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Extraction of Dyes from Natural Sources: An Implication for Exploring Millet (Bajra Pennisetum Americanum)

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Abstract:
Dyeing of fabrics has been known to man since prehistory. It was a trade dominated by women who did everything possible to provide "life" to fabrics. Dyeing is done with chemical substances known as dyes. Dyes come in different forms depending on their source of procurement. Some are obtained from synthetic origin and others are obtained from natural sources. Over the past years, there has been over-concentration on synthetic dyes probably because of their so-called bright colours and fastness properties. Meanwhile the natural dyes which are more accessible and easy to procure have been downgraded. This study therefore sought to explore millet (a cereal crop) produced mostly in the tropics for dyes which could be used to colour fabrics. Cotton fabric was chosen because of its affinity for the dye. The descriptive (qualitative) research method and experimentation were utilised to describe and synthesize data and variables of the study. The survey and participant observation approach were the main instruments used for data collection. The data revealed that fifty-five percent (55%) of the respondents who participated in the study were male while forty-five percent (45%) were female. This was considered to be a fair gender distribution of the respondents. The main findings of the study are that, the millet dye fades easily without the assistance of sodium chloride. Also, the dye has affinity for only cotton fabrics. It must also be noted that without straining, the dye is impure. Apart from these, the dyeing period is also longer as compared to most of the synthetic dyes. It is therefore recommended that efforts should be made by future researchers on this topic to modify the dye to have all the qualities of a good dye.

Keywords: *Dyeing, Dyes, Fastness, Cotton Fabric, Experimentation.*

1. Introduction

Textiles became known to mankind since the biblical era. After man had eaten from the forbidden fruits in the Garden of Eden, he realized that he was naked so he naturally used leaves to cover his nakedness. Later, the leaves were discarded for animal furs and skins which were obtained from the animals he hunted. With the aging of time and the advancement in technology, more complex machines such as power looms, circular knitting machines, rapier and water jet looms were introduced which helped a great deal in the manufacture of fabrics. These new ways of fabric production guaranteed protection and the comfort of the wearer. However, with the passage of time, protection and comfort of the wearer were no longer the priority of most fabric manufacturers. Instead, attention started shifting towards the beatification of such fabrics and this gave birth to the process known as dyeing. Dyeing is a process of adding colourants in the form of dyes and chemicals to textile fibres, yarns or fabrics. A dye is any chemical substance that has affinity for its substrate; that is fibre, yarn or fabric. There are basically two types of dyes that are used for dyeing. These are synthetic and natural dyes. Synthetic dyes, most of which are made from petroleum by-products and coal-tar are corrosive to machine parts and poisonous to human beings. Quite apart from that, many individuals find the smell of synthetic dyes repulsive and even nauseating. Natural dyes on the other hand are easily accessible and have less damaging effect on human health because of the way they are extracted. Although they are not as pure and fast as the synthetic dyes, most of them possess qualities such as good affinity, brilliant colours and fastness properties which make them compete favourably with synthetic dyes. Natural dyes can be classified into animal, plant and mineral dyes depending on their source of procurement. The animal dyes are mostly scarce because they can be obtained from very few animals while the mineral dyes are limited to only rock and clay sources. Plant dyes, as the name suggests, are obtained from different parts of a plant such as roots, stems, barks of trees, leaves, fruits and seeds.

The aim of this research is to explore the millet plant which is used for dyeing "wakye" a delicacy in Ghana made from rice and beans. A deep red dye is extracted from the stalk by soaking and boiling for at least 30 minutes. This dye is then used to dye the

"wakye". After several experimentations, it came to light that, it is feasible to dye cotton fabrics with the dye obtained from the stalk of millet. However, there existed a small challenge concerning the fastness properties of the dye. This was immediately rectified by adding sodium chloride (common salt) to the dye bath.
This paper therefore presents the systematic ways through which the dye was extracted, treated and applied on fabric samples of cotton. It is hoped that, this novelty will help boost the interest of textile designers to use natural dyes instead of the expensive synthetic dyes.

2. Literature Review
This section of the study discusses various literatures on natural dyes. It looks at the definition of dyes, a brief history about dyes, classification of dyes and how to produce natural dyes.
According to (Wikipedia) natural dyes are colorants derived from plants, invertebrates, or minerals. By definition, dyes can also be said to be coloured, ionising and aromatic compounds which show an affinity towards the substrate to which it is being applied. It is said by many dyers that all things dyed naturally, go together. There are no richer colours than those found with natural dyes. A submission by Woolery (1981) suggests that natural dyes have a beauty and depth of colour that cannot quite be obtained with synthetics. Chemical colours tend to be harder and sharper and so need to be carefully colour-matched while it is often said that warm, soothing naturally dyed colours display harmony in any combination and become even more beautiful with age. Wild Colours (2014) states that although it is very exciting to dye a fibre directly from plants that you have grown yourself, natural dye extracts are economical, very concentrated and easy to repeat a colour. They save time as they do not require lengthy pre-soaking and simmering. Plant dyes use no toxic or polluting chemicals and organic matter left-over from dye plants can be put to good use. According to Margaret Furry and Bess Viemont (1935) "though for most purposes, synthetic dyes are more satisfactory, there are certain qualities about natural dyes that give them commercial value." These values according to them are their easy accessibility and brilliant colours.
The ability of natural dyes to colour textiles has been known since ancient times. The earliest written record of the use of natural dyes was found in China, dated 2,600BC. Chemical tests of red fabrics found in the tomb of King Tutankhamen in Egypt show the presence of alizarin, a pigment extracted from madder. Wikipedia submits that archaeologists have found evidence of textile dyeing, dating back to the Neolithic period. In China, dyeing with plants, barks and insects has been traced back more than 5,000 years. The essential process of dyeing changed little over time. Typically, the dye material is put in a pot of water and then the textiles to be dyed are added to the pot, which is heated and stirred until the colour is transferred. Plants have been used for natural dyeing before history was recorded. The staining properties of plants were noted by humans and have been used to obtain and retain these colours from plants throughout history. Native plants and their resultant dyes have been used to enhance people's lives through decoration of animal skins, fabrics, hair and even bodies. "Textile Learner", explains that dyeing is the process of colouring fibres, yarns or fabrics with either natural or synthetic dyes. It further explains that dyeing is an ancient art which predates written records. It was practised during the Bronze Age in Europe. Primitive dyeing techniques included sticking plants to fabrics or rubbing crushed pigments onto cloth.
Dyes are classified based on the fibres to which they can be applied and the chemical structure of each dye. Dyes are complex unsaturated aromatic compounds fulfilling characteristics like intense colour, solubility and fastness.
It is evident that the various literatures reviewed on the topic did not touch on a possible way of extracting dyes from the millet plant. This puts the topic in the right perspective to contribute to knowledge.

3. Methodology
The Methodology describes the various scientific methods used to conduct the research. It talks about background information about Millet, Research Design, Target Population, Sample Population and Research Instruments.

3.1 Millet
Millet is an important staple food in most of Asia, Russia and Western Africa. In the United States and Western Europe, they are used chiefly for pasture or to produce hay. Millet is high in carbohydrates and protein content varying from 6 to 11% and fat varying from 1.5 to 5%. In Ghana, the plant is grown mostly in the northern part of the country and it is used for a popular local beverage known as "pito" and also for dyeing "wakye" (rice and beans), a local delicacy. Millet is also cooked and consumed like rice with stew. Considering the colouring properties of the stalk of millet, this study seeks to explore the plant for possible dyeing of cotton fabrics.

3.2 Research Design
By the nature of this study, the descriptive and the experimental research methods were used to conduct the research. They were combined with statistical methods in the form of tables and graphs to analyse and interpret data.

3.2.1 Descriptive Method
The descriptive method was adopted by the researchers to describe and interpret events and processes throughout the study. According to Anderson (1990) any approach that attempts to describe data might be referred to as a descriptive method.

3.2.2 Experimental Method.
For a study like this, experimentation was indispensable. This method was therefore used to control variables by pre-testing the dye on cotton fabric samples. After the first dyeing, it was observed that the dye had affinity for the fabric but there existed a

problem with the fastness properties of the dye. This problem was swiftly rectified by first treating the fabric with sodium chloride (common salt). The resultant fabric was then tested for wash and light fastness by severally washing the fabric in soapy water and continually exposing it to intensive sunlight. The result was very encouraging.

3.3 Target Population

Considering the technicality of the research topic, the Target Population chosen for the study included textile tutors and professionals of textiles including batik and tie-dye designers in the Ho Municipality. This amounted to one thousand, two-hundred (1200) respondents.

3.4 Sample Population

Due to the vast nature of the Target Population, it was prudent to scale it down to a more accessible population. The Random Sampling Technique was therefore used in which 30% of the Target Population was considered to be ideal, considering the scarce resources that were available for the conduct of this research. Thus, the Sample Population in terms of numbers was three-hundred and sixty (360) respondents.

3.5 Research Instruments

The research instruments mainly used for the study were the questionnaire (survey approach) and observation.

3.5.1 Questionnaire

A 3-page well structured questionnaire copies were administered to the Sample Population made up of 360 respondents to solicit their views on the research topic. This survey technique was adopted because most of the respondents were literate. The questionnaire sought to know respondents view about whether it was possible to dye cotton fabric with the stalk of millet and whether the dye was fast to washing and sunlight.

3.5.2 Observation

Considering the experimental nature of the study, a lot of observations were made to ascertain the feasibility of procedures. It was observed that the dye obtained from millet had affinity for cotton fabric but did not stay in the fabric for long. It faded after washing and drying in the sun. This obviously explained the fact that the millet dye is not fast to washing and sunlight.

4. Analysis and Discussion of Data

This section of the study presents the data analysis procedures used in analysing data. Various statistical methods were used to analyse and interpret data. The data collected were pretested, synthesized and analyzed using pie charts and tables. These were done to determine the validity of the data collected and to make it easy for logical conclusions to be drawn. The main data collection tool used was the questionnaire approach. The following statistical descriptions show how data collected for the study were analyzed. The analysis of data was considered to be the true and factual discussion of data.

4.1 Demographic Characteristics of Respondents

4.1.2 Gender Distribution of Respondents

The gender of respondents who participated in the study was fairly distributed. 45% of respondents who participated in the study were female while 55% were male. The pie chart below illustrates this scenario.

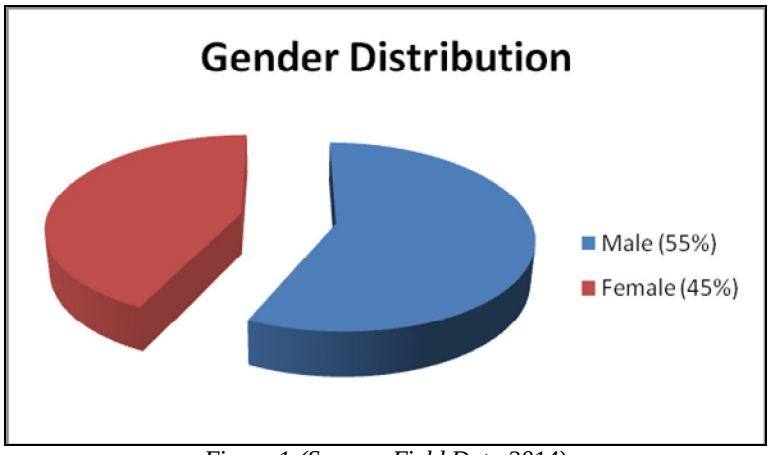

Figure 1:(Source: Field Data 2014)

AGE	FREQUENCY	PERCENTAGE
15-25	16	5.0
26-30	72	20.0
31-40	250	69.0
41 and above	22	6.0
Total	**360**	**100**

Table 1: Age Distribution of Respondents
(Source: Field Data 2014)

Respondents falling within the following age ranges participated in the study: 15-25, 26-30, 31-40, 41 and above. In all, 360 respondents knowledgeable in the field of textiles participated in the study. The table above shows that respondents between the ages of 31 and 40 recorded a frequency of 250 which is indicative of the fact that more middle-aged persons are interested in textiles than the very young ones. The table also shows that respondents between the ages of 15 and 25 recorded the lowest frequency of 16 which confirms the earlier assertion that very young persons are not interested in textiles.

Educational Level	Frequency	Percentage (%)
Primary	0	0.0
JHS	34	9.0
SHS	57	16.0
Tertiary	269	75.0
Total	**360**	**100**

Table 2: Educational Level of Respondents
(Source: Field Data 2014)

The table above shows that none of the respondents is a JHS leaver. Meanwhile 269 respondents which represent 75 % of the sample population attended a tertiary institution. 34 respondents most of whom are tie-dye and batik producers recorded 9% of the sample population while 57 respondents representing 16 % of the sample population are SHS leavers.

Area of Specialization	Frequency	Percentage (%)
Visual Art	336	93.0
Humanities	10	4.0
Sciences	5	1.0
Engineering	9	2.0
Total	**360**	**100**

Table 3: Professional Distribution of Respondents
(Source: Field Data 2014)

The technical nature of the study dictated the calibre of respondents who took part in the study. The participating respondents were therefore dominated by people with artistic background. As high as 336 respondents representing 93% of the sample population were visual artists while 10 respondents representing 3% of the sample population were from the humanities. The sciences recorded the lowest number of 5 respondents representing only 1% of the sample population. Respondents with engineering background were 9 and this represented 2% of the sample population.

Responses	Frequency	Percentage (%)
Yes, I'm aware	355	99.0
No, I'm not aware	5	1.0
Total	**360**	**100**

Table 4: Yes or No Responses as to whether dyes can be extracted from the stalk of millet.
(Source: Field Data 2014)

In the table above, respondents' views have been sought about the possibility of extracting dyes from the stalk of millet. From the results presented, it came out that 355 respondents representing 99% of the sample population responded 'Yes' to the question while 5 respondents representing 1% of the sample population responded 'No' to the question.

Statement	Responses	Frequency	Percentage (%)
There are two major sources of dyes.	Yes, I'm aware	335	93.0
	No, I'm not aware	25	7.0
Total		**360**	**100**

Table 5: Responses on the major sources of dyes.
(Source: Field Data 2014)

In Table 5 above, responses to the statement that only two major types of dyes exist have been tabulated. It came out that 335 respondents representing 93% of the sample population gave an answer of "Yes" while 25 respondents representing 7% of the sample population gave an answer of "No".

Statement	Responses	Frequency	Percentage (%)
Majority of the dyes these days are from synthetic source.	Strongly Disagree	13	4.0
	Disagree	20	6.0
	Agree	240	66
	Strongly Agree	87	24
Total		**360**	**100**

Table 6: Responses on the popularity of synthetic dyes
(Source: Field Data 2014)

The table above gives a breakdown of results collated from respondents concerning the assertion that most of the dyes which exist now are from synthetic origin. Majority of the respondents (240) representing 66% of the sample population agreed with the assertion while as low as 10 respondents representing 4% of the sample population strongly disagreed with the assertion. However, 87 respondents representing 24% of the sample population strongly agreed with the assertion. Additionally, 20 respondents representing 6% of the sample population disagreed with the assertion.

Statement	Responses	Frequency	Percentage (%)
Synthetic dyes are harmful to the body if not carefully handled.	Strongly Disagree	7	2.0
	Disagree	35	10.0
	Agree	252	70.0
	Strongly Agree	66	18.0
Total		**360**	**100**

Table 7: Responses on the harmful nature of synthetic dyes
(Source: Field Data 2014)

Table 7 displays the results collated from 360 respondents concerning how harmful synthetic dyes can be if not handled with care. The results show that, 252 respondents representing 70% of the sample population agreed to the statement while 7 respondents representing 2% of the sample population strongly disagreed. On the other hand, 66 respondents representing 18% of the sample population strongly agreed to the statement. Also, 35 respondents representing 10% of the sample population disagreed.

Statement	Responses	Frequency	Percentage (%)
Natural dyes are safer to handle.	Strongly Disagree	15	4.0
	Disagree	130	36.0
	Agree	159	44.0
	Strongly Agree	56	16.0
Total		**360**	**100**

Table 8: Responses on whether natural dyes are safer to handle than the synthetic dyes
(Source: Field Data 2014)

Table 8 above presents the views of respondents on how safe natural dyes are as compared to synthetic dyes. The results revealed that 159 respondents representing 44% of the sample population agreed with the assertion while 15 respondents representing 4% of the sample population strongly disagreed with the assertion. Additionally, 130 respondents representing 36% of the sample population disagreed with the assertion while 56 respondents representing 16% of the sample population strongly disagree with the assertion.

Statement	Responses	Frequency	Percentage (%)
Natural dyes are less expensive as compared to the synthetic dyes.	Strongly Disagree	7	2.0
	Disagree	85	23.0
	Agree	212	59.0
	Strongly Agree	56	16.0
Total		**360**	**100**

Table 9: Responses about the affordability of natural dyes
(Source: Field Data 2014)

Table 9 above displays responses about the affordability of natural dyes. The responses indicate that 212 respondents representing 59% of the sample population agreed to the statement while 7 respondents representing 2% of the sample population strongly disagreed with the statement. Furthermore, 56 respondents representing 16% of the sample population strongly agreed with the statement while 85 respondents representing 23% of the sample population disagreed with the statement.

Statement	Responses	Frequency	Percentage (%)
Natural dyes are not toxic.	Strongly Disagree	20	6.0
	Disagree	76	21.0
	Agree	215	59.0
	Strongly Agree	49	14.0
Total		**360**	**100**

Table 10: Responses about whether natural dyes are toxic.
(Source: Field Data 2014)

Table 10 explicitly displays responses about whether or not natural dyes are toxic. The responses reveal that 215 respondents representing 59% of the sample population agreed to the assertion while 76 respondents representing 21% of the sample population disagreed with the assertion. Also, 49 respondents representing 14% of the sample population strongly agreed with the assertion while 20 respondents representing 6% of the sample population strongly disagreed with the assertion.

5. Materials and Methods

This section of the study presents the various materials and production methods that were adopted by the researchers to carry out the study. It is evident from the results of the study that most respondents accept the fact that natural dyes are easy to get, less expensive and not very poisonous as compared to the synthetic dyes. It is based on these facts and the staining properties of the dye obtained from millet that the researchers decided to embark on this study. In Ghana, millet is commonly used for preparing the local beverage “Pito” and for garnishing “rice and beans” (a local delicacy) but not for dyeing fabrics. The study was therefore targeted at exploring the leaves and stalks of millet for possible dyeing on cotton fabric. Cotton was chosen because of its absorptive properties. The stalk were then boiled in hot water and strained to remove particles that might contaminate the dye. The dye extracted from the stalk of millet is deep red. Below are photographs of the stalk of millet and the dye solution.

Figure 2: Plate 1: stalk of millet

Figure 3: Plate 2: millet dye

After the first dyeing, it was observed that the dye presented a pale red shade. The fabric was then tested for wash fastness but the result proved negative as the dye surprisingly came out of the cotton fabric. This was later improved by adding sodium chloride (common salt) to the dye bath but since this was not 100% perfect, the fabric itself was saturated in brine (salt solution) for 10 minutes before the actual dyeing process took place. It was observed after this experimentation that the dye was 98% fast to washing.

Figure 4: Plate 3: a dyed fabric

To enhance the aesthetic qualities of the dye, certain portions of the fabric were resisted from absorbing dye and this was done using the tie-dye method. The photograph below shows a resisted fabric which is ready for dyeing. The fabric was resisted by tying using raffia thread and then immersed into the dye for twenty (20) minutes. The style of tying resulted in the creation of concentric circles. Photographs of the resisted fabric can be seen below:

Figure 5: Plate 4: resisted fabric

Figure 6: Plate 5: dyed resisted fabric

After dyeing, the fabric was untied by carefully cutting the raffia threads which were used in resisting the fabric. This was a very important activity because if care was not taken in cutting, the fabric itself will be damaged. The following plate shows the finished product:

Figure 7: Plate 6: finished product after dyeing

The fabric was then finished by drying in the sun, application of starch (size) and finally ironing to enhance its beauty.

6. Major Findings of the Study

Since this study was more or less a project work, a practical approach was adopted in solving all the problems encountered throughout the research. Major questions which kept lingering in the minds of the researchers were connected with whether or not the study was viable. But at the end, it came out clearly that this study was a viable one. The following findings were recorded:

- The millet dye has affinity for cotton fabric.
- The stalk of millet is readily available and cheap to acquire.
- The extraction of the dye is less cumbersome.
- Although millet dye has the affinity for cotton, it cannot stay in the fabric for long without the help of sodium chloride.
- Without straining, millet dye is impure.
- The dye doesn't have affinity for other types of fabrics except cotton.
- The dyeing period as compared to that of synthetic dyes is a bit longer.

7. Conclusion and Recommendations

The advancement in technology and the rapid demand for dyed fabrics have necessitated the need to explore indigenous ways of dye extraction .Quite apart from that, natural dyes hitherto were relegated to the background due to the so-called bright colours of the synthetic dyes. But one thing people have lost sight of is the toxic and corrosive nature of most synthetic dyes which predisposes the wearer to the contraction of dangerous diseases such as skin cancer and lungs diseases. Natural dyes on the other hand are less toxic and corrosive. This study is therefore a novelty aimed at promoting the use of locally manufactured dyes and at the same time demystifying the myth surrounding their existence. The study was handled in a practical manner through numerous experimentations to ascertain the facts. It is hoped that by this study, the attention of more researchers will be drawn to the exploration of natural dyes. The following recommendations based on the findings of the study have been propounded:

- More innovative methods should be developed to improve the millet dye to allow it to be used on other types of fabrics apart from cotton.
- Efforts should be made to explore other sources of natural dyes.
- The millet dye should be modified to make it pure.
- The dye should also be modified so as to reduce the dyeing period.
- A more complex and convenient process of dyeing should be developed to commercialize the use of the dye.
- A less toxic and corrosive chemical substance apart from sodium chloride should be developed to improve upon the fastness properties of the dye.
- Apart from wash fastness and light fastness, the dye should be tested for fastness properties against ironing, perspiration and friction.

8. References

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