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Effects of Extraction Methods and Mordants on Colorfastness of Cotton Fabric Treated with Dyes Extracted from Beetroot Plant

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Abstract

Effects of extraction methods and mordant on the colorfastness of cotton fabric treated with dyes extracted from beetroot (Beta vulgaris) indigenous plant was studied. Research and Development (R and D) design was adopted in the study and was carried out at the University of Nigeria, Nsukka, Enugu State and at the International Textiles Industries (ITI), Limited, Lagos, Nigeria. The colorfastness tests were done at the ITI, Lagos according to the International Standard Organization (ISO, 105/A03; 1993) specification. The extent of color fade or staining was rated using Gray Scale and recorded with Fastness Test Rating Scale (FTRS). Data were analyzed using general linear model for factorial experiments and descriptive statistics. Analysis of Variance (ANOVA) was used to test a null hypothesis and Scheffe's post hoc test compared the treatment mean at 0.05 probability level. Findings include among others; prototype samples were fast to alkali perspiration (3.00± .14) and dry rubbing (3.00 ±84). There were no significant differences ($P>0.05$) in the mean effects of dye extraction methods but differences exist ($P<0.05$) in mordant effects on the colorfastness of the prototypes. Based on the above findings, recommendations were made.

Key words: Beetroot Dye, Dye Extraction, Mordant, Fabric, Colorfastness, Clothing and Textiles Education.

Introduction

Dye is an organic chemical compound which imparts permanent colour to other materials. Dye is generally described as a coloured substance that has affinity to the substrate which it is being applied (Kolender, 2003). Dye is used in the wood, food, paper, photography, leather and leather product, clothing and textiles industries as well as in educational institutions and at homes. In textiles and clothing industries, dyes are used to impart colors to give aesthetic finishes to fabrics either at the fibre, yarn, fabric or garment stages. In educational institutions, dyes are very essential instructional materials for teaching and learning and for skill acquisition in Home Economics Art and craft related courses such as clothing and textiles, allied and advanced allied craft courses among others.

Dyes are obtained from synthetic or natural sources. Synthetic dyes are prepared in the laboratory from aromatic compounds or chemical reagents while natural dyes are extracted from animals, minerals and from different parts of plants including roots, stems, bark, leaves, flowers, calyces, seeds and resins. Both synthetic and natural dyes are classified based on how they are applied to the fibre in the dyeing process and include inter alia; acidic, basic, direct, substantive, sulphur, vat, reactive, disperse, azoic and mordant dyes (Finar, 1973). Of interest to this study was natural dye, specifically, plant dye and more emphasis was placed on mordant dye as most natural dyes are classified as mordant dyes, that is, dyes that require mordants to be fixed or firmly attached to the fibre or material to be dyed. A mordant is a chemical element that quickens the rate of chemical reaction taking place between for instance, a natural dye and a fibre. Mordants help to open up the fabric fibre to enable the dye get absorbed. They not only deepen the shade of the dye but can completely change the final colour significantly giving rise to a new colour (Llewellyn, 2000). Aluminum sulphate (alum), citric acid, ferrous sulphate, stannous chloride, chromic acid, tannic acid among others are some examples of mordants that can be used in natural dyeing.

For any sustenance to be called a dye, it must be soluble in water or dispersible in solvent and transferable to the substrate by the process of absorption or exhaustion (Grollier, 1999). A good dye on fabric must be colorfast and organoleptically acceptable. Colorfastness is the ability of a dye to resist fading due to external and environmental stressors such as sunlight, washing, acid rain or gases in the air, perspiration, abrasion and crocking or rubbing (Marshal, Jackson, Stanley, Kefgen & Tonchie-Speeht, 2000). A single dye may not be colorfast in all circumstances. Weber (1990), stressed that what matters is that the dye remains viable and gracefully ages with the product. Color fastness is a measure of how well the dye is attached to the fibre and a characteristic that makes a textile product serviceable over a long period of time. The colorfastness of a dye depends on the dye, fibre and the method of applying the dye to the fabric (Johnson & Foster, 1990). Dye extraction method such as boiling, steeping or solvent have also been put forward as a contributing factor to the colorfastness of a dye on fabric since fabric comprises of different elements.

Fabric refers to a flexible material made up of a network of natural and synthetic fibres formed by any of weaving, knitting or other fabrication methods (Vanderhoff, Frank & Campbell, 1985). Cotton, linen, silk and wool are the major natural fibre while synthetic fibre fabrics are polyester, nylon, acrylics and so on. Finar (1973) emphasized that natural dyes work well in natural fibres whereas synthetic dyes perform better in synthetic fibres. For this reason, cotton fabric was selected for this study to determine the colorfastness of beetroot plant dye for Clothing and Textiles Education.

Clothing and Textiles Education is a component of Home Economics Education that equips students with relevant knowledge, attitude and skill in clothing and textiles programme. The clothing component deals with the knowledge attitude and skills needed to design and construct garment while the textile aspect is concerned with the knowledge of different fibres, fabrics, clothing selection and maintenance (Igbo, 1989). Clothing and textiles programme offers career opportunities to students upon graduation. Instructions in many curricular components of Clothing and Textiles Education including fabric and garment printing and dyeing coloration utilize dyes.

It has been observed that dyes are scarce and synthetic dyes imported into the country are not easily available. Presently, in Nigeria, funding for many schools is a great challenge and the inability of the schools to purchase instructional materials and consumables such as dyes in sustainable supply poses threat to practical work. Inadequate supply of instructional materials is a major constraint to practical programmes in Home Economics Programmes (Anyakoha, 1992). Practical exercises are often skipped or stalled and students will not acquire the necessary skills that promote entrepreneurship in Home Economics Education. Consequently, students may graduate without acquiring the needed practical skills in Fabric coloration techniques which could launch them into relevant entrepreneurial activities. It thus becomes necessary to explore dyes locally. This will not only ensure sustainable supply of dyes for teaching and learning and for skill acquisition on fabric coloration but will boost the quantity of dyes for textiles and clothing products in the nation's textile and clothing industries for economic empowerment of both the individuals and the nation at large.

Abundant species of dye yielding plants are locally available. Jansen & Cardon (2005), made a comprehensive list of 43 unexplored dye yielding plants including not exhaustive; beetroot, roselle, cuberoot, oil palm, oil bean, that are locally available. Natural dyes are presently gaining worldwide interest because they are less polluting, biodegradable and eco friendly, less toxic and non carcinogenic unlike their synthetic counterparts (Jothi, 2008., Lao Silk & Craft 2009., Apparel Search Company., 2009). Natural dyes are readily available. They offer economic, health and pharmacological benefits and can give an array of interesting colours. It thus becomes necessary to explore (*Beta vulgaris*) beetroot indigenous plant for dye extraction. Beta vulgaris has many varieties including garden beet which evolved by continuous selection and inter-crossing. The garden beet specie which is the cultivar with deep red roots are the most valuable and were used for this study. Beetroot are notable for their large pigment content. It contains 3-8percent sugar. Boiled roots are also eaten as a cooked vegetable either plain, fried or served with sauces while the tender leaves are sometimes used as a pot herb (Purse, 1991). Plant dyes are usually extracted by mechanical processes such as grinding, crushing, steeping, boiling or simmering, chopping, pounding or squeezing. More recent development in liquid extraction from plant flowers, gum, calyces, resins leaves and other parts that cannot be extracted by other means is the use of organic solvents (Douglas, 2010).

Purpose of the Study

The main purpose of the study was to study the dye potentials, effects of extraction methods and mordants on the colorfastness of dyes extracted from beetroot (*Beta vulgaris*) indigenous plant for Clothing and Textiles Education in Enugu State. Specifically, the study;

- extracted dyes from beetroot plant using boiling, steeping and solvent techniques.
- applied the extracted dyes to samples of cotton fabric mordanted with alum, citric acid, tannic acid and no-mordant sample (control)
- tested the colorfastness of the dyes to sunlight, washing, perspiration (acid and alkali) and crocking or rubbing.

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

H_O1: There is no significant difference in the mean rating effects of extraction methods and mordant on the colorfastness of alum, citric acid, tannic acid and no-mordant (control) samples of cotton fabric treated with beetroot dye extracted by boiling, steeping and solvent techniques.

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 colorfastness 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* :** Dye extraction, application and analysis of data were done at the University of Nigeria, Nsukka, Enugu State while the colorfastness tests of the treated cotton fabric samples (prototypes)
were conducted at the ITI, Limited, Lagos State, Nigeria.

***Materials*:** Materials used include; beetroot plant, Cotton fabric (100%), aluminum sulphate (Alum), citric acid and tannic acid mordant, stainless steel, dyeing pots, weighing scales, buckets, thermometer, mixing bowl, ferrous sulphate, heater, protective, washing soda (Sal soda), ethanol solvent, distilled water, gloves, towel, un chipped enamel dyeing pot, goggle, cap and hand gloves protective.

Instrument for Data Collection Two types of instruments were used for data collection. They include:

- ***Gray Scale:*** Gray scale is a standard scale for checking off the extent of fade or staining of adjacent fabric (colorfastness) of a sample of colored fabric to sunlight or other source of light, washing, perspiration or crocking. The calibration on the scale range from 2, 2/3, 3, 3/4 , 4, 4/5 and 5. In the scale, 5 indicates no fade or staining and high fastness. 3 is the average and minimum acceptable range while 2 indicates poor fastness according to ISO standards.
- ***Fastness Test Rating Scale (FTRS):*** This scale was developed and used to record the triplicate results of the colorfastness tests with the Gray Scale. The points in the scale range from 5 to 1 where 5 indicate no change or stain, 4 indicate very slight change, 3-slight change, 2-much change and 1 excessive change or stain in colour. In this scale,3 was the minimum acceptable range or cut off.

***Method of Data Collection*:** Data were collected in three phases. *Phase 1* deals with dye extraction from beetroot plant using boiling, steeping and solvent techniques. .

Procedure: Fresh beetroot (40g) were washed, peeled and wet milled in two different portions separately. One portion was heated with water in the ratio of 1:2 weight per volume (w/v) of the plant ie 40g beetroot: 80ml distilled water at a temperature range 80oC – 90oC for 30 minutes. It was allowed to cool. The second portion was steeped in distilled water in the same ratio and allowed to stand overweight while the third portion (50g) was dissolved in 98% ethanol (absolute) in the ratio of 1.2.25. It was shaken to mix properly to allow extraction in an air tight container and allowed to stand for 24hours. The heated and steeped portions were filtered with 0.5 mesh (Particle size) to collect the dye liquor while the ethanol extracted portion was filtered with cheese cloth and dried. The three dyes extracted were labeled as follows: BDB – Beetroot dye extracted by boiling, BDST-Beetroot dye extracted by steeping and BDSV-Beetroot dye extracted by solvent.

Phase II was the mordanting and application of the BDB, BDST and BDSV on mordanted samples of cotton fabric (prototype Development). Samples of cotton fabric (8" x 8") were scoured in warm water with detergent to remove all finishes. Four samples each of the cotton fabric were heated in a solution containing 500ml distilled water, 0.1g sodium carbonate (sal soda) and each of alum, citric and tannic acid mordants 1hour at a temperature 80^oC . The last four samples were scoured without mordanting (control). Each of the alum, citric and tannic acid mordanted samples plus control sample was treated with each of the three dyes and replicated in triplicates to produce 36 dyed samples (Prototypes) using contemporary plain dyeing method. The colour of the dyed samples were modified with 0.5g ferrous sulphate for each sample. Samples were taken out and dried under a shade for fastness tests after completion of dyeing.

In *Phase iii,* the following colorfastness tests of the prototypes were conducted at the ITI, Limited, Lagos;

- *Fastness to Sunlight :* Each of the strips of 36 prototype samples (2″ x 5″) was subjected to fastness to sunlight using the ITI controlled manual method according to ISO/AO3: 1993). The samples were prepared and exposed to normal day light for 72hours. Gray scale and FTRS instrument were used to check and record the extent of fade for analysis.
- *Fastness to Washing:* Each of the prototype samples (2″ x 5″) was covered with plain white fabrics, tightly tied and fed into the 4-rack testing pots inside the Shirely Development Limited (SDL) Auto Wash Electronic Washing Machine bit by bit. The temperature of the machine was set at 32± 2^{o}C for 45minutes. The samples were brought out, allowed to cool and untied. Using the Gray scale, the extent of staining or bleeding was checked off and recorded with FTRS for data analysis.

Fastness to perspiration (Acid and Alkali)

- *Acid Perspiration Test:* For this test,5.5g sodium chloride was dissolved into a solution of 1litre distilled water and 5g disodium hydrogen orthophosphate dodecahydrate ($Na_2HPO_{12}0_20$) with 5g histidine. O.IN acetic acid was dissolved into the solution to bring the acidic P^H to 5.5. The different prototype samples (2″ x 5″ each) were dipped into the solution, allowed to dry and covered with plain white fabric and tied strongly as in washfastness tests. They were fed into the oven and allowed to stay for 4hours at the temperature 32 ± 2^{o}C. The prototypes were allowed to cool; untied and the extent of fade or staining were checked off with Gray scale and recorded with FTRS for analysis.
- *Alkali Perspiration Test :*The materials and procedures were same with acidic perspiration test except that alkaline medium was obtained by dissolving O.IN Sodium hydroxide in 1litre of distilled water to bring the solution to P^H = 8.0. The prototype samples were treated as in acidic perspiration test, rated and recorded with FTRS.
- *Fastness to Crocking/Dry Rubbing :* The prototype samples (2″ x 5″) each were covered with plain white test cloth, tightly tied and fed into the nozzles of the electronic crock meter machine which scrubbed each sample 15 times for 5minutues. The samples were brought out, untied and the extent of fade or staining were checked off and recorded.

Method of Data Analysis: The data generated from the colorfastness tests were analyzed using descriptive statistics and general linear model for factorial experiment of the SPSS version 16.0. Any sample with mean score 3 or above was regarded as a colorfast sample where as any sample with score below mean 3 was regarded as a non-fast sample according to ISO standard. Analysis of variance (ANOVA) was used to test a null hypothesis while Scheffe's test compared the treatment mean at 0.05 probability level.

Findings

- Three types of dyes and 36 prototype samples were produced (Table I).
- The grand mean colorfastness of the prototype samples was established. Prototype samples were fast to alkali perspiration and crocking but non-fast to sunlight, washing and acid perspiration fastness (Table 2).
- There were no significant differences in the mean rating effects of dye extraction method but significant differences exist in the mean effects of mordants at 0.05 level of significance. Null hypothesis was accepted in six instances but rejected in four instances for mordant effects (Table 3).
- Tannic acid and alum were the source of differences. They had comparable positive effects on the colorfastness of the prototypes more than citric acid and non-mordanted samples (Table 4).
- All tannic acid mordanted prototype samples changed completely to black different from the common brown shades of others.

Table 1: Dyes Extracted from Beetroot Plant and Dyed Cotton Fabric Samples Mordanted with Alum, Citric acid, Tannic acid and No Mordant (Prototype samples)

Fabric	Mordant	BDB	BDST	BDSV
Cotton	Alum	BDB – AC	BDST – AC	BDSV – AC
	Citric	BDST – CC	BDST – CC	BDSV – CC
	N (control)	BDST – NC	BDST – NC	BDSV – NC
	Tannic	BDST – TC	BDST – TC	BDSV – TC

Table 1 shows different dyes extracted by boiling, steeping and solvent techniques and the samples of mordanted cotton fabric developed from the dye. Each of the three dyes extracted was used to dye three mordanted and one non-mordanted (control) samples of cotton, fabric making a total of twelve. These include: Beetroot dye extracted by;

- boiling on alum mordanted cotton (BDB-AC)
- boiling on citric acid mordanted cotton fabric (BDB-CC)
- boiling on non-mordanted cotton fabric (BDB-NC)
- boiling on tannic acid mordanted cotton (BDB-TC)
- steeping on alum mordanted cotton (BDST-AC)

- steeping on citric acid mordanted cotton (BDST-CC)
- steeping on non-mordanted cotton. (BDST-NC)
- steeping on tannic acid mordanted cotton (BDST-TC)
- solvent on alum cotton. (BDSV-AC)
- solvent on citric acid mordanted cotton (BDSV-CC)
- solvent on non-mordanted cotton. (BDSV-NC)
- solvent tannic acid mordanted cotton (BDSV-TC)

The 12 prototype samples were replicated in triplicates making a total of 36 samples for colorfastness tests.

Table 2: Mean Ratings of the Colorfastness Potentials of the Alum, Citric Acid, Non-mordanted and Tannic Acid Mordanted Samples of Cotton Fabric Treated with Beetroot Dyes Extracted by Boiling, Steeping and Solvent Techniques

Colorfastness	Dye	Mordant	N	$\overline{X}$	SD	Remark
Sunlight	BDB	Alum	3	3.000	.000	F
		Citric	3	3.000	.000	F
		Control	3	2.000	.000	NF
		Tannic	3	4.000	.000	F
	BDST	Alum	3	3.333	.577	F
		Citric	3	2.667	.577	NF
		Control	3	2.000	.000	NF
		Tannic	3	3.667	.577	F
	BDSV	Alum	3	3.333	.577	F
		Citric	3	3.000	.000	F
		Control	3	2.000	.000	NF
		Tannic	3	3.333	.577	F
		Total	36	2.944	.240	NF
Washfastness	BDB	Alum	3	3.333	.577	F
		Citric	3	2.000	.000	NF
		Control	3	2.000	.000	NF
		Tannic	3	3.333	.577	F
	BDST	Alum	3	3.000	.000	F
		Citric	3	2.333	.577	NF
		Control	3	2.333	.577	NF
		Tannic	3	3.000	.000	F
	BDSV	Alum	3	3.333	.577	F
		Citric	3	2.667	.577	NF
		Control	3	3.333	.577	NF
		Tannic	3	3.333	.577	F
		Total	36	2.69	.336	NF
Acid Perspiration	BDB	Alum	3	4.000	.000	F
		Citric	3	2.000	.000	NF
		Control	3	2.000	.000	NF

		Tannic	3	3.000	.000	F
	BDST	Alum	3	4.000	.000	F
		Citric	3	2.000	.000	NF
		Control	3	2.000	.000	NF
		Tannic	3	3.000	.000	F
	BDSV	Alum	3	4.000	.000	F
		Citric	3	2.000	.000	NF
		Control	3	2.000	.000	NF
		Tannic	3	3.000	.000	F
		Total	36	2.750	.000	NF
Alkali Perspiration	BDB	Alum	3	3.000	.000	F
		Citric	3	3.000	.000	F
		Control	3	1.667	.577	NF
		Tannic	3	4.333	.557	F
	BDST	Alum	3	3.000	.000	F
		Citric	3	2.667	.577	NF
		Control	3	2.00	.000	NF
		Tannic	3	4.000	.000	F
	BDSV	Alum	3	3.000	.000	F
		Citric	3	3.000	.000	F
		Control	3	2.000	.000	NF
		Tannic	3	4.000	.000	F
		Total	36	3.000	.144	F
Dry Rubbing or Crocking	BDB	Alum	3	3.667	.577	F
		Citric	3	3.333	.577	F
		Control	3	3.000	.000	F
		Tannic	3	3.667	.577	F
	BDST	Alum	3	3.667	.577	F
		Citric	3	3.333	.577	F
		Control	3	3.000	.000	F
		Tannic	3	3.667	.577	F
	BDSV	Alum	3	4.000	.577	F
		Citric	3	3.667	.577	F
		Control	3	3.000	.000	F
		Tannic	3	4.000	.000	F
		Total	36	3.000	.384	F

Key: $\overline{X}$ – Mean, F – Fast, SD – Standard deviation, NF – Non-fast, N – Number of samples.

Data in table 1 above reveal that of the five colorfastness tests, prototypes showed slight fade or stain in colour in fastness to alkali perspiration and crocking/rubbing. This is seen by their grand mean rating of 3.00 each respectively indicating moderate fastness. For fastness to sunlight washing and acid perspiration, it was observed that though the grand mean were not up to the acceptable points for sunlight ($\overline{X}$ 2.94), washing ($\overline{X}$ 2.69) and acid perspiration ($\overline{X}$ 2.75) eight of the prototypes out of twelve were rated highly ranging from mean 3 to 4, eight to washing and five to acid perspiration. Mean 3 and 4 indicate slight and very slight fade or stain in colour meaning moderate to high fastness in colour.

It could also be observed from the same table that alum and tannic acid mordanted samples of cotton fabric treated with the beetroot dye extracted in the different media (prototypes) rated higher in all the fastness tests than citric acid and non-mordanted samples.

Hypothesis I: There is no significant difference in the mean rating effects of extraction methods and mordants on the colorfastness of the alum, citric acid, tannic acid and non-mordanted samples of cotton fabric treated with beetroot dyes extracted by boiling, steeping and solvent techniques.

Table 3: Univariate Analysis of Variance (ANOVA) Results of the effects of Extraction Methods and Mordants on the Colorfastness of Cotton Fabric Prototypes

Fastness	Source	Type III Sum		Mean Square	F-Value	P-Value	Sig.
Sunlight	Mordant	13.444	3	4.481	32.267	.000	S
	Dye	.058	2	.028	.200	.820	NS
Washing	Mordant	9.222	3	3.074	15.810	.000	S
	Dye	.722	2	.361	1.857	.178	NS
Acid Perspiration	Mordant	24.750	3	8.250	-	-	NS
	Dye	.000	2	.000	-	-	NS
Alkali Perspiration	Mordant	22.306	3	7.435	89.222	.000	S
	Dye	.056	2	.028	.333	.720	NS
Rubbing/Crocking	Mordant	3.667	3	1.222	6.286	.003	S
	Dye	.500	2	.250	1.286	.295	NS

ANOVA results in table 2 above show that there are significant differences ($P<0.05$) in the mean rating effect of mordants on the colorfastness to sunlight ($F = 0.00$), washing ($F=0.00$) alkali perspiration ($F=0.00$) and rubbing/crocking ($F=0.003$) of the prototype samples. The null hypothesis stating that there are no significant differences are therefore rejected in these instances. The Scheffe's post hoc tests revealed the source of differences as presented in table 4.

On the other hand, the ANOVA results on same table indicate that there is no significant difference ($P >0.05$) in the mean effect of extraction methods used on the lightfastness ($F=.82$), washfastness ($F=.18$), alkali perspiration ($F=.72$) and rubbing ($F=.3$) of the prototypes. Both mordant and dye extraction method F and P values of acid perspiration fastness could not be computed with alpha = 0.05 since all values are same. The null hypothesis which states that there is no significant difference ($P>0.05$) in the mean effect of extraction methods on the fastness of the prototype samples is accepted in these instances.

Table 4: Scheffe's Post Hoc Test Homogenous Subsets.
Mordant Interaction Main Effects

Fastness	Mordant	No	Subsets		
			1	2	3
Sunlight	Control	9	2.00^{c}		
	Citric	9		2.89b	
	Alum	9		3.22ab	3.22ab
	Tannic	9			3.67a
	Sig.				.122
Washing	Control	9	2.11^{b}		
	Citric	9	2.33^{b}		
	Alum	9		3.22^{a}	
	Tannic	9		3.22^{a}	
	Sig		.768	1.000	
Alkali Perspiration	Control	9	1.89^{C}		
	Citric	9		2.89^{b}	
	Alum	9		3.00^{b}	
	Tannic	9			4.11^{a}
	Sig.		1.000	.880	1.000
Rubbing/Crocking	Control	9	3.00^{b}		
	Citric	9	3.44^{ab}	3.44^{ab}	
	Alum	9		3.78^{a}	
	Tannic	9		3.78^{a}	
	Sig.		.234	.477	

Key: Means for groups in homogenous subsets are displayed. Values are means of triplicate determination. Means in the same column with same superscript letter grades are not significantly different from each other at P ≤ = 0.05 probability level using Scheffe's test.

The Scheff's post hoc mordant interaction main effect in table 3 above reveals that tannic acid is the source of the difference. It had exceptional positive effects which is not significantly different from those of alum on the lightfastness, washfastness and rubbing/crocking fastness of the prototype samples but are significantly different from those of citric acid and control in their mean effect. For alkali perspiration fastness, tannic acid effect is significantly different from those of alum, citric acid and control at 0.05 level of significance.

Discussion

The Research question 1 asked question on the dyes that could be produced using boiling steeping and solvent extraction methods. Nine different dyes were produced and 36 prototype fabrics also yielded dye potentials, effects of boiling, steeping and solvent extraction techniques and alum, citric and tannic acid mordants and no mordant on the colorfastness of cotton fabric samples treated with beetroot dyes were studied.

Three beetroot dyes and 36 prototypes were produced (table 1).

Regarding the colorfastness of the extracted dyes, the prototypes were fast to alkali perspiration and crocking/rubbing as seen in table 2 by their grand mean scores of 3.00 each. Though the grand mean scores were not up to the mean cut off, majority of the prototypes were fast to sunlight, washing and acid perspiration (table 2). This finding confirms Jansen and Cardon (2005) observation that beetroot plant could yield dye and supports Jothi (2008), Lao Silk and Craft (2009) and Apparel Search Company (2009) that many plants including beetroot yield natural dyes which are useful for the coloration of textiles and fabrics. This finding also agrees with Weber (1990) that a single dye may not be colorfast in all situations.

The study finding revealed that there were no significant differences in the mean effects of extraction methods (boiling, steeping and solvent) on the colorfastness of the prototypes as shown in table 3 by the ANOVA F and P values. The null hypothesis stating that there was no significant difference was accepted in this instance. This implies that any of the extraction method used following the standard procedure would produce quality dyes. However, the same ANOVA table showed that there were significant differences in the mean ratings effect of mordants on the colorfastness of the prototypes to sunlight, washing, alkali perspiration and rubbing. Scheffe's post hoc multiple comparison mordant interaction main effect showed that the source of the difference was tannic acid which had the greatest positive effect followed by alum. An interesting finding on tannic acid mordanted prototype samples was a sudden change to black different from the common brown shades produced by alum, citric acid and non-mordanted samples. This finding supports Llewellyn (2000) who stressed on the action of mordants and emphasized that some mordants can change the colour of the dyes completely giving rise to a new colour. Though the beetroot dye turned to black in tannic acid mordanted samples, prototypes were fast to sunlight, washing, acid and alkali perspiration as well as crocking. This has implication to Clothing and Textiles Education. Citric acid mordanted samples were not as strong as alum but more effective than non-mordanted samples which were the weakest in boosting the colorfastness of the prototype samples. This finding agrees with Naomi (2010) and Kulkarni (2011), that mordants play very essential role in natural dyeing as dye fixatives since without mordants most natural dyes will either change or loose colour instantly to chemicals or photochemical attack or bleed away in washing water.

Conclusion

This present study finding shows that beetroot dyes can be used as dyes. The extraction methods used did not have significant difference in their effects on the colorfastness of the dyes on cotton fabric. As natural dye fixative, tannic acid and alum mordants had comparative positive effects in improving the light, wash, acid and alkali perspiration as well as rubbing/crocking fastness of cotton fabric treated with beetroot dyes. Tannic acid changed the colour of the beetroot dye completely to black different from brown colour yielded by alum, citric and non-mordanted samples of cotton fabric with beetroot dyes.

Recommendation

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

- ❖ Home Economics Lecturers and teachers at all levels of education should encourage their students to explore and utilize beetroot in their environment through classroom experiments and research development efforts. This should form part of their continuous assessment scores for semester or termly examinations.
- ❖ Textiles and Clothing Industries should find ways of sourcing, improving the quality and utilizing beetroot dyes through their textile chemists.
- ❖ Home makers or individuals who practice dyeing should be educated through seminars, workshops, conferences on the need to explore plant dyes including beetroot. Rather than wasting the stalk after boiling, the pigment should be used for fabric or garment dyeing or renovation.

Suggestion for Further Studies

- ❖ Organoleptic attributes of the dyes on cotton fabric should be studied.
- ❖ Sublimation properties of the dyes on cotton fabric should be studied.
- ❖ Other plants in the immediate environment should be explored for dye extraction and utilization for fabric coloration.

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