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Variations in the Application of Mordant of Dye Extracted from Coconut Husk on Cotton Fabric

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Abstract: ***Mordants are substances that help to bind the dye to the fabric to improving the colour fastness and durability of the dye. Dye was extracted using soxhlet extraction method, the percentage yield of the dye was also determined. Three different modant were used in the dyeing process, namely vinegar, table salt and baking soda. Colourimeter was used to collect information on assessment of colours of the extracted dye from coconut husk. The result obtained shows the % yield of extract to be 40%, which is significantly high, this is an indication that coconut waste is rich colour pigment. The delta value (ΔE) of light fastness of the dye extract on cotton fabric with no modant was higher than the (ΔE) modanted fabric. The modanted, vinegar has the highest (ΔE) with 69.2nm over baking soda 68.2nm, while table salt give the lowest (ΔE) with 61.5nm. The wash fastness quality characteristic also indicate that table salt used as modant has the highest e (ΔE) to be 66.6nm, over vinegar with 52.3nm, while baking soda has a (ΔE) of 51.9nm.***

Keywords: Dye, Mordant, Fabric, Extraction, Ethanol.

I. INTRODUCTION

Mordants are substances that help to bind the dye to the fabric to improving the colour fastness and durability of the dye. The choice of mordant and the methods of application can significantly affect the final colour and quality of the dyed fabric. Different types of mordant or their combination when applied on a textile fabric has great potential to obtain varying colour/ shade by increasing the dye uptake and to improve the colour fastness behaviour on a cotton fabric [1].

Dyes are known for their use in colouring of food substrate, leather as well as natural protein fibres like wool, silk and cotton as major areas of application since pre-historic times [1]. Coconut husks are agricultural waste product that has been identified as a potential source of natural dye. Natural dyes are obtained from roots, leaves, barks, fruits and fruit-coat or wood of the plants [2].

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It exhibits better bio-degradability and has a better suitability with the environment and its use in coloration of fabric materials, it also possess lower toxicity and allergic reaction than synthetic dyes [3]. Thus, the use of coconut waste as a natural dye can reduce the cost of waste management and help prevent environmental pollution [4].

In addition, coconut husk also contains tannin and potassium. The coconut husk consists of the endocarp, mesocarp, and exocarp which make up about 30-35% of the whole coconut [5]. It is estimated that 5280 kg of dry coconut husk is produced per hectare every year which is significant and there is a dire need to find a way to manage the waste [6]. One approach is to add value to the waste by utilizing the coconut husk as a dye substance for colouring cotton fabric. Coconut husk waste is cheap, non-toxic, efficient, and readily available. It is therefore against the background that this study investigates the yield of the colour pigment extracted from coconut husk, the light fastness quality and wash fastness quality of the modanted fabric and no-modant fabric.

II. MATERIALS AND METHODS

A. Study Area

The study was carried out at Federal University of Agriculture, Abeokuta at the Department of Home Science and Management Textile Laboratory and Analytical Laboratory of Food Science and Technology of the Department of Food Science and Technology.

B. Coconut Husk (Cocos Nucifera)

Coconut husk is the main plant waste used for the extraction of dye for this study. *Cocos nucifera*, is commonly known as the coconut as show in plate 1, is a member of the Arecaceae family (palm family) [7]. It composed of 30% fiber and 70% pith. [8]. coconut husk also contains potassium. The coconut husk consists of the endocarp, mesocarp, and exocarp which make up about 30-35% of the whole coconut [5]. It is estimated that 5280 kg of dry coconut husk is produced per hectare every year which is significant and there is a dire need to find a way to manage the waste [6].

The coconut husk commonly found in Nigeria was purchased from Eleweran market, Abeokuta in Ogun State. The Nuts of coconut (*Cocos* nucifera) were purchased and the husk (bark of coconut fruit) was removed as a waste shredded into coir (powder) form and used for the study as shown below. The dried husk of coconut was washed with distilled water, dried at room temperature, chopped into smaller pieces separated into different particle sizes and the measured quantities

of pulverized samples were fed into the muslin bag and prepared for extraction.

[Fig.1: Cocos Nucifera]

C. Solvent and Reagent Used

i. Coconut husk was source from a local market in Eleweeran, ogun state.
ii. Ethanol (CH_3CH_2OH) sourced from Shandong Jinta Machinery Group CO.
iii. Cotton fabrics (100% white) sourced from Itoku market, Ogun State.
iv. Muslin cloth: is a plain-woven cotton fabric made in various weights.
v. Soxhlet extractor.
vi. Heating Mantle:
vii. Weighing balance scale:
viii. Pots: a cylindrical container, typically metal, used for cooking.
ix. Water Bath:.
x. Rotary Evaporator:
xi. Thermometer:
xii. Colourimeter:
xiii. Digital pH meter
xiv. Volumetric flask (100ml/ 500ml),.
xv. Beakers of varying sizes,
xvi. Graduated Measuring Cylinder of volume size 10, 20, 25 and 100ml,

D. Extraction of Dye from Coconut Husk

Soxhlet extractor was used to extract colour out from coconut husk, with ethanol as the extracting solvent. 30g of coconut husk powder was weighed in a muslin cloth. The muslin clothe was put in the thimble and fix in the siphon tube. The empty container was label. The apparatus was adjusted with water inlet connected in and out of the condenser, allowing it to pass through from below to top of the condenser to avoid air bubbles and over-floating. After filling solvent into the conical flask, the heating mantle temperature kept at 60℃ for 30mins, the siphon tube would first siphon, then fill half of the tube and solvent would drop back into the conical flask. The sample was then from thimble, the muslin cloth sample and conical flask was kept to dry in room temperature for 24 hours. When the smell of sample was free, it means it has been dried. The set-up was put in a water bath with a continuous boiling temperature of 60°C and the solvent was heated to reflux. The same technique was followed for another 30mins, as the dye generated did not exhibit the predicted deep colour cloth staining capacity during the first phases of the experiment.

E. Determination of Percentage Yield of Dye Extracted from Coconut Husk

Extracted dye yield was measured by determining the solvent's efficiency to specific components from original material [9]. This was defined as the amount of extract recovered in mass compared to the initial amount of the whole plant. This was expressed in percentage (*Ey %).*

Equation used for calculation of the extracted dye yield is

$$E_y\ (\%) = \frac{W_1 - W_2}{W_1}$$

F. Evaluation of the Quality Characteristics of Extracted Dye

Conventional mordanting technique used by Mahangade *et al.*, (2009) [10]. it was adopted for the extracted dye from coconut husk (*cocos nucifera.L*) which was utilized to determine the quality characteristics of extracted dye for the coloration of cotton fabric. The conventional mordanting technique was explored to study the effect on the colour strength and fastness properties of the dyed samples.

G. Scouring and Mordanting of Fabric

The cotton fabric was washed in order to remove all the impurities and starch present in the fabric and the fabric was later dried at room temperature [11]. In order to charge the cotton fabric (which is substrate) to be dyed [13], cooking salt, vinegar, or baking soda can either be used for the treatment [14]. One-liter (1litter) of water was filled in a pot; 1 tablespoon (1 Tb) each of cooking salt [15], vinegar and baking soda was added simultaneously in different bows were added to it plus the substrate at 40˚C with constant starring and simmered for 20 minutes [16]. The substrate (fabric) was allowed to cool off and soaked in the mordant solution overnight [17].

H. Dyeing of Fabric

The proportion of the fabric to be dyed with the dye extract was constant in all the operations. 5ml of the concentrated solvent dye extract was used for the dyeing process. The measurement of the fabric was 4cm by 4cm. 5ml of the liquid dye was measured into a container and the fabric was submerged into the container and the fabric was stirred approximately for 20 minutes. The dyed fabric was removed and aired for oxidation to take place for 5minutes. It was rinsed separately in running water and dried under room temperature.

I. Determination of Colour Fastness Properties

The colour parameters of Coconut Husk extract for Ethanol are L*, a*, b* values were determined using a Colourimeter (Chroma Meter, CR-410, Konica Minolta, INC.japan.). L* is known as lightness (i.e. when L = 0 black, and when L =100 white)

a* (-a = greenness, +a = redness)

b* (-b values = blueness, +b = yellowness)

The colorimeter used to collect information on assessment of colours of the extracted dye from coconut husk as shown below, the extraction trials were carried out under different time interval, for the colorimetric characteristics, and fastness properties of extracted dye molecules which were tested in the current study. This information help in establishing a wide spectrum of colors properly define the colorimetric limits of coconut husk extract.

[Fig.2: Colour Assessment Using Colourimeter]

III. RESULT AND DISCUSSION

A. Percentage Yield of Extracted Dye

To Calculate the percentage yield of extracted dye (%)

$$E_y\ (\%) = \frac{W_1 - W_2}{W_1}$$

Where W_1 is weight of dry husk before extraction
W_2 is Weight of dry husk after extraction
Weight of dry husk before extraction = 30g

$$Ey = \frac{30g - 17.9g}{30g} \times 100 = 40.3\%$$

B. Quality Characteristics of Dye extracted

i. Light Fastness of dye extract on cotton fabrics with No-Mordant.

The quality characteristic of extracted dye was determined using the light fastness test. The colour parameters result of the light fastness properties of dyed cotton fabric with No mordant were presented in table the below. However, the table reveals the whiteness to blackness (L), greenness to redness (a), and blueness to yellowness (b) for each dyed fabric samples.

Table 1: Colour Parameters of Light Fastness for Dyed Cotton Fabric with No Mordant

Light to Fastnest Image	L	a	B	L_{nm}	a_{nm}	b_{nm}	ΔEnm
	72.2	6.5	12.4	72.1	6.4	12.3	72.1

Note: nm = no mordant, L = whiteness to blackness, a = greenness to redness, b = blueness to yellowness,
L_{nm} = whiteness to blackness no mordant, a_{nm} = greenness to redness no mordant, b_{nm} = blueness to yellowness no mordant,
ΔEnm = Delta E no mordant

Table 2: Colour Parameters of Light Fastness of Dyed Cotton Fabric Mordanted with Vinegar

Light to Fastnest Image	L	a	b	L_{vi}	a_{vi}	b_{vi}	ΔEvi
	64.2	11.4	23.6	64.1	11.3	23.5	69.2

Note: vinegar= v L = whiteness to blackness, a = greenness to redness, b = blueness to yellowness,
L_{vi} = whiteness to blackness vinegar, a_{vi} = greenness to redness vinegar, b_{vi} = blueness to yellowness vinegar, ΔEvi = Delta E vinegar

Table 3: Colour Parameters Value for Light Fastness of Dyed Cotton Fabric Mordanted with Table Salt

Light to Fastnest Image	L	a	B	L_{ts}	a_{ts}	b_{ts}	ΔEts
	57.9	11.6	17.6	57.8	11.5	17.5	61.5

Note: ts = table salt L = whiteness to blackness, a = greenness to redness, b = blueness to yellowness, L_{ts} = whiteness to blackness
table salt, $a_{ts=}$ greenness to redness table salt, b_{ts} = blueness to yellowness table salt, ΔEts = Delta E

Table 4: Colour Parameters Value for Light Fastness of Dyed Cotton fabric Mordanted with Baking Soda

Light to Fastnest Image	L	a	b	L_{bs}	a_{bs}	b_{bs}	ΔEbs
	52.2	27.9	34.2	52.1	27.8	34.1	68.2

Note: bs = baking soda L= whiteness to blackness, a= greenness to redness, $b_{1=}$ blueness to yellowness, $L_{bs=}$ whiteness to blackness
baking soda, $a_{bs=}$ greenness to redness baking soda, $b_{bs=}$ blueness to yellowness baking soda, ΔEbs =Delta E baking sod

ii. Wash Fastness dye extract on cotton fabrics with no mordant.

The dyed cotton fabric samples that was not mordanted was tested for wash fastness while the results of wash fastness properties of dye extract from coconut husk on cotton fabrics were presented in Tables 5,6, and 7 below.

Table 5: Colour Parameters Value for Wash Fastness of Dyed Cotton Fabric with No-Mordant

Wash Fastness Image	L	A	b	L_{nm}	a_{nm}	b_{nm}	ΔEnm
	72.3	5.4	11.2	72.2	5.3	11.1	73.2

Note: nm = no mordant, L = whiteness to blackness, a = greenness to redness, b = blueness to yellowness, $L_{nm=}$ whiteness to blackness no mordant, $a_{nm=}$ greenness to redness no mordant, $b_{nm=}$ blueness to yellowness no mordant, ΔEnm= Delta E no mordant.

Table 6: Colour Parameters Value for Wash Fastness of Dyed Cotton Fabric Mordanted with Vinegar

Wash Fastness Image	L	A	B	L_{vi}	a_{vi}	b_{vi}	ΔEvi
	52.3	8.6	29.6	52.2	8.5	29.5	60.6

Note: vinegar, L = whiteness to blackness, a = greenness to redness, b =

blueness to yellowness, L_{vi} = whiteness to blackness vinegar, a_{vi} = greenness to redness vinegar, b_{vi} = blueness to yellowness vinegar, ΔEvi = Delta E vinegar.

Table 7: Colour Parameters Value for Wash Fastness of Dyed Cotton Fabric Mordanted with Table Salt

Wash Fastness Image	L	a	b	L_{ts}	a_{ts}	b_{ts}	ΔEts
	66.6	4.8	15.8	66.5	4.7	15.7	68.5

Note: ts = table salt, L = whiteness to blackness, a = greenness to redness, b = blueness to yellowness, L_{ts} = whiteness to blackness table salt, a_{ts} = greenness to redness table salt, b_{ts} = blueness to yellowness table salt, ΔEts= Delta E table salt.

Table 8: Colour Parameters Value of Wash Fastness Test of Dyed Cotton Fabric Mordanted with Baking Soda

Wash Fastness Image	L	a	b	L_{bs}	a_{bs}	b_{bs}	ΔEbs
	51.9	18.6	40.3	51.8	18.5	40.2	68.1

Note: bs = baking soda, L = whiteness to blackness, a = greenness to redness, b = blueness to yellowness, L_{bs} = whiteness to blackness baking soda, a_{bs} = greenness to redness baking soda, b_{bs} = blueness to yellowness baking soda, ΔEbs = Delta E baking soda.

Table 9: Summary of Colour Parameters Value of Light Fastness Quality Characteristics of Mordanted and No-Mordant Fabric

L_{nm}	a_{nm}	b_{nm}	L_{vi}	a_{vi}	b_{vi}	L_{ts}	a_{ts}	b_{ts}	L_{bs}	a_{bs}	b_{bs}
72.1	6.4	12.3	64.1	11.3	23.5	57.8	11.5	17.5	52.1	27.8	34.1

Note: L_{nm}= whiteness to blackness no mordant, a_{nm}= greenness to redness no mordant, b_{nm}= blueness to yellowness no mordant, L_{vi} = whiteness to blackness vinegar, a_{vi} = greenness to redness vinegar, b_{vi} = blueness to yellowness vinegar, L_{ts} = whiteness to blackness table salt, a_{ts} = greenness to redness table salt, b_{ts} = blueness to yellowness table salt, Lbs = whiteness to blackness baking soda, a_{bs} = greenness to redness baking soda, b_{bs} = blueness to yellowness baking soda.

Table 10: Summary of Colour Parameters of Wash Fastness Quality Characteristics of Mordanted and No-Mordant Fabric Dyed

L_{nm}	a_{nm}	b_{nm}	L_{vi}	a_{vi}	b_{vi}	L_{ts}	a_{ts}	b_{ts}	L_{bs}	a_{bs}	b_{bs}
72.2	5.3	11.1	52.2	8.5	29.5	66.5	4.7	15.7	51.8	18.5	40.2

Note: L_{nm}= whiteness to blackness no mordant, a_{nm}= greenness to redness no mordant, b_{nm}= blueness to yellowness no mordant, L_{vi} = whiteness to blackness vinegar, a_{vi} = greenness to redness vinegar, b_{vi} = blueness to yellowness vinegar, L_{ts} = whiteness to blackness table salt, a_{ts} = greenness to redness table salt, b_{ts} = blueness to yellowness table salt, Lbs = whiteness to blackness baking soda, a_{bs} = greenness to redness baking soda, b_{bs} = blueness to yellowness baking soda.

IV. DISCUSSION

The result obtained shows that the % yield of extract to be 40%, which is significantly good, this is an indication that coconut waste is rich colour. The quality characteristics of the dye extracted was also investigated, colourimeter was used to collect information on assessment of colours of the extracted dye from coconut husk, the light fastness of the dye extract on cotton fabric with no modant is higher than the modanted fabric. The modanted, vinegar has the highest delta value(ΔE) with 69.2nm over baking soda 68.2nmn, while table salt give the lowest delta value (ΔE) with 61.5nm. The wash fastness quality characteristic also indicate that table salt used as modant has the highest delta value (ΔE) to be 66.6nm, over vinegar with 52.3nm, while baking soda has a delta value(ΔE) of 51.9nm.

V. CONCLUSION

This study showed that colour pigments can be extracted from Coconut husk (cocos nucifera), it also demonstrated good evidence of colour composites which the dyed cotton fabrics showed varied colour shades and hues with different mordants, such as vinegar, table salt and baking soda. The mordanted fabrics showed better light and wash fastness properties compared to the no mordanted fabrics. The poor light and wash fastness of the unmordanted fabrics are characteristics of natural dyes compared to synthetic dyes [12].

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