and then steamed or otherwise treated to form the insoluble metallic hydroxide. The mordanted fiber is dried then placed in a solution of the dye when the latter is held by the hydroxide of the metal on the fiber by chelated complexes which are formed only when the resulting dye has a five- or six- membered ring, which is again possible only when OH group in the dyestuff is present, ortho to one of the following groups: -OH, -CO, -NO, -NO2, -COOH, -NH, -NH2 and -N=N-.The chemistry of bonding of dyes to fibers involves direct bonding, H-bonds and hydrophobic interactions. Mordants to this effect increase binding of dye to fabric by forming a chemical bridge from dye to fiber, (Redwan Jihad, 2014).

***Determination of color strength and color fastness***
***Color strength (K/S)***

Tinctorial value or color strength (K/S) is considered as the most important parameter to test the quality measurement of a sample in terms of the depth of the color dyed fabric. The color strength of a dyed fabric is usually pronounced by its K/S value. Color strength of a pigment, is defined as its ability to impart color to other materials. It depends on the absorption coefficient (K) of colorant and the scattering coefficient (S). Consequently, the strength of any colorant (dyestuff / pigment) is related to absorption property. Reflectance (%) of the dyed fabric samples can be measured by using Data color 650 TM spectrophotometer. Kubelka – Munk theory provides the following relation between reflectance and absorbance: $K/S = [\{(1-R)^2 / 2R\}]$.

(AATCC Evaluation Procedure 6-2008; Instrumental Color Measurement).This evaluation procedure is a reference document to support the proper measurement of the color of specimens by instrumental means as required in many of the current AATCC test methods.

***Color Difference by CMC DE***

The CMC system was actually developed by R McDonald. Later, it was recommended by the Colour Matching Committee of the SDC with only minor modifications. In this color space, L* indicates lightness, C* represents chroma, and h is the hue angle. The value of chroma C* is the distance from the lightness axis (L*) and it starts at 0 in the center. Hue angle starts at the +a* axis and is expressed in degrees (e.g., 0° is +a*, or red, and 90° is +b, or yellow).L*=lightness, C*=chroma, h = hue, (Avik Kumar, 2017).

***Color fastness testing***

Color fastness is a term used in the dyeing of textile materials that are characterized by color resistance to fading or running. Different color fastness tests will be carried out such as fastness to wash, fastness to rubbing (dry and wet), and then fastness to perspiration (acid) through ISO methods. Wash fastness test will also be carried out through ISO-105-C03 method treating 10 cm × 4 cm sized composite sample , with soap solution in a washing machine. Furthermore, the fastness rating by using color fading grey scale and color staining grey scale in color matching cabinet will also be evaluated. In addition, rubbing fastness will be carried out by ISO-105-X12 method taking a sample size of 14 cm × 5 cm. Hand crank is turned 10 times at the rate of 1 turn/sec and fastness rating will then be evaluated by color staining grey scale. In addition, ISO-105-E04 method may be followed for testing color fastness to perspiration **(**Avik Kumar,2017)**, (**J. Lee, 2013), (Kanchana, 2013), .

## DISCUSSION

Md. Reazuddin *et al*, 2016, have studied the optimization of dyeing temperature of Cotton for sustainable coloration using banana (Musa Sapientum) waste. Natural dye retrieved from banana floral stem by roller squeezer machine. Dyeing was carried out according to exhaust method by Infra-red lab sample dyeing machine for 60 minutes at varying temperatures of 60, 70, 80, 90, 100 and 110 $^{0}$C respectively at 60 minutes. Effect of temperature variation on colorimetric appearance was expressed using CIE L*a*b* color space in terms of color co-ordinates, color strength (K/S), brightness index (BI) and degree of color levelness values. The color strength (K/S) value of the dyed samples was measured by data color spectrophotometer based on Kubelka Munk theory $K/S=(1-R)^2/2R$, Mcdonald, R (1997). Where, R is reflectance of an incident light from the dyed material, K & S is absorption and scattering coefficient of the dyed fabric respectively, as shown in Fig. 4

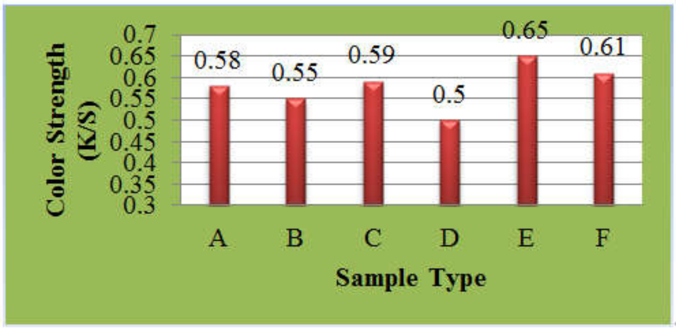


**Figure 4** Color strength (K/S) values, (Md. Reazuddin *et al*, 2016)

The color fastness to wash, water, perspiration, rubbing and light was assessed. Except light fastness property almost color fastness value was 3-5 i.e. good to excellent. Best result of K/S, bright index % and color levelness value recorded 0.65, 50.58 and 0.069 respectively for 100$^{0}$C. From all colorimetric and color fastness properties the optimal dyeing temperature is 100 $^{0}$C for cotton coloration with banana floral stem sap.

*Kumar*, *et al* (2017), have studied and evaluated the eco-friendly pretreatment of cotton fabric (woven plain) pretreated with banana ash and dyed using banana sap. Also, dyeing was carried out with banana sap along with different mordants that are eco-friendly and cost saving. Firstly, the cotton fabric was scoured using manually extracted banana root's ash at (pH-10.2). It was then dyed with banana sap (pH-5.4) without and with mordants, where potash alum and horitoky were used. Four different samples were used: Sample A was conventionally scoured and dyed with banana sap without mordant. Sample B, banana ash scoured and dyed with banana sap without mordant. Sample C, banana ash scoured and dyed with banana sap using mordant (alum). Finally, sample D, banana ash scoured and dyed with banana sap using mordant (horitoky) . Meta-mordanting (metachrome) was carried out where the mordant was added in the dye bath itself. In addition, fastness properties and performance of dyeing were measured through CIE L*C*h, K/S values, and different color fastness tests. It was observed that fabric scoured with banana ash have shown better absorbency than the chemically scoured fabric. Results of K/S value of different dyed samples are shown in fig.5

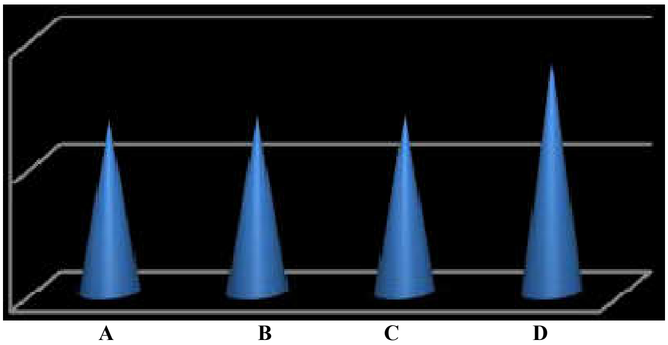


**Figure 5** K/S Values of different samples**,** *Source: Kumar*, *et al* (2017)

It was found that fabric scoured with banana ash, and dyed with banana sap, using mordant (horitoky), provided the best dyeing performance and color fastness to wash, rubbing, and perspiration than the others as shown in table 1.

**Table 1** Results of color fastness to washing, rubbing, and perspiration of samples

| Sample | Washing fastness | | Rubbing fastness | | Fastness to perspiration | |
|---|---|---|---|---|---|---|
| | Fading | Staining | Dry | Wet | Fading | Staining |
| A | 4 | 4 | 4 | 3 | 4-5 | 4-5 |
| B | 4 | 4-5 | 4-5 | 4 | 5 | 4-5 |
| C | 4-5 | 4-5 | 4-5 | 4 | 5 | 4-5 |
| D | 5 | 4-5 | 4-5 | 4 | 5 | 5 |

***Source:*** *Kumar*, *et al* (2017)

Md. Reazuddin, *et al* (2016), investigated the optimum dyeing time for exploiting banana agricultural bio-resource waste for sustainable dyeing of 100% knitted single jersey, commercially scoured-bleached cotton fabric. Natural dye was retrieved from banana floral stem by roller squeezer machine. Selected samples were dyed at 100°C for 20, 30, 40, 50, 60 and 70 minutes respectively. Effect of time variation were calculated using CIE L*a*b* color space in terms of colorimetric properties of colored fabric viz. color co-ordinates, color strength (K/S), brightness index (BI), degree of color levelness. Figure- 6 illustrates the effect of time variation on the dye fixation of dyed materials (where A,B,C,D,E,F are samples dyed at 100°C for 20, 30, 40, 50, 60 and 70 minutes respectively). The color strength values were found E>F>D>B>C>A orderly. The maximum color strength 0.65 is yield for E. The K/S value of A, B, C, D and F samples were 29.23%, 24.62%, 27.69%, 20% and 16.92% lower than E.

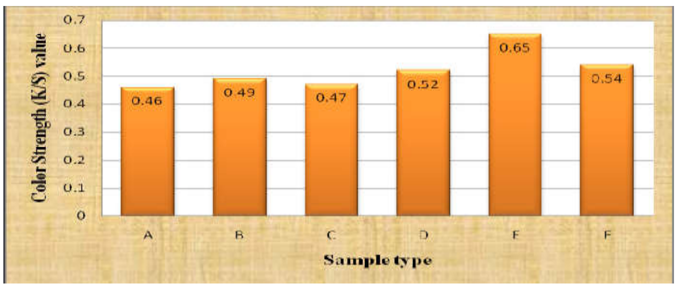


**Figure 6** Color Strength (K/S) values. Source: Md. Reazuddin, *et al* (2016)

Color fastness to wash, water, perspiration, rubbing and light were valued for estimating the color durability. Except light fastness property all the tested color fastness properties were found in the range of 3-5 (good to excellent). For all evaluated parameters samples dyed for 60 minutes exhibited the best result. This reports forecasts a sustainable technology for effective utilization of banana floral stem sap bio-resource waste for coloration of cotton fabric.

B. M. Dzomeku and O. K. Boateng, 2013, have carried out a study to explore the potential of banana sap as a dye for the Adinkra industry in Ghana. Pseudostem extract of banana and stem bark extract of Bridelia micratha were extracted by boiling in water as done by the local people and compared as dyeing stuff, using batch dyeing method. A consumer preference study was also conducted to assess the acceptability of the products developed. The results revealed that a combination of banana sap and B. micratha dye ensure a high levelness on dyed fabrics. It could serve as a good mordant. Laboratory trial has been conducted to test sap as mordant with natural dyes which indicated good fastness properties of these dyes when used with sap. The process for using sap as mordant has been standardized by Patil and Kolambe (2011).

The results on consumer acceptability showed that the mixed product from 50% v/v of banana sap and 50% of B. micratha recorded a good acceptance by manufacturers. A deep brown colour was obtained which was also preferred by many people as a peculiar product used by royals. The results showed that dyes with no or little of B. micratha dye inclusion showed no sign of solidification. It could be concluded that equal volumes of banana sap and B. micratha dye could be used for the Adinkra industry as an alternative for the sole B. micratha dye that requires a mordant. This would reduce the cost of buying and using synthetic dyes. Further study may be conducted to explore the potential of other banana and plantain saps as dyeing agents for the Adinkra industry in Ghana.

Salah. M, *et al*, (2013), studied the eco-friendly dyeing of cotton fabric with natural colorants extracted from banana leaves. Pigments extracted from banana leaves were used as natural waste source to dye some Egyptian cotton fabrics. Both alkaline and acetone extracted solutions were analyzed using a high performance thin layer chromatography (HPTLC) analysis technique. The solutions were applied to the premordanted bleached and mercerized cotton fabrics made from Giza 86 and Giza 90 cotton varieties. Ferrous sulphate, copper sulphate and potassium dichromate were used as mordants. The factors affecting the fixation of the extracted dye with cellulose was studied. The treated and untreated fabrics samples were tested for their mechanical properties expressed as tensile strength and elongation%. Dyeing performance in terms of color parameters (K/S, L*, a*, b* and ΔE) as shown in table 2, and fastness properties (wash, perspiration, and light fastness) were studied. The samples show high tensile strength, high color strength, and high fastness properties.

These results are important for industrial application with the production of a natural dye as an inexpensive source from banana leaves as a by-product. Another objective is to increase the production of eco-textile garments with a good price for the Egyptian customers.

Saleh *et al*.,(2013) studied extraction of flavonoid aglycones from banana, carrot by-products and dyed on pre-mordanted hemp fibres. Analysis of the vegetable colorant was done by TLC (Thin layer chromatography) and HPLC (High performance layer chromatography). Two solvents for extraction were applied on banana leaves. In the alkaline extract luteolin and apigenin and in the acetone extract chlorophyll a, and b and β-carotene were analysed with HPLC. With ferrous sulphate, copper sulphate and potassium dichromate premordanted cotton fabric was dyed in a closed bath for 5 min. at 56°C. The results showed high tensile strength, high colour strength, and high fastness properties.

Khaleque A. and Debashis K.(2016), studied the use of banana fibre for efficient removal of colours of some reactive dyes from textile effluent such as, Novacron Blue FN-R, Novacron Yellow FN-2R, and Novacron Red-FN 3GL. The study results showed that removal is affected by pH of dye solution, contact time, concentration of dye in the solution, and the amount of adsorbent. The optimum removal of dyes from effluent is at pH 2; where adsorption is very quick, and completed within only 20 minutes. The study suggests that the banana fibre can be used as a sustainable adsorbent to remove reactive dyes from textile effluents efficiently.

R.S.Mane, V.N.Bhusari,(2012) evaluated the use of banana and orange peel as natural adsorbent for removal of colour from waste effluent of textile industry. Different doses of peel at different pH and time of treatment. The results show that colour removal capacity for banana peel is 87% and for orange peel is 68 % respectively at normal pH and temperature conditions. The equilibrium time was found 55min. for orange peel and 45min. for banana peel. The experimental adsorption data fitted well with Langmuir and Freundlich adsorption isotherms. The experimental result show that banana and orange peel have good potential for removal of colour from waste effluent and have a good potential as an alternate low cost adsorbent

Ashraful Islam, Arun K.Guha, 2013 studied the use of naturally occurring aquatic/non aquatic water hyacinth, water lily and bark of plantain plant (banana) plants as adsorbents of pollutants. Remarkable result was achieved in case of using plantain plant (banana) bark from inlet effluents of Echotex Ltd; Chandra, Gazipur, Bangladesh.

**Table 2** Color measurements of cotton Giza 86 and Giza 90 fabrics dyed with alkaline and acetone Banana leaves extraction, and

| Method | K/S | | L* | | a* | | b* | | ΔE | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cotton variety | I | II | I | II | I | II | I | II | I | II |
| Control* | 0.1 | 0.12 | 85.7 | 83.45 | -0.17 | -0.13 | -1.21 | -1.69 | 14.36 | 16.65 |
| Unmordant* | 0.42 | 0.52 | 75.82 | 77.01 | 0.9 | 0.52 | 7.1 | 5.6 | 25.2 | 23.63 |
| Fe* | 1.71 | 1.9 | 62.43 | 69.54 | 6.92 | 3.6 | 25.35 | 19.43 | 45.79 | 36.24 |
| Cu* | 1.12 | 1.7 | 64.3 | 68.1 | -2.54 | -3.1 | 16.13 | 16.4 | 39.18 | 35.9 |
| Cr* | 0.26 | 0.36 | 81.81 | 79.1 | -1.1 | -1.12 | 3.6 | 4.5 | 18.5 | 21,4 |

Source: Salah. M, et al, (2013),

Better removal of pH and TDS from textile effluents was obtained, pH value was reduced from 7.3 to 6.5 and TDS values was reduced from 2700 mg/L to 2600 mg/L. Different combinations of coagulants were also used for color removal and sludge separation. The best color removal and sludge separation was obtained in case of $FeSO_4 + CaO$.

Nurizza Fauziyah, Luchman Hakim, (2015) investigated the use of 12 plant species including banana *(Musa paradisiaca L.*), used as natural dyes in Batik dyeing. The importance of each plant was analyzed using Relative Frequency of Citation (RFC) index. It is consisted of Teak, Mahogany, Ketapang, Tamarind, Mangosteen, Mango, Suji, Pandan, Indigofera, Guava, Banana and Onion. Teak and Mahogany have the highest value of RFC, 1.00. Both species were the most frequently cited species as sources of natural dyes, whereas banana have relatively shown medium value of (RFC= 0.5) and a brown dye color. Therefore natural dyes from plant species need to be introduced to the public.

## CONCLUSION

Due to increasing awareness among people about the harmful effects of synthetic dyes, products made from natural materials are gaining popularity, as natural dyes show nontoxic, non-allergic effects and results in less pollution impact. The study reviewed recent researches, innovative approach towards documenting the treasure of indigenous knowledge and literature on utilization of banana extracts using different parts namely leaves, pseudo stem sap, flowers, roots and fruit peels, as long as extraction, characterization, application, on cellulosic textile materials for coloration, removal of dyes from effluents, binders, pigments, and other important applications for producing more appealing and highly functional value-added textiles. Review provides literature information about classification techniques of natural dyes, dyeing principles and mechanisms, testing methods. It could be concluded that dyes extracted from banana are of textile importance. Dyeability, colorfastness, and color strength investigated indicated potential use in the textile industry. The extract could be used efficiently for, removal of some reactive dyes from textile effluents, binders, and as mordants. Dyeability and dye fixation could be improved well by adding mordants to the dye bath.

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