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Colouring Properties of Plant Pigments on Fabric: Survey on Preference for Antimicrobial Naturally Dyed Mask.

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Abstract

Synthetic dyes have high fastness property and are stable under diverse conditions but over time it is seen that they are toxic to the environment and some are carcinogenic. Dyes derived from natural sources like tartrazine, cochineal red and sunset yellow may cause allergies when used alone or in a combination. Some of the colourants that had been approved by the Food and Drug Administration for use in various industries like food, pharmaceuticals, cosmetics are found to promote cancer. The purpose of the present study is to extract natural dyes from peel of fruits and vegetables, flowers and study the effect of different mordanting techniques (pre-mordanting, simultaneous mordanting, post-mordanting) on dyeing, The extracts were applied as direct dyes in the presence of mordants. Dyeing of cotton cloth was performed using extracts of Pomegranate peel (*Punica granatum*), Orange peel (*Citrus sinensis*), Marigold flowers (*Tagetes erecta*), Kidney bean seed coat (*Phaseolus vulgaris).* Colour strength, shade and fastness properties of the dyes have been tested. In pre and post mordanting, colour change was observed in Marigold and Pomegranate. In simultaneous mordanting, colour change was seen in Marigold, Pomegranate, Orange peel and Kidney bean. The obtained results have shown the dyeing potential of organic wastes as a source for cotton dyeing. Using waste as a source of natural dyes will help in reducing the environmental pollution. Our studies on market research for demand led us to the conclusion that there is demand for comfortable environmental friendly mask having increased functional properties.

Keywords Natural dyes; Mordanting; cotton cloth; antimicrobial properties

Introduction

Synthetic dyes have better colour fastness property, less expensive and requires small amounts to colour the substrate (1). They are used in every field from textile, paper, food, pharmaceutical, tattoos and plastics. Despite the advantages of synthetic dyes it is a fact that they are harmful for the environment and cannot be degraded easily. These dyes are mutagenic and carcinogenic to the human population and have the tendency to get accumulated in the environment and form a recalcitrant compound. Textile effluent discharge contains harmful synthetic dyes which are polluting the water system and some of the dye products are carcinogenic For example benzidine dyes cause bowel cancer (1,2) Some dyes like tartrazine, cochineal red and sunset yellow may cause allergies when used alone or in a combination. Some of the colourants that had been approved by the Food and Drug Administration for use in various industries like food pharmaceuticals, cosmetics are found to promote cancer. Dyes derived from natural sources have emerged as an important alternative to potentially harmful synthetic colours. and their demand is ever increasing because of their eco-friendly, non-toxic properties.

Natural bio-colourants that are in use from ancient times include the roots of madder *Rubia tinctoria*,the rhizome of *Rheum emodi* and *Curcuma longa* insects like *Lacifer lacca,* Dactylopius coccus (3). Egyptian cuneiform texts were dyed with bio-colourants like Madder, Murex sp.,Indigofera etc,(4,5). Natural dyes have poor reproducibility, inadequate fixation, limited shades, blending problems and low colour fastness and require a mordant to overcome this problem (3). Fixation of natural dyes on fabric is done with the help of mordanting agents. Different types of mordanting agents are present like metallic mordant (potassium dichromate, ferrous sulphate), tannins, tannic acid and oil mordants. Mordanting agents are basically heavy metal salts because they have free outermost orbital and easily form bond between dye and fabric (6). The mordanting process can be done in three ways: pre-mordanting, simultaneous mordanting and post-mordanting (7). Alum, chrome, stannous chloride, copper sulphate, ferrous sulphate etc. are the commonly used mordants (8).

Natural dyes can be extracted from the plant sources such as orange peel (9), pomegranate peel(10), almond shell (11), gallnut (12), *Hibiscus mutabilis (13)*, madder (14). *Bixa orellana*, commonly called annatto is a natural dye yielding plant native to Central and South America. Yellow-orange colour dye is isolated from the seeds of annatto which has high biodegradability, low toxicity, and is environment friendly. Annatto seeds majorly contain bixin, nor-bixin and other less important cryptoxanthin, lutein, zeaxanthin, and methylbixin (15). Bixin is the main colouring compound present in the annatto seeds with two carboxylic groups in its structure, out of which one is esterified and responsible for more than 80% of the total pigment (16,17). *Punica granatum* (Pomegranate) is from the family *Punicaceae.* and it grows in all warm countries of the world and was originally a native of Persia (8). The rind of pomegranate contains a considerable amount of tannin, about 19% with pellitorine (18,19). The main colouring agent in the pomegranate peel is grenadine which is present in the alkaloid form N-methyl granatonine (20). Adzuki bean is used to prepare many kinds of foods in east Asia, and the seed coat contains water-soluble anthocyanins, catechins, and flavones (21).

Increasing health awareness around the globe is creating a demand for antimicrobial textiles. Growth of microorganisms can damage the textile material and produce an unpleasant odour, allergies, and infections. To prevent these effects, textiles are being

treated with antimicrobial agents (22). In recent years, natural antimicrobial agents for the development of functional fabrics with antimicrobial properties are being explored (23). Chitosan is an amino polysaccharide used in the textile finishing process as a functional agent to develop insect repellent, UV protection, water resistant properties and provides antimicrobial textile surface. (24). Studies show that cotton, silk, and wool fabrics exhibit antimicrobial activity against *Staphylococuus aureus* and *Klebsella pneumonia* when dyed with the extracts of pomegranate peels. Some dyes naturally exhibit the antimicrobial activity due to the presence of bioactive phytochemicals eg. curcumin from turmeric, naphthoquinones like lawsone from Lawsonia inermis, juglone from walnut, catechin from Acacia (25).

Acacia catechu, Acacia nilotica (family Fabaceae) (26), Azadirachta indica (family Meliaceae) are common medicinal plants of India. and belongs to the family Meliaceae. The phenolic compounds and flavonoids present in neem have antimicrobial activity and have the ability to inhibit the growth of Gram-positive and Gram-negative bacteria (27,28). Natural dyes are now used in the sportswear and medicinal fields due to their antimicrobial and UV protection properties (27).

The objective of the present study is to extract natural dyes from Pomegranate peel (*Punica granatum*), Orange peel (*Citrus sinensis*), Marigold flowers (*Tagetes erecta*), Kidney bean seed coat (*Phaseolus vulgaris)* and study the effect of different mordanting techniques (pre-mordanting, simultaneous mordanting, post-mordanting) on dyeing*;* Novel techniques have been used for extraction of pigments lately like solid-liquid, dynamic superheated liquid extraction, ultrasonic and pulse electric fields techniques and their efficiency and suitability.

Keeping in mind the current Covid- 19 pandemic and increasing demand for masks a survey in form of a questionnaire was given to understand the customer preference to buy masks with antimicrobial properties.

Materials and Method

Plant material

The raw material was collected from various places. Fruit peels were collected from the juice vendors and the waste which is generated through our homes . Residual flowers and garlands were collected from various sites such as temples, gardens, and households.

Pigment extraction

The collected plant material was washed in water, sundried, powdered and stored in air -tight glass bottles at room temperature till further use. The pigment was extracted by Solvent extraction method at room temperature using ethanol in a 1:1 and 1:2 ratio, kept in a shaker for 24 hours at 90 rpm /min. Residue was filtered using two layers of muslin cloth and the filtrate was collected and dried in a rotavapor.

Scouring of Cotton Cloth

The cotton cloth which was meant to be dyed was cut in equal sizes after washing in a solution containing 0.5g/lit Sodium carbonate; 2g/lit nonionic detergent (Tween 80) at 50°C for 25 mins, in a shaker at 130 rpm/ min keeping the fabric to liquor ratio at 1:40. The scoured cotton was thoroughly washed with tap water and dried at room temperature. The scoured cloth was soaked in clean water for 30 mins before dyeing

Mordanting and Dyeing

The dyes extracted from various sources were used for dyeing of scoured cotton cloth using two mordants: copper sulphate and ferrous sulphate in the ratio 1:1 (20 grams of copper sulphate and 20 grams of ferrous sulphate were added in 1000 ml of distilled water), 1:3 (20 grams of copper sulphate and 60 grams of ferrous sulphate were added in 1000 ml of distilled water), 3:1 (60 grams of copper sulphate and 20 grams of ferrous sulphate were added in 1000 ml of distilled water). Dyeing along with mordanting techniques includes pre-mordanting, simultaneous mordanting and post-mordanting. For pre- mordanting, 12 test tubes were taken and labelled with cloth pieces inside them. The test tubes were labelled A, B and C. 40 ml of each mordant solution was put in separate test tubes. The test tubes were then heated at 80°C for 60 minutes and then left to cool. Then, the cloth was dipped in 2 ml of dye and left to dry on blotting paper. For simultaneous mordanting, after labelling the test tubes, the cloth was dyed in 2 ml of dye and then simultaneously the mordant solution was added to each and heated at 80°C for 60 minutes. Cloth piece was taken out and left it to dry on a blotting paper. For post-mordanting, dyed cloth in extracted pigment was followed by heating at 80°C for 60 minutes. After cooling it the mordant solutions were added to these cloth pieces and kept for 1 hour. The cloth was dried on a blotting paper. All colours attained were visually observed.

Results and Discussion

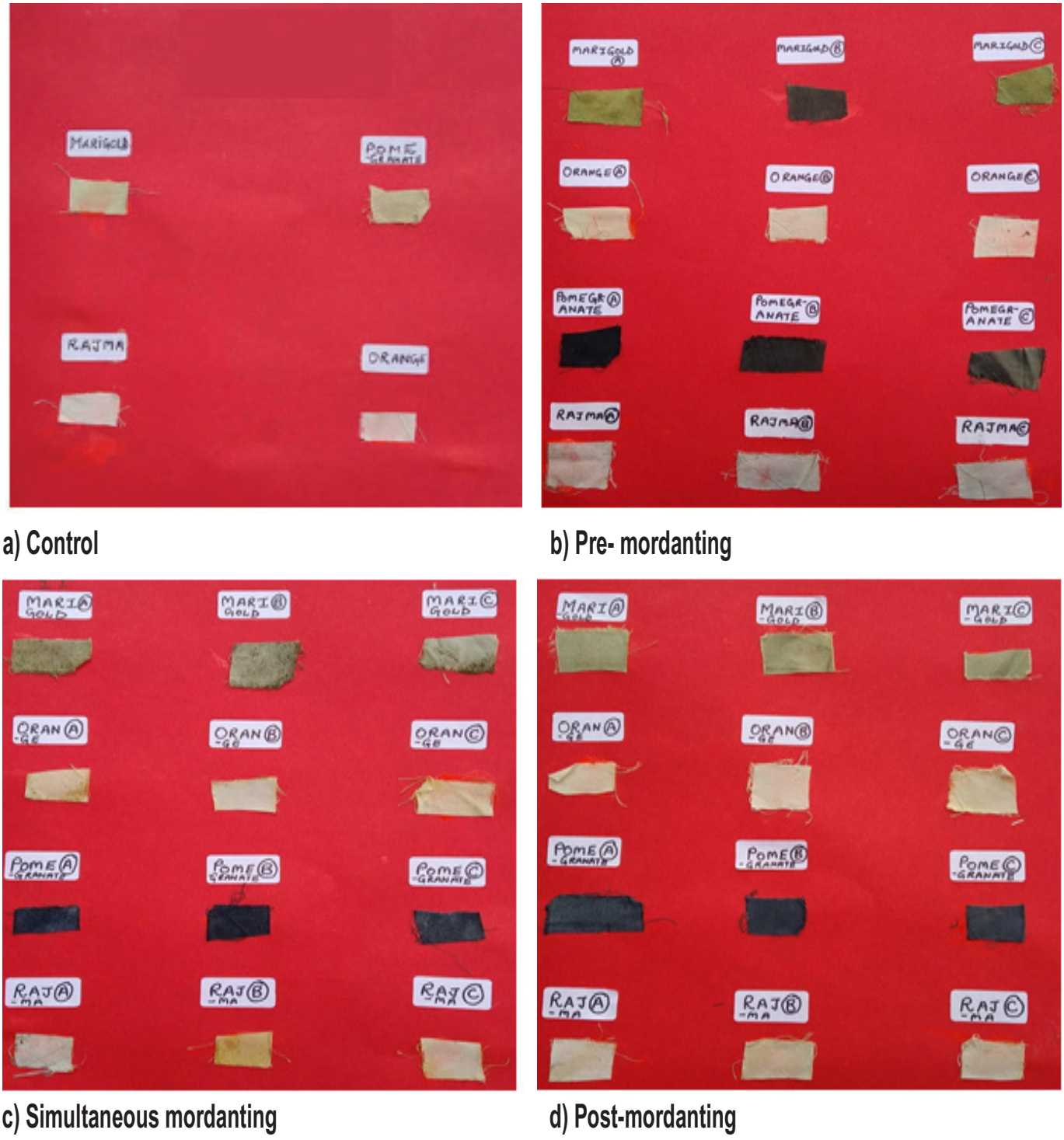
Different colours were obtained on the cotton fabric when extracts of Marigold, pomegranate, Kidney bean, orange were applied on the cloth. The colour variation observed was due to mordanting methods. In dyeing the cotton fabrics mordants were applied on the fabrics using pre-mordanting, simultaneous mordanting and post mordanting methods separately. In pre and post mordanting, colour change was observed in Marigold and Pomegranate. In simultaneous *mordanting,* colour change was seen with Pomegranate peel (*Punica granatum*), Orange peel (*Citrus sinensis*), Marigold flowers (*Tagetes erecta*), Kidney bean seed coat (*Phaseolus vulgaris*) as shown in Table 1 and Figure 1. Pre-mordanting is preferred in case of Marigold derived pigments whereas for Kidney bean similtaneous mordanting can be preferred.

Data collected during a Market survey (100 people) conducted by us showed that 65% of consumers preferred wearing antimicrobial masks as shown in Fig 2 and Fig 3.Consumers showed their preference for comfort as well as increased functional properties of their masks which will also prevent microbial infection

Adding a layer of smart fabric that is dyed with natural dyes, along with antimicrobial properties if sold at an economical price will be beneficial for both user and environment. Consumers today are aware of the requirement for leading a hygienic lifestyle also there is a necessity and expectation for the production of a wide range of finished textile products with antimicrobial properties.

Conclusion

The whole process of extraction and dyeing is environmentally friendly and does not harm the natural balance of the environment



a) Control

b) Pre- mordanting

c) Simultaneous mordanting

d) Post-mordanting

Figure 1: Colour changes seen after pre-mordanting, semi- mordanting and post -mordanting with pigments isolated from the plant waste material a) control; b) pre-mordanting technique; c) simultaneous- mordanting technique; d) post-mordanting technique. Pre-mordanting is preferred in case of Marigold derived pigments whereas for kidney beans simultaneous- mordanting can be a preferred technique (A,B,C indicate 1:1 (20 grams of copper sulphate and 20 grams of ferrous sulphate were added in 1000 ml of distilled water), 1:3 (20 grams of copper sulphate and 60 grams of ferrous sulphate were added in 1000 ml of distilled water), 3:1 (60 grams of copper sulphate and 20 grams of ferrous sulphate were added in 1000 ml of distilled water)

In addition, it provides for economic gains from waste. The obtained results have shown the dyeing potential of organic wastes as a source for cotton dyeing. Good fastness exhibited by the dyed clothes is because of the mordants used. Textiles have always played a central role in human culture evolution by being at the forefront of both technological and artistic development. The protective aspect of textiles has always been a priority and has led to innovative developments. Textile material is the best place for the growth of Microorganisms can easily grow on textile material which can damage the material and produce an unpleasant odour, allergies, and infections. To alleviate these problems' textiles are being treated with antimicrobial agents post dyeing. Chitosan, and extracts of

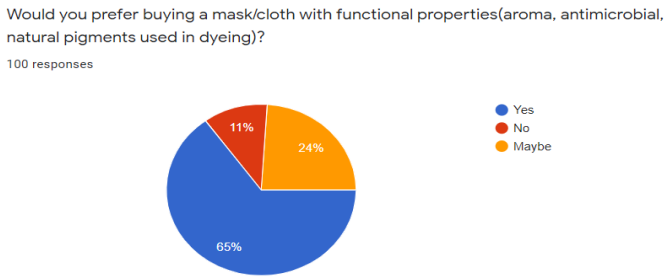


Figure 2: Users preferences on buying a mask with functional properties such as use of natural pigments for dyeing and antimicrobial activity,

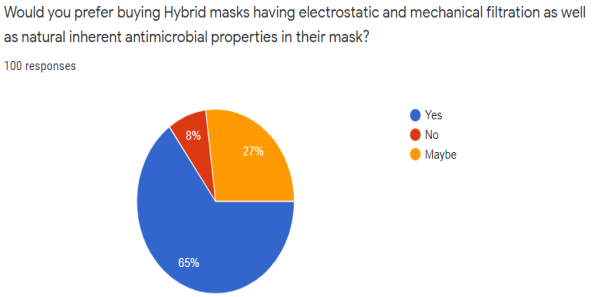


Figure 3: Users preferences on buying a hybrid mask with electro-static and mechanical filtration as well as antimicrobial property.

Table1: Dyeing of cotton cloth with different mordanting techniques

Extract	Control	Pre-mordanting			Simultaneous mordanting			Post-mordanting		
		Color of A (1:1)	Color of B (1:3)	Color of C (3:1)	Color of A (1:1)	Color of B (1:3)	Color of C (3:1)	Color of A (1:1)	Color of B (1:3)	Color of C (3:1)
Marigold	Light yellow	Green	Dark green	Green	Green	Green	Green	Green	Green	Green
Orange	White	Light yellow	Light yellow	Light yellow	Yellow	Yellow	Yellow	No change	No change	No change
Pomegranate	Light yellow	Black	Black	Black	Royal blue	Royal blue	Royal blue	Royal blue	Royal blue	Royal blue
Rajma	White	No change	No change	No change	No change	Yellow	Light Yellow	No change	No change	No change

pomegranate, neem and turmeric are some of the promising natural dyes with antimicrobial properties.

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