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Comparative Study of the Effect of Mordants on Dyeing Cotton Fabric with *Anacardium Occidentale's* (Cashew) Root Grown in Ankpa, Kogi, Nigeria

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Abstract

Pollution associated with synthetic dyes have caused several health hazards both to human and the environment. In order to curb this trend, especially from industrial effluents, a non – toxic, biodegradable and environmentally compatible dye from nature have to be sourced. In view of these, the root of *anacardium occidentale* was extracted of its dye and applied on fabrics alone and in the presence of mordants and also applied as colorant on food, cosmetics and alcoholic drinks. The root of *anacardium occidantale* collected was dried at room temperature and pulverized. 200g was weighed and extracted in 300mL absolute ethanol. Alum, $K_2Cr_2O_7$ and $FeSO_4$ were the fixatives used. Pre – mordanting, Post – mordanting and Simultaneous mordanting methods were adopted. Varied color hue was imparted on the fabrics and their fastness properties were tested. Alum mordant showed superiority to fastness in simultaneous mordanting in wash with mild soap and fastness to light. Pre – mordanted method showed $K_2Cr_2O_7$ mordant to retain color in both wash in mild soap and fastness to light. $FeSO_4$ mordant retained its color in simultaneous mordanting method across the fastness test displaying superiority over the rest mordant. An excellent color was imparted on food, cosmetic and alcoholic drink. They colors imparted on the substrates are distinct and promising and shows that the root of *anacardium occidandale* could be of significance in textile, printing and coloration industries.

Keywords: *Anacardium occidentale*, mordant, fabric and dyeing.

Introduction

Anacardium occidentale belongs to the family *anacardiaea* and order sapindale. It is commonly known as cashew. The tree is large and evergreen growing to 14 m with a short irregularly shaped trunk. The leaves are

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spirally arranged, leathery texture, elliptic to obviate, 4 – 22 cm long and 2 – 15 cm broad with smooth margins. The flowers are produced in a panicle up to 26 cm long, each flower is small, pale green at first then turning reddish with five slender acute petals, 7 – 15 cm long. the seed is kidney or boxing glove shaped, which is often considered as nut in the culinary, (Morton, 1987).

The *anacardium occidantale* plant was not considered of any importance in decade past, aside the editable fruit which produces succulent juice when ripe. The apples of *anacardium occidantale* were only seen as indicator of ripeness and useless, not knowing its importance as antioxidant, anti-inflammatory and as wound healer. Its health benefits were stated to include weight loss, improve eye health, immune booster, improve gastrointestinal condition, promote muscular disorder and healthy heart amongst other (weight management, 2020). Research have shown *anacardium occidentale* parts to be useful in diverse area. The seed is use in food industry as cashew nut snack, cashew butter, cashew milk and cashew cheese. The seed is traditionally used as medicine to treat diarrhea, dysentery and fever. The cosmetic industry uses the seed oil as moisturizers and emollient and in hair care product to promote and prevent hair loss. The cashew nut shell liquid (CNSL) is use as fuel source in boilers and furnaces and also use in the production of synthetic resins, coatings and adhesives (Babu & Rostogi, 2013).

Dyeing of fabrics and coloration of other substrates as food, alcoholic drinks and cosmetic using natural plants have become pertinent owning to the fact that synthetic dyes are hazardous to both human and the environment. In view of these, the return to nature have been advocated by several scholars in recent time as natural plants are eco – friendly, biodegradable and environmentally compatible. These facts have thrown scholars into search for more plants that contain not only medicinal component but also dyes / colorant that can serve as substitute to synthetic ones.

Color has always fascinated mankind in several ways. It could be produced synthetically or naturally from plants (Key 2016; Edward & Stothers, n. y). Before the advent of synthetic dye natural dye was the dye in use. It was obtained from plants parts like the bark, leaves, stem, fruit, roots etc. The need to extract dye from natural sources is to

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avoid or reduce environmental pollution. The effluents problems of synthetic dyes occur not only during their application in the industries, but also during their manufacture and possibly during the synthesis of their intermediates and other raw materials (Geetha & Judia, 2013). The coming of synthetic dyes diminished the use and economic influence of natural dyes because they have better color reproducibility than natural dyes but it came with lots of hazards. It is known to cause health effect linked to cancer and allergies, hyperactivity, learning impairment, irritability and aggressiveness in children. The toxin deposited on skin by synthetic dyes greatly increase the risk of sensitivity and irritation, these toxins could block pores on the skin and could lead to a greater acne, they toxins are also associated with thyroid, kidney and tumor conditions as well as allergic reactions (Milton & Stokes 2010; Christina 2020). Hence, the need for its substitution with natural plant.

Natural plants have the advantage of minimal environmental impact as they are bio - degradable, safe and renewable; their colors payoff as soft hue or soothing shade. Uma (2019) explained that color produced by natural dyes are vibrant, biodegradable, non – toxic and non – allergic; the scholar also added that natural dyes neither contain harmful chemicals nor carcinogenic components common to synthetic dyes and that their usage will help preserve the environment and lower human dependence on harmful products. The scholar further reveals that "natural dyes provide higher U/V absorption in fabrics and that the use of naturally dyed fabrics will fully protects the skin from the harmful rays of the sun. Natural plant contains medicinal value which make them more important when use as colorant on food, cosmetic and alcoholic drink. Padma (2000) opined that as search moves towards overcoming the limitation of synthetic dyes; natural eco – friendly dyes / colorant should be welcome back. *Anacardium occidentale* parts; especially the nut has its industrial importance well explored; this could explain the rush during its fruiting season in the research area and it environ by both local and foreign investors. The coloration potential of some parts of *anacardium occidandale* is established by some scholars. According to Siavash (2012), the extract of the leaves of *anacardium occidandale* was found to produce a dark greenish color during the production of cosmetic product, this was not the scholar's

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desired color and had to decolorize the product with activated carbon granule tea bag system, however, his affirmation of the greenish color on the products tells the color / dye potentials of the leave as good colorants. Also, a concentrated and purified extract of carotenoid obtained after processing juice from the fruit of *anacardium occidandale* fruit was found to produce color of great interest in the food industry that could serve as replacement to artificial colors, this perspective has opened *anacardium occidentale* production chain with great value in food and color industries (Lavoura, 2012). Aside the nut much have not been explored on the dyestuff potential of the other parts of the plant especially the root. Benson *et al*., (2022) extracted dye from *anacardium occidentale* nut shell waste and applied on a fabric in the presence of mordants; their findings show $FeSO_4$ mordant to provide the best fastness in wash and in light. In an application of cashew nut peel as dye conducted byTusharhala *et al*., (2023) in the presence of mordants; $CuSO_4$, alum and $FeSO_4$ mordants displayed good to excellent washing fastness with $CuSO_4$ and $FeSO_4$ recommended for application on silk as they produced better fastness characteristic in light. Lutamyo *et al*., (2022) obtained anacardic acid from cashew nut shell liquid (CNSL) and used as dye on cotton and polyester fabrics, from their findings, they assert that both fabrics demonstrated good wash fastness. In the light to exploy the full potential of the *ancardium occidentale* parts as dye, this work extracts dye / colorant from the root and use to dye fabrics and color food, cosmetic and alcoholic drink.

Materials and Methods

The root of *anacardium occidentale* was used to dye cotton fabrics and color starchy food, illicit gin and petroleum jelly. Absolute ethanol was the solvent for extraction. Iron (II) sulphate ($FeSO_4$), alum and potassium dichromate ($K_2Cr_2O_7$) were the mordants used as fixatives.

Plant collection and preparation

The root of *anacardium occidentale* was obtained in Ankpa, Kogi, Nigeria and was identified and authenticated by a Botanist in Kogi State University, Anyigba and stored in the Department of Biology of our institution. The root of *anacardium occidentale* collected was chopped into tiny pieces; dried at room temperature and pulverized to fine particle size for most intimate contact with the absolute ethanol. The pulverized sample, 200g was

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weighed and extracted in 500mL absolute ethanol, the mixture was allowed to stand for 2 weeks for proper extraction after which the mixture was filtered and the solute obtained sacrificially, it was dried at room temperature, weighed and stored (Leonard *et al*., 2022).

Preparation of dye solution

The plant extract, 1g was weighed into 250 mL beaker and water was added to make it to paste after which it was made up to 100 mL at 50^{o}C.

Preparation of dye bath

From the dye solution, 25 mL was measured into a 250 mL beaker and was made up to 100 mL.

Preparation of mordants

Each mordant, 2g was weighed and dissolved in 100 mL of water.

Preparation of fabrics

The fabrics to be dyed was scoured in a detergent to remove any form of interference prior to dyeing. This process allows proper dye penetration on the fiber of the fabrics (Sharma, 2011)

Dyeing processes

Crude dyeing.

The dye bath solution, 100 mL was heated to 60^{o}C; the scoured fabrics (2g) was immersed in it and dyed for 30min. it was then removed and air oxidized for 10min, rinsed in cool water to remove any undissolved particle that may have adhered to the fabrics and then air dried (Otutu *et al*., 2010).

Pre – mordanting

The mordant solution, 100 mL was measured and heated to 60^{o}C; 2g of the scoured fabrics was introduced into it and heated for 30 minutes, it was then transferred into the dye bath at 60^{o}C and dyed for 30 minutes. the fabrics was then removed, air dried for 10 minutes, rinsed in cold water and air dried.

Simultaneous mordanting

To the 100 mL dye bath; 2g of the mordant was weighed and properly dissolved. The solution was heated to 60^{o}C and the scoured fabrics was immersed and dyed for 30 minutes; the fabrics was then removed, air oxidized for 10 minutes, rinsed in cold water and then air dried.

Post – mordanting

The scoured fabrics, 2g was immersed into 100 mL dye bath at 60^{o}C and was dyed for 30 minutes. it was then transferred into a 100 mL solution of the mordant at 60^{o}C and mordanted for 30 minutes, it was removed, air oxidized for 10 minutes, rinsed in cold water and then air dried.

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Fastness properties

The fastness tests were demonstrated as described by Otutu *et al*., (2010).

Light fastness

A set of the dyed fabrics was expose to sunlight for a week while the second set was kept in dark wrapped in polyethene and kept away from sunlight for the same period of time. Both sets were rated on the grey scale.

Wash fastness

A set of the dyed fabrics was washed in mild soap and the second set was washed with detergent and air dried at room temperature. The washed fabrics were compared with the unwashed one on a grey scale.

Coloration

The coloration methods employed is as described by Otutu *et al*., (2010).

Food Coloration

The starch, 100g was weighed and dissolved in H_2O. 2g of the dye sample was weighed into a glass beaker, water was then added to make it up to 200 mL at 60°C with continuous stirring. The dye solution was heated until it boils. The boiling dye solution was poured into the starch solution in a 500 mL beaker and the mixture was stirred vigorously until a uniform molten meal was obtained.

Cosmetic Coloration:

Petroleum jelly, 100g was weighed and melted. 2g of the dye sample was weighed into a test tube and was dissolved using ethyl alcohol, the dissolved dye was introduced into the melted petroleum jelly and the mixture was heated to 80°C for an even mixture of the dye molecule.

Alcoholic drink coloration:

The dye sample, 2g was weighed into a glass bottle. 100 mL of illicit gin was measured into the glass bottle and corked. The mixture was vigorously shaken for 10 minutes until a homogeneous mixture was obtained

Results and Discussion

Table 3.1 preliminary results

Plant	Color of extract	Color in aq. solution	$Wtp_{(g)}$	$Wte_{(g)}$	% yield	Solubility cold H_2O	warm H_2O

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Root of *Anacardium Occidentale*	Dark Brown	Dark Brown	200	13.5	6.6	Soluble	Soluble

Wtp = weight pulverized, Wte = weight extracted

Table 3.2. color hue and the fastness properties of the various mordanted method

Unmordanted/ mordants	dyeing methods	colors imparted	LF	WMS	WDER
Unmordanted		pink	4	2	5
Alum	Pre – mordanting	light pink	2	1	4
	Post – mordanting	light pink	3	1	4
	Simultaneous – mordanting	light pink	5	2	5
$K_2Cr_2O_7$	pre – mordanting	off white	5	4	5
	Post – mordating	brown	4	3	5
	Simultaneous – mordanting	light pink	4	4	4
$FeSO_4$	Pre – mordanting	ash	3	2	4
	Post – mordanting	ash	4	3	5

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Key: 1 = poor fastness, 2 = fair fastness, 3 = good fastness, 4 = very good fastness, 5 = excellent fastness

WMS = wash in mild soap, WDER = wash in detergent, LF = light fastness

Table 3.3 Color imparted on substrates

Sample	Substrates	Color imparted
Root of *anacardium*	Corn starch	Pinkish – brown
Occidentale	Cosmetics	Light brown
	Illicit gin	Ox-blood

Below is pictorial (histogram) representation of the fastness properties in different processes.

Fig. 3.1 Fastness properties of alum mordant in different mordanting methods

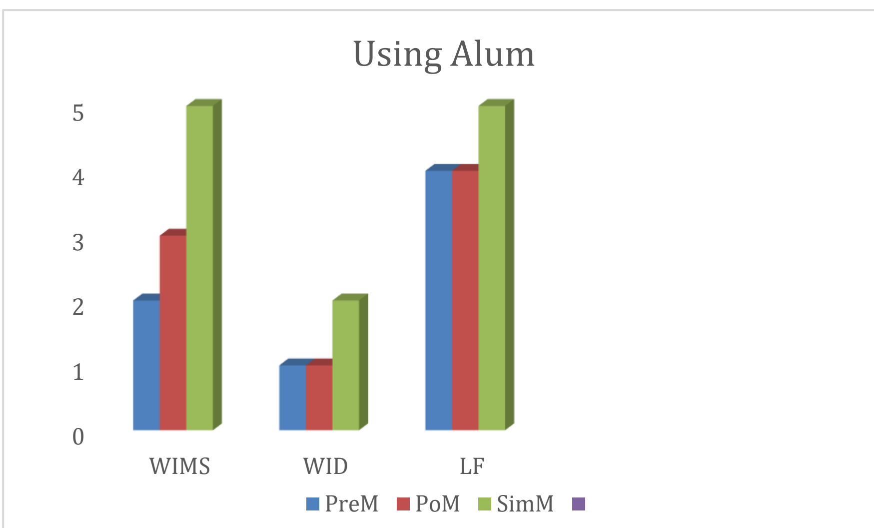

Fig. 3.2 Fastness properties of $K_2Cr_2O_7$ mordant in different mordanting methods

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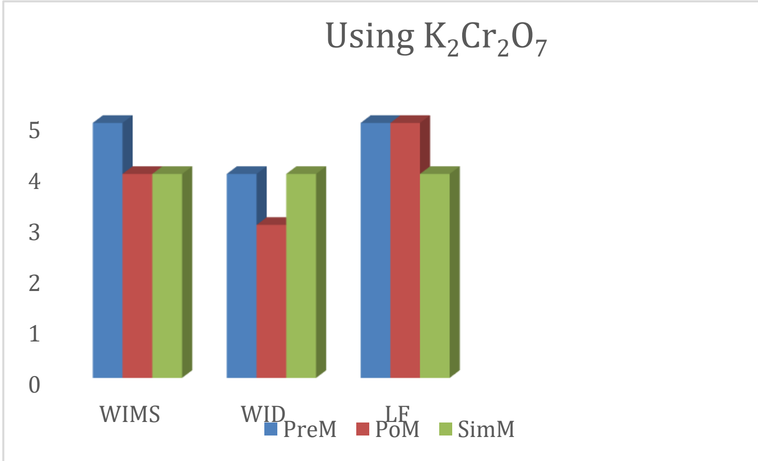

Fig. 3.3 Fastness properties of $FeSO_4$ mordant in different mordanting method

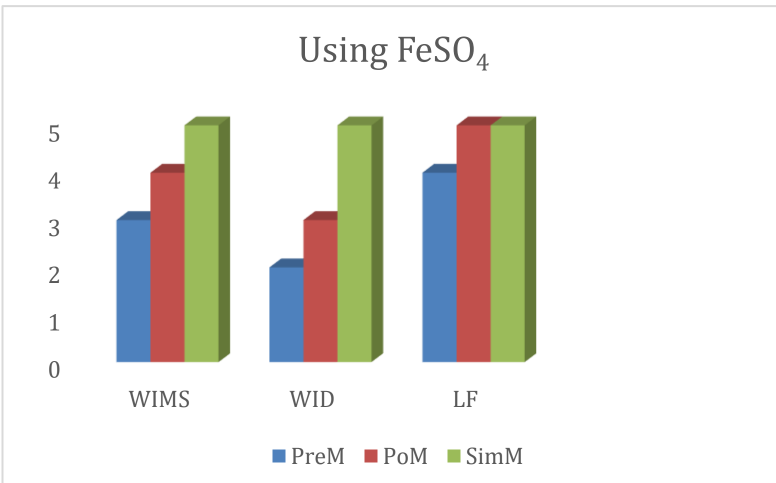

Fig. 3.4 Fastness potential of mordants in mild soap on the different mordanting methods

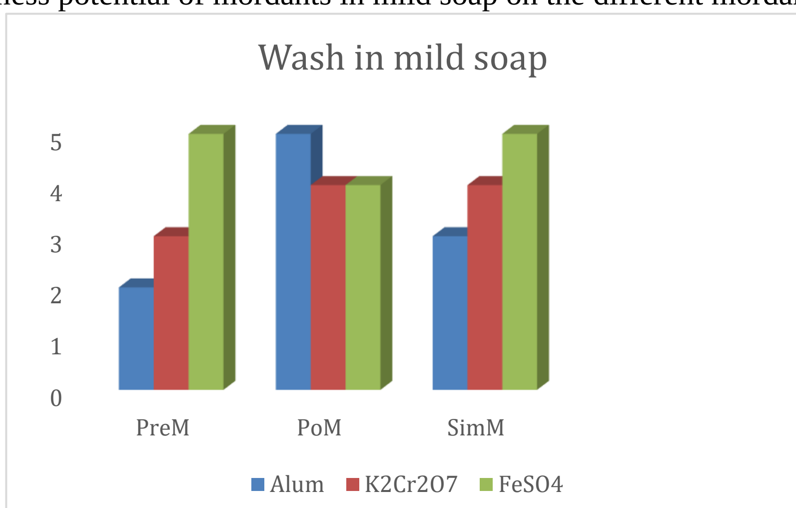

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Fig.3.5 Fastness potentials of the mordants in detergent in the Fastness potential of mordants in wash in detergent on different mordanting methods

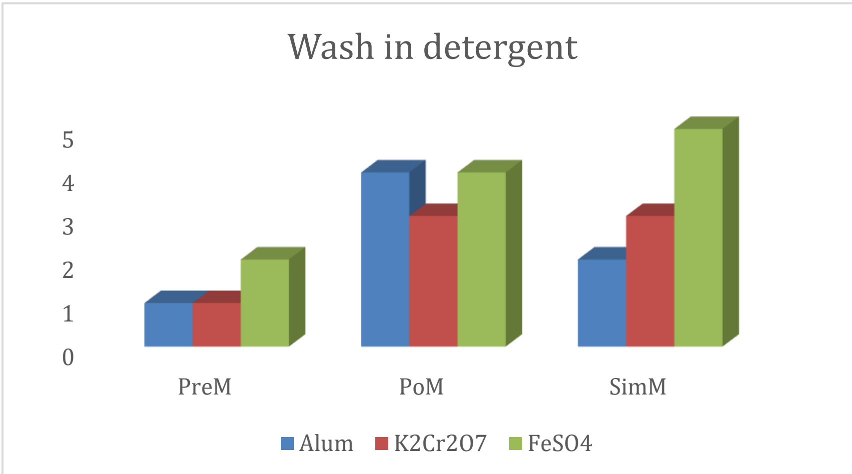
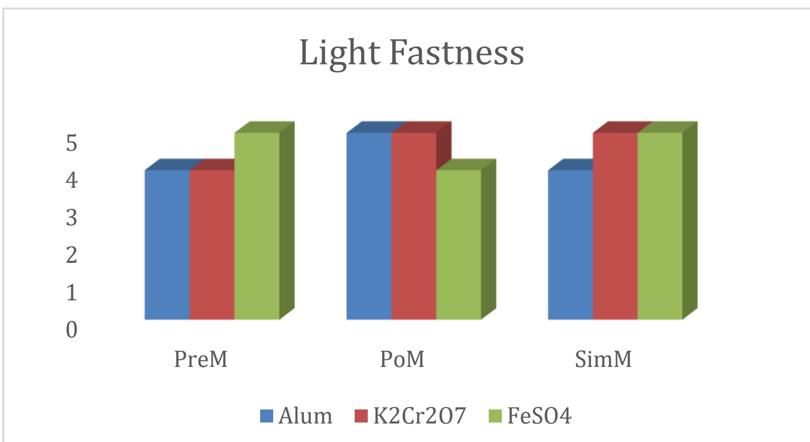


Fig. 3.6 Fastness potential of the modants light in the different methods



Key: WIMS = wash fastness in mild soap; WID = wash fastness in detergent: LF = light fastness

PreM = pre mordanting; PoM = post mordanting; SimM = simultaneous mordanting

Table 1 shows the color of the extract to be dark brown with a poor yield of 6.6%. The extract is soluble in both cold and warm water. Table 2 shows the crude or unmordanted dyed fabrics to be imparted pink color with an excellent light fastness and very good fastness to wash in mild soap and fair fastness to wash in detergent. Alum mordant in pre – mordanting method imparted light pink color on the fabrics with very good

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light fastness, fair fastness in wash in mild soap and poor fastness to wash in detergent. The post mordanting method also imparted light pink color on the fabrics with very good light fastness, good fastness to wash in mild soap and poor fastness to wash in detergent. Alum mordant also imparted light pink color on the fabrics in simultaneous mordanting method with excellent fastness in both light fastness and wash in mild soap and a fair fastness to wash in detergent. The $K_2Cr_2O_7$ mordant displayed an off-white color on the fabrics in pre – mordanting method with excellent fastness to light and wash in mild soap, with a very good fastness to wash in detergent. The post mordanting method imparted brown color on the fabrics with excellent fastness to light, very good fastness to wash in mild soap and a good fastness to wash in detergent. In simultaneous mordanting method, $K_2Cr_2O_7$ shows a light pink color on the fabrics with a very good fastness property across the fastness test. $FeSO_4$ mordant imparted ash color on the fabrics with very good fastness to light, good fastness to wash in mild soap and fair fastness to wash in detergent. In Post mordanting method, $FeSO_4$ also imparted ash color on the fabrics with excellent color fastness to light, very good fastness to wash in mild soap and a good fastness to wash in detergent, in the simultaneous mordanting method, $FeSO_4$ mordant imparted light ash color with an excellent color retention across the fastness test.

Table 3 shows food, cosmetic and alcoholic drink to have been imparted by the plant extract with pinkish brown, light brown and oxblood colors respectively. This color displayed by the plant extract shows the varied color potentials embedded in the plant part.

The result shows simultaneous method of mordanting to display better color adherence and retention by $FeSO_4$ and alum mordant. However, $K_2Cr_2O_7$ mordant showed better fastness in pre – mordanting method. The excellent color retention to light and wash fastness displayed by $FeSO_4$ mordant is in agreement with Benson *et a*l., (2022) in a work in which they evaluated the potential of natural dyes from nutshell waste of cashew; also, in agreement is aresearchconducted in Bhubaneswar India by Tusharbala *et al.*, (2023) on the nut peel of cashew as dye where $FeSO_4$ and alum showed excellent fastness to wash and $FeSO_4$ to light. These results shown by the root of *anacardium occidentale,* though

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with agreement with the nutshell exhibits similar characteristic in term of the great richness in dye and this dye potential need to be economically harnessed by all a sundry in other to expand the usefulness of *anacardium occidentale's* plant.

Conclusion

Natural plants are less harmful, environmentally friendly and biologically degradable and hence the return to nature has become inevitable as synthetic dyes poses serious threat to the users and the environment. This work revealed the root of *anacadium occidantale* to be of importance in dye, color, printing, food, cosmetic, alcoholic drink and textile industries as it produces an appealing and soothing hue on the substrates with mordants improving its fixative properties on fabrics. We encourage its usage by all a sundry as it is safe and will help conserve, preserve and reduce environment pollution as compared to synthetic dyes.

Recommendation

In view of our findings, we recommend the use of this plant part as colorant as it would add value to textile, printing and coloration industries. However, screening and toxicological analysis is recommended for further study especially as it relates to its application to food, cosmetics and alcoholic drinks.

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