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Technical Report
Value Addition of Agro Residues Through Textile Colouration

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Abstract

The agro-residues are having plenty of scope in diversified filed. Many research attempts have been made to derive enzymes, dyes fibres, etc from the agro residues. The ease of availability in abundance and cheap price attracts the researchers to go ahead in this field. The present work deals with the scope agro-wastes as a source of natural dyes for textiles, including the extraction and application methods. The manuscript has been written in the industrial point of view. The commercial availability and the potentiality have been taken in to consideration, during the selection of agro-wastes. The important works in the fields of theses agro-wastes and their results has been reviewed. A study has been performed to find out the cost involved for stating a small scale dyeing cum garment unit.

Key words: Dyeing, agro-wastes, mordants, natural dyes, waste utilization

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INTRODUCTION

Natural dyes produce unique, earthy, soothing, soft and pastel shades as compared to synthetic dyes. The non-reproducibility and non-uniformity of shades and colours from natural dyes make each design or product as a unique item thus further glorifying the use of natural dye. New area of natural dyes has been explored by utilizing agricultural/agro-industrial waste and using it as a potential source of dyeing. Every year huge amounts of agriculture waste are burnt in landfills and improperly disposed. A large amount of residues are released to the environment without proper disposal that causes harmful effect to the environment and the human beings. Most of the agro based industrial wastes are left untreated and underutilized, results in maximum disposal of it either by burning, dumping or unplanned landfilling[1]. Agricultural wastes are rich source of bioactive compounds. These wastes can be used as an alternative for the production of different products like biogas, bio fuel, enzymes, bio absorbents, dyes, packaging material, fiber, etc[2,3]. The use of agricultural/agro-industrial wastes can be used to reduce the pollution load from the environment[4]. Many kinds of research have been done to explore the residues to be used as dyes, as the amount of residue produced by industries and agricultural lands is far greater than exploiting them from natural sources. A great deal of scientific analysis and experimentation is needed to make maximum utilization of these potential alternatives.

The colour value increases the aesthetics of the fabric, In addition to the aesthetic appearance, the consumers are also aware of the functional properties viz., ultraviolet and antimicrobial protection, aroma, etc provided by the fabric. These functional properties of natural dyes sources come from different active compounds like saponins, flavonoids, tannins, polyphenol, etc. Growing consciousness about the environment and human health around the globe has again generated renewed interest of consumers towards natural dyes, as they are eco-friendly, non-toxic and non-carcinogenic.

Thus keeping the above factors, an attempt is made to accumulate the literature information regarding the use of agro-waste as a potential source of natural dyes. The important agro-wastes, their extraction and application methods, availability, scope and challenges have been incorporated. A break even analysis is also performed to find out the cost involved for setting up of a small scale dyeing cum garment unit for natural dyeing.

DIFFERENT EXTRACTION PROCESSES

The nature and the characteristics of the colouring (plants and insects) material must be ascertained before using the extraction process. There are some different methods for extraction of colouring material.

Aqueous extraction: Aqueous extraction was traditionally used to extract dyes from plant materials. Material is soaked with water in earthen, metal, wooden and stainless steel vessels for a period of time to loosen the cell structure. After soaking boil the water to get solution, which is filtered to remove the non-dye remnants[5].

Acid and alkali extraction: Mostly dyes having glycosides that can be extracted under dilute acidic or alkaline conditions. Acid and alkali help to hydrolysis of glycosides resulting in better extraction and good colouring material. Acid extraction is suitable for the dyes having a flavone group to prevent oxidation and alkali extraction is suitable for the dyes having a phenolic group to improve the dye yield[6-7].

Ultrasonic and microwave extraction: This extraction process helps to reduce the quantity of required time, solvent and temperature. When the plant material is treated under the presence of ultrasound, very small bubbles or cavitations occur in the liquid. The bubbles busted with high temperature and pressure and this process helps to increase the extraction efficiency. In the microwave extraction process, plant material is treated with a minimum amount of solvent in the presence of microwave energy sources. Microwave helps to complete the process in shorter time with better results[8,9].

Fermentation: In this extraction process uses enzymes produced by the microorganism present in the environment for assisting the extraction process. e.g., indigo extraction, fresh leaves in twigs soaked in the warm water at 32°C. Fermentation sets in and glucoside indican broke down that is present in the indigo leaves. The fermentation extraction is similar to aqueous extraction with exception does not require high temperature.

Enzymatic extraction: The plants contain cellulose, pectin and starches as structural integrity. The enzymes i.e., cellulase, pectinase and amylase have been used for loosing the hard outer material of the plant under the milder conditions. These enzymes are used for the extraction of the hard part of the plants e.g., barks and roots.

Supercritical fluid extraction: In this extraction method carbon dioxide (CO_2) is used to extract the dye. Critical temperature and pressure values for carbon dioxide are 31.4°C and 1070 psi (pounds/square inch). Saravana *et al.*[10] reported the extraction of natural dye from brown seaweed (*Sargassum* sp.).

Spray drying technique: While the dye liquor (dye extracted in suitable solvents i.e., water, ethanol, etc.) is introduced in the spray dyer, due to high temperature, the water will evaporate and the dye power will be collected at the bottom. Since some of the colouring compounds in the natural dyes are sensitive to the temperature, proper precautions need to be taken while using this technique.

ROLE OF AGRO WASTES AS A SOURCE OF NATURAL DYES

The proliferating tension on the environmental exploitation is a major concern today. The reasons for such a devastating effect on the environment are major pollution. The environmental impact of agro waste has increased tremendously as they are stored or buried in the wrong way which may leak or enter the habitat and thereby affecting the environment. Environment policymakers and researchers have scrutinized the issue and urged to effectively utilize waste into valuable products. Agro wastes are any waste that is produced from agriculture or related field that are not used in the production for e.g., rice husk, wheat straw, sugarcane bagasse, fruit peel husk, etc. These agro wastes harbor enough potential if used in innovative ways. Properties of these wastes can be used in combination to get a better output. This way these unexplored resources are used for sustainable living and result in reduced environmental problems by contributing to waste disposal management[11].

Researchers have been worked for alternative uses of the agro residue few of which are: Dye extraction from peanut husk, chickpea husk, walnut husk, pomegranate rind and many more (Table 1). Reuse, recycle and reduce of agro waste can transform waste into gold. Proper waste collection, storage, treatment, transfer and utilization must be a universal remedy to a healthy ecosystem. The table demonstrates the uses of various agro wastes as a source for textile dyes.

Table 1: important agro-residues for dyeing

Sources	Colours
Peanut skin	Brown
Chick pea husk	Brownish yellow
Pomegranate rind	Yellow
Turkish red pine wood dust	Brownish yellow
Henna leaves	Orange-red
Fustic wood	Yellow
Walnut bark	Brown
Saffron flower	Yellow
Marigold flower	Yellow
Teak leaves	Yellow
Annatto	Red
Logwood	Black
Saffron flower	Yellow
Myrobalan seed	Yellow
Garcinia mangostana shell	Brown
Basella alba sap	Maroon

Some important agro residues as a source of natural dyes

Peanut skin: India is in a prime position in the production of peanuts. A major portion of the peanut is going on the peanut processing industries. It is a common practice to remove the red colour skin from the peanut before packing. A huge amount of peanut skin is produced as a byproduct from these industries and the industries are disposing it as a waste. Pandey *et al.*[12] extracted dyes from the peanut skin and successfully applied on cotton, wool and silk fabrics. Post dyeing experiments show that the affinity of the dye is better in wool and silk fabric than cotton. The phytochemical analysis showed the presence of glycosides, phenol, flavonoids and saponins. Crude dye yield was found to be 22.8%. The colour values, fastness characteristics and ultraviolet protection factor of the dyed fabrics were evaluated and found to have satisfactory results.

Chickpea husk: Jose *et al.*[3] used the outer husk of chickpea, an abundant agro-industrial processing residue available in India, to extract textile grade dye. The phenols, terpenoids, flavonoids tannins groups present in chickpea extract were analysed by phytochemical analysis and Fourier transform infrared spectroscopy. The chickpea dye was used to impart colour to cotton, silk and wool fabric at different temperatures without any mordants. It was found that the colour extracted from chickpea is having more affinity to protein fibre than cellulosic fibre. The dyed fabrics exhibited good ultraviolet protection property and excellent resistance against *S. aureus* and *E. coli* bacteria. The technology not only reduces the environmental pollution by utilizing the agricultural processing residues but will also provide additional income to the chickpea cultivators as well as processing units.

Pomegranate rind: *Punica granatum* (pomegranate) is generally grown in warm areas. Kulkarni *et al.*[13] experimented on cotton dyeing with natural dye with pomegranate peel. The pomegranate having a large amount of tannin content with 19% of pelletierine. Granatonine is the major colouring agent in the pomegranate that is present in the alkaloid from N methyl granatonine. Two mordants i.e., copper sulfate and

ferrous sulfate were used to dye the cotton fabric in the ratio of 1:1, 1:3, 3:1. A different mordanting technique which included pre mordanting, simultaneous and post mordanting was used to obtain various types of shades from the pomegranate dye.

Walnut husk: The walnut tree is its well-known member constituting an important species of deciduous trees found in temperate areas and cultivated in southern Europe, North Africa, Eastern Asia, The United States and Western South America. Mirjalili and Karimi[14] studied the extraction and characterization of natural dye from walnut shells. The natural dye was used on the polyamide fabric with different alum, cupric sulfate and ferric sulfate mordants. The dyeing was performed at slightly acidic medium for 60 min at 100°C. The antibacterial activity of the dyed fabrics was analyzed by AATCC test method 100-1999 against *S. aureus* and *E. coli.* The study revealed that in addition to colour, the presence of phenolic and naphthoquinone compounds present in the walnut imparted antimicrobial finishing to the fabric.

PROBLEMS ASSOCIATED WITH NATURAL DYES-AN INDUSTRIAL POINT OF VIEW

Some of the major problems associated with the natural dyeing industries are as follows. While taking the agro wastes for commercial dye production, the below issues may be taken into consideration.

Poor dye yield: Unlike synthetic dyes, the natural dyes are having poor dye yield. The yield is calculated as follows. The pre-cleaned dye source is boiled in the aqueous medium and after extraction, the water is allowed to evaporate, by keeping in an oven. The weight of the powdered remnant is taken. The yield is calculated on the weight of raw dye source and expressed in percentage. The yield of the dye may vary depending upon the method of extraction, the temperature of extraction and the solvent used. The actual dye yield from the natural dyes varies source to source and is reported 5-30%, depending upon the process and dye source.

Availability and collection of raw materials: The raw materials availability is an important factor. As stated earlier, since the actual dye yield of the natural dyes is very less in comparison with synthetic dyes, a huge amount of dyes may be required to produce dark shades in bulk scale. For example, if the capacity of the dyeing machine is 20 kg, to produce 100% shade, 20 kg of raw dye may be required. Sometimes, whilst the raw material may be available in huge quantities, the collection of raw material may be an important concern, because the raw material may be available in scattered areas. The collection and transportation may cost a lot of manpower and effort.

Cost: The prime focus of a business is to earn money. So the cost of production is an important criterion. The dyer should prefer the dyes which are abundantly available at low cost, same time gives better colour yield. If the selected dye source can have a good affinity towards the fibre, the cost of mordanting can be reduced.

Affinity and fastness properties: Most of the natural dyes are good affinity towards protein fibres like wool and silk, but poor affinity with cellulosic fibre[15]. The affinity and fastness properties of the dyes can be enhanced by proper mordant and mordanting technique. The fastness properties of the natural dyes are directly proportional to dye affinity. However, the poor light fastness of the natural dyes is still a researchable issue.

Poor colour reproducibility: Natural dyes are originated from agricultural resources. The colour of the dye will be highly influenced by the area of cultivation, climatic conditions, soil and plant breed/variety. Thus the same dye source procured from different markets may give various shades after dyeing because of the above said factors. Sometimes this causes problem to the dyer while matching the shade in dyeing industries.

Marketing: Natural dyed fabric and garments are not available plenty in the market. They have selected customer preference and highly customized market. The price of the naturally dyed garment is at least 5-10 times that of the synthetic dyed garment.

Storage: One of the important concerns in using the agro residue is related to its storage. Agro residues are well prone to the attack of microorganisms and will start to decompose within a short period of time. So it is important to convert the agro wastes into suitable form at the earliest. Generally, they are dried under the shade to remove the moisture content and thus can be stored for a long time.

SCOPE OF INDUSTRIAL AGRO PROCESSING RESIDUES IN DYEING INDUSTRIES

Physical, mechanical and chemical properties of various agricultural or agro based industries waste make it a dynamic resource to be in various applications. Using the suitability of these properties will not only help in open up a new avenue

Table 2: Break-even analysis

Cost description	Fixed costs (Rs)
Fixed cost	
Winch fabrication	100,000
Lab glass wares	3,000
Cutting machine	7,000
Stitching machine	5,000
Heating mantle	3,000
Utensils	7,000
Water tank	5,000
Total	13,0000
Running cost	
Cotton fabric at 300/-	120,000
Dye at 30/-	18,000
Enzymes at1000/-	60,000
Other Chemicals/Items	6,000
Buttons/Elastic at 10/-	4,000
Care Labels at 20/-	16,000
Packing	10,0000
Fire Wood	5,000
Technical 1 person at 25000/-	20000
Manager 1 person at 20000/-	25,000
Labour 2 person at 500/-	30,000
Stitching charges at 20/-	80,000
Repairs and maintenance	4,000
Advertising	3,000
Car, delivery and travel	10,000
Rent	10,000
Utilities (water/LPG Etc)	5,000
Insurance	5,000
GST at 5%	120,000
Electricity	35,000
Bank interest	10,000
Miscellaneous expenses	15,000
Total	700,000

Break-even calculations were made for 30 kg dyeing production/day for 25 days, stitching charges were calculated on knitted undergarments

avenue for these fibers, dyes or any other product but also emphasize the importance of agricultural waste as future material. Agricultural waste materials are economical and eco-friendly due to its unique composition, abundance, degradability, cost-effectiveness and efficiency. The major advantages of agro wastes as a source of the dye are:

- Easily available
- Cheap in price
- Huge in quantity
- Reduces disposal problem of agro processing industries
- Additional income to farmers and processing industries
- Rural employment
- Eco-friendly
- No need to cultivate, getting as a by-product
- Avoiding deforestation

Cost analysis for the natural dyeing and garment unit: Based on the above facts, a study was performed to find out the actual cost involved for setting up a small scale industry for natural dyeing and garments. The Break even analysis details are shown in the Table 2.

CONCLUSION

The utilization of agro wastes for the natural dyeing is still an under-exploited area. Agro residues are abundantly available at cheap price. Many agro wastes like pomegranate rind, walnut husk, etc., are already found commercial applications. The research is still going on the feasibility of the extraction of the dyes from the unidentified sources. The developed counties are encouraging the policies of reduce, recycle and reuses. In this aspect, there is a warm welcome for these agro wastes dyes in western counties. The dyeing with agro wastes are quite ecofriendly in nature and doesn't cost much man-power, thus ideal for small scale and medium scale industries.

SIGNIFICANCE STATEMENT

This study reveals the potentiality of agro-wastes as a source of natural dyes for textile application. The increase in the health conscious and raising environmental pollutions from textile industries is the governing factors for the re-introduction of natural dyes. Many research works has been performed on natural dyes, however, most of the dyes are not abundant in nature, creates the issues related to bulk scale of dyeing. Thus, the present paper deals with the scope of agro-wastes, which are abundant and having sufficient colour yield also. The study especially will help the rural entrepreneurs for setting up a small scale dyeing unit.

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