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Evaluation of the Organoleptic Attributes and Acceptability of Cotton Fabric Treated with Dyes Extracted from Beetroot (*Betavulgaris*) Indigenous Plant for Fabric Coloration

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Abstract

This study evaluated the organoleptic attributes and acceptability of cotton fabric treated with dyes extracted from beetroot [Beta vulgaris] indigenous plant for fabric coloration. The study design was Research and Development (R and D) and was conducted at the University of Nigeria, Nsukka. The study population comprised 41 evaluators made up of 17 Lecturers and 24 Postgraduate students from University of Nigeria, Nsukka. Organoleptic Attributes and Acceptability Evaluation [OAAE] instrument was used for data collection and data were analyzed using descriptive statistics. t-test statistic tested a null hypothesis at 0.05 Level ofsignificance There were no significant differences(P>0.05) in the mean rating responses of lecturers and postgraduate students on the acceptance of the organoleptic attributes of the beetroot dye on cotton fabric in six instances but difference existed in one instance. The null hypothesis was therefore accepted in six instances and rejected in one instance at 0.05 probability level. Recommendations were made based on the findings.

Key words: Dye, Dye extraction, Mordant, Organoleptic attribute, Cotton fabric.

Introduction

Dye is a coloured substance that imparts permanent colour to other substances. Dye is an indispensable processing chemical used as colorant in the food, wood, photography, paper, leather and leather products, textiles and clothing industries as well as in educational institutions as raw consumables for teaching and learning and at homes for garment and fabric coloration and renovation. For any colored substance to be called a dye, it must be colorfast. This implies that the dye must be capable of being fixed or firmly attached to the fibre or substance resisting removal by

the action of environmental stressors such as sunlight, washing, perspiration, including acids and alkalis and crocking or rubbing(Marshal, Jackson, Stanley, kefgen and Touchie-specht, 2000) A good dye must also have good organoleptic attributes and be acceptable by consumers (Ozougwu and Anyakoha, 2013). Organoleptic attributes of a dye refers to the qualities of the dye that can be seen, touched or felt, perceived or smelt and therefore involves the senses of sight, touch or feel and smell. The organoleptic attributes sought for in a dye include the different dimensions of colour, texture, odour and evenness of shade or level dyeing.

Colour is an aspect of visual experience (Websters Collegiate Encyclopedia, 2000). The colour of a dye plays major role and most often the primary motivation for the purchase of textiles and clothing items and accessories. The dimensions of color include- hue, value, chroma or intensity (Johnson and foster, 1990; Marshal, et al, 2000). Hue from physicist point of view is the wavelength reflected from a material. Different wavelengths indicate different hues and approximately 150 hues can be detected in the visible spectrum (Kolender, 2013). Hue from the artist or dyers' perspective is the name of a color family such as red, blue, green. This study takes cue from the latter's perspective. Color hue is being described as warm or cool. Warm hues are those found in the sun and fire such as red, yellow, orange and cool hues are those found in water including blue, green and violet. The warmth or coolness of a hue carries with it, an illusion of weight. For instance, warm hues are known as advancing hues as they emphasize the body size and contours and make objects, shapes or areas appear larger, more important and closer than others whereas cool hues minimize body size and make objects, areas and shapes appear smaller, less important and farther away than other colors (Johnson and Foster, 1990).

Value describes the lightness or darkness of a color. When the color white is added to a color, a lighter color referred to as tint is obtained while a darker color, shade is obtained when black is added to another color. Whatever color value yielded by a natural dye must be acceptable to consumers. Chroma or intensity describes the purity of a color expressed as the strength or weakness, dullness or brightness or the degree of saturation of a color.High chroma colors are pure, strong, brilliant, saturated colors and areacceptable, but low chroma colors are muted, weak, grayed and dull and unacceptable. Johnson and Foster (1990) emphasized that each hue in the color wheel is presented at its fullest, purest, chroma meaning that the colour is at its greatest saturation, its greatest brightness, its most brilliant and fullest intensity. Texture is a sensory impression involving touch and sight (Marshal et al 2000). Texture absorbs light differently and can change the colour of fabrics. The same dyes applied on different textures produce different colors. 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 aspect includes the coarseness, softness or crispness and rigidity. Whatever dye applied to finish a fabric that renders it unusable for purposes for which it should serve is unacceptable.

A good dye should be soluble in water or dispersible in a solvent resulting in evenness of shade or level dyeing in fabric. Crocking is the rubbing off of dyes from fabric, an indication that dye was not well absorbed or firmly attached to the fabric. Grayness or crystals of dyes on fabric's surface produce uneven or un-level dyeing which is unacceptable. Finally, a good dye should have a pleasant odor on fabric. Any dye, synthetic or natural that gives offensive odor to fabric is unacceptable.

Synthetic dyes are prepared in the laboratory from aromatic compounds. Natural dyesaredyes thatare extracted from natural sources from animals, minerals and from the roots, stems bark, leaves, seeds, calyces, fruits and resins of plants. Natural dyes are often referred to as mordant dyes since natural dyes require mordant to be colorfast. A mordant is a chemical element that quickens the rate of chemical reaction taking place between a dye and a fibre. Mordant also helps to open up the fibre for dye absorption and deepen the shade of the dye.

Presently there has been a global interest for exploitation of natural dyes perhaps due to their numerous benefits. Natural dyes are biodegradable and environmental friendly. They are less toxic and non-carcinogenic unlike their synthetic counterparts (Jothi, 2008; Lao Silk and Craft, 2009). Natural dyes have health and economic benefits and are readily locally available but are largely unexplored for utilization either for fabric coloration, skill acquisition or teaching and learning.

Clothing and Textiles is a component of Home Economics Education that equips students with relevant knowledge, attitude and skills in clothing and textile programme. Fabric dyeing and printing coloration are entrepreneurial activities that provide career opportunities to students upon graduation. With paucity supply of dyes, practical exercises in these areas are often skipped and students will not acquire the needed skills. Lack of entrepreneurial skills predisposes graduatesto unemployment or joblessness where white collar jobs are not easily available. As a way of contributing to filling the gap of dye scarcity, Ozougwu and Anyakoha(2013), embarked on an R and D study on dye extraction from beetroot plant and evaluated the effects of three extraction methods (boiling, steeping and solvent) and mordant (alum,citric acid, tannic acid and no mordant(control) on the light, wash, perspiration (acid and alkali) and crocking fastness of cotton fabric treated with dye extracted from beetroot indigenous plant. The study findings showed among others that beetroot dye has dye potential that showed reasonable colorfastness on coton fabric; there was no significant

difference in the effects of extraction methods used but significant differences existed in the effect of mordant on the colorfastness of the dye. Alum and tannic acids exhibited comparable positive improvement on the colorfastness of the dyes more than citric acid and non-mordantedprototypes; tannic acid changed completely all prototypes to black. The study suggested organoleptic attribute evaluation of the beetroot dye among others which was the focus of this present study.

Purpose of the study: The main purpose of the study was to evaluate the organoleptic attributes and acceptability of cotton fabric treated with dye extracted from beetroot(*Beta vulgaris*) indigenous plant for Clothing and Textiles Education. Specifically, the study:

- ❖ extracted dye frombeetroot plant using boiling extraction method
- ❖ applied the extracted dye to samples of cotton fabric mordanted with aluminum sulphate (alum)
- ❖ evaluated the organoleptic attributes and acceptability of the dye on cotton fabric.

Research question: One research question guided the study;

- ❖ What are the organoleptic attributes and acceptability index of the cotton fabric treated with dye extracted from beetroot (*Beta vulgaris*) indigenous plant for Clothing and Textiles Education?

Hypothesis: One null hypothesis was tested by the study at 0.05 significant level.

Ho1: There is no significant difference in the mean responses of Lecturers and Post graduate students on the acceptability of the organoleptic attributes of the cotton fabric treated with dye extracted from beetroot plant for Clothing and Textiles Education.

Methodology

Design of the Study: The study adopted Research and development (R and D) design model of Gall, Gall and Borg (2003). R and D design is an industry based development model in which the findings of research are used to design new products and procedures which then are systematically field tested, evaluated and refined until they meet the required criteria of effectiveness, quality or similar standards (Gall, Gall & Borg, 2007). The R & D model of Gall et al (2003) which has seven steps was more appropriate for product development of this nature. The activities within the stages of dye extraction, application and organoleptic attribute acceptability evaluation stages of the study were built into three major phases of the cycle and include:

- ❖ Specific objectives and criteria for product development.
- ❖ Development of prototype based on scientific evidence available for pertinent research findings.
- ❖ Conducting a main field test of the product.

Area of the Study: The study was carried out at the Clothing and Textiles Laboratory of the Department of Home

Science, Nutrition and Dietetics, University of Nigeria, Nsukka, Enugu State

***Population of the Study*:** The study population was 41 evaluators made up of two categories of evaluators namely; lecturers and Postgraduate students.17 lecturers from different departments of the University of Nigeria who have Home Economics background or have knowledge of either production or utilization of dyes for fabric coloration. They include;

- Seven Home Economics lecturers from VTE department
- Six lecturers from Department of Home Science, Nutrition and Dietetics, UNN.
- Two lecturers from the Department of Pure and Industrial Chemistry, UNN.
- Three lecturers from Fine and Applied Arts Department, UNN.

The second category of judges was 24 Postgraduate (PG) students from the different departments selected for the study. This group was part of the study because many of them teach Home Economics in various tertiary institutions in Enugu state and so will be part of the consumers of the research findings. The details include;

- Twelve PG students from VTE (Home Economics)
- Eight PG students from the department of Home Science, Nutrition and Dietetics, UNN.
- Two PG students from the department of Pure and Industrial Chemistry, UNN.
- Two PG students from the department of Fine and Applied Arts, UNN.

***Instrument for Data Collection*:** Data were collected using the OrganolepticAttributes and Acceptability of the Treated Fabrics Evaluation (OAAE) instrument. The instrument comprised three sections. Section A elicited information on the personal data of the evaluators. Section B collected data on the organoleptic attributes such as colour and its dimensions includingthe degree of warmness or coolness of hue, lightness or darkness of value, brightness or dullness of chroma or intensity; smoothness or roughness of texture (Sight), softness or coarseness of texture (Feel/touch), pleasantness/odorless/offensiveness of odourand dyeing related quality such as level dyeing or even shade of dye on fabric. Sections B and C were rated on 5 point scale. Section C evaluated the acceptability of the organoleptic attributes of the beetroot dyed cotton fabric samples by the judges where 5 indicates very highly accepted (VHA), 4 indicates highly accepted (HA), 3 indicates averagely accepted (AA), 2 indicates unaccepted (UA) and I highly unaccepted (HU) for each of the attributes identified.

***Validity and Reliability of the Evaluation Instrument*:** The instrument was face validated by five experts from the four departments used for the study. Ten copies of the instrument were pretested by four lecturers and six Pg students from the Department of

Human Ecology, University of Uyo, Akwa Ibom State, Nigeria. Cronbach alpha was used to determine the reliability coefficient of specific clusters in the testing protocols and established at 0.713 and 0.875 for sections B and C respectively.

***Method of data Collection*:** Data were collected in three phases.

Phase1 of the study dealt with sourcing of beetroot plant and extraction of dye from the plant.

Materials used include: beetroot plant (collected from the major distributors at NKN No 9 & 10 salad line Ogbete Enugu), Cotton fabric (100%), aluminum sulphate (Alum), stainless steel, dyeing pots, weighing scales, buckets, thermometer, mixing bowl, ferrous sulphate, heater, washing soda (Sal soda), distilled water, gloves, towel, un chipped enamel dyeing pot, goggle, cap and hand gloves protective.

Extraction of dye from beetroot plant was done using boiling method according to Kolender (2003). Fresh beetroot plant (200g) were washed, peeled and wet milled. The milled beetroot was heated with distilled water in the ratio of 1:2 weight per volume (w/v) of the plant, that is, 200g beetroot to 400ml distilled water at the temperature range between 80^0C for 30 minutes. It was allowed to cool and then sieved with .05 mesh (particle size) to collect the dye liquor.

Mordanting of the fabric and application of the dye to cotton fabric was carried out in *Phase ii of the study.* Cotton fabric 25g (40"x40") was scoured thoroughly in warm water with detergent three times to remove all sizing. 1 litre distilled water was heated and 6.25g aluminum sulphate (alum) and 0.5g washing soda (sal soda) were dissolved in. The wet scoured cotton fabric was immersed and gently but thoroughly stirred so that it is opened out in the solution. It was heated at 80^0C for 1 hour and allowed to cool overnight in the solution then squeezed off excess water for dyeing. The mordanted cotton fabric was immersed in the dye bath for 1 hour at a temperature of 80^0C using the contemporary plain dyeing method. The colour was modified with additional 0.25g ferrous sulphate added to the dye bath. The dyed fabric was taken out and dried under a shade.

In Phase iii, the organoleptic attributes and acceptability of the dyed fabric was done by a panel of 41 evaluators using a set of 45 copies of the OAAE instrument. The evaluators' mean rating responses were collated for data analysis and the rating was done in a single session.

Data Analysis: Data collected from the judges were analyzed using descriptive statistics (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. t-test statistic was used to test one null hypothesis at 0.05 probability level.

Summary of Findings

The following findings were made;

- Seven beetroot dye organoleptic attributes were identified.
- Colour hue is brown and fairly warm/cool.
- Colour value is fairly light/light..

- ❖ Colour Chroma is fairly brilliant/dull
- ❖ Texture (Sight) is smooth.
- ❖ Texture (Feel or touch) is soft.
- ❖ Odour is odourless/offensive
- ❖ Shade is even shade.
- ❖ Six beetroot organoleptic attributes were unanimously accepted by both categories of evaluators.
- ❖ There were no significant differences(P>0.05) in the mean rating responses of lecturers and postgraduate students on the acceptance of the organoleptic attributes of the beetroot dye on cotton fabric in six instances but difference existed(P<0.05) in one instance. The null hypothesis was therefore accepted in six instances but rejected in one instance at 0.05 probability level.

Research Question 1: What are the organoleptic attributes and acceptability of cotton fabric treated with dye extracted from beetroot plant?
The answer to research question 1 is presented in tables 1 and 2.

Table 1: Mean Rating Responses of Lecturers and Postgraduate Students on the Organoleptic Attributes of Cotton Fabric Treated with Dyes Extracted from Beetroot Plant.

S/N	Beetroot Organoleptic Attributes	$\bar{x}$i	Ni	SDi	$\bar{x}$ii	Nii	SDii
1	Colour hue (Brown)	3.76	17	.572	2.88	24	.741
2	Colour value	3.65	17	.862	4.00	24	.590
3	Colourchroma	3.47	17	.717	2.83	24	.816
4	Texture (sight)	4.00	17	.791	4.00	24	.590
5	Texture (touch)	4.76	17	.732	4.12	24	.448
6	Odour (smell)	3.53	17	.717	2.92	24	1.018
7	Evenness of shade	3.88	17	.485	3.67	24	.702

Key: $\bar{x}$i - Mean of Lecturers Ni -Number of Lecturers Nii- No of Postgraduate Students SDi-Standard Deviation for Lecturers, SDii-Standard Deviation for Postgraduate Students $\bar{x}$ii-Mean for Postgraduate Students

Table 1 shows that all the organoleptic attributes scored highly above the mean cut off by the lecturers but three out of the seven organoleptic attributes were scored below mean cut offby Pg students. However, while the lecturers agreed that beetroot colour hue, brown, is warm (3.76±.74), the Pg students objected that they are cool (2.88±.74). Colour value was fairly light for lecturers but light for Pg students. The lecturers agreed that the beetroot odour is odorless (3.53±.71), it is offensive for Pgstudents (2.92±1.01). Colourchroma was fairly bright for the lecturers(3.47±71), but dull for the Pg students(2.83±.82). The highest scored attribute by both was texture as it relates to touch (4.76±.73 and 4.12±.448 respectively) followed by texture of visual perception (4.00±.791, 4.00±.590 respectively). The least scored attribute was colourchroma (2.83±.82) showing it is dull for Pg students. Both agreed that the shade of dyed fabric was fairly even.

Table 2: Mean Rating Responses and t-test Results of Lecturers and Postgraduate Students on the Acceptability of the Organoleptic Attributes of Beetroot Dyes on Cotton Fabrics.

Acceptability of the organoleptic attributes.	Xi	Ni	SDi	Xii	SDii	Nii	t/Cal	Df	P-value	Remark
Colour hue (brown)	3.59	17	.712	3.33	.482	24	1.369	39	.179	NS
Colour value	3.53	17	514	3.38	.576	24	.883	39	.382	NS
Colourchroma	3.47	17	.624	3.21	.415	24	1.618	39	.114	NS
Texture (sight)	3.76	17	.562	3.88	.537	24	.636	39	.529	NS
Texture (touch)	3.71	17	.849	3.96	.462	24	-1.23	39	.228	NS
Odour/smell	3.41	17	.712	2.71	.751	24	3.019	39	.004	S
Evenness of shade	4.00	17	.612	3.96	.464	24	.248	39	.805	NS

Key: $\bar{x}$i - Mean of Lecturers Ni -Number of Lecturers Nii- No of Postgraduate Students SDii-Standard Deviation for Postgraduate Students SDi- Standard Deviation for Lecturers t/cal-T calculated ,d/f- Degree of Freedom $\bar{x}$ii- Mean for Postgraduate Students NS -Non Significant, S-Significant

Table 2 on the acceptability of the organoleptic attributes of the dye reveal that all the attributes minus odour of the dye were unanimously accepted by both the lecturers and Pg students as they had ratings between3.33 and 4.00 indicating averagely to highly accepted. Evenness of shade was the most accepted attribute of beetroot by lecturers while odour was the most unaccepted attribute by Pg students.

Discussion

Research question one asked question on the organoleptic attributes and acceptability of beetroot dye on cotton fabric samples by lecturers and Pg students evaluators. Findings from results (Table 1) clearly show that all the organoleptic attributeswere rated highly by the lecturers. Though three of the attributes were scored a little below the mean cut off, others were scored highly by the Pg students.The beetroot dye brown colour hue is fairly warm, (lecturers),colour value is fairly light, chroma is fairly bright, (lecturers) textures are smooth and soft, odour is odorless (lecturers) and fairly even shade. The high mean score on the beetroot dye attributes on samples of cotton fabric reveal that beetroot plant has dye potentials in these aspects and may be accepted by consumers. This finding supports Apparel Search Company, (2009) and Lao Silk and Craft (2009) and Chenghaiah et al (2010), who stressed that natural dyes produce wide range of interesting colours and by using natural plant dyes, natural dyeing experts find beautiful coloursprings 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.

On the acceptability of the organoleptic attributes of beetroot dyes on cotton fabric, findings in table 2 revealed that all the organoleptic

attributes of beetroot dye on cotton fabric were accepted by all the evaluators except the odour which was rated offensive by the Pg students. The highest accepted organoleptic attribute was evenness of shade by both category of evaluators. Evenness of shade is resultant of level dyeing, an indication of solubility of the dye in the dye bath. This attribute supports the findings of Ozougwu and Anyakoha (2013) on the colorfastness of beetroot dye to crocking and alkali. A dye that is insoluble in water or dispersible in solvent leaves off particles of dyes on the surface of the fabric or substrate being dyed. A dye that is incapable of being fixed, attached or absorbed into the fibre leads to rubbing off or crocking, an undesirable and unacceptable attribute. The exceptionalhigh score on the soft texture of sight and feel of the beetroot dyed cotton fabric confirms Chenghaiah, Rao, Kumar, Alagusundaram and Chetty (2010),observation that natural dyes produce soft texture, feel or "hand" in fabric and give a cooling sensation and are calmitives that revitalize the skin. The findings also supports Ashis and Agarwal (2009), who emphasized that natural dyes produce uncommon soothing and soft shades compared to synthetic dyes.

The null hypothesis stating thatthere is no significant difference (P>.05) in the mean rating responses of lecturers and Pg students on the acceptability of the organoleptic attributes of the beetroot dyed cotton fabric was accepted in six instances for colour hue (P=0.179), value (P=0.382), chroma (P=0.114), texture for sight (P=0.529), texture for feel (P=0.28), evenness of shade (P=0.805), but rejected in one instance for odour (P=0.004) at 0.05 level of significance.The unanimous agreement by both categories of evaluators signifies that beetroot dye qualifyorganoleptically and aesthetically to be called and used as dye for cotton fabric coloration.

Conclusion

This study is a follow-up of the study on "Effects of extraction methods and mordant on the colorfastness of cotton fabrics treated with dyes extracted from beetroot (Beta vulgaris indigenous plant)by Ozougwu and Anyakoha(2013). The study finding showed that beetroot dye has reasonable colorfastness property. This present study also identified seven organoleptic attributes of the dye. Colour hue was brown and warm, value was fairly light, chroma or intensity was fairly bright, textures of visual perception and feel were smooth and soft, odour was between odorless and offensive. All the attributes were unanimously accepted except the odour of the dye.

Recommendation

Based on the findings of the study, the following recommendations were made;

- Home Economics Lecturers and teachers at all levels of education in Nigeria should encourage their students to explore beetroot and other plants in their environment for dye extraction for fabric coloration, skill acquisition in Clothing and Textiles and other allied craft courses.

- Home makers, artisans, individuals and small to medium scale dyeing industries should explore beetroot plant for extraction. Beetroot contains large amount of pigment which are often wasted during boiling for food. Careful and controlled processing of the stalk would be of utmost benefit for fabric or garment coloration or renovation. They should be sensitized through seminars, workshops, women conferences and meetings.
- Textiles and Clothing industries through their textile chemists should find ways of improving the odour of the beetroot dye and other attributes of the dye such as the chroma and value.
- The Nation's Raw Materials and Development Centers (RMDC) should encourage researchers in this area by patronizing research and development efforts in form of stipends to students.

Suggestion for Further Researches

- Sublimation properties of the dye on cotton fabric should be studied.
- The spectrophotometric attribute of the dye should be studied from the physicist point of view.

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