Utilization of Banana Extract for Eco-friendly Functional Finishing of Textile Materials: A review

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ABSTRACT

With the consumer's enhanced awareness of eco-safety, there has been an increasing tendency towards the use of sustainable and environmentally friendly materials. Thus considerable attention has been given to products from plants, for use in various 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 functional finishing, some important finishes, and their evaluation tests methods. In addition to focus on recent researches concerning utilization and application of banana extract for various textile finishing purposes such as coloration, deodorizing, flame retardant, UV protection, antimicrobial activity, and other important applications around the world for producing appealing and highly functional value-added textiles such as fibers, dyes , pigments, polyphenols, and other biologically active compounds.

Key words: Banana**,** functional finishing, extraction, eco-friendly**,** textiles**.**

INTRODUCTION

Wet processing of textile substrates starting from its preparatory to coloration followed by finishing is important for its value addition in terms of aesthetic value, removal of impurities, color shade, color pattern and requisite functionality. However, some of the traditional processes are water, energy and chemical intensive. Recently, due to global awareness on environmental pollution, and sustainability, both the academic research and textile industrial product development have been intensified to seek for sustainable dyeing and finishing processes, using plant waste and non-food plant extracts,(Samanta.*et al*, 2017). Based on environmental friendly plant-based products characterized by biocompatibility, biodegradability, non-toxicity, in addition to their recently discovered properties such as insect repellent, deodorizing, flame retardant, UV protection, and antimicrobial activity are gaining popularity all around the world for producing more appealing and highly functional value-added textiles, (Wai *et al*. 2015), (Yuyang and Cheng, 2017), (Shahid, . 2013), (Kartic, *et al*. 2014), (Sasmita et al. 2013), (Salah, 2013), (Hou *et al*. 2013) and (Yi and Yoo, 2010). Natural bioactive compounds as promising alternatives to synthetic finishing agents have recently gained increasing attention in the textile industry due to their eco-friendliness, low irritation, and biocompatibility, antibacterial activity, (Teli, *et al*. 2014), antioxidant, and UV-protective properties, (**Yuyang**. and Cheng, 2017). A wide variety of finishing chemicals from plants are now available in the market that meet or exceed the expectations of consumers, (Roshan, 2015). 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). Plant parts including roots, leaves, twigs, stems, heartwood, bark, wood shavings, flowers, fruits, rinds, hulls, husks, and the like serve as natural dye sources. In addition most of the natural dyes have inherently antimicrobial properties and consequently, could possess high medicinal potential properties, (Sujata, and Raja, 2014). Among these plants banana extract is used in various applications for dyeing and finishing of textile. Consequently, researchers have begun to search in its eco-friendly utilization for functional finishes. The purpose of this paper is to over view and focus on papers about extraction application and utilization of banana plant for functional finishing of textile substrates.

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. Banana sap consists of different chemical constituents like carbohydrates, cellulose, lignin, ash, coloring matter and portentous material. (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 as fruits, (Ramesh, 2017). Musaceae is a family of flowering plants composed of three genera with ca 91 known species, placed in the order Zingiberales. Banana family is native to the tropics of Africa and Asia. 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 fiber 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). Presently, the banana pseudo stem is hazardous waste, it has been used in several countries to develop important bio-products such as fiber which is spun to make yarn, which is woven or knitted to produce fabric, apparel, as well as fertilizer, bio-chemicals, paper, handicrafts, pickles ,candy, (Mohiuddin, 2014). Banana extract may be used for dyeing and printing of textiles, finishing of textiles can also be obtained such as anti- microbial, flame retardant, ultra violet protection finishing, besides their use as pigment binders, resins, and mordanting agents, (Paul. 2013). Banana plant parts are engaging in textile arena such as table mat, stylish hand bag, eco-shopping bag, laminated fabric, yarn, saree, shirt, female dress, night dress, coaster etc. Moreover, it is involved with mordants, for cotton dyeing and promising dye adsorbent for treatment of textile effluent (Reazuddinm, 2016), (Paul, 2013), (Shuaibing, 2013).

METHODS OF EXTRACTION

Traditional method: The traditional method used for extraction is that the plant material is added directly to the dye bath. This has been used by dyers for centuries and is still used by many dyers in north eastern states of India. The disadvantage of this method is that the plant material has to be separated from the textile. It is not applicable to modern textile fabrication machines (pumps and spinnerets will be choked). Two types of extraction may be carried out for characterization of the colorant as well as analyzing the effect of newly found dye resources on cotton silk and wool. These extraction procedures are:

Alcoholic extraction: Dry plant(leaves)are finely crushed through a grinder and then subjected to soxhlet extraction, using methanol as a solvent. The cycle is repeated for three times at 60 º C. Then the cooled extract is filtered through a filter paper and the solvent may be removed through a rotary evaporator.

Aqueous extraction: Respective plant parts are taken and poured in boiling water and then kept on water bath at 60 º C for about one hour so as to extract all the material from them. The extraction techniques are shown according to figure-1.

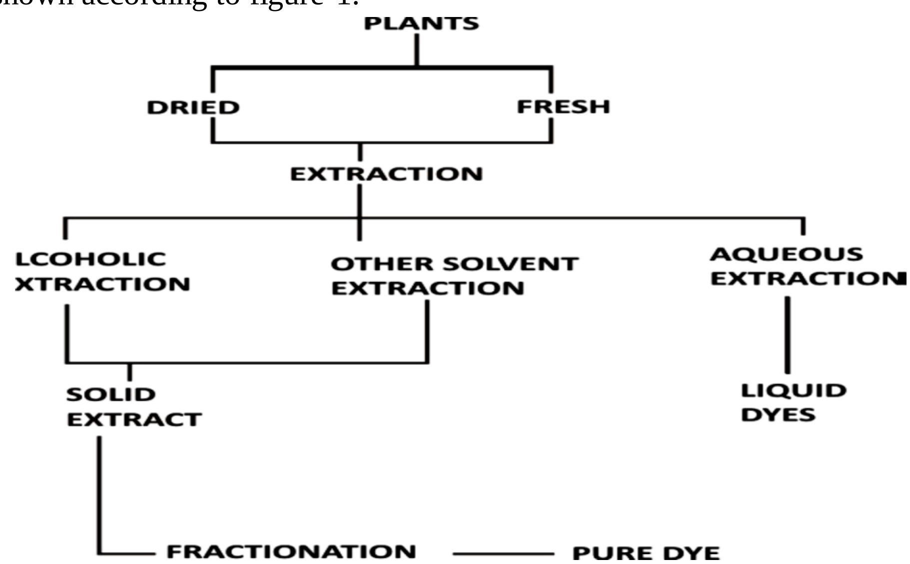

Figure-1 Different Types of Extraction Techniques

Innovative Method for Extraction:

Efficient extraction of plant material is very important for standardization and optimization of material from plants. Utilizing four types viz:

a) **Soxhlet**: When a compound of low solubility needs to be extracted from a solid mixture a soxhlet extraction can be carried out. The technique places a specialized piece of glassware in-between a flask and a condenser. The refluxing solvent repeatedly washes the solid extracting the desired compound into the flask. Soxhlet extraction will be carried out for identification of extract. Dried plant parts will be put into thistle of soxhlet extractor and methanol is used as solvent. Temperature is maintained well under boiling point of the used solvent. Several cycles of solvent will be run for better extraction.

b) **Supercritical fluid extraction** (SCFE): SCFE is a two-step process, which uses a dense gas as solvent usually carbon dioxide above its critical temperature (31°C) and critical pressure (74 bar) for extraction. The natural product is powdered and charged into the extractor. Carbon dioxide is fed to the extractor through a high-pressure pump (100-350 bar). The extract charged carbon dioxide is sent to a separator (60-120 bar) via a pressure reduction value. At reduced temperature and pressure conditions the extract precipitates out in the separator. SCFE is superior over the traditional solvent extraction of natural dyes because it uses a clean, safe, inexpensive, nonflammable, nontoxic, environmentally friendly, nonpolluting solvent-carbon dioxide (CO_2). In addition, the energy costs associated with SCFE is lower than the conventional techniques.

c) **Subcritical water extraction**: It is performed with some plants to extract natural products. Water is purged with nitrogen to remove dissolved oxygen prior to the extraction. Deoxygenated water will be used in an HPLC pump programmed for a constant flow of 1–3 ml/min^{-1}. A 10.4 ml extraction cell equipped with 0.5 m frit at the inlet and outlet is connected to a 1 m cooling loop outside of the oven.

d) **Sonicator methods**: Ultrasound-assisted extraction is carried out by mixing dried and ground sample in methanol or any solvent in a flask, which is then placed in an ultrasonic bath for 30 min. At the beginning, the temperature of extraction is kept 20-40°C and after one hour of extraction it must be raised to 60 °C. The extraction is repeated two-three times and the extracts is then collected, (Handa., *et al*. 2008), (Lee, 2013).

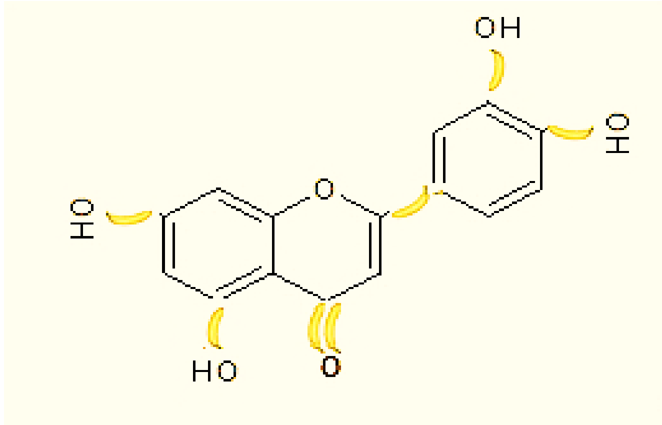

Figure 2**:** Structure of the banana peel crude alkaline extracted compound

CLASSIFICATION OF FUNCTIONAL FINISHES

Broadly, the finishing can be classified into the following classes, which are used individually or in combination with each other: mechanical, chemical and biotechnological finishes. Both mechanical and chemical finishes are classical finishes and these two types are, in fact, complementary. For example, the results obtained in mechanical finishing are greatly influenced by the previous chemical history of the fabric, and to obtain maximum benefit from chemical finishing, careful selection of relevant mechanical finishing treatments is essential, **(Paul, 2015**).

Mechanical finishing: Involves the application of physical principles such as friction, tension, temperature, pressure, etc.

Chemical finishing: Traditionally, many of the functional properties given to textiles are achieved at the final finishing stage, where the chemical treatment of the fibers changes their appearance and improves their functional and comfort properties. The finishing is imparted by means of chemicals of different compositions and a textile can receive new properties otherwise impossible to obtain with mechanical means. A wide variety of functional properties can be created on textiles by means of chemical finishing and it is also possible to develop multifunctional textiles. The major application methods include padding, exhaustion, coating, spraying and foam application. With the advent of nanotechnology, a new area has developed in the realm of textile finishing. Nanotechnology is opening new avenues in chemical finishing, either resulting in improved processes or helping to achieve new functional properties like self-cleaning effects, which were not possible with conventional finishes.

Biotechnological finishes: The recent trends in industrial biotechnology show that social, environmental and economic benefits go hand-in-hand with applications of this technology. Enzymes are the most important biological agents that are now used in the textile industry **(Paul, 2015**). Today, enzymes are used to treat and modify fibers, particularly during textile pretreatments and for finishing the textiles afterwards.

Finishes for protecting wearers and textiles:

These finishes deal with the protective aspects of the functional finishes for both wearers and textiles. The different finishes include insect repellent finishes.

Functional finishes for textiles: antimicrobial finishes; hydrophobic and oleophobic finishes; flame retardant finishes; ultraviolet protection finishes; radiation protection finishes; antistatic and electrically conductive finishes; biological and chemical protection finishes; and ballistic and stab protection finishes.

Antimicrobial finishes:

Textiles, especially those made of natural fibers, are an excellent medium for the growth of microbes when the conditions are favourable. Most synthetic fibers are more resistant to microbes than are natural fibers, due to their high hydrophobicity. The structure and chemical nature of natural fibers can induce microbial growth, but it is the humid and warm environment that aggravates the problem further. The growth of microbes negatively affects the textile material as well as the wearer. Hence, antimicrobial finishes should be applied to textiles to prevent the growth of microbes**,** and to destroy or suppress the growth of microorganisms and their negative effects of odors, staining and deterioration (Kumari et al. 2016), and also to protect the textiles from strength and color loss, unpleasant odour and quality deterioration **(**Akhilesh, 2012), **(**Mamta and Kaur, 2013).

Flame retardant finishes:

Flame retardant treatments are usually applied to combustible fabrics used in children's sleepwear, carpets and curtains for preventing these highly flammable textiles from bursting into flame. Ideally, the best flame retardant system for textiles should char the fiber, releasing no toxic smoke or gases, and prevent afterglow. The future of flame retardancy is hindered greatly by environmental and eco-toxicological considerations, both of the flame retardant chemicals and of the toxic nature of the byproducts released upon combustion of textile fabrics (Xu et al. 2012), (White et al. 2013), (Alongi et al. 2011). Research is also focusing on 'green' solutions like enzymes and in tumescent flame retardants such as expandable graphite.

Ultraviolet protection finishes:

Textiles have been used for protection against solar radiation since the time of ancient civilizations. Textile structures render unique characteristics required for sun screening apparel such as pliability, good mechanical strength, softness, aesthetics and other engineered properties. But textiles as such may not be able to provide effective protection and should be treated with UV blocking agents to ensure that the fabrics deflect the harmful UV rays. The extent of skin protection required by different types of human skin depends on UV radiation intensity and distribution with reference to geographical location, time of day and season. Several UV blocking agents are being developed to add to or improve the UV protection function of textiles. There are both organic and inorganic UV blockers. The organic blockers are also known as UV absorbers as they absorb the UV rays, whereas the inorganic blockers efficiently scatter both UVA and UVB rays, the main cause of skin cancer **(Paul, 2015**).

CHARACTERIZATION

The extracted components will be determined and characterized for each plant by using different apparatus such as FTIR, NMR, HPLC, DSC, TGA, GPC and WAXD.

Application of finishing on textile materials:
The characterized extracts will be applied to a 100% cotton fabric by:
Exhaustion, pad-dry-cure, coating, spray, foam and micro capsulation techniques. Various methods for improving the durability of the finish include:
- In solubilisation of the active substances in/on the fiber.
- Treating the fiber with resin, condensates or cross linking agents.
- Micro encapsulation of the antimicrobial agents with the fiber matrix
- Coating the fiber surface.
- Chemical modification of the fiber by covalent bond formation.

Testing and Evaluation*:*
Antimicrobial Test:
Antimicrobial activities of the treated fabric with antimicrobial extract will be evaluated by qualitative (AATCC147) and/or quantitative (AATCC100)methods against ((Gram + ve and Gram − ve bacteria) and fungi), before and after washing**.**
Insect Repellent:
The treated fabric with insect repellent extracts will be tested by cone test method which is recommended by WHO.
Measurement of Physical Properties:
The physical properties for the treated fabric such as:
Surface morphology: by using scanning electron microscope (SEM).
Tensile strength: Measurement of tensile stress–strain properties is the most common mechanical measurement on fabrics. It is used to determine the behavior of a sample while under an axial stretching load.
Tear strength: Tear strength is the tensile force required to start, continue or propagate a tear in a fabric under specified conditions. A tear strength test is often required for woven fabrics used for applications including army clothing, tenting, sails, umbrellas and hammocks.
Water repellent properties: This test method is applicable to any textile fabric, which may or may not have been given a water-repellent finish. It measures the resistance of fabrics to wetting by water according to (AATCC Test Method 22-2005 Water Resistance: Spray Test) and/or (AATCC Test Method 35-2006 Water Resistance: Rain Test).
Evaluation of flame retardants:
Many factors influence the flammability of textiles, including the fiber type, the fabric weight and construction, the method of ignition, the extent of heat and material exchange, and the presence or absence of flame retardants. A measure that enables an obvious assessment of flame protection properties is the limiting oxygen index (LOI), determined according to ASTM D-2863.
Vertically held specimens, determination of the ease of ignition/the flame spread properties, ISO 6940/6941. The LOI is defined as the content of oxygen in an oxygen/nitrogen mixture that keeps the sample at the limit of burning
LOI = $100 \times O_2 : (O_2 + N_2)$, (Horrocks, 2000), (Horrocks, 2003).

DISCUSSION

Mansour, (**2012**), have evaluated banana peel (Musa, cv. Cavendish) as a multi-functional antibacterial and UV protective agent for some Egyptian cotton fabrics treated with aqueous extract (0.1%) NaOH**.** The alkaline fractions of banana peel have been used as a natural dye for cotton fabrics. The extracted solution was analyzed using a high performance thin layer chromatography (HPTLC) analysis technique. The nit was applied to Ferric sulphate premordanted bleached and mercerized Egyptian cotton fabrics made from a blend of Giza 89 and Giza 80 cotton varieties. Antibacterial activity against Staphylococcus aureus and Klebsiella pneumonia was analyzed qualitatively in terms of zone of inhibition, and quantitatively in terms of % reduction in bacteria.

Table 1: The bacteriostatic reduction rates (%) of Giza 89 and 80 control and fabrics dyed with banana peel extracts against Staphylococcus aurous and Klebsiella pneumonia

Klebsiella pneumonia	Staphylococcus aurous	Sample	Fabric variety
0.32	0.65	Control	Giza 89
92.10	95.70	Unmercerized	
98.32	99.90	Mercerized	
0.12	0.50	Control	Giza 80
90.31	93.80	Unmercerized	
97.77	98.90	Mercerized	

Source: Mansour, (2012)

Dyeing performance in terms of color parameters K/S, L*, a*, b* and ΔE were studied. Effectiveness of banana peels against ultraviolet radiation was evaluated in terms of ultraviolet protection factor value (UPF). The data obtained showed that the mercerized fabrics have excellent antibacterial activity as shown in Table1, high dye uptake with high UV protection properties (64.0) among the control (19.8) and the unmercerized cotton fabrics (48.9). The data obtained revealed that Giza 89 had the higher antibacterial activity, dye uptake with high UV protection properties than Giza 80 with (UPF) of 59.8 for mercerized, 44.3 for unmercerized, and 17.99 for the control fabric. These results are very important for industrial application with the production of a natural dye, antibacterial, and UV protected materials as an inexpensive source from waste banana peel as a by-product.

Saravanan, and Bhaarathi, (2017). Carried out a comparative study of antimicrobial activity of different plants extract which conducted a survey for 7 days with 5 dish cloths, on which the survey was at normal kitchen environment with normal temperature at the various districts of Tamilnadu. The kitchen fabrics contaminated with a strain were investigated biochemically and fabric supports the growth of bacteria/genus, namely Staphylococcus, Klebsiella, Shigella species. The natural agents such as banana peel, Pomegranate peels, Casein & Cyclodextrin in extract form were applied to the kitchen fabric by conventional pad-dry-cure method. Antibacterial tests carried out following AATCC 100 2004, on these treated fabric samples proved that the plant extracts & natural agents act as a good antibacterial agent for kitchen fabrics. The Banana peel, Casein and Cyclodextrin extracts treated cotton fabric had higher bacterial growth reduction %, in comparison with Murraya Koenigii and Pomegranate peels, especially combination of Banana peel, Casein and Cyclodextrin extracts treated cotton fabric showed the highest efficiency among the other treated fabric samples.

Basak, *et al.*, (2015) studied the flame retardancy of cellulosic cotton textile using banana pseudostem sap (BPS), an eco-friendly natural product. The extracted sap was made alkaline and applied onto pre-mordanted bleached and mercerized cotton fabrics. Flame retardant properties of both the control and the treated fabrics were analysed in terms of limiting oxygen index (LOI), horizontal and vertical flammability. Fabrics treated with the non-diluted BPS were found to have good flame retardant property with LOI of 30 compared to the control fabric with LOI of 18, i.e.an increase of 1.6 times. In the vertical flammability test, the BPS treated fabric showed flame for a few seconds before it was extinguished. In the horizontal flammability test, the treated fabric showed no flame, but was only burning with afterglow and a propagation rate of 7.5 mm/min, which was almost 10 times lower than that noted with the control fabric; the results of flammability parameters are shown in Table 2.

Table 2: Flammability parameters of treated and washed fabric

Flammability parameters	Fabric parameters		
	Control sample	Sap treated (1,0) samples	
		After washing	Before washing
LOI	18	24	30
Horizontal flammability			
Warp way burnrate mm/min.	75	20	7.5

Source: Basak, *et al*, (2015)

Due to higher LOI, the total burning time could be increased from 60 s in the control sample to 900 s in the BPS treated sample. Only banana pseudostem sap without any dilution was found to be the best for application in the cotton textile under alkaline conditions. The thermal degradation and the pyrolysis of the fabric samples were studied using a thermo gravimetric analysis (TGA), and the chemical composition by FTIR, SEM and EDX, besides the pure BPS being characterized by EDX and mass spectroscopy. The treated fabric was found to produce stable natural khaki color, and there was no significant degradation in mechanical strengths. Based on the results, the mechanism of imparting flame retardancy to cellulosic textile and the formation of natural color on it using the proposed BPS treatment have been postulated.

Yee, and Khin, (2017) investigated the flame resistant effect of alkaline banana pseudostem sapat different concentration sapplied to premordanted bleached cotton fabrics with tannic acid , and alum. Treated fabrics were tested for some physical properties such as weight, and breaking strength. The results showed improved physical properties. The fabric treated with the higher concentration of sap gives the best flame retardance as compared to the other treated fabrics.

Basak, *et al.*, (2015) studied the flame retardancy of ligno-cellulosic jute textiles treated with alkaline banana pseudostem sap (BPS), which was applied to a pre-mordanted greige fabric. The flame-retardant properties of both the control and treated fabrics were analysed for limiting oxygen index (LOI), horizontal and vertical flammability, and the total heat of combustion. The treated jute fabrics showed a far better flame-retardant property compared to the control fabric. By 1.9 times increase in the LOI after application of the alkaline BPS, the treated fabric (1:4) LR. Showed no flame and got self-extinguished within one minute. Based on thermal degradation, pyrolysis and dehydration studies, and analysis of the chemical composition of the flame-retardant finish prepared from the BPS, the mechanism of imparting flame retardancy to jute textiles has been postulated. The imparted finish was found semi-durable in soap wash, and did not cause any significant loss in tensile and tear strength of the fabric.

Ramesh. V, (2017), investigated the aqueous extract of banana peel on functional properties of plasma treated cellulose fabrics for medical applications.

Cellulosic fabrics (cotton, viscose, tencel) were treated with alkaline fractions of banana peel, which was evaluated as UV protective agent and multi-functional antibacterial agent on the cellulose substrate. The solution was extracted using 0.1% NaOH and was analyzed by Fourier Transform Infrared Spectroscopy analysis technique. Two sets of fabrics normal set and plasma treated set were tested. The dye extracted was applied to the ferrous sulphate premordanted cellulosic fabrics (for both set of fabrics). Effectiveness of cellulosic fabrics dyed with banana peel extract against ultraviolet radiation was evaluated in terms of ultraviolet protection factor (UPF) as shown in Table 3 and Table 4. Antibacterial activity was analyzed in terms of percentage reduction in bacteria. Dyeing performance in terms of color parameters was studied. The data obtained showed that the plasma treated cotton, viscose and tencel fabrics have good antibacterial activity, good dye uptake with good UV protection properties than untreated normal cellulosic fabrics. The plasma treatment increases the antibacterial activity, dye uptake and UV properties up to certain extent. The addition of Fe as a mordant increases all the above mentioned parameters due to ternary complex of Fe on one site with the fiber and on the other site with the dye and also the coordination sites of Fe metal which are unoccupied can absorb UV incorporated into the fibers convert electronic excitation energy into thermal energy. These results are very important for industrial application with the production of a natural dye, antibacterial, and UV protected as an inexpensive source from waste banana peel as a byproduct.

Table 3: Ultraviolet protection factor values of normal fabric

Type of fabric	UPF Factor	UVA	UVB	UV%
Cotton	40	3.62	2.42	97.38
Viscose	38	3.21	2.22	96.50
Tencel	42	3.81	2.63	97.92

Source: Ramesh, (2017)

Table 4: Ultraviolet protection factor values of plasma treated fabric

Type of fabric	UPF Factor	UVA	UVB	UV%
Cotton	41	3.89	2.72	97.98
Viscose	39	3.65	2.54	96.90
Tencel	42	4.05	2.73	98.02

Source: Ramesh, (2017),

Alvakonda, (2016), investigated an eco-friendly silver nanoparticles using banana peel extract as natural reducing agent to synthesize biodegradable silver nanoparticles. Natural silver Nanocomposite hydrogels were prepared by a green process by reducing AgNO3 with banana peel extract using acrylamide with banana peel extract. It was found to reduce the silver ions (Ag+ to Ag^0) and capping agent. The characteristic color of hydrogel is changed to reddish brown in the reaction due to reduction. The UV-Vis spectrum of silver nanoparticles revealed a characteristic surface plasmon- resonance peak at 460 nm. X-ray diffraction revealed their crystalline nature. Scanning electron microscope showed monodispersed spherical shaped nanoparticles. The average size of nanoparticles was 10nm as confirmed by Transmission electron microscope. Fourier transform infrared spectroscopy (FT-IR) affirmed the role of banana peel as a reducing and capping agent of silver ions. The antibacterial activity of these nanoparticles was also studied against Gram-positive and Gram-negative bacteria. The characteristic color of hydrogel is changed to reddish brown in the reaction due to reduction of $AgNO_3$.

Benitta, and Kavitha, (2014) studied the use of banana stems as a source of fiber. It is used all over the world for multiple purposes such as making tea bags or sanitary napkins to Japanese yen notes and car tyres. It is also known as strongest natural fibers. Banana stem, hitherto considered a complete waste, is now being made into banana-fiber cloth which comes in different weights and thicknesses based on what part of the banana stem the fiber was taken from. The innermost sheaths are where the softest fibers are obtained, and the thicker and sturdier fibers come from the outer sheaths. High water absorbing property of this fabric makes this clothing cool to wear.

Gopika and Mophin, (2016) investigated the suitability of banana stem juice as a natural coagulant for textile industrial wastewater treatment. Three main parameters were studied, namely, total suspended solids (TSS), pH, and turbidity of effluent. Coagulation experiments using jar test were performed with a flocculation system where the effects of textile industrial wastewater as well as banana stem juice dosage on coagulation effectiveness were examined at different pH levels. High EC, TS, and turbidity removal percentages by the banana stem juice were observed at pH 4 as 50, 50.1, and 97.5% respectively. Results reveal that banana stem juice has tremendous potential as natural coagulant for textile wastewater.

Alvakonda, (2016) studied the synthesis of eco-friendly biodegradable silver nanoparticles (AgNPs) from banana peel extract (BPE) which act as natural reducing agent. Natural silver nanocomposite hydrogels were prepared by a green extract of banana peel with acrylamide (AM). BPE was found to reduce the silver ions (Ag+ to Ag0) and capping agent. The characteristic color of hydrogel was changed to reddish brown in the reaction due to reduction. The UV-Vis spectrum of silver nanoparticles of the results revealed a characteristic surface plasmon- resonance peak at 460 nm. X-ray diffraction (XRD) revealed their crystalline nature. Fourier transform infrared spectroscopy (FT-IR) affirmed the role of BPE as reducing and capping agent of silver ions. The antibacterial activity of these nanoparticles was also studied against Gram-positive and Gram-negative bacteria. The characteristic color of hydrogel was changed to reddish brown in the reaction due to reduction of AgNO3.

Zaida *et al*, 2016**,** extracted fibers from banana pseudo stems residues by mechanical means. They studied the viability of using banana fibers to obtain a yarn suitable to be woven, after an enzymatic treatment, which is more environmentally friendly. Extracted long fibers were cut to 50 mm length and then immersed into an enzymatic bath for their refining. Conditions of enzymatic treatment have been optimized to produce a textile grade of banana fibers, which have then been characterized. The optimum treating conditions were found with the use of Biopectinase K (100% related to fiber weight) at 45 °C, pH 4.5 for 6 h, with bath renewal after three hours. The first spinning trials show that these fibers are suitable to be used for the production of yarns. The next step is the weaving process to obtain a technical fabric for composites production.

Ashraful, and 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. 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.

Deepti and Shanaz, 2017, carried out a study of an eco-friendly way, to make a fabric UV protective. The extracts of fruit peels, banana, apple, orange and Lemon, were applied to the cotton fabric, using the exhaust method. As a result, good to very good UV protection properties were achieved. For untreated cotton UPF is 9.9 but for treated it was found in the range of 15(the lowest) for banana peel up to 40 (the highest) for lemon peel. It can be concluded that, fruit peels have potential to be used as an UV protective finish, for the cotton fabric, which would not only protect the skin against harmful UV rays, but also help in utilizing the waste of fruits in a productive term.

CONCLUSIONS

In the current studies, it can be concluded that banana plant extracts from (leaves, pseudostem, peels) could be used as a multi-functional eco-friendly finishing agents such as antibacterial activity against Staphylococcus aureus and Klebsiella, UV protective agents on normal cellulosic fabrics and plasma treated cellulosic fabrics. It was investigated that banana pseudostem sap is capable of imparting flame retardancy to jute textiles, the treated fabrics showed improved physical properties such as weight, and breaking strength. The suitability of banana stem juice was tested as a good natural coagulant and adsorbents for textile industrial wastewater treatment for removal of total suspended solids (TSS), pH, and turbidity, from textile effluents. The use of banana pseudostems as a source of fiber for producing fabric to be used in different purposes was investigated. An eco-friendly biodegradable silver nanoparticle (AgNPs) was extracted from banana peel as reducing agents. We believe that the results of the review are interesting for industrial application of banana extract (byproduct) as green finishing agents, and this will assist in reduction of environmental pollution.

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استخدام مستخلص الموز كصديق للبيئة لمعالجة المواد النسجية : استعراض

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مع زيادة وعي المستهلك بالسلامة البيئية، كان هناك اتجاه متزايد نحو استخدام مواد مستدامة وصديقة للبيئة. وبالتالي نجد أن المنتجات من النباتات وجدت اهتماماً كبيراً لاستخدامها في مختلف الصناعات لاسيما في صناعة الغزل والنسيج والتجهيز. وفي هذا المسح النظري تم اختيار الموز من بين هذه النباتات ، ويعتبر ثاني أكبر فاكهة منتجة بعد الحمضيات ، مما يساهم بنحو 16٪ من إجمالي إنتاج الفاكهة في العالم. تقدم هذه الدراسة معلومات أدبية حول تصنيف التجهيز الوظيفي وبعض التجهيزات الهامة وتقييم طرق الاختبارات الخاصة بها. بالإضافة إلى التركيز على الأبحاث الحديثة المتعلقة باستخدام وتطبيق مستخلص الموز لمختلف أغراض تجهيز المنسوجات مثل التلوين ، وإزالة الروائح الكريهة ، و مثبطات اللهب ، و الحماية من الأشعة فوق البنفسجية ، والنشاط المضاد للميكروبات ، وغيرها من التطبيقات الهامة في جميع أنحاء العالم لإنتاج منتجات ذات قيمة عالية مضافة للمنسوجات مثل الألياف ، و الأصباغ ، و البجمنت ، و البولي فينول ، وغيرها من المركبات النشطة بيولوجيًا.