ISSN NO: 292-3247 (Print), 2992-3255 (Online) https://cipesjournal@gmail.com

Extraction, Characterization and Usage of Dyes from Mango Rinds

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https://doi.org/10.5281/zenodo.20492369

ABSTRACT

Dyes are substances used to colour fibres and fabrics in everyday applications and are broadly classified as natural or synthetic. Increasing environmental and health concerns associated with synthetic dyes have intensified interest in sustainable, eco-friendly alternatives. This study investigates the extraction, characterization, and application of natural dyes derived from discarded mango rinds, an abundant agricultural waste. Mango rinds were sourced from consumers and fruit vendors in Ogbomoso, then washed, dried, pulverized, and subjected to aqueous and hydrothermal extraction. The resulting dyes were characterized using ultraviolet-visible (UV-Vis) spectroscopy and Fourier Transform Infrared (FTIR) spectroscopy to determine their optical and chemical properties. Dyeing experiments were conducted on cotton and silk fabrics using alum and lime as mordants. The dyed samples were evaluated for colour fastness to water, detergent, and sunlight exposure. Results indicate that mango rinds yield appreciable natural dyes with distinct colour intensities. UV-Vis analysis suggests the dominance of carotenoid pigments, while FTIR confirms the presence of functional groups such as hydroxyl, carbonyl, and nitro compounds. The colour shades varied with mordanting conditions and exhibited moderate to good fastness properties. Cotton fabrics showed better dye retention compared to silk. However, excessive mordant concentration, particularly with alum, adversely affected fabric strength and led to degradation. The study demonstrates that mango rind is a viable, sustainable source of natural dye, contributing to waste valorisation. Further research on purification, large-scale production, and application on diverse substrates is recommended to enhance industrial viability.

Keyword: *Mango rinds (Mangifera Indica), Mordanting, Cotton and Silk fabric, Colour fastness*

1. Introduction

Dye is a substance used to colour fibre and fabrics that are used in day-to-day life. There are two types of dyes, natural and manmade or synthetic dyes. According to Dass *et al.* (2018), dyes with natural sources are usually found in small amounts mixed with other non-dye materials. The synthetic dyes are used since 1856 to dye the fibre and fabric materials due to their superior properties to the naturally extracted substances. (Mokashi *et al*, 2023). However, because of the quality of their dyeing property, the use of natural colorants for dying textile materials has been reintroduced for usage, most especially to circumvent the environmental problems associated with synthetic dyes. (Ayele *et al*, (2020).

Natural dyes are important since they are better than synthetic dyes in many ways. Natural dyes are healthier products, purely because they do not contain chemicals capable of damaging the body system of humans (Chungkrang *et al,* 2021). Natural dyes from plants and other sources could contain more than one chemical constituent, each exhibiting diverse colours and properties operating singly or in a combination with different groups, depending on their functional group (chemical composition and structure). (Ayele *et al*., 2020). On the other hand, during the use of synthetic dyes, a lot of waste and other materials are released into the environment causing health hazards, pollution and disturbing the eco balance. This has led to the substitution of synthetic dyes with natural ones especially those extracted from plants (Onyeson, 2017). For instance, waste mango littering the ground and consequently generating flies and related diseases can be utilized by investigating the possibility of making the use of the rinds in dye making towards reducing waste associated with the fruits and creating value to farm produce.

There has been an interest to revive natural dyes across the world. This is because some synthetic dyes are forbidden in Western nations owing to their

poisonous, carcinogenic, and polluting characteristics (Ragab *et al* 2022). Natural plants have many compounds and their properties differ depending on their oil type. Dyes are one of the most important uses of plants, however the yielding of dye in plant has received little attention. This is partially because availability of crops vary due to the weather conditions.

Mango fruit is one of the popular, nutritionally rich fruits with unique flavour fragrance. Most parts of the tree are used medically, and its bark contains tannis, which is used for dyeing in fabric (Govindan, 2019). Mango bark has been used on silk and cotton materials as a source of natural dyes, and a wide range of colours have been produced using different mordants (Mohammad, 2015). Apart from the application of mango leaves and bark, different plants have been reportedly used to extract colours which were used in dying of silk and other materials. (Mahajan *et al*., 2005). In the recent time, there is a growing interest in using natural colours for dyeing of various materials because it is believed to be more environmentally and economically friendly, and biodegradable than synthetic dyes. This study establishes pathways towards reducing reliance on synthetic dyes, and avoiding the environmental pollution that is associated with synthetic dye usage. Furthermore, findings of this study, if implemented, will create new values to farming produce as well as job opportunities for mango farmers and assist economic growth of the nation, as well as reduce dumping of synthetic dyes in Nigeria by foreign countries. It will generate more knowledge on usage of natural dye sources, its production and application. The aim of this study, therefore, is to extract, characterize and establish the usage of dyes from the rinds of mango .

2. Literature Review

Several studies have been conducted on sources, types and methods of extracting dye and application of same on fabric. For instance, Oyesom (2017) extracted natural dyes from the stem bark of *Nesorgodonia papavrifera* and *Berlinia grandiflora* using methanol, water, acetone, methanol KOH, acetone KOH, as solvents at different temperatures and times. Findings on the extraction revealed that water extracted most for *berlinia grandiflora* while acetone was found to be the best solvent for the extraction colourant from *nesorgodonia papaverifera*. The mixture of the dye was separated using column chromatography and the purity was monitored using tin layer chromatography (TLC). Its characterized purified dye extract using Gas Chromatography – Mass spectrophotometer (GC/MS) and infrared spectrophotometer (IR), Ultraviolet visible spectrophotometer (UV-visible) and CNMR spectrophotometer and HNMR analyses. The result of the characterization suggested the presence of functional groups in the dye extracts (OH, CH_3, CH_2 CH, C=C-, OCH_3, C-C, C-O-R, C=O). The chromophores present in the dye extract are C=O and $–(C=C)_5$ for *nesorgodonia papaverifera* and =C-C=C-C=O and –C=C- for *berlinia gradiflora*. It used the extracted natural dye in dyeing nylon and cotton fabrics without mordant and with mordant (stannous chloride and potassium dichromate). It evaluated the wash fastness, light fastness, rubbing fastness and percentage exhaustion. Findings revealed that all the fastness properties of the dye extracts on the fabric improved on application of mordant and in identifying potassium dichromate as preferred mordant due to the ability to produce better light fastness on both fabrics. It also revealed that the natural dye extracted from both plants possess intrinsic affinity for both natural (cotton) and synthetic (nylon) fabric. As interesting as the results here, they were from stem bark and the need for extraction from the rinds of the two plants under consideration here remains a gap to be filled.

Lene *et.al* (2019) extracted natural dye from turmeric rhizome (*cucuma longa*) using the ethanol as solvent method and it characterized using Ultraviolet visible spectroscopy to determine its absorbance against wavelength. The findings from UV- visible analysis confirmed that the colourant absorbs strongly in the yellow region of the visible range of the electromagnetic spectrum. Physio-chemical properties such as melting point and its solubility in different solvents were determined. The dye extracted was tested on cotton and wool fabric using three salts as mordant such as aluminum chloride, Sodium chloride and ammonium chloride. The findings revealed that curcuma longa is the most suitable dyeing wool fabric when aluminum chloride was used as mordant for dye fixation, as the hue produced was deeper than the other two mordants tested. The colourant was also applied to personal care product such as body cream and result obtained that the concentration of colour employed determines the strength of the hue in the product. These studies, like the earlier ones, did not compare with mango

Plate 1
Mango Tree,
Author (2023)

Plate 2
Mango Fruit
Author (2023)

Plate 3
Mango Rind
Author (2023)

(*Mangifera Indica*)

Okonkwo *et a*l, (2019) also extracted natural dye from *Ogu n eje* (*Whitfieldia Lateritia*) leave using 1% alkaline as solvent, the extracted dye was analyzed in area of fabric dyeing using mixture of alum and tannic acid as mordant and sodium dithionite as reducing agent and pre mordanting technique was used. Its extract was characterized with UV- visible spectroscopy and FTIR spectroscopy machine and the colour fastness to washing, perspiration and daylight were also carried out. The findings revealed that *whitfieldia lateritia* dye is a direct dye since it dyed cotton fabric without a mordant, however the application of mordant improved the colour fastness of the dyed cotton fabric. The mordanted fabric gave best colour fastness properly to washing, perspiration and daylight, the reducing agent such as sodium dithionite was not so pronounced. The findings from the UV-visible spectroscopy and FTIR spectroscopy confirmed the presence of some percentages of flavonoids, polyphenols and tannins. These studies focus on the leave of *ogu n eje* not the rinds of mango.

Moe *et al*. (2019) extracted natural dye from the rinds of pomegranate (*punica granatum*) using aqueous method. The mineral contents of the samples were analyzed by energy Dispersive x-ray fluorescence (EDXRF) spectroscopy, physical properties (PH, specific gravity viscosity) natural dye extracted was determined by using AOAC official method. Two different mordants such as common salt and ash were used in the dyeing process, after which the extracted dye was applied in dyeing of wool, yarn, cotton cloth and silk cloth and rubbing fastness and washing fastness test were used to predict the performance of the dye in wool yarn, cotton cloth, and silk cloth. The finding on dye extract showed that pomegranate has little amount of mineral which makes it rich in organic compound and the result revealed that very aesthetically pleasing colourants can be extracted from the rinds of pomegranate for colouring textiles or any other dyeing purpose. It concluded that the use of natural dye should be increased to prevent synthetic dye pollution and other harmful effect. The study, however, did not address the extraction process from the rinds of mango.

Kumar and dhinakaran (2017) extracted natural dyes from orange and lemon peels to dye cotton fabric using cold ethanol in three different ratios of which 1:1 has proved to have higher concentration of dye extract. Two organic solvents, alum and sodium carbonate, are used in pre-mordanting in three different ratios which are 10%, 20% and 30%. The findings revealed that 30% of pre mordanting has given a superior dye uptake. The dye yield was higher for both orange peel and lemon peel. Orange peel was observed to be higher with 50ml ethanol extraction and among orange peel and lemon peel, orange peel gave better dye yielding when compared to lemon peel and both extracts have shown better fastness to rubbing in dry and wet stages. The finding also indicates that both dye extract from orange and lemon peels could be used as sources of natural dyes for cotton fabrics which will result in a better utilization of orange and

lemon waste from food processing industry as value addition. It will reduce the extent of pollution in the conventional textile dye industry. Orange and lemon peels were the focus here leaving the study of mango and its rinds a huge gap.

Akorede *et al* (2024) also extracted dye from guinea corn leave using both distilled water and ethanol (90:10 u/v) and (10;9 u/v) respectively. Dye standardization was done using UV- visible spectrophotometer in the range of between 315nm to 800nm the wavelength of maximum absorbance was gotten to be 575nm and used in determining the absorbance at various concentrations (100-700mg/L). The photochemical properties such as PH level, dye, colour, percentage yield and solubility of aqueous extracted dye was found to be 6.86 reddish brown in colour, 15.66% dissolved freely in warm water while that of the ethanolic extracted dye was found to be 6.68% wine in colour, 21.48% partially soluble in warm water. The characterization of the dye was done using FTIR, UV-visible spectroscopy scanning electron microscope, brunauer-Emmett- Tellers theory, thermogravimetric analysis and differential thermal analysis. The extracted dye was then used in dyeing pre-post mordant white cotton fabric using both alum and magnesium sulphate as mordants. Fabric which improves the colour shades and fastness properties of the dyes enhances their esthetic value. Findings revealed that the ethanol is more proper and suitable solvent than aqueous extraction because it produces more yielding of dye and the extracted dye samples were found to be slightly acidic with almost being neutral at PH 7 hence will have no effect on either acidic or basic substrates. The extract contains vital minerals that are very useful for the body system if applied or used as food supplement. Studies in this area only concentrated on corn leave, not on mango.

Johnson *et .al* (2024) extracted dye from beetroot (*Beta vulgaris*) using a Soxhlet method and the dye extract was applied to cotton fabric. The extracted dye was analyzed with the use of FTIR, GC/MS, AND UV -visible spectroscopy. On the cotton fabric that has been dyed the properties of scouring, wash fastness, and light fastness were assessed with the used of mordant such as: $Sncl_2$, $FeSO_4$, and $K_2Cr_2O_7$ and the cotton fabric was treated with the natural dye extract. The findings revealed that the dye extract had a red colour according to FTIR characterization data suggested the presence of N-H, CH, C=C, C-H, C-N and C-CL functional groups in the dye extract. Fifty-one compounds were isolated and identified by GC-MS melezitoze, 5 hyroxymethylfurfural and 4 mercaptophenol has the highest percentage area (70-19%) and CIS- O- Nonadecenoic acid, 9 octadecenoic acid (E) – and Cis – vaccinenic acid has the lowest percentage area , (0.07%) N-H and C=C were the chromophore found in the dye extract. The findings of colour fastness of washing revealed the materials fastness grade increase to range 3 indicating a fair grade of fastness when the dye was applied using $SnCl_2$ as a mordant while the colour fastness to light showed that cotton fabric was dyed with mordants. The fastness grade increased a range of 5 which indicates a moderate fading resistance when the dye was applied to fabric using $FeSO_4$ as the mordant using $K_2Cr_2O_7$ as the mordant the fastness grade slightly decrease to a range of 1, indicating very poor grade of fastness. The result of colour fastness and $SnCl_2$ light fastness of the dye demonstrated a moderate resistance to fading and a fair colour look on cotton. The colour fastness to rubbing showed that 3-4 and 2-3 colour changes were experienced for dry and wet stage respectively with mordant, the outcome of the colour fastness of the dye showed a very good affinity to remain on the fabric when mordant is applied.

Kassim (2025) also extracted dye from zobo (*hibiscus sabdarifa*) using Soxhlet extraction method with methanol at a 1:4 solid -to solvent ratio for 48hours, followed by concentration, filtration, rinsing and drying for 8 hours. The yield of the dye was 0.5 percent, from 900g of dried petals, characterization involved UV- visible spectroscopy which revealed the absorption maximum at 520nm, indicative of anthocyanin and FTIR analysis confirm the presence of phenolic, flavonoids, and carbohydrate – base compound. The dye was applied on cotton and wool fabrics using three mordants such as aluminum sulfate, ferrous sulfate, copper sulfate. The dye was carried out at a controlled temperature of 100^{o}c. the exhaustion rate showed that wool absorbed more dye (35,90 -39-11) percentage compare to cotton (22-00-26-40 percent) with aluminum sulfate providing the highest exhaustion for both fabrics. The findings reveal that the fastness test indicate that cotton fabric dyed with aluminum sulfate had washing rating 4-5 while wool fabrics had rating of 4. The study highlights that *habbiscuss sabdarifa* offers a variable, ecofriendly dye with moderate of good fastness, paving the way for more sustainable textile practice.

Melaku (2023) also extracted dye from spent coffee ground and bio-mordant from mango bark. The raw

materials were collected washed, dried, crushed and their physio- chemical properties were determined, the samples were extracted using solvent extraction method. During the extraction process the central composite design method, (CCD) was used to analyze and optimize the effect of dosage (g/l) temperature (^{o}c) and time (min). The findings revealed that a maximum of 18.4% was obtained at a dosage of 60g/I temperature of 70^{o}c and time of 90min also the highest mordant yield of 19.03% was achieved at value of 45g/I, 70^{o}c and 90min. the fastness properties of dye and mordant cotton fabric results were within the range of acceptable standard value. It was concluded that using spent coffee ground for natural dyes and mango bark for natural dyes and mango bark for natural mordant can be feasible commercial alternative to synthethic dyes in textile and dyeing industries.

Ayele *et al* (2020) extracted natural dye from mango peel and aqueous techniques and the cotton fabric was dyed using dyes extract and followed by mordant. Different mordants that were used were aluminum sulphate (alum) copper sulphate, copper chloride, zinc chloride and ferrous sulphate to fix the dye on the fabric. The dyeing performances of extracted colouring agents were assessed in terms of colour value, dye absorption (%) colour fastness properties and colour strength. The findings revealed that dye extracted from mango leave result in more colourized material than dye derived from mango peel extract. Moreover, the dye extract exhibited a deeper shade, the result also shows that cotton fabric dyed with the same extract but different types of mordants resulted in a fabric that shows diverse colours, moderate to good fastness value was recorded (4-5). It concluded that the dye extracted from various parts of the mango plant could be an effective colouring agent for use on cotton fabric.

Kusuwati *et al* (2017) extracted natural dye from fresh mango steen (*Garcina mangostana L*) peel using aqueous technique. The extracted mango steen is tested on cotton fabric by using alum as mordant in agent and processed by pre- mordant dyeing procedure and fixation using three different types of fixer, washing procedure has been performed using Turkish red oil (TRO) before mordanting stage with varying washing time and repeating frequency of dye. The finding revealed that application of pre-mordanting dyeing method and fixation using iron (II) sulphate ($FeSO_4 - 7H_2O$) Alum $(KA1)(SO_4)_2(12H_2O)$ and lime (CaC) produced very good colour from mango steen peel dye extract and cotton fabric that has been through pre - mordanting dyeing procedure using dye extract of mango steen peel consecutively bring green, light brown and dark brown colour each of the fixation result using iron (II) sulfate alum, and lime. The optimization of the washing time and frequency showed the decreasing reflectance percentage which was in the range of 52.88% - 9.85% in line to the increasing colour intensity of cotton fabric which the sample with washing time for 1-3minute and 38.44%-7.23% of cotton fabric sample that have been through dyeing process that repeated 5 and 10 times. The process paves way for the invention of a new type of natural dye that can be produced through a number of stages in an experiment that systematic and well structured. The plants covered in the study never include any mango.

It is revealed from the review of literature above that while many studies have been conducted on the composition and extraction of natural dyes from different plants or their parts, not much has been done on mango especially the species around Ogbomoso in Southwest of Nigeria. The Ogbomoso mango is essentially known for its incomparable quality in the world. Whether or not this will be reflected in the elemental composition and quality of dyes to be produced from its rind will be of utmost interest and focus of this study.

3. Materials and Methods

The rinds of mango were collected from fruits sellers and consumers in Ogbomoso, Oyo state. Silk and Cotton fabrics were used to test the dye ability and fastness of the extracted dye from the rinds. For this study, simultaneous mordanting method was adopted and two mordants were used which were lime juice and alum. Lime fruit and alum were purchased from 'Waso Market' in Ogbomoso Oyo State, Nigeria.

Characterization

The FTIR of the powdered sample was traced on SHIMADZU FTIR-8400S machine within the wave number range of 4000-500cm was carried out at the Redeemer University Chemistry Laboratory Ede, Osun State. UV-Vis spectroscopy was used to carry out the analysis for the extracted liquid dyes from mango rinds scanned with 350-900 wavelength using CECIL CE 7200 machine and computer system which was carried out at the Ladoke Akintola University of Technology Central Research Laboratory Ogbomoso, Oyo state.

Sample Treatment

The rinds of mango fruit were collected, washed with clean water, cut into small pieces and sun-dried in a well-ventilated place for a week. After drying, the dried rinds were weighed 66.40g on mini electronic measuring scale, The dried rinds were ground into powder form using new electric VTCL grinder with steel blade with power consumption of 750 watts, duty circle 60 min, R.PM (Aprox -16000-18000) power supply – 220/240 volts A/C, cont. Rating -5Mts. This type of grinder was used because it is fast and grinds smoothly, The powder was put in a generic fine mesh plastic sieve net to remove the unwanted chaff after which it was weighed on mini electronic measuring scale and 53.28g was obtined after sieving. The powdered material was well packaged in plastic transparent jar. 10g of the powdered mango rind was put in a small laboratory glass jar for the Fourier, transform infra-red spectroscopy test was carried out at Redeemers University Ede Osun State Nigeria. The powered material was taken to the Chemistry Laboratory (Analytical section) at the Ladoke Akintola University of Technology Ogbomoso, Oyo State, Nigeria for the extraction using aqueous method, hydrothermal and reflux technique. The powdered substance (40.28g) was put in conical flask with use of funnel, 700ml of distilled water was poured inside the powder with one magnetic bar and put on the JOAN electric hotplate stirrer model; HS-12, input; 220V, 50100H2, power,180W, serial number 202205042, for 40 minutes after which it was brought down to cool. Then, it was filtered with filter paper and the 400ml liquid dye was extracted from the rinds. 5ml of dye extracted was put in laboratory plastic micro centrifuge tube for the Ultra Violet-Visible spectroscopy test was carried out at the Central Research Laboratory of the Ladoke Akintola University of Technology Ogbomoso Oyo State, Nigeria.

Extraction of Natural Dye Solution from the Rinds of Mango

The aqueous extraction of mango rinds was carried out at analytical section of Chemistry laboratory, Department of Pure and Applied Chemistry at the Ladoke Akintola University of Technology Ogbomoso. 43.28g of powdered mango rinds was put into the conical flask with the use of funnel, then 700ml of distilled water was poured inside the sample and one magnetic bar was put in after which it was put on JOAN electric hotplate stirrer model; HS-12, input; 220V, 50100H2, power,180W, serial number 202205042. Reflux method was adopted for this process so that boiling will maintain the constant temperature. The sample was boiled for 40 minutes, then it was removed from hotplate to cool. Then, it was decanted and sieved with generic fine mesh plastic sieve net to remove shaft. Thereafter, the solution was filtered with filter paper to get the dye extraction of 400ml dye solution obtained from the extraction.

Control dye (without mordant)

The 100ml each of the sample mango rinds was measured in each plastic container, then each desized fabric (cotton and silk was soaked into the two samples for 1 hour then it was removed from the sample, squeezed and dried The dyeing was carried out without mordant to serve as control dye and the process was carried out under the room temperature

Mango dye on cotton and silk with alum mordant

80ml of mango dye was poured in 2 plastic containers (dye bath), one level spoon of alum was put inside each container and left to dissolve within 5minutes. Then a 12 cm by 12 cm each of fabric was soaked into the dye for 1 hour, the fabric was removed and dried under room temperature for 3 hours to dry.

Mango dye on cotton and silk with lime mordant

80ml of mango dye was poured in 2 plastic containers (dye baths), then 15ml of lime juice was put inside each container, 12 cm by 12 cm each of the fabric was soaked into the dye for 1 hour, the fabric was removed and dried under room temperature for 3 hours to dry .

The dye that was extracted from mango rinds is tested for fastness on cotton and silk when the fabrics wa wet and dry as shown below in Tables 1 and 2.

Table 1: Fastness of mango (MI) dye on fabric at wet stage

Colour Shade			
Fabric type	**Unmordanted**	**Alum mordant**	**Lime mordant**
Cotton	Neutral white	Cream white	Creamy white
Silk	Yellow white	Whisper white	White smoke

Source: Author's results (2025)

Table 2; Colour shade fastness of mango dye on fabric at dry stage

Source: Author's results (2025)

Colour Shade			
Fabric type	**Unmordanted**	**Alum mordant**	**Lime mordant**
Cotton	Ivory white	Ivory white	Cream white
Silk	Ivory white	Ivory white	Ivory white

RESULTS AND DISCUSSION

Characterization of Extracted Dyes with Infrared (IR) Spectroscopy and Ultraviolet-Visible (UV-Vis) Spectroscopy

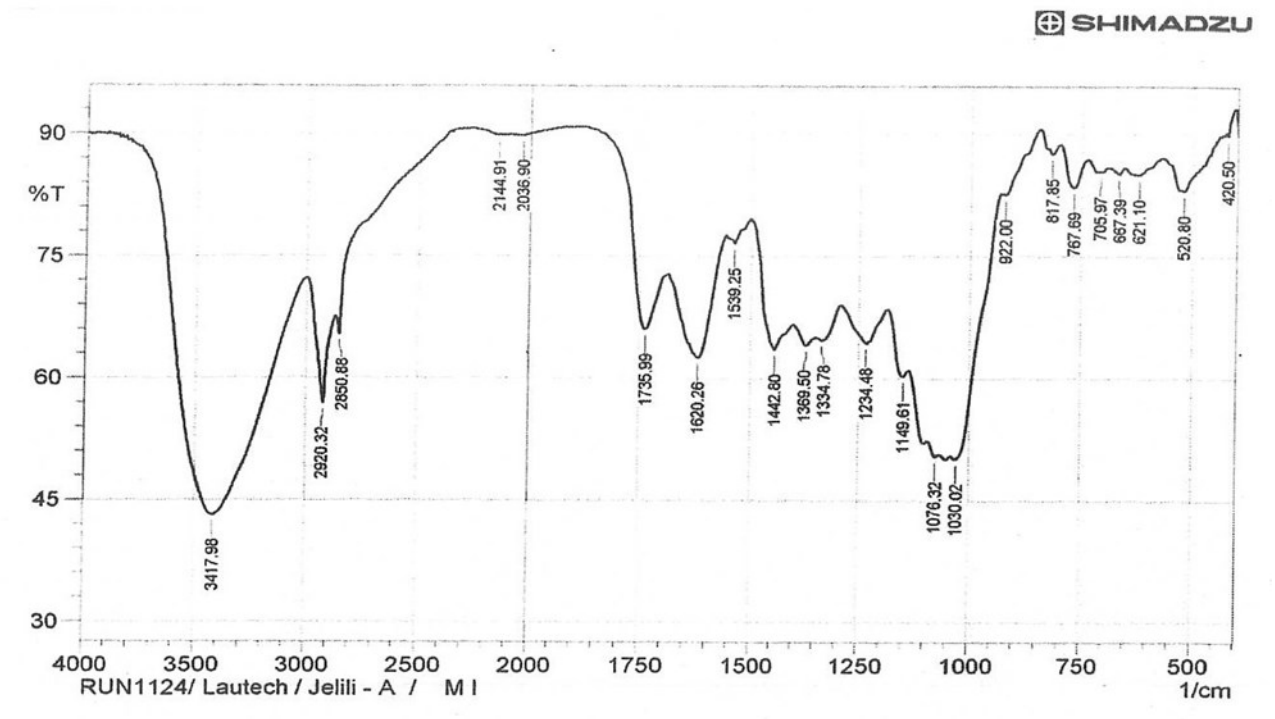


Figure 1: Functional Group and peak Value in Mango Rinds

Infrared (IR) Spectroscopy

Methyl (-CH3) groups: 1375-1390 cm-1 (C-H bending) and 2850-2950 cm-1 (C-H strectching)

Hydrocarbon Chains:720-770 cm-1 (C-H rocking) and 2850-2950 cm-1 (C-H stretching)

Conjugated double bond: 1600-1650 cm-1 (C=C stretching)

Hydroxyl (-OH) groups:3200-3600 cm-1 (O-H stretching)

Keto (C=O) groups: 1650-1700 cm-1 (C=O stretching)

Nuclear Magnetic Resonance (NMR) Spectroscopy

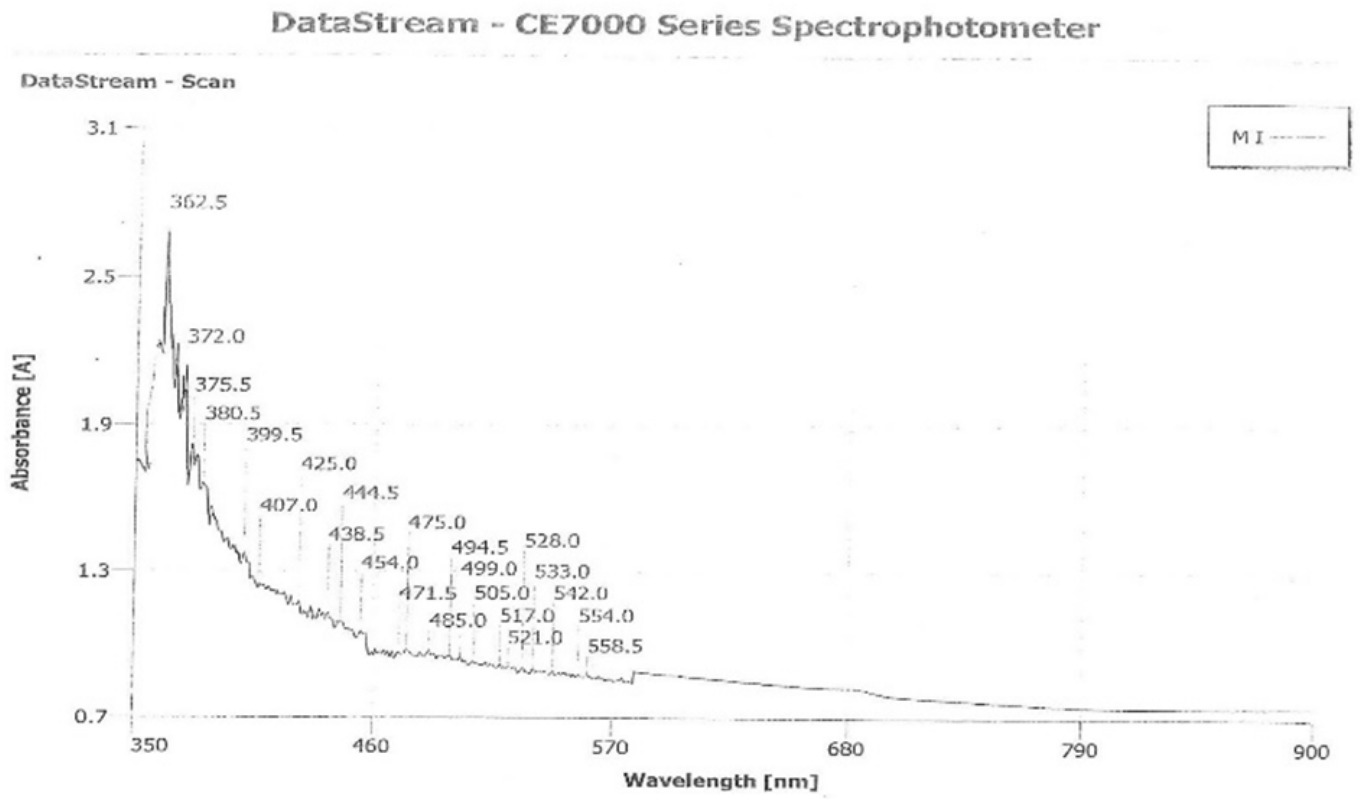
Methyl (-CH3) groups 0.5-2.5 ppm (1H NMR)

Methylene (-CH2-) groups: 1.0-3.0 ppm (1H NMR)

Conjugated double bond: 5.0-7.0 ppm (1H NMR)

Hydroxyl (-OH) group: 3.5-5.5 ppm (1H NMR)

The FTIR spectrum of MI (Fg 1) showed a broad absorption band at 3417.98 cm^{-1}due to O-H stretching vibration (hydrogen bonded), the absorption band at 2920.32 $cm^{-1}$and 2850.88cm^{-1} is a characteristic of C-Hasymmetric and symmetric stretching vibration of alkane respectively. It is important to note that the absence of peaks nearly above 3000 cm^{-1} shows the absence of C -H stretching vibration of either alkene or alkyne. The absorption band at 1735.99 cm^{-1} was due to C=O of esters while the absorption band at 1620.26 cm^{-1} was due to C=C stretching vibration which may overlap with N-H bending vibration. Peaks at 1539.25 $cm^{-1}$and 1334.78 cm^{-1} were due to asymmetric and symmetric stretching, respectively of nitro compound. Twin bands at 1442.80 cm^{-1} and 1369.50$cm^{-1}$are due to C-H bending of alkane while the band at 1234.78cm^{-1} was due to C-N stretching vibration. Bands at 1076.32 cm^{-1} and 1030.02 cm^{-1}were due to C-O



stretching vibration, while peak at 922.00 is characteristic of C-H rocking of alkane

Figure 2

Ultraviolet-Visible (UV-Vis) Spectroscopy

Conjugated double bonds: 400-500 nm (visible region)

Caratenoid backbone: 250-300 nm (UV region)

The UV-visible spectrum of MI (Fg 2)show wavelength maxima between 362.5 nm and 558.5 nm The wavelengths are due to n-π* and π-π*transition and due to the presence of chromophoric groups like nitro, azo, carbonyl groups among others and long chain conjugation system (> 4 C=C) which shift the absorption to higher wavelength. The wavelengths were also around the visible region (>400 nm) which showed that the components were made up of coloured compounds. It can therefore be inferred that the dye extracted from mango rinds contain Caratenoid.

Fastness of mango dye on fabrics after washing with ordinary water at wet stage

After the colour fastness of mango dye has been tested on cotton and silk for purpose of fastness at different stages of wetness and dryness (Tables 1-2), the fabrics were also subjected to fastness properties when they are washed as presented in Tables 3 and 4

After the product was removed from the sample, it was washed with ordinary cold water, then spread and the colour was observed at wet stage for visual observation of the dye and mordant effects on the selected fabrics at room temperature)

Table 3: Colour shade of mango dye on fabric at wet stage after wash with ordinary water water

Colour Shade			
Fabric type	**Unmordanted**	**Alum mordant**	**Lime mordant**
Cotton	Off white	White yellow	Cream ivory
Silk	Eggshell	Linen	Alabaster

Source: Author's results (2025)

Table 4: Colour shade fastness of mango dye on fabric at dry stage after wash with ordinary water

Colour Shade			
Fabric type	**Unmordanted**	**Alum mordant**	**Lime mordant**
Cotton	Bone white	Tan white	Coconut white
Silk	Coconut white	Eggshell	Bone white

Source: Author's results (2025)

Table 5: Wash fastness properties of dye extracted from mango rinds on cotton and silk with ordinary water (wet and dry)

Colour Shade						
Fabric type	**Unmordanted**		**Alum mordant**		**Lime mordant**	
	Wet	Dey	Wet	Dry	Wet	Dry
cotton	1	1	3	2	2	3
silk	1	1	2	1	2	1

Wash fastness rating; 1-Poor, 2 – Fair; 3 –Good;

Fastness of mango dye to cloth after washing with ordinary water at dry stage.

The fastness of fabric dyed with mango rind dye without mordant at dry stage was compared with the grey colour and the washed fabric with alum and lime mordant was observed and also compared with grey colour (Table 4).

After the fastness of the extracted dye has been tested on cotton and silk at different stages of wetness and dryness the fabrics were later subjected to the colour fastness when they were washed with ordinary water as summarised. The result of the washing fastness properties of the dye extracted from mango without mordant showed poor fastness (1) was observed on cotton fabric at wet stage and dry stage and on silk fabric poor fastness (1) was also observed both at wet and dry stage. When the dye solution with alum mordant was applied on the cotton fabric the fair fastness (2) was observed at wet stage and poor fastness (1) was observed at dry stage. On the silk fabric, poor fastness (1) was observed at both wet and dry stages. The dye solution from mango rinds and alum mordant was reacted on the cotton fabric which resulted on cloth ruptured when washing with water which implies that the pH present in alum is higher than the one in the cotton fabric.

The dye extracted with lime mordant was applied on cotton fabric, and good fastness (3) was observed at wet stage and fair fastness (2) was observed at dry stage which indicates that there is decrease in colour shade after exposing to sunlight. On silk fabric, fair fastness (2) was observed at wet stage while poor fastness (1) was observed at dry stage which also indicates that there is change in shade of colour reduction at the dry stage.

Testing of colour fastness of extracted mango dye cotton and silk washed with detergent

After the fastness of mango rind dye on fabric washed with ordinary water at wet and dry stages was observed, it was later subjected to washing with detergent to compare with the one with ordinary water, the fabric was washed with 2.5ml of detergent into 200ml of cold water and washed for 2 minutes.

Testing of colour fastness of extracted dyes on cotton and silk fabric exposed to sunlight

Colour fastness is the ability of a dye to retain its colour after being exposed to washing, crocking, respiration, sunlight, fumes, and other colour destroying condition (Sekhri 2010). This fastness was done by following the resistance of the fabric to fading when exposed to sunlight The 12 by 12cm^2 of dyed fabrics were cut into two and some parts were unexposed and the other part was washed with detergent and exposed to morning sunlight between 10am and 12 noon (for 2 hours), the one unexposed was compared to the exposed one and the result of the text was recorded.

After the fastness of mango rind dye washed with ordinary water at wetness and dryness stage was observed at room temperature, it was later subjected to washing with detergent to compare with the one with ordinary water, which was later exposed to sunlight to observe the resistance to fading.

Table 6 shows that when the product of mango dye without mordant on cotton fabric was washed with detergent and exposed to sunlight the poor fastness (1) was observed both at wet and dry stages which shows there is reduction in colour shade compared to the one washed with water. On silk fabric, poor fastness (1) was also observed both at wet and dry stages. When the extracted dye from mango rinds with alum mordant on cotton fabric was washed with detergent and exposed to sunlight, poor fastness (1) was observed at wet and dry stages. This showed there was poor colour shade fastness for the two stages and on silk fabric poor fastness (1) was observed at a wet stage and fair fastness (2) was observed at a dry stage. The dye solution from mango rinds with lime mordant was applied on cotton fabric and poor fastness (1) was observed at wet and dry stages, and on silk fabric fair fastness (2) was observed at a wet stage and on silk fabric poor fastness (1) was also observed at a wet stage, while fair fastness was observed at a dry stage after exposure to sunlight.

Table 6: Washing fastness properties of the mango dyes product with detergent and to sunlight at wet and dry stages.

Colour Shade						
Fabric type	**Unmordanted**		**Alum mordant**		**Lime mordant**	
	Wet	Dey	Wet	Dry	Wet	Dry
cotton	1	1	1	1	1	1
silk	1	1	1	2	2	1

Wash fastness rating; 1-Poor, 2 – Fair; 3 –Good

Conclusion

There is an increasing demand for environmentally friendly natural dyes. The study has shown that dye can be extracted from the rinds of mango. The UV-Vis and IR spectroscopic analysis revealed that dye extracted from rind of mango contains Caratenoid. The extracted dye was tested on cotton and silk fabric then subjected to washing with ordinary water, to know if the fastness of the dye would wash off, and later subjected to washing with detergent to know the chemical reaction that would take place between the dye extract and the fabrics, then exposed to sunlight for two hours to test the fastness to fading. It was discovered that the shade of white for cotton and silk fabric dyed with mango extract without mordant was very tinted, while the shade of white of the fabric tends towards the cream white colour. The chemical reaction took place when subjected to detergent and sunlight which made the colour fastness to be low compared with the one washed with water.

The chemical reaction of alum and fabric took place when washed with ordinary water after dyed which led to tearing of cotton fabric and made the fabric structure to degenerate and result into shades which made the colour fastness lower both with water, detergent and sunlight. The silk fabric fastness is lower than the cotton but the silk weave structure remains on unruffled after the reaction of alum mordant. Mango extract with lime mordant gives low fastness because the colour was washed off on cotton, while the silk fabric was not vividly distinguishable both on water, detergent and sunlight which implies silk is better than cotton with lime mordant.

After all the test on washing and sunlight fastness of the dye extracted from mango rind has been done, it is concluded that the dye can be extracted from mango with the help of mordant to increase the colour shade and that the use of natural dyes should be increased to prevent synthetic dye harmful effect by exploring the option of mango rinds as a source. Further studies are also necessary especially to explore the possibility of using other natural sources such as African star apple, among many others. It will also be useful to compare two or more fruits like mango rind, zobo etc

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