academicJournals

Vol. 11(33), pp. 3074-3081, 18 August, 2016
DOI: 10.5897/AJAR2014.9108
Article Number: 5523E5660031
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Acceptability of cotton fabric treated with dye extracted from Roselle (*Hibiscus sabdariffa*) calyces based on its phytochemical composition and evaluation of organoleptic attributes

Ozougwu, Stella U.[1]* and Anyakoha, Elizabeth U.[2]

[1]Department of Home Science, Nutrition and Dietetics, Faculty of Agriculture, University of Nigeria, Nsukka, Enugu State, Nigeria.
[2]Department of Vocational Teacher Education Faculty of Education, University of Nigeria, Nsukka Enugu State, Nigeria.

Received 1 September, 2014; Accepted 23 April, 2016

The study evaluated the acceptability of 100% cotton fabric treated with dye extracted from roselle (*Hibiscus sabdariffa)* calyces based on its phytochemical compositions and organoleptic attributes. A quasi-experimental design was adopted by the study and was carried out at the University of Nigeria Nsukka, Enugu State, Nigeria. The study population comprised of 41 panelists made up of 17 Lecturers and 24 Postgraduate students drawn from the university. Spectrophotometric and gravimetric methods were adopted for the quantitative analysis of phytochemical constituents of extracts from roselle calyces. Questionnaire was used to collect data on the organoleptic attributes and acceptability of cotton fabric treated with roselle dye and data were analyzed using descriptive statistics including percentages, means, and standard deviation. A null hypothesis was tested at 0.05 level of significance using t-test. The following phytochemical components were present in roselle dye extract: carotenoid (1.96%), flavonoid (0.02%), lutein (0.03%), polyphenol (0.12%), tannin (0.88%) per 100 g of roselle calyces. 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 colour which were all accepted as good attributes of dye on fabrics by both categories of evaluators. There were no significant differences (P>0.05) in the mean rating responses of both categories of evaluators on the acceptability of the organoleptic attributes of cotton fabric treated with roselle dye. The null hypothesis was accepted at 0.05 level of significance. Roselle dye has good organoleptic attributes and could be used for 100% cotton fabric colouration.

Key words: Phytochemical, organoleptic attributes, roselle dye, cotton fabric.

INTRODUCTION

Roselle calyces (*Hibiscus sabdariffa*) 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 (Schippers, 2000; The Technical Centre for Agricultural and Rural Co-operation ACP-EU, 2006) but has not been adequately explored for its dye for fabric colouration despite its large pigment content. Dye is an organic chemical compound which imparts permanent colour to other materials. The scarcity of quality dyes in sustainable supplies and the challenging and threatening effects in the nation's textiles and clothing, wood, food, paper, photography, leather and leather product industries as well as in educational institutions and at homes calls for urgent need for research and development efforts into sourcing and exploitation of locally available plant dyes in sustainable supplies to substitute and/or supplement the imported ones (Onwualu, 2006). A quality dye should among other factors, 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, colourfast, organoleptically appealing and as well have commendable quality of sticking to fabrics to avoid crocking (Finar, 1973). Crocking is the rubbing off of dyes from fabric; an indication that the dye is not well absorbed or firmly attached to the fabric. Grayness or crystals of dyes on fabric's surface implies uneven or un-level dyeing which is unacceptable to clothing and fabric consumers. Fabric refers to a flexible material made up of a network of natural or manufactured fibres formed by any of weaving, knitting or other fabrication methods (Vanderhoff et al., 1985). Cotton fabric is processed from cotton plant, a natural fibre, and treated in this study to test the organoleptic quality of dye extracted from roselle calyces.

Roselle calyces have been reported to possess large pigment content and some dye attributes (Technical Centre for Agricultural and Rural Co-operation ACP-EU, 2006), which may be due to the presence of some phytochemicals. Phytochemicals are chemical compounds or bioactive non nutrient compounds that occur in plant and some of the plants are beneficial to human in health and disease prevention. Saponin, Phytate, carotenoid, polyphenols, lutein, flavonoids and tannin among others are phytochemicals in plants which contribute to the colour of plants and other organoleptic attributes of plants from which natural dyes of plant origins are extracted (Win and Swe, 2008).

Organoleptic attributes of a dye are the qualities of a dye that can be seen, touched or felt, perceived or smelt and therefore involve the senses of sight, touch or feel and smell. The colour, texture, odour and evenness of shade or level dyeing are all components of organoleptic attributes of a dye. Colour is an aspect of visual experience (Websters Collegiate Encyclopedia, 2000). The colour of a dye in fabrics or clothing is an important factor in the choice and selection of textiles and clothing items and accessories. Hue, value, chroma or intensity are aspects of colour (Johnson and foster, 1990; Marshal et al,, 2000). Hue is the wavelength reflected from a material. Different wave lengths indicate different hues and approximately 150 hues can be detected in the visible spectrum (Kolender, 2013). Hue is the name of a color family (red, blue, green) and may be warm or cool. Warm hues are red, yellow, orange as found in the sun rays and fire while cool hues are those found in water (blue, green and violet) (Johnson and Foster, 1990). Value is the lightness or darkness of a colour while Chroma or intensity explains the purity of a color expressed as the strength or weakness, dullness or brightness or the degree of saturation of a color. High chroma in colours makes a colour pure, strong, brilliant and saturated and is thus preferred in the choice of dye source than low chroma in colours which makes the colour mute, weak, grayed and dull and less acceptable in the dyeing of fabrics. Johnson and Foster (1990) emphasized that each hue in the color wheel is presented at its fullest and purest chroma or intensity meaning that the colour is at its greatest saturation and brightness; thus can be said to be at the peak of its brilliance. Texture is a sensory impression involving touch and sight (Marshal et al., 2000). Different textures absorb light differently and can change the colour of fabrics. The same dyes applied on different textures produce different colours. The visual aspect of texture is perceived by the eye because of the degree of light absorption and reflection on the surface of the material and can be hard or soft, rough or smooth, hot or cold. Such impressions are the result of sensory impression understood by sight and other sense organs (Bartley, 1996; Hobbs and Rush, 1997). The tactile, feel or 'hand' aspect of texture in fabrics includes the coarseness, softness or crispness and rigidity and are often influenced by the type of dye used in fabric colouration.

Fabric dyeing and printing coloration techniques are vital aspects of clothing and textile components of Home Science programme. Fibre, yarn, fabric and garment dyeing, printing and their variations are indispensable career opportunity or job oriented areas that equip students with relevant entrepreneurial skills that prepare them for the world of work. Dyes are very crucial instructional materials or raw consumables required for teaching and learning and for skill acquisitions in the coloration techniques. No fabric colouration can be successfully carried out without one form of dye or the other

Currently, much emphasis is placed globally on natural dyes because they are biodegradable and eco-friendly. The devastating effect of the environmental pollution and health hazards caused by some non-biodegradable and carcinogenic synthetic dyes could be minimized by exploitation and utilization of natural dyes. Natural dyes are commonly used in the cosmetic industry due to no side effects, their UV protection and anti-aging properties. Extraction of roselle dye will contribute to ensuring

*Corresponding author. E-mail: ozougwusu@yahoo.com. Tel: +2348033318006.

sustainable supply of dye for effective teaching and learning of textiles and clothing and other fields that utilize dyes. Indigenous or home dyers, small and medium scale clothing and textiles industries may increase the volume of clothing and textiles production to generate income thus reducing unemployment, poverty and associated crimes.

It has been observed that the local supply of dyes as important processing chemicals in textile and clothing sector are low and scarce and fail to meet the need of the sector (Onwualu, 2006), many of the synthetic dyes imported into the country are eco unfriendly and pose threat to human life. Presently, in Nigeria, funding for many schools is a great challenge and the inability of the schools to purchase instructional materials and consumables including dyes in sustainable supply poses threats to practical work. Practical exercises are often skipped or stalled and students will not acquire the needed skills that will promote entrepreneurship. Consequently, students may graduate without acquiring the necessary practical skills in clothing and textile programme which could launch them into relevant clothing related entrepreneurial activities. This is a problem. About 143 unexplored dye yielding plants including roselle are locally available (Jansen and Cardon, 2005). These however, have remained largely unexplored. It then becomes necessary to evolve workable ways of sourcing the dyes which students can use for practical work locally.

The general objective of the study was to evaluate the acceptability of cotton fabric treated with dye extracted from roselle (*Hibiscus sabdtariffa*) calyces based on its phytochemical composition and organoleptic attributes.

Specifically, the study sought to:

1. Assess the phytochemical constituents of roselle calyces for carotenoids, flavonoids, lutein, polyphenol and tannins.
2. Evaluate the organoleptic attributes of cotton fabric treated with dye extracted from roselle calyces.
3. Determine the acceptability of cotton fabric treated with roselle dye extract.

Hypothesis

One null hypothesis was tested by the study at 0.05 level of significance:

$H_0 1$: There is no significant difference in the mean responses of lecturers and post graduate students on the acceptability of cotton fabric treated with dye extracted from roselle calyces.

MATERIALS AND METHODS

The study was carried out at the University of Nigeria, Nsukka, (UNN) Enugu State, Nigeria using quasi experimental research design. The experimental aspect of the study was carried out in the Analytical laboratory of Home Science, Nutrition and Dietetics Department to determine the phytochemical constituents while assessment of the organoleptic attributes was carried out in the Clothing and Textile laboratory of Home Economics Unit of Vocational Teacher Education Department (VTE), all at the University of Nigeria, Nsukka. The study population comprised of 41 evaluators made up of 17 lecturers and 24 Postgraduate students purposively sampled from the following Departments: Vocational Teacher Education (VTE), Home Science, Nutrition and Dietetics, Pure and Industrial Chemistry, Fine and Applied Arts, all at the University of Nigeria, Nsukka. These departments offer courses relating to dye production or/ and utilization. The lecturers and postgraduate students (who also teach or work with dyes in their various establishments) are in a better position to give accurate evaluation of the organoleptic quality of dye produced from roselle calyces. They are also co-consumers. The detail of the lecturers who were part of the study population was as follows:

1. Seven home economics lecturers from VTE department;
2. Six lecturers from Home Science, Nutrition and Dietetics department;
3. Two lecturers from the Department of Pure and Industrial Chemistry and
4. Three lecturers from Fine and Applied Arts Department UNN. This gave a total of 17 lecturers from the four departments (Source; Departmental records).

The postgraduate (PG) students were also drawn from the respective departments as for the lecturers. The detail of the population of this category was: 12 PG students from (Home Economics Unit) VTE Department:

1. Eight PG students from the department of Home Science, Nutrition and Dietetics, UNN.
2. Two PG students from the department of Pure and Industrial Chemistry and
3. Two PG students from Fine and Applied Arts Department, all from UNN (Source; Departmental Registers 2014 academic session).

Red dry roselle calyces, Aluminum sulphate ($AlSO_4$) (alum), sal soda, ferrous sulphates, methanol. Other materials and equipment used include: Cotton (100%), distilled water, heater, thermometer, rubber hand gloves, Thomas Willey milling machine, stainless and plastic bowels, spoons, laboratory blender, desiccators and freezer. Their uses were explained below alongside the procedure of the work.

Procedure

Red dry roselle calyces (4 kg) were collected from Enugu and further dried under room temperature (40°C for 40 min) in the Green House to enhance quick and smooth milling. The calyces were milled into fine powder using Thomas Willey milling machine. The roselle powder was then kept under room temperature and used within seven days for both chemical analysis of the phytochemical constituents and dye extraction for cotton fabric dyeing and acceptability evaluation.

Quantitative determination of phytochemical compositions of roselle calyces

Carotenoid was determined by gravimetric method as described by Harborne (1973): About 3 g of powdered roselle calyces was homogenized in methanol using a laboratory blender. A 1:10 (10%) solution of methanol was used. The homogenate was filtered to obtain the initial crude extract. Ether (20 ml) was added to the filtrate to take up the carotenoid content. The sample was mixed up very well in a separating funnel and 20 ml of distilled water was added. The ether layer was recovered and then evaporated to dryness at low temperature (35-50^{o}C) in a vacuum desiccator. The dry extract was then saponified with 20 ml of ethanoic potassium hydroxide (KOH) and left over night in a dark cupboard. The next day, the carotenoid were taken up in 20 ml of ether and then washed with two portions of 20 ml distilled water. The carotenoid extract (ether layer) was dried in a desiccator and then treated with a light petroleum (petroleum spurt) and allowed to stand in a freezer (-10°C). The next day, the precipitated steroid was removed by centrifugation and the carotenoid extract was evaporated to dryness in a weighed evaporation dish, cooled in a desiccator and weighed. The weight of carotenoid was determined and expressed as a percentage of the sample weight.

Flavonoid determination was done using gravimetric method as described by Boham and Kocipai-Abyazan (1994). About 10 g of roselle calyces sample were extracted repeatedly with 100 ml of 80% methanol at room temperature. The whole solution was filtered through Whatman filter paper No 42 (12.5 mm). The filtrate was later transferred into a crucible and evaporated to dryness over a water bath and weighed to a constant weight.

Lutein analysis was carried out using the diethyl ether spectrophotometric method as described by Nurhidayati and Irianty (2012). About 1 g of the powdered roselle calyces was treated with 30 ml of acetone containing 0.1 ml Magnesium Carbonate ($MgCo_3$) in a glass beaker with constant stirring for 16 h. This was filtered and the residue re-extracted with 20 ml acetone until the filtrate became clear. Then 10ml of 50% Potassium Hydroxide (KOH) was added and the filtrate KOH mixture seated on a hot plate for 10 min. The solution was put in a separating funnel and 30 ml diethyl ether and 20 ml water added. The aqueous layer was discarded while the ether layer was recovered and measured in a spectrophotometer at 445 nm against a blank diethyl ether.

Polyphenols determination was by spectrophotometric method according to Association of Official Analytical Chemists (AOAC) (2005). The fat free sample of powdered roselle calyces was boiled with 50 ml of ether for the extraction of the phenolic component for 15 min. 5 ml of the extract was pipetted into a 50 ml flask, and then 10 ml of distilled water was added. 2 ml of ammonium hydroxide (NH_4OH) solution and 5 ml of concentrated amylalcohol were also added. The samples were made up to mark and left to react for 30 min for colour development. This was measured at 505 nm.

Tannin analysis was done using spectrophotometric method according to Van-Burden and Robinson (1981). A 500 mg sample of roselle calyces was weighed into a 50 ml plastic bottle. 50 ml of distilled water was added and shaken for 1 h in a mechanical shaker. This was filtered into a 50 ml volumetric flask and made up to the mark. Then 5 ml of the filtrate was pipetted out into a test tube and mixed with 2 ml of 0.1 M Iron III Chloride ($FeCl_3$) in 0.I N Hydrogen Chloride (HCl) and 0.008 M Potassium ferrocyanide (K_4 $(FeCN)_2$. The absorbance was measured at 720 nm within 10 min. If the absorbance was not measured within 10 min, Iron III Chloride ($FeCl_3$) may become too thick or heavy and refuse to be read in the spectrophotometer.

Mordanting cotton fabric

To pre-mordant the fabric, 25 g of cotton fabric (40"x40") was scoured thoroughly in warm water with detergent three times to remove all finishes. Aluminum sulphate ($AlSO_4$) (alum) of 6.25 and 0.5 g of sodium carbonate ($NaCo_3$) were dissolved in 1 L of heated distilled water. The wet scoured cotton fabric was gently immersed and thoroughly stirred so that it opened out in the solution. It was heated at 80°C for 1 h and allowed to cool overnight in the solution then squeezed off excess water.

Dye extraction and fabric dyeing

Extraction of dye from roselle calyces was done using boiling method as described by Kolender (2003). A portion of 80 g rosselle powder was dissolved in 160 ml distilled water in the ratio 1:2 (W/V) and heated at 80°C for 20 min and allowed to cool. The heated portion was filtered with 0.5 mm mesh (Particle size) to collect the dye liquor. The mordanted cotton fabric was immersed in the roselle dye bath for 1hr at a temperature of 80°C using the contemporary plain dyeing method. The colour was modified with additional 0.25 g ferrous sulphate ($FeSO_4$) added to the dye bath. The dyed fabric was taken out, washed and dried under a shade.

Evaluation of the organoleptic attributes and acceptability of roselle dyed cotton fabric

The rating of the organoleptic attributes and acceptability of the dyed fabric was done by a panel of 41 evaluators using a set of 41 copies of the OAAE instrument. The instrument comprised three sections. Section A sought personal data of evaluators including the department and status (lectuerer/student, male/female, married/single). Section B dealt with organoleptic attributes of cotton fabric treated with roselle dye including colour hue, value, chroma, textures of sight and feel, odour and levelness or evenness of shade of roselle dye on dyed cotton fabric. A 5-pont scale with real limit of numbers was used to take decisions on the organoleptic attributes where mean in the range of 5 in the scale represents the highest identified attribute and mean in the range of 1 indicate the least attribute as shown below using table of real limit of numbers (Table 1).

Section C evaluated the acceptability of the organoleptic attributes of roselle dyed cotton fabric by the evaluators. Mean 3 and above on any attribute of the roselle dyed cotton fabric indicate that such attribute is accepted by evaluators as good attribute of a dye on dyed fabric while mean below 3 shows that a particular attribute is not accepted by the evaluators. The table of real limit of numbers below was used to take decisions on the acceptability of the roselle dyed fabric by the evaluators.

Table 2 show real limit of numbers for evaluating the acceptability of roselle dyed cotton fabric. The rating was done in a single session and the evaluators' mean rating responses were collated for data analysis.

Data analysis

Data were analyzed using descriptive statistics (Percentages, mean and standard deviation). Mean 3.00 and above indicate positive and accepted organoleptic attribute whereas mean below 3.00 indicate negative and unaccepted organoleptic attribute. The t-test statistic was used to test the stated null hypothesis. Null was accepted when P-value is less than or equal to 0.05 ($P \leq 0.05$) and rejected when P-value is greater than 0.05 ($P > 0.05$) significant level.

RESULTS

1. The following phytochemical constituents were present in roselle calyces per 100 g; carotenoid (1.96%), flavonoid (0.02%), lutein (0.03%), polyphenol (0.12%), tannin (0.09%) (Table 3).
2. Identified organoleptic attributes include: Roselle

Table 1. Roselle dye attributes and range of means for taking decisions.

Roselle dye	**Range of means for taking decisions**				
Range of means	5.00-5.90	4.00-4.90	3.00-3.90	2.00-2.90	1.00-1.90
Colour Hue (Maroon)	Very warm	Warm	Fairly warm	Cool	Very cool
Value	Very light	Light	Fairly light	Dark	Very dark
Chroma/Brightness	Very bright	Bright	Fairly bright	Dull	Very dull
Textures of sight	Very smooth	Smooth	Fairly smooth	Rough	Very rough
Textures of feel	Very soft	Soft	Fairly soft	Crisp/coarse	Very crisp
Odour/Smell	Very pleasant	Pleasant	Odourless	Offensive	Very offensive
Evenness of Shade	Very even	Even	Fairly even	Uneven	Very uneven

Table 2. Real limit of numbers for evaluating the acceptability of roselle dyed cotton fabric.

Range of mean	**Decision**
5.00-5.90	Very highly accepted (VHA)
4.00-4.90	Highly accepted (HA)
3.00-3.90	Averagely accepted (AA)
2.00-2.90	Unaccepted (UN)
1.00-1.90	Highly unaccepted (HU)

Table 3. Percentage of carotenoid, flavonoids, lutein, polyphenol and tannin phytochemical contents of roselle calyces per 100 g (N=3).

Constituents	**X_1**	**X_2**	**X_3**	**X_4**	**SD**	**SE**
Carotenoid	**2.0285**	**1.8997**	**1.9518**	1.9600	0.0282	*0.0200*
Flavonoid	**0.0168**	**0.0180**	**0.0171**	0.0173	0.0000	0.0000
Lutein	**0.0259**	**0.0249**	**0.0257**	0.0255	0.0035	0.0025
Polyphenol	**0.1211**	**0.1207**	**0.1242**	0.1220	0.0014	0.0010
Tannin	**0.0877**	**0.0875**	**0.0873**	0.0875	0.0049	0.0035

X_1 X_2 X_3 = Mean± SD of three determinations, X_4 = grand mean, SD = standard deviation, SE= standard error of mean.

colour is maroon with fairly warm hue, fairly light value, fairly brilliant chroma, smooth and fairly soft texture, odourless and even shade (Table 4).

3. All the roselle dye attributes on treated cotton fabrics were accepted by both categories of evaluators. There were no significant differences (P>.05) in mean responses of the lecturers and postgraduate students on acceptability of the organoleptic attributes of mcotton fabrics treated with roselle dye at 0.05 significant level (Table 5).

Data in Table 3 shows that of all the phytochemical constituents of roselle calyces determined, carotenoid had the highest quantity present (1.96%), followed by polyphenol (0.12%), tannin (0.09%) and lutein (0.03%). The least phytochemical constituent present was flavonoid (0.02%).

Data in Table 4 reveal that all the organoleptic attributes of roselle dyed alum mordanted cotton fabrics were rated highly by both the lecturers and postgraduate students as shown by the grand mean and standard deviation scores of each attribute. Colour hue when cotton fabric is mordanted with alum mordant was maroon and was fairly warm (3.69±0.73). Value was fairly light (3.59± 0.54). Chroma was fairly bright (3.63±0.57), and textures of visual perception and feel were smooth and fairly soft respectively (4.12±0.57 and 3.85±0.82). Roselle dye was odourless (3.68 ± 0.72), and shade of colour was even (4.02±0.58). The roselle dyed cotton fabric attribute that attracted the highest rating as shown by the grand mean of both categories of evaluators was texture of sight (4.12 ± 0.58) while the lowest rated attribute was colour value (3.59 ±0.54).

All the organoleptic attributes of roselle dyed cotton fabric were rated from averagely to highly acceptable by

Table 4. Mean responses of lecturers and postgraduate students on the organoleptic attributes of cotton fabric treated with roselle dye.

S/N	Attributes	X_1	SD_1	X_2	SD_2	X_3	SD_3
1	Hue (Maroon)	3.59	0.793	3.79	0.658	**3.69**	**0.726**
2	Value	3.35	0.702	3.83	0.381	**3.59**	**0.542**
3	Chroma	3.88	0.485	3.37	0.648	**3.63**	**0.567**
4	Texture (Sight)	4.24	0.562	4.00	0.590	**4.12**	**0.576**
5	Texture (Feel)	3.82	0.951	3.88	0.680	**3.85**	**0.816**
6	Odour/ smell	3.53	0.800	3.83	0.637	**3.68**	**0.719**

X_l, Mean of lecturers; n_l, Number of lecturers; SD_l, standard deviation for lecturers; X_2, mean of postgraduate students, n_2, number of postgraduate students; X_3, grand mean; SD2, standard deviation of postgraduate students; N-Total number of respondents SD_3. standard deviation for grand mean.

Table 5. Mean rating responses and t-test results of lecturers and postgraduate students on the acceptability of the organoleptic attributes of cotton fabric treated with roselle dye.

S/N	Attributes	n_1=17		n_2=24		N_T=41		T-cal	P-val
		X_1	SD_1	X_2	SD_2	X_3	SD_3		
1	Hue (Maroon)	4.12	0.600	4.08	.502	**4.10**	**0.551**	0.198	0.844
2	Value	4.00	0.612	3.88	.612	**3.94**	**0.612**	0.644	0.523
3	Chroma	3.71	0.849	3.96	.462	**3.84**	**0.656**	-1.225	0.228
4	Texture (Sight)	4.08	0.502	4.12	.600	**4.10**	**0.551**	0.198	0.844
5	Texture (Feel)	3.88	0.322	4.21	.415	**4.05**	**0.369**	-2.684	0.011
6	Odour/smell	3.24	0.752	3.21	.415	**3.23**	**0.584**	0.147	0.884
7	Evenness of shade	4.00	0.707	4.00	.417	4.00	0.562	0.000	1.000
	Average	3.86	0.640	3.90	.470	3.89	0.555	-.557	0.581

X_l, Mean of lecturers; N_l, number of lecturers; SD_l, standard deviation for lecturers; X_2, mean of postgraduate students; N_2, number of postgraduate students; Df, degree of freedom (39); SD_2, standard deviation of postgraduate students; T-cal, T calculated.grand mean; SD_3, standard deviation for grand mean.

both categories of evaluators. This could be seen by their different grand mean values ranging from 3.23 to 4.10 in Table 5. For instance the roselle maroon colour hue, texture of visual perception and feel as well as evenness of shade of roselle dye on cotton fabric were all highly accepted with mean scores in the range of 4 as shown in the table. While colour hue was warm (4.10±0.55), value was fairly light (3.94±0.61), chroma was fairly bright (3.82±0.65), textures on visual perception and feel of the treated cotton were smooth and soft (4.10±0.55 and 4.05±0.36 respectively). Roselle dyed cotton fabric was odourless (3.23±0.58) and attained level dyeing or evenness of shade of colour.

Hypothesis 1

There is no significant difference in the mean responses of Lecturers and Postgraduate students on the acceptability of the organoleptic attributes of cotton fabric treated with roselle dyes. The calculated p-value of 0.58 of the total or cluster mean in Table 5 is greater than 0.05 ($p>.05$) significant level at degree of freedom 39. This result indicates that there is no significant difference in the mean responses of lecturers and postgraduate students on the acceptability of the organoleptic attributes of cotton fabric treated with roselle dye.

Decision rule

If p-calculated is greater than 0.05 null hypothesis will be accepted while alternative hypothesis will be rejected but if p-calculated is equal or less than ($p<0.05$) 0.05, null hypothesis will be accepted while alternative hypothesis will be rejected. Null is therefore accepted at 0.05 level of significance since the p-value (0.581) is greater ($P\geq 0.05$) than 0.05 level of significance.

DISCUSSION

The study findings on the phytochemical quantitative estimation of the crude yield of roselle calyces reveal that it is high in carotenoid (1.96%), flavonoid (0.02%), lutein (0.03%), polyphenol (0.12%), tannin (0.09%). Flavonoid (0.03%) was the lowest phytochemical constituent of roselle calyces amongst those studied. This finding supports Rao and Seshadri (1942) in Ali et al. (2005), who isolated flavonol glycocides from the flowers of *H. sabdariffa* and observed that the content of flavonol glycosides in the calyces was very low and that these compounds were to be found primarily in the flower petals.

Regarding the organoleptic attributes of roselle dyed cotton fabric, seven attributes were identified. For instance the colour hue was maroon and fairly warm, value was fairly light, chroma was fairly bright, textures on visual perception and feel were smooth and fairly soft respectively. Roselle dyed cotton fabric was odourless and attained level dyeing or evenness of shade of colour. Win and Swe (2008) emphasized that the presence of tannin, carotenoids, polyphenols, lutein flavonoids among other phytochemicals in plants contribute to the colour of plant. Roselle is a plant. These phytochemical constituents were present in roselle calyces in considerate quantities as shown by the study findings and could have probably contributed to the organoleptic attributes of roselle dye on cotton fabric studied. This could be seen by their different mean ratings ranging from 3.23 to 4.10. Colour hue (Maroon) was the attribute most accepted concurrently by both lecturers and PG students though with different but closely related mean (4.12 ±.60 and 4.08±.50, respectively). This finding supports Apparel Search Company (2009) and Lao Silk and Craft (2009), that natural dyes produce wide range of interesting colours with different mordants. Roselle dye yielded interesting maroon colour on 100% cotton fabric using alum as mordant. When 100% cotton fabric is mordanted with other mordants other than alum, roselle dye could produce a different colour or more. They stressed that by using natural plant dyes, natural dyeing experts find beautiful colour springs from unlikely places and by using traditional recipes with new variations, artisans, individuals and home makers can transform roots, leaves, bark, berries and seeds of plants in their home backyards into natural dyes to produce colours and designs on textiles and garments that appeal to people aesthetically and in fashion. The very high score on texture of feel of the roselle dyed cotton fabric by the lectuuers confirms Chengaiah et al. (2010), observation that natural dyes produce soft texture, feel or “hand” in fabric and give cooling sensations that are calmatives and revitalize the skin as many of the plants natural dyes possess remarkable antimicrobial activity and are currently used in cosmetics industry due to no side effects but possess UV protection and anti-aging properties (Chengaiah et al., 2010). The finding also supports Ashis and Agarwal (2009), who emphasized that natural dyes produce uncommon soothing and soft shades compared to synthetic dyes.

In preliminary investigations, an ‘Analysis of fabrics treated with dyes extracted from roselle calyces was conducted. The colour fastness of 100% cotton, stone silk (60% silk, 40% polyester) and polyester (100%) fabrics mordanted with alum and treated with dyes extracted from roselle calyces was explored. Roselle dyed cotton fabric was found to show reasonable fastness to sunlight, acid perspiration and crocking but relatively poor to washing and generally non fast to stone silk and polyester prototypes. The findings also revealed no significant differences in the effect of boiling, steeping and solvent extraction methods used but significant differences existed in the effects of mordant or dye fixatives (alum, tannic and citric acid) used on the colour fatness of the roselle dyed fabrics. Alum and tannic acid mordants had comparable more positive improvements on the colour fassness of the prototype dyed fabrics studied.

Conclusion

Findings from the present study showed that roselle calyces contain reasonable quantities of carotenoid, polyphenol, tannin, lutein and flavonoid phytochemical constituents in descending order of magnitude per 100 g. The identified organoleptic attributes of cotton fabric treated with raselle dye which were acceptable by the evaluators were attributed to the phytochemical constituents of the dye. With the results of the preliminary study on the colourfastness of roselle dye on 100% cotton fabric using alum mordant, roselle dye is a promising dye that can serve as a useful colourant to 100% cotton fabric when mordanted with alum. This has much implication to textiles and clothing students and teachers, home dyers, medium and large scale textile and clothing industries, agriculturists and textile chemists.

RECOMMENDATIONS

1. Textile and clothing teachers at all levels of education in Nigeria should encourage their students to explore plants in their environment for dye extraction and utilization through classroom experiments and research development efforts. The exploitation of the plant dyes will contribute greatly to availability of dyes in sustainable supply for academic, industrial and entrepreneurial purposes.
2. Home makers and artisans or individuals who practice fabric dyeing of any sort should be educated through workshops, seminars, conferences and community meetings on the need to explore the plants in their communities or even their home backyard gardens including roselle dyes using the processes and procedures in the study. These should be explored for entrepreneurship in fabric colouration and other

purposes.

3. The large scale textiles and clothing industries should appreciate the findings of this study by using the identified roselle dye. The industries should find ways of sourcing and improving the quality of the dyes through their textile chemists.

4. More cotton and roselle plants should be cultivated by the agriculturist to ensure sustainable supply of the plant dyes and cotton fibres.

5. The Federal and State Governments through their various agencies and programmes such as skill training and acquisition Programmes should assist individuals, rural dwellers, medium and small scale dyeing enterprises owners or those who would want to embark on dyeing related enterprise using natural dyes by way of funding and bursary awards.

6. A replication of the study could be carried out using other mordants that are human and environmental friendly other than alum used in this work to study their effects.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Ali BH, Wabel NAl, Blunden G (2005). Phytochemical, pharmacological and toxicological aspects of Hibiscus sabdariffa L: A review. Phytotherapy 19:369-375.

Apparel Search Company (2009). Dye definition for the clothing and fabric industry. http://www.apearelsearch.com/definition/Dye/dye

Ashis KS, Agarwal P (2009). Application of natural dyes on textiles. Indian J. Fibre Textile Res. 34:384.

Association of Official Analytical Chemists AOAC (2005). Official methods of analysis, 17th Edition. Washington DC.

Bartley SH (1996). Visual perception: Concise Encyclopedia of Psychology. In: Cosiri RJ, Alerbach AJ New York. John Willy & Sons P 298.

Boham BA, Kocipai-Abyazan C (1994). Flavonoids and condensed tannins from leaves of Hawaiian Vaccinium vaticulatum and V. calycinium. Pac. Sci. 48:458-463.

Chengaiah B, Rao KM, Kumar K, Alagusundaram M, Chetty CM (2010). Medicinal importance of natural dyes - A review. Int. J. Pharm. Technol. Res. CODEN (USA). IJRIF 2(1):144-154.

Finar IL (1973). Organic chemistry, the fundamental principle. UK. Longman Group Limited P 875.

Harborne JB (1973). Phytochemical methods: A guide to modern techniques in plants analysis London. Chapman and Hall pp. 49-188.

Jansen PCM, Cardon D (2005). Plant resources of Tropical Africa 3- dyes and tannins. Wageningen, PROTA Foundations P 11.

Johnson JG, Foster AG (1990). Clothing, image and impact. Cincinnati. Ohio. South Western Publishing Co. P 145.

Kolender C (2003). Chemistry of Dyes http://www.aurasilk.com/info/naturaldying.shtm/.

Marshal SG, Jackson JO, Stanley MS, Kefgen M, Tochie–Specht P (2000). Individuality in clothing selection and personal appearance. New Jersey. Prentice Hall Inc. 18:220.

Onwualu P (2006). Role of research and development in industrial raw material sourcing in Nigeria: 2nd, distinguished lecture of the School of Postgraduate Studies, University of Nigeria, Nsukka. http://www.rmrddc.gov.ng P 22.

Rao SP, Seshadri TR (1942). Isolation of hibiscitrin from the flowers of Hibiscus sabdariffa: constitution of hibiscetin. Proc. Indian Acad. Sci. 15a:48-153.

Schippers RR (2000). African indigenous vegetables. An overview of cultivated species. Uk. National Resources Institute /ACP-EU. P. 119.

The Technical Centre for Agricultural and Rural Cooperation ACP- EU (2006). Spore: EU Tech. Centre Agric. Rural Cooperation Biol. Monthly Bull. 126:7.

Van-Burden TP, Robinson WC (1981). Formation of complexes between protein and tannin acid. J. Agric. Food Chem. 1:77.

Vanderhoff M, Frank L, Campbell L (1985). Textiles for Homes and Peoples. Massachusetts. Gin and Company 14:122, 133.

Websters M (2000). Dye, something used as a coloring matter. Merriam Websters Collegiate Encyclopedia USA. Websters Incorporated P 3.

Win ZM, Swe MM (2008). Purification of natural dyestuff extracted from mango bark for application on protein fibres. World Acad. Sci. Eng. Technol. P 46.