ASSESSMENT OF *Sorghum bicolor* Leaves and *Hibiscus sabdarifa* CALYCES AS DYE ON COTTON FABRICS FOR WEALTH CREATION IN POST-COVID-19 PERIOD

[1]ABDULQUADIR, I. O. & [2]ADEBISI, T.T.
1: Department of Home Economics, Federal College of Education Iwo, Iwo, Osun State
abdulquadirismailo@gmail.com: +2348141584531

2: Department of Home Economics and Food Science, University of Ilorin, Ilorin Kwara State
adebisitunrayo@yahoo.co.uk: +2348065942340

ABSTRACT

*The study assessed the extraction and application of dyes from Sorghum bicolor leaves and Hibiscus sabdarifa calyces on cotton fabrics as a means of wealth creation during covid_19 period. It examined extracted dyes from the two plants, the composition, the color properties, and acceptability of consumers on these plant dyes for wealth creation. The study adopted research and development design. The composition were determined by High Performance Liquid Chromatography. Colorimeter was used to determine the L*a*b* colour properties. Acceptability of Treated Fabric Evaluation with a rating scale of 1-5 and 3 was decision rule. Two coded samples treated with the dye extracts were assessed by sixty respondents. Frequency, mean, and standard deviation were used to analyze the data. The HPLC analysis of the extracts showed that anthocyanin is the major colour bearing compound in Sorghum bicolor leaves and Hibiscus sabdarifa calyces. The colour properties identified showed that sample HYS is brighter with the value 54.82 than sample SXB with 54.07. The redness to greenness shows that the samples are reddish however, SXB is more reddish with a* value of 14.50 than HYS with a value 11.43. HYS is more bluish with b* value-19.21 while sample SXB has a value of -6.39. It was revealed that the two samples were acceptable in terms of overall acceptability: HYS is more acceptable with a value of 4.74 and SXB is 3.57. It was concluded that Sorghum bicolor and Hibiscus sabdarifa are good sources of natural plant dyes as they are rich in colour yielding compounds. It was recommended that the awareness of its utilization for households and commercial dyeing should be publicized as means of wealth creation.*

Keywords: Dye, *Sorghum bicolor*, *Hibiscus sabdarifa*, Fabric and Wealth.

INTRODUCTION

Clothing, food, and shelter are the basic needs of man. However, clothing is anything placed on the body to protect or adorn as well as to cover human nakedness. Most clothing articles particularly clothes are made from fabrics. On a larger scale, fabrics are used for the construction of sewn garment which are worn on the body, around us in almost everywhere, in the home, at work places among other places serving different purpose, that. In addition, different fabrics have different characteristics and so one has to choose wisely considering one need, the cost of the fabric and also the care of the fabric (Anyakoha, 2015). The characteristics of different fabrics chiefly depend on the fibre that it is produced from. It is the basic component of fabric

and fibre could be from natural or artificial sources. Natural fibres are gotten from plants, animal or mineral sources. Cotton fibre is a natural fibre obtained from the plant *Gossypium hirsutum*.

While cotton fabrics are white in colour, dyes can however be applied to make them more colourful. Cotton fabrics are however white in their grey state as such they require some colour finishes as such, the dyeing process become unavoidable.

Dye is a coloured substance that has an affinity for the substrate to which it is being applied. It is generally applied on an aqueous solution and requires a mordant to improve the fastness of the dye on the fabric (Ekeh, and Okoronkwo, 2016). Generally, dyes have been used to alter the appearance of fabric by changing their colour since ancient times. Ozougwu and Anyakoha (2013) postulated that dye is an organic chemical compound which imparts permanent colour to other materials. Dyes however are either natural from natural sources or synthetic from chemical industries. All dyes were basically natural, extracted from some plants and animals until the advent of synthetic dyes in the middle of 19th century (Osabohien, Otutu, and Ukponmwan, 2013). Dyes are obtained from natural sources such as plants, animals, fungi, microbes, minerals and man-made sources which are generally referred to as synthetic dyes as stated by Jabar and Abayomi (2015). Nigeria has abundant resources in terms of plants which contain dyes in parts such as the roots, bark, leaves, seeds, fruits and flowers (Nwoye and Ezema, 2017). Of such plant is Sorghum bicolor which serve as one of the major farm waste in Nigeria.

Sorghum bicolor (Guinea corn) belongs to the grass family, *Poaceae*. Guinea corn leaf is an important source of carbohydrate, protein and minerals such as calcium, selenum, manganese and iron in which the bioavailability depends on the level of interactions with various anti-nutrients, the leaves of which constitutes greatly to farm wastes in Nigerian farm, (Osabohiern, 2014). The plant is also known as Soursour in Sierra Leone, dab or bissap in Senegal and surrounding countries, oseille de Guinean or Roselle in French, marakwanga in Northern Uganda, Jamaican sorrel or Florida crambery in the Caribean areas (Yılmaz, and Bahtiyari, 2017). Another important plant ithat is yet to be fully employed in textile dyeing is roselle.

Hibiscus sabdarifa (Roselle) plant is a tetraploid belonging to the family Malvaceae. Ozougwu and Anyakoha (2016) asserted that roselle plant has been extensively utilized for various purposes for making beverages, manufacture of newsprint and found useful in medicinal and pharmacological fields and for making food colourants but has not been adequately explored for its dye for fabric colouration despite its large pigment content.

Ozougwu and Anyakoha (2016) stated three techniques of dye extraction; boiling method, steeping method and solvent extraction method. Mordants are "metallic salts" that are used in natural dyeing to help set the dye pigment and improve color and light fastness. The word comes from the Latin word "mordere" meaning "to bite". Bechtold and Mussak (2009) stated that mordants are used for fixation of the dyestuff, increasing the fastness properties or variation in the color appearance.

Anthocyanins are one of the most important groups of water soluble pigments visible to the human eye. They are responsible for many of the attractive colours, from scarlet to blue, of flowers, fruits, leaves and storage organs (Castaneda-Ovando, Pacheo-Hernandez, Paez-Hernandez, Rodriguez, and Galan-Vidal, 2009). However, there are six most common anthocyanins found in vascular plants or higher plants, namely, delphinidin, malvidin, cyanidin, pelargonidin, peonidin and petunidin (Castañeda-Ovando et al., 2009). Anthocyanidins are

available singly in certain fruit. Hibiscus anthocyanins were identified as having Delphinidin-3-sambubioside (Dp-3-sam) (70% of the anthocyanins) and Cyanidin-3-sambubioside (Cyn-3-sam) as the major pigments, with Delphinidin-3-glucoside (Dp- 3-glu) and Cyanidin-3-glucoside (Cyn-3-glu) as the minor ones (Amor and Allaf, 2009). Awika, and Rooney (2004), found out that three components of anthocyanin in *Sorghum bicolor* plant are the 3-deoxyanthocyanidins which includes Apigenidine and Luteolinidine. These anthocyanins have a small distribution in nature and are distinct from the more widely distributed anthocyanidins in that they lack a hydroxyl group at the C-3 position and exist in nature substantially as aglycones.

The broad objective of the study is Extraction Dye from Selected Plants and their application on Cotton Fabrics. The specific objectives are to:

1. Extract dyestuffs from *Sorghum bicolor* leaves and *Hibiscus sabdarifa* calyces.
2. Determine the composition of the dyestuff extracts responsible for the colour pigment and their quantities.
3. Assess the qualities of the dye extracts for wealth creation on cotton fabrics
4. determine the colour properties of the dyed fabrics for wealth creation
5. Determine the perception of consumers on the acceptability of the dyed fabrics as means of wealth creation

MATERIALS

Dried Leaves of *Sorghum bicolor* and *Hibiscus sabdarifa* was purchased at Ipata market, Ilorin, Kwara state. Cotton fabric and alum were bought at Oja-Oba market, Ilorin, Kwara State. The equipment used for the experiments are: mortar and pestle, sieve, knife, spatula, weigh balance, measuring cylinder, funnel, and bowls.

METHODS

Dye Extraction

Solvent extraction was used for the extracting the dye (Lizamoni, Smita, and Ava, (2021). The collected dried *Sorghum bicolor* leaves were chopped into smaller bits 100g of this was added to 500ml of methanol (absolute) and then left for three days. This was then filtered using a cotton fabric and a filter funnel. The filtrate was kept airtight in a container. Dried calyces of *Hibiscus sabdarifa* were milled and then 100g of this was added to 500ml of methanol (absolute) then left for three days. This was then filtered using a cotton fabric and a filter funnel. The filtrate was kept airtight in a container labeled as samples SXB and HYS for dye extracts from *Sorghum bicolor* leaves and *Hibiscus sabdarifa* cayxes respectively.

Determination of the chemical composition of the extracts responsible for the colour pigment and their quantities was carried out using HPLC analysis (Wang, Kalt, & Sporns, 2000). HPLC machine of Agilent 110 Series was used for the analysis with a detector of agilent 1260. 10µl of each sample was injected into the machine at dimension of 5 micrometer, 4.6*250 mm at flow rate of 1.0ml/Min. The column used was YMC-Pack PROC18 Rs at column temperature of 30ºC and a dimension of 5 micrometer, 4.6*250 mm. the following solvents were used for the gradient elution: Solvent A; Water: Formic Acid (90:10) and Solvent B: Acetonitrile: Methanol: Water:

Formic Acid (22.5:25.5:40:10). The analysis was run for the two extracts separately using the system specifications provided.

Fabric Treatment: cotton fabric was cut into 24" by 14" which measures 25g. It was then washed with warm soapy water so as to remove the fabric finishes applied on fabric. 5 gram of alum and 1 g of table salt was dissolved in 500 ml of boiling distilled water. Each of the fabric was mordanted for 2 hours after which they were removed.

Dyeing Method: contemporary plain dyeing method (Ozougwu and Anyakoha, 2016) was adopted for the dyes application. The dye bath was prepared with 112 ml of the dye liquor in 500 ml of distilled water for each of the samples. The fabric is then immersed in the dye bath, and heated to 80^{o} Celsius for 15 minutes, it was then left to cool for 5 hours after which the fabric was removed and dried in an airy shady place. This procedure was repeated for the remaining sample and so two different dyed fabrics were developed.

Determination of Colour Properties: The colour properties of the dyed fabrics was analyzed using colorimeter to measure the CIE L* a* b* values of each of the dyed fabrics, where each fabric sample was exposed to the colorimeter. However, the instrument was validated by five experts in the field of clothing textiles.

Data Collection: The instrument used for data collection is Organoleptic Attributes Acceptability of Treated Fabric Evaluation (OAATFE), which was adapted for this study, with a rating scale of 1-5 with 5 Very highly Accepted (VHA), 4 Highly Accepted (HA), 3 Averagely Accepted (AA), 2 Unaccepted (U) 2 and 1 Highly Unaccepted (HU). Data was collected from the respondents during the assessment sessions which comprises of 60 trained panelists from the department of Home Economics, University of Ilorin, Ilorin South, Kwara state.

Data Analysis

The data collected was analyzed using frequency, mean and standard deviation. A decision rule of 3.0 was chosen which depicts that the sample is acceptable.

RESULTS AND DISCUSSIONS

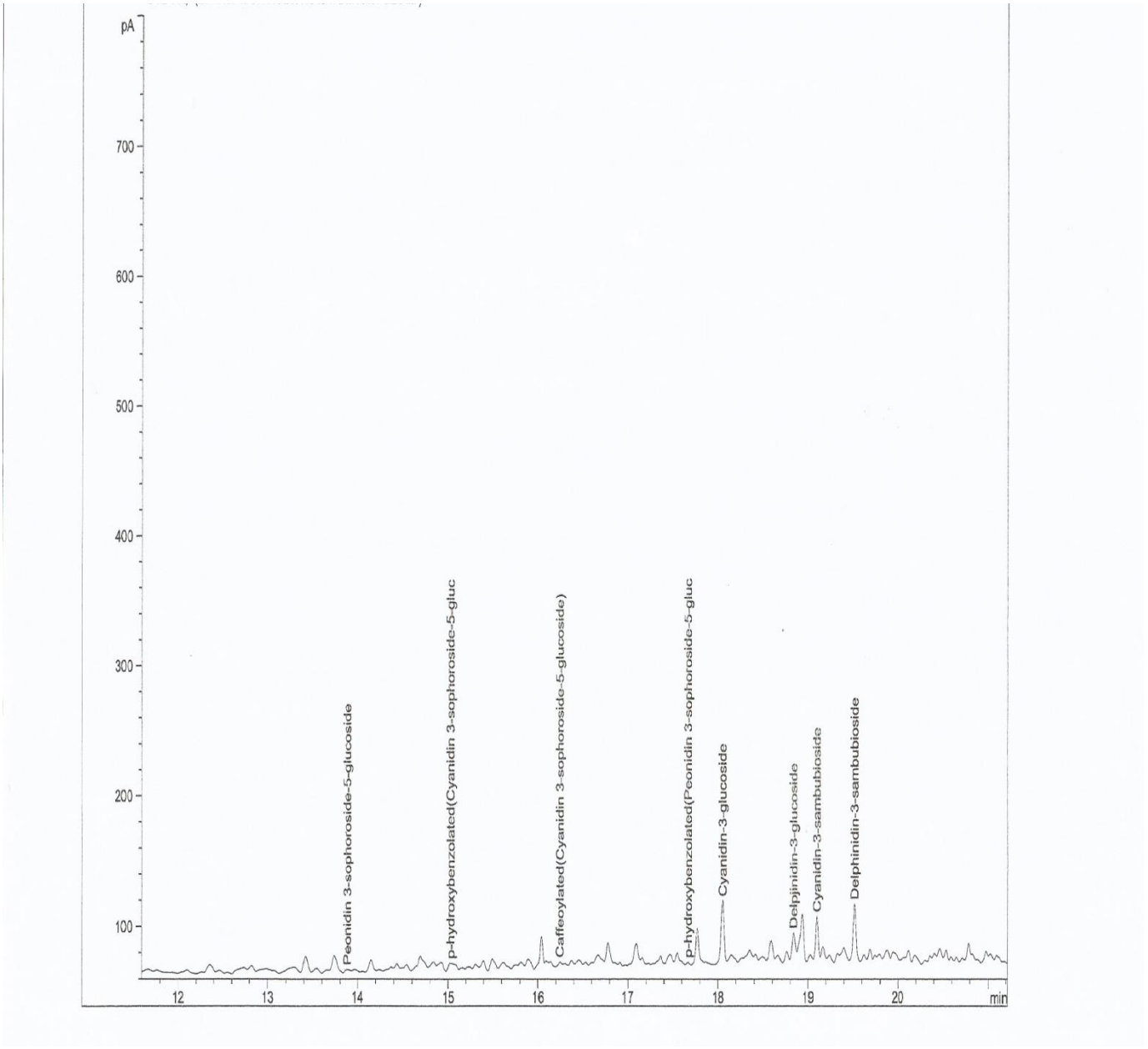

Figure 3: Peaks of Absorption with Time of the Colour Bearing Compound Discovered in Methanolic Extracts of *Sorghum bicolor* Leaves

Analysis Method : C:\HPCHEM\1\METHODS\ANTHO-A.M
Last changed : 7/16/2018 4:06:41 AM
ANTHOCYANINS ANALYSIS

External Standard Report

Sorted By : Signal
Calib. Data Modified : 7/16/2018 4:06:01 AM
Multiplier : 1.0000
Dilution : 1.0000

Signal 1: UVD1 A,

RetTime [min]	Type	Area [pA*s]	Amt/Area	Amount [mg/100g]	Grp	Name
13.882	VV	32.65039	1.87688e-5	6.12808e-4	1	Peonidin 3-sophoroside-5-glucoside
15.025	VV	82.23447	2.66241e-5	2.18942e-3	1	p-hydroxybenzolated(Cyanidin 3-sophoroside
16.244	VV	53.54709	1.90968e-5	1.02258e-3	1	Caffeoylated(Cyanidin 3-sophoroside-5-glu
17.666	VV	47.49277	1.52625e-5	7.24859e-4	1	p-hydroxybenzolated(Peonidin 3-sophoroside
18.053	VV	212.43033	3.72135e-2	7.90527	1	Cyanidin-3-glucoside
18.840	VV	121.70590	2.20435e-1	26.82827	1	Delpjinidin-3-glucoside
19.101	VV	130.17502	1.75070	227.89744	1	Cyanidin-3-sambubioside
19.519	VV	197.42175	4.28611	846.17059	1	Delphinidin-3-sambubioside

Totals : 1108.80612

Results obtained with enhanced integrator!
Group summary :

Group ID	Use	Area [pA*s]	Amount [mg/100g]	Group Name
1		877.65771	1108.80612	TOTAL ANTHOCYANINS

Figure4: Amount of Each Anthocyanin Group in mg/100g of the *Sorghum bicolor* Leaves Extract

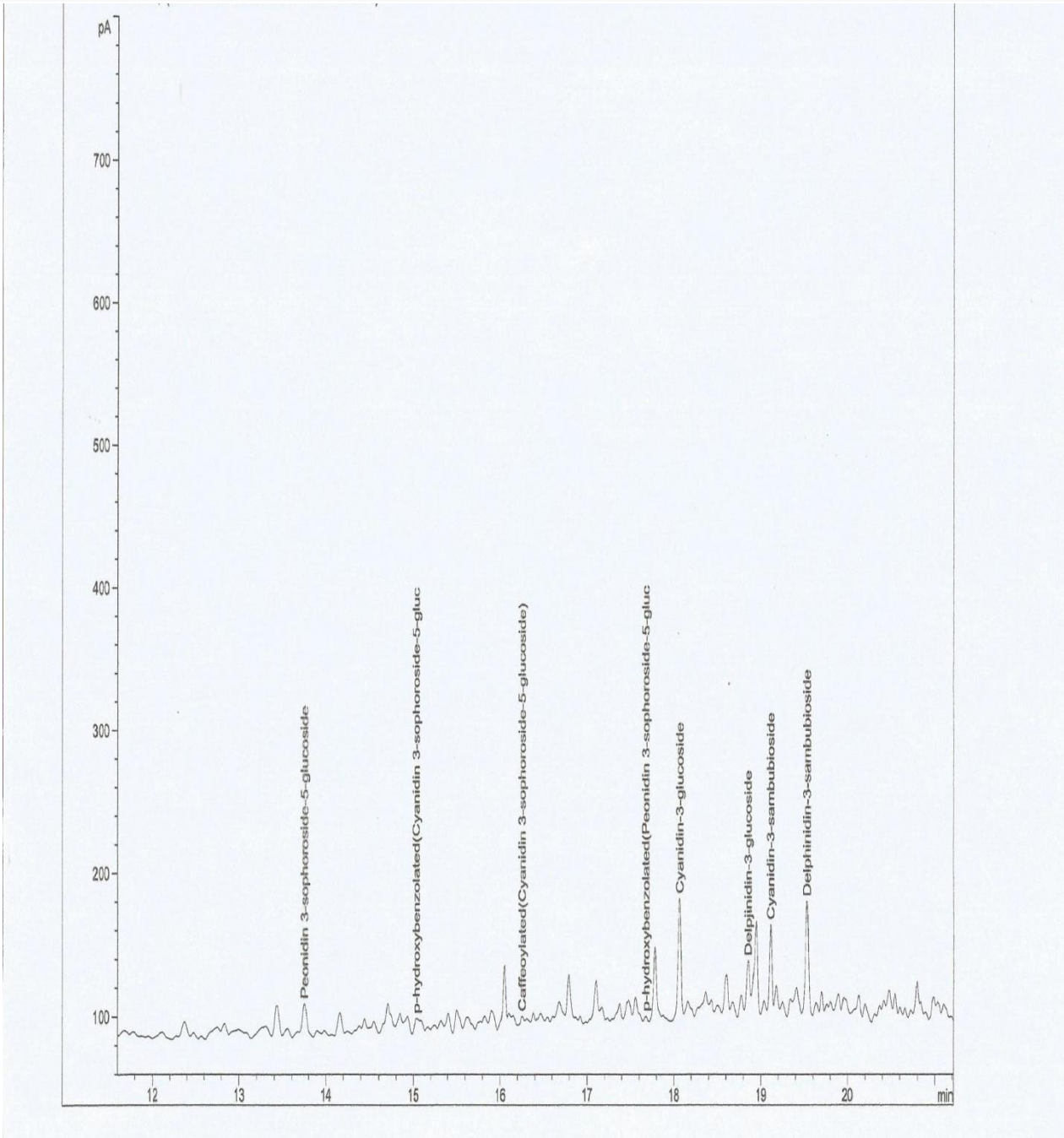

Figure 5: Peaks of Absorption with Time of the Colour Bearing Compound Discovered in Methanolic Extracts of *Hibiscus sabdarifa* calyces

Analysis Method : C:\HPCHEM\1\METHODS\ANTHO-B.M
Last changed : 7/16/2018 3:59:45 AM
(modified after loading)
ANTHOCYANINS ANALYSIS

External Standard Report

Sorted By : Signal
Calib. Data Modified : 7/16/2018 3:59:41 AM
Multiplier : 1.0000
Dilution : 1.0000

Signal 1: UVD1 A,

RetTime [min]	Type	Area [pA*s]	Amt/Area	Amount [mg/100g]	Grp	Name
13.748	VV T	56.25774	1.87688e-5	1.05589e-3	1	Peonidin 3-sophoroside-5-glucoside
15.034	VV T	39.20222	2.66241e-5	1.04372e-3	1	p-hydroxybenzolated(Cyanidin 3-sophoroside
16.252	VV T	25.63211	1.90968e-5	4.89491e-4	1	Caffeoylated(Cyanidin 3-sophoroside-5-gluc
17.675	VV T	18.21258	1.52625e-5	2.77970e-4	1	p-hydroxybenzolated(Peonidin 3-sophoroside
18.064	VV T	236.98555	4.35692e-2	10.32527	1	Cyanidin-3-glucoside
18.852	VV T	135.52890	2.32749e-1	31.54417	1	Delpjinidin-3-glucoside
19.114	VV T	155.51489	2.03583	316.60198	1	Cyanidin-3-sambubioside
19.530	VV T	222.81064	4.68165	1043.12097	1	Delphinidin-3-sambubioside

Totals : 1401.59525

Results obtained with enhanced integrator!
Group summary :

Group ID	Use	Area [pA*s]	Amount [mg/100g]	Group Name
1		890.14463	1401.59525	TOTAL ANTHOCYANINS

Figure 6: Amount of Each Anthocyanin Group in mg/100g of the *Hibiscus sabdarifa* calyces Extract

Table I: Chemical Composition of *Sorghum bicolor* Leaves and *Hibiscus sabdarifa* Calyces Responsible for the Colour Pigment

From Table I, the assessment of the chemical compound present in the dye extracts responsible for the colour pigment using HP-LC analysis showed that anthocyanin is the major colour

Anthocyanin Group	Name of Anthocyanin Pigment	Amount in *Sorghum bicolor* (mg/100g)	Amount in *Hibiscus sabdarifa* (mg/100g)
1	Peonodin 3-sophoroside-5-glucoside	$6.128e^{-4}$	$1.056e^{-3}$
1	p-hydoxybenzolatedcyanidi-3-sophoroside-5-glucoside	$2.189e^{-3}$	$1.044e^{-3}$
1	Caffeoylatedcyanidin 3-sophoroside-5-glucoside	$1.023e^{-3}$	$4.895e^{-4}$
1	p-hydoxybenzolated peonidin 3-sophoroside-5-glucoside	$7.247e^{-4}$	$2.780e^{-4}$
1	Cyanidin 3-glucoside	7.905	10.326
1	Delpjinidin 3-glucoside	26.826	31.544
1	Cyanidin 3-sambubioside	27.897	316.610
1	Delpjinidin 3-sambubioside	846.171	1043.120
Total		**1108.806**	**1401.600**

bearing compound in *Sorghum bicolor* leaves and *Hibiscus sabdarifa* calyces. This agrees with Suganya, Saravanakumar, and Mohandas (2011) that identified the 3-deoxyanthocyanidins (apigeninidin and luteolinidin) in the methanol extract from sorghum. This also agrees with Castañeda-Ovando *et al.*, (2009) that postulated that anthocyanin pigments are responsible for the array of attractive colours such as orange, pink, red, purple and blue. The result also showed the different groups of anthocyanins present in *Sorghum bicolor* leaves and *Hibiscus sabdarifa* calyces were identified these are Delphinidin-3-sambubioside, Cyanidin-3-sambubioside, Delphinidin-3-glucoside, Cyanidin-3-glucoside, Peonidin 3-sophoroside-5-glucoside, p-hydroxylbenzolated (Cyanidin 3-sophoroside-5-glucoside), caffeoylated(cyanidin 3-sophoroside -5-glucoside), and p-hydroxylbenzolated(Peonidin 3-sophoroside-5-glucoside), this agrees with Castañeda-Ovando et al., (2009) and Amor and Allaf, (2009) that postulated the same thing but only named four of the anthocyanins which were Delphinidin-3-sambubioside (Dp-3-sam) and Cyanidin-3-sambubioside (Cyn-3-sam) as the major pigments, with Delphinidin-3-glucoside (Dp- 3-glu) and Cyanidin-3-glucoside (Cyn-3-glu) as the minor ones. The result also showed that Delphinidin-3-sambubioside has the highest quantity in *Sorghum bicolor* leaves and *Hibiscus sabdarifa* calyces with having 846.17mg/100g and 1043.12mg/100g of the dye extract respectively this also agrees with Amor and Allaf, (2009) who asserted that Delphinidin-3-sambubioside has over 70% in the total anthocyanin in *Hibiscus sabdarifa* plant. The study agrees with Awika, and Rooney (2004), who found out three components of anthocyanin in *Sorghum bicolor* plant which are: cyanidin, delphinidin and peonidin. However, in addition to Awika and Rooney (2004) this study has discovered five more anthocyanin pigments present in the extracts from *Sorghum bicolor* leaves and *Hibiscus sabdarifa* calyces

Table I shows the amount of each colour components present in the *Sorghum bicolor* leaves and *Hibiscus sabdarifa* calyces. The table reveals that *Hibiscus sabdarifa* has a greater total amount of anthocyanin pigments than *Sorghum bicolor leaves* has.

Contemporary plain dyeing is adopted in applying the dyestuffs on cotton fabric. The following are the colour properties of the samples using the CIE L*a*b* values

Table II: Colour Properties of the Sample

Sample Codes	L*	a*	b*
HYS	54.82	11.43	-19.21
SXB	54.07	14.50	-6.39

Key: **HYS:** fabric dyed with *Hibiscus sabdarifa* dye extracts

SXB: fabric dyed with *Sorghum bicolor* dye extracts

Table II shows the colour properties of the samples, where L* means whiteness of the samples; where values toward 100 depict whiteness while values towards 0 depicts blackness, a* mean the redness or greenness of the samples; with positive value showing degree of redness and negative values showing level of greenness, and b* means the yellowness or blueness of the samples; with positive value showing degree of yellowness and negative values showing level of blueness.

However, the colour properties identified shows that the L* value indicates that sample HYS with the value 54.82, is the brightest and then sample SXB with 54.07, This result showed that the fabric dyed with dye extracts from *Sorghum bicolor* leaves and *Hibiscus sabdarifa* calyces are the are evenly dyed as the brightness is within the optimum value of brightness. The redness to greenness shows that all the samples are more reddish with SXB with a value of 14.50 and HYS with a value 11.43. This shows that the anthocyanin present in *Sorghum bicolor* leaves produces more of red colorations. The blueness to yellowness values showed that, HYS is the bluest with a value of -19.21 while sample SXB has a value of -6.39. The result shows that the blueness is highest in HYS and least in SXB. This shows that dye from *Hibiscus sabdarifa* calyces could give a shade that is closer to blue. This is because anthocyanin present in *Hibiscus sabdarifa* calyces produced more of blue coloration as described by (Castaneda-Ovando *et. al* 2009).

TableIII: The Mean and Standard Deviation of the Acceptability of the Organoleptic Attributes of the Samples

Sample Codes	Colour	Texture (Sight)	Texture (Touch)	Odour	Evenness of Shade	Overall Acceptability
HYS	$3.80+0.99^{ab}$	$3.65+0.82^{a}$	$3.85+0.84^{a}$	$3.77+0.79^{a}$	$3.83+0.89^{a}$	$4.75+6.52^{b}$
SXB	$3.87+0.91^{a}$	$3.78+0.69^{a}$	$3.87+0.77^{ab}$	$3.70+0.81^{a}$	$3.67+0.93^{b}$	$3.97+0.71^{c}$

Key: **HYS:** fabric dyed with *Hibiscus sabdarifa* dye extracts

SXB: fabric dyed with *Sorghum bicolor* dye extracts

For the colour, it is observed that Sample SXB is the more acceptable with the mean value of 3.87 while sample HYS is less acceptable with a mean value of 3.80. This agrees with
For the texture (sight), Sample SXB is the more acceptable with the mean value of 3.78 while sample HYS is the less acceptable with a mean value of 3.3.65.
For the texture (touch), Sample SXB is the most acceptable with the mean value of 3.87 while sample HYS is less acceptable with a mean value of 3.85. However, all the samples are acceptable in term of texture (sight and touch) with mean values higher than 3, this agrees with Samanta and Konar, (2011) who postulated that shades produced by natural dyes are usually soft, lustrous and soothing to the human eye. Likewise the finding is in line Chengaiah, Rao, Kumar, Alagusundaram, and Chetty, (2010) that observed that natural dyes produce soft texture, feel or "hand" in fabric and give cooling and soothing sensations that revitalizes the skin.
For the odour, Sample HYS4 is the most acceptable with the mean value of 3.77 while sample ASH8 is the least acceptable with a mean value of 3.50. A quality dye should have pleasant odour on the fabrics.
For the evenness of shade Sample HYS4 is the most acceptable in with the mean value of 3.83 while sample ASH8 is the least acceptable with a mean value of 3.23. The findings support Ashis and Agarwal (2009), who discovered that natural dyes produce uncommon soothing and soft shades compared to synthetic dyes
Sample HYS is the most acceptable in terms of overall acceptability with the mean value of 4.75. This agrees with Ozoagwu and Anyakoha (2013) who stated that Organoleptic attributes of cotton fabric treated with dye extracted from roselle calyces identified include: Fairly warm maroon colour hue, fairly light value, fairly brilliant chroma, smooth and fairly soft textures, odourless and even shade which were all accepted as good organoleptic attributes. A quality dye should be soluble in water or dispersible in a solvent resulting in evenness of shade or level dyeing in fabric colouration, have pleasant odour on the fabric, and organoleptically appealing.

CONCLUSION

Based on the findings the study concludes that *Sorghum bicolor* and *Hibiscus sabdarifa* are good sources of natural dyes as they are rich in colour yielding compounds (anthocyanin) that are suitable for textile dyeing. Also, the dye plants are good for textile dyeing with appreciable colour properties. Finally, *Sorghum bicolor* and *Hibiscus sabdarifa* plants can serve economic purposes as a means of wealth creation.

RECOMMENDATIONS

Dye extracts from *Sorghum bicolor* and *Hibiscus sabdarifa* can be utilized in dyeing cotton fabric in especially in fabric recycling. The awareness on the use of vegetable dyes particularly dyes from *Sorghum bicolor* and *Hibiscus sabdarifa* plants as means of wealth need to be created. More research works should be carried out on natural dye exploration particularly vegetable dyes in textile dyeing.

REFERENCES

Amor, B. & Allaf, K. (2009). Impact of Texturing Using Instant Pressure Drop Treatment Prior to Solvent Extraction of Anthocyanins from Malaysian Roselle *(Hibiscus sabdariffa)*. *Food Chemistry*, 115(3). 820-825.

Anyakoha, E. (2015). *Home Management for Schools and Colleges*. Onitsha, Nigeria. Africana Publishers.

Awika, J. & Rooney L., (2004) Sorghum Phytochemicals and their Potential Impact on Human Health. *Phytochemistry* 65. 1199–1221.

Bechtold, T. & Mussak, R. (2009). *Handbook of Natural Colorants.* The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom. John Wiley & Sons Limited. Add pages

Castaneda-Ovando, A., Pacheo-Hernandez, L., Paez-Hernandez, E., Rodriguez, J., & Galan-Vidal, C., (2009). Chemical Studies of Anthocyanins: A Review. *Food Chemistry*. 113.859-871.

Chengaiah, B., Rao, M., Kumar, M., Alagusundaram, M., & Chetty, M. (2010). Medical Importance of Natural Dyes- A Review. *International Journal of PharmTech Research.* 2(1). 144-154.

Ekeh, J. & Okoronkwo, S. (2016). Assessment of the Potentials of Dyes Extracted from Selected Plants on Cotton Fabric. *Social Science and Law Journal of Policy Review and Development Strategies* 5(1). 67-80.

Jabar, J.M. and Abayomi, L. T. G. (2015). Effect of Temperature on Affinity of Natural Dye from Coconut Coir Fibre for Cotton Fabric. *International Journal for Research in Applied Chemistry*. 2(2): 1 – 9.

Lizamoni, C., Smita, B., & Ava, P. (2021). Natural Dyes: Extraction and Applications *International Journal of Current Microbiology and Applied Sciences.* ISSN: 2319-7706. 10(01). 1669-1677.

Nwoye U. & Ezema, P. (2017). Extraction and Utilization of Natural Dye Extract from Guinea Corn Leaf. *International Journal of Development Strategies in Humanities, Management and Social Sciences*. 7, 40-51.

Osabohien E. (2009). Extraction and Utilization of Natural Dyestuffs from Maesobotyra staudtyii
and *Chrosophylum albidum. Nigerian Journal of. Science and Environment*. 8. 93-97.

Osabohien, E., Otutu, O., & Ukponmwan, O., (2013) Dyeing and Colouring Using the Extract from a Plant; *Bosqueia angolensis. International Journal of Scientific Research*. 3(1). 1-6.

Osabohien, P. (2014*).* Extraction and Application of Dyestuff from the Leaves of Guinea Corn and Onion Skin. *International Journal of Biological and Chemical Sciences.* 8(2). 811-820.

Ozougwu, U. & Anyakoha, U. (2013). Evaluation of the Organoleptic Attributes and Acceptability of Cotton Fabric Treated with Dyes Extracted from Beetroot (*Betavulgaris*) Indigenous Plant for Fabric Coloration. *Journasl of Home Economics Research.* 18(1). 261-263.

Ozougwu, U. & Anyakoha, U. (2016). Acceptability of Cotton Fabric Treated with Dye Extracted from Roselle (Hibiscus sabdariffa) Calyces based on its Phytochemical Composition and Evaluation of Organoleptic Attributes. *African Journal of Agricultural Research.* 11(33). 3074-3081.

Samanta K. & Konar, A. (2010). *Dyeing of Textiles with Natural Dyes*. Department of Jute and Fibre Technology, Institute of Jute Technology, University of Calcutta India. pp 30. Article retrieved from https://www.researchgate.net/publication/221919685_Dyeing_of_Textiles_with_Natural_Dyes. December, 2023.

Suganya, P., Saravanakumar, M., & Mohandas, S. (2011). African Identification of 3-deoxyanthocyanins from Red Sorghum (Sorghum bicolor) Bran and its Biological Properties. *Journal of Pure and Applied Chemistry*. 5(7). 181-193.

Wang, J. Kalt, W. & Sporns, P. (2000). Comparison between HPLC and MALDI-TOF MS Analysis of Anthocyanins in High Bush Blueberries. *Journal of Agriculture and Food Chemistry* 48: 3330-3335.

Yılmaz, F. & Bahtiyari, I. (2017). Investigation of the Usability of Hibiscus Plant as a Natural Dye Source: *International Symposium on Innovative Technologies in Engineering and Science*. 29-30.