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Indigenous plants in Uganda as potential sources of textile dyes

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Natural dyes derived from plant-based materials have proved to be important alternatives to the use of synthetic dyes in the textile industry. A large plant resource base for natural dyes exists in Uganda but remains in the wild and largely unexploited. Forty (40) plant species with potential to produce natural dye compounds for textile applications belonging to twenty two (22) families were identified in this study. *Harungana madagascariensis*, *Bixa orellana* Linn, *Syzygium cordatum, Indigofera arrecta, Curcuma longa* Linn, *Albizia coriaria* and *Justicia betonica* were the most common plants identified having the ability to dye local vegetable and craft materials and for other decoration purposes while *Lawsonia inermis* Linn, *Vitex doniana, Indigofera arrecta* and *Morinda lucida* were the least known plants as potential source of dye. Mimosaceae was widespread in several communities with seven species, followed by Myrtaceae and Caesalpianaceae, each with four species and Rubiaceae, Bignoniaceae, Moraceae, Guttiferae, Anarcardiaceae and Papilionaceae, each with two species. The thirteen families remaining each had one species. From the results, some of the plants studied are promising dye-yielding plants and could be exploited as sources of textile dyes and important economic plants. The paper provides information on the botanical names of forty potential dye-yielding plant species, their families, local names, vegetation (growth form), habitat, plant parts used and colour produced on 100% cotton fabrics.

Key words: Uganda, plants, indigenous, natural dyes, potential.

INTRODUCTION

Traditionally, plants in Uganda have been utilized as a source of colourants in the making of mats, ropes and other home-based craft materials for a long time. Natural dyes derived from plants have recently gained economic advantage over synthetic dyes because of their non-toxic, non-carcinogenic and biodegradable nature (Bhuyan and Saikia, 2008; Samanta and Agarwal, 2009). They are environmentally friendly making them a top priority for use in the textile industry (Bhuyan and Saikia, 2005; Debajit and Tiwari, 2005), with a growing need to find suitable and less toxic alternative sources of natural dyes (Paitoon et al., 2002; Kar and Borthakur, 2008). Various researches have shown that some dyes from plants generally possess desirable colour properties and good performance on natural fibres which are comparable to some highly rated synthetic dyes (Siva, 2007; Purohit et al., 2007; Padma and Rakhi, 2007; Verissimo et al., 2003; Kadolph, 2005).

Several studies in the last 10 to 20 years have characterized and promoted the use of natural dyes from different plant species, partly because of recent scientific developments in instrumental methods of colour measurements, analysis and structure determination (Bhuyan and Saikia, 2005; Bhuyan et al., 2002; Sule, 1997; Debajit and Tiwari, 2005; Deo and Desai, 1999). Consequently, many potential dye-yielding plants and major dye components have been identified through colourimetric and spectroscopic investigations (Bhuyan and Saikia, 2005; Adetuyi et al., 2005; Young-Hee and Han-Do, 2004). Based on instrumental approach, several dye yielding constituents exhibiting different colours, have

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been demonstrated in plants (Kenneth, 1973; Bechtold et al., 2007; Jansen and Cardon, 2005; Bhuyan et al., 2002).

A great potential for natural dyes from dye-yielding plants exists in many communities in developing countries. Reports from ethnobotanical literature and survey indicate that *Bixa orellana* Linn (Bixaceae), *Curcuma longa* Linn (Zingiberaceae), *Lawsone inermis* Linn (Lymraceae), *Morinda lucida* (Rubiaceae) and *Rubia cordifolia* (Rubiaceae) among many common indigenous plants in Uganda, possess dye- yielding properties, although, none of them has been systematically investigated for colour production and performance on any textile materials (Katende et al., 1995, Jansen and Cardon, 2005). Uganda is reported to have over 6000 plant species, especially the dye-yielding plants, which have not yet been characterized (Mayunga, 2007). They have neither been identified, named nor documented except for use in local herbal medicine care systems and represent an enormous reservoir of new molecules with potential dye activities which are awaiting to be discovered (Hostettmann et al., 2000; Katende et al., 1995; Katumba et al., 2004). Traditional dyeing in Uganda has showed that several plants contain important colour constituents with desirable dye properties, although, for many dyes producing species, the exact nature of the chemical compounds responsible for colour is not yet known and the dyes are not characterized (Jansen and Cardon, 2005; Katende et al., 1995, Bosch and Borus, 2006). In the present study, some indigenous plants in Uganda with potential to colour textiles were identified. The study however reflects the tip of the iceberg of a research that should be carried out in more detail and over a longer period of time.

MATERIALS AND METHODS

Collection of dye-yielding plants and materials

Field survey was conducted in the Eastern, Southern and Western Districts of Uganda between January, 2004 and December, 2008. Only plants mentioned in literature and interviews that are having dye were collected from Mukono, Kampala, Wakiso, Pallisa, Mbale, Mbarara, Arua, Luweero and Jinja Districts (Table 1). Many other plants were collected for experimentation which was not mentioned by any of the sources. No plants were collected which did not possess dye in any part of their anatomy. Many other plants were collected for experimentation which was not mentioned by any of the sources. Plants, which do not possess dye in any part of their anatomy were not collected. And considering that thousands of plants in Uganda are not known or documented and have not yet been studied especially for dye constituents phytochemically, selection of the most important plants with dye-yielding properties was very difficult and time consuming. The study therefore attempts to provide a representative selection of some potential dye-yielding plants in Uganda. The method described by Vicki (1990) based on literature search, information gathered from some traditional herbal practitioners on plants which gave colour when boiled, field collections of plants mentioned in the literature or interviews was used in this study. Secondary information from unpublished undergraduate students' research reports in the department of Art and Industrial Design at Kyambogo University was also sought on indigenous dyes and plants in Uganda. Forty (40) potential dye-yielding plants were identified and since it was difficult in some cases to know what plant part had preponderance of dye, several elements such as roots, leaves, seeds, fruits and bark were collected for experimentation (Table 1). Local names for the majority of the dye-yielding plants mentioned in literature and interviews together with their geographical locations were largely reported by Katende et al. (1995).

Extraction of colour components

Plant parts were harvested and cut into small pieces, spread on clean polyethene material, and left to dry in open air. The dried plant parts were separately ground to powder and kept in plastic containers of different sizes at ambient temperature. Ten (10 g) of dried and pulverized plant materials (roots, bark, leaves, seeds and fruits) were soaked overnight in sufficient distilled water (200 ml) in a beaker (400 ml). Dye extraction and preparation were done according to the method described by Deo and Roshan (2004). Distilled water was the main medium chosen for extraction of the colour components. The soaked plant materials were heated and the temperature gradually raised to 85 to 90°C over a period of 30 min. The temperature was then maintained at 90°C for 1 h to ensure maximum extraction of the colour components. The coloured solution was left to stand for a minimum of 10 hours and then filtered. The resultant dye solution (150 ml) was diluted with distilled water to 200 ml in a beaker (250 ml) and then used immediately for dyeing.

Dyeing of cotton fabrics

Cotton fabrics (8 x 10 cm) weighing about 1.41 g were dyed using an open pyrex beaker (250 mls) to which 10% of weight of fabric (o.w.f) of alum mordant was added. Dyeing of the cotton fabrics was done according to the method described by Katy (1997). A single bath process where both dyeing and treatment with mordant are done in the same solution was employed. The dye solution and mordant were treated in this mixture for 60 min at the boil (90°C). The pH of the dye bath was maintained between 6.5 and 7.5 with acetic acid (40%). A liquor ratio (LR) of 1:200 was used in all the dyeings. Sixteen (16) randomly selected plants were tested for colour yield using different parts of single species. The specific focus was, however, on parts easily available at the time of harvest. Mixtures of different parts of the same plant are also potential sources of a variety of colours, especially when applied using different mordants. The dyed fabrics were removed from the exhausted dye solution and rinsed for ten (10) min in warm distilled water to which a liquid detergent had been added. The cotton fabric was then rinsed in cold distilled water until there was no more colour bleeding. The fabrics were then dried in open air.

RESULTS AND DISCUSSION

Forty (40) plant species with potential dye-yielding properties, belonging to twenty two families, were identified (Table 1). Mimosaceae was the most dominant with seven species. Caesalpiniaceae and Myrtaceae each had four

Table 1. Plant species having potential in yielding natural dyes in Uganda.

Species	Local name	Family	Vegetation	Distribution and habitat	Parts used	Colour produced
A. senegal	Ekodokodwo (Ateso)	Mimosaceae	Shrub	Gweri in Soroti district; grows up to 12 m, in swampy or wooded grassland.	bark	Red brown
A. seyal	Ekaramai (Ateso)	Mimosaceae	Tree	Gweri in Soroti district; grows up to 18 m, found in swampy areas.	bark	Burnt umber
A. coriaria	Mugavu (Luganda)	Mimosaceae	Tree	Kiwewa in Mukono District; but also grows in several other districts in the central region; grows up to 36 m in woodland grasslands and thickets.	bark	Fallow brown
Albizia zygia	Mulongo (Lusoga)	Mimosaceae	Tree	Kabwangasi in Pallisa district; grows up to 20 m and is found in woodlands and forest edges.	bark	Fallow brown
A. cordifolia	Luzibaziba (Luganda)	Euphorbiaceae	shrub	Kiwewa in Mukono district, grows up to 6 m on hilly wooded grasslands and thickets.	bark/roots	light-stone brown
Alizia coriaria	Musiita (Luganda)	Mimosaceae	Tree	Kabwangasi in Pallisa District; grows up to about 36 m in wooded grassland orwoodland and thickets.	bark	Alabaster brown
A. senegalensis	Ebolo (Ateso)	Annonaceae	Shrub	Gweri in Soroti district; grows between 3 to 8 m in dry wooded grassland.	bark	Pink brown
A. indica	Neem (English)	Miliaceae	Shrub	Kyambogo in Kampala district; grows in lowlands especially in Eastern districts of Uganda up to 20 m tall.	bark	Red brown
B. orellana L.	Kikunku (Fuula) (Luganda)	Bixaceae	Tree	Kirugu in Mukono district; grows up to 10m tall around homes and in village outskirts.	Seeds	Yellow orange
C. africana	Musisa/Akasinsa (Lugwere/Luganda)	Ulmaceae	Tree	Kabwangasi in Pallisa district, grows up to 12 m in lowland forests.	bark	Brown pink
C. Longa L.	Binzaali (Luganda)	Zingiberaceae	Shrub	Bombo in Luweero District; but is cultivated in a few other districts in the central regions as a spice; grows up to 1 m tall in open fields or grasslands.	Rhizomes (roots)	chrome yellow

Table 1. Contd.

E. abyssinica	Mwolola (Luganda)	Mimosaceae	Tree	Kiwewa in Mukono district; grows up to 15 m in wooded grassland and hills.	bark	cygnet brown
E. abyssinica	Muyirikiti (Jjirikiti) (Luganda)	Papilionaceae	Shrub	Kiwewa in Mukono District but also found in Kyambogo in Kampala district; grows up to 10 m in dry savannah areas or grasslands.	bark	Cadmium yellow
F. exasperata	Iseno (Lugwere)	Moraceae	Shrub	Kabwangasi in Pallisa district; grows up to 8 m in a swampy are or in thickets.	roots	Brown pink
F. natalensis	Mutuba (Luganda)	Moraceae	Tree	Kyambogo in Kampala district but also grows in all other districts of Uganda; grows up to 30 m in dry forest and thickets.	bark	Alabaster brown
G. huillensis	Nsaali (Luganda)	Guttiferae	Shrub	Kyengera in Wakiso District; grows up to 12 m in thickets or forest edges.	roots	Pink beige
H. madagascariensis	Mulilira (Luganda)	Guttiferae	Tree	Katente in Mukono district, grows between 3 to 18 m, grows at forest edges.	bark	Raw umber
H. sabdariffa	Kajamusayi (Luganda)	Malvaceae	shrub	Nakunsi in Mbale distric;t grows up to 6 m in open grasslands and forest/savannah environment.	leaves/roots	Alabaster brown
I. arrecta	Omusoroza (Rukiga/Runyankore)	Ppapilionaceae	Shrub	Kyamugolani in Mbarara Dsitrict; but also grows in a few other districts in the East and Central regions of Uganda; grows up to 3 m tall in open grassland. Is cultivated for medicinal uses.	leaves	Warm grey
J. betonica	Muzukizi (Mufoka) (Luganda)	Acanthaceae	Shrub	Nakawuka in Wakiso District; grows upto 3 m in banana plantations or as a herb in people's gardens.	leaves	Bluish purple
K. africana	Edodoi (Ateso)	Bignoniaceae	Tree	Gweri in Soroti district, up to 9m in open woodland and forests.	fruit	Lightstone brown
K. africana	Lukulungu (Lugishu)	Bignoniaceae	Tree	Busiu - Bumwanga in Mbale District but also grows in several other districts in Uganda; grows up to 20 m in open grasslands.	bark	Fallow brown

Table 1. Contd.

M. lucida	Mubajansali (Luganda)	Rubiaceae	Tree	Kiwewa in Mukono district; grows up to 18 m tall in grassland, thickets and forests.	Roots/bark	Mustard yellow
M. indica	Muyembe (Lunyoli)	Anacardiaceae	Tree	Kyambogo in Kampala District; but is a common plant found throughout Uganda; grows up to 20 m and is widely cultivated.	bark	Yellow green
P. americana	Avocado (English)	Lauraceae	Tree	Kyambogo in Kampala district; grows up to 20 m in open gardens and moist areas.	bark	cygnet brown
P. reclanata	Lukindu (Lugishu)	Palmae	Shrub	Nansana in Wakiso Distric;t but also grows in several districts in Uganda; grows up to 15 m in lowland woodlands, beside swamps and rivers.	leaves	Jonguil yellow
P. thonningii	Epapai (Ateso)	Caesalpiniaceae	Shrub	Gweri in Soroti district; grows between 3 to 8 m commonly found in wooded grassland and forest.	bark	Brown pink
P. thonningii	Mulama (Lunyoli)	Caesalpiniaceae	Shrub	Nakunsi in Mbale district but also grows in other districts in the Eastern region of Uganda; grows up to 8 m in wooded grassland.	bark	cygnet brown
P. africana	Ekiki (Lugwere/Ateso)	Mimosaceae	Tree	Ikiki in Pallisa district; grows up to 20 m in tall grassland and wooded grassland.	bark	Red brown
P. guajava	Guava (English)	Myrtaceae	Shub	Kyambogo in Kampala district and is also cultivated in all other regions of Uganda; grows up to 10 m in compounds, gardens and open grasslands.	bark	Lightstone brown
R. natalensis	Omusheshe (Runyankore)	Anacardiaceae	Shrub	Kyamugolani in Mbarara District;grows up to about 8m in thickets and open grasslands.	bark	Raw umber
R. cordifolia	Kasalabakesi (Luganda)	Rubiaceae	Climber	Kiwewa in Mukono district and in Kyambogo in Kampala district; climbing stems on fences of up to 10 m long.	roots	Pinkish red

Table 1. Contd.

S. cordatum	Kanzironziro (Luganda)	Myrtaceae	Shrub	Kulambiro in Kampala distric;t grows between 3 to 8 m, found in thickets and on hillsides in Arua.	bark/stem	Fallow brown
S. cuminii	Jambula (Luganda)	Myrtaceae	Tree	Kyambogo in Kampala District; but also grows in several other districts in the central region; grows up to 30 m in compounds and secondary forests.	bark	Alabaster brown
S. guineense	Sizanzass (Lugishu)	Myrtaceae	Shrub	Nakunsi in Mbale district; grows up to 0m in open woodland.	bark	Red brown
T. indica	Omuhungwa (Lunyoli)	Caesalpiniaceae	Tree	Kangalaba in Butaleja district; grows up to 30 m in savannah wooded grasslands especially in Eastern and North Eastern districts of Uganda.	bark	Fallow brown
T. brownii	Epiyei (Luganda)	Combretaceae	Tree	Gweri in Soroti Dsitrict; grows up to 15 m in wooded grassland and semi-arid woodland.	bark	cygnet brown
T. fassoglense	Mbatiti (Lugwere)	Caesalphiniaceae	Shrub	Nakunsi in Mbale district grows up to about 6 m on dry hillsides and in thickets.	leaves	Alabaster brown
V. paradoxa	Nakunguli (Lugwere)	Sapotaceae	Tree	Kabwangasi in Pallisa district; grows up to 20 m in dry savannah or open woodlands.	bark	cygnet brown
V. doniana	Ewelo (Ateso)	Verbenaceae	shrub	Gweri in Soroti district; grows up to 15 m in wooded grassland, savannah and thickets.	bark	Warm grey

species, Guttiferae, Bignoniaceae, Rubiaceae, Moraceae, Papilionaceae and Anacardiaceae with two species each. The remaining 13 families each had one species. They were all investigated for colour production and yield using the crude extracts and the majority of the plants produced noticeable shades of colour on the cotton fabrics. Out of the forty plants investigated, *Morinda lucida* (roots), *Syzygium cordatum* (bark), *Albizia coriaria* (bark), *Terminalia brownie* (bark), *Harungana madagascariensis* (bark), Curcuma longa linn(roots), *Justicia betonica* (leaves), *B. orellana* Linn (seeds), *Syzygium cuminii* (bark) *Albizia zygia* (bark), *Erythrina abyssinica* (bark), *Indigofera arrecta* (leaves), *Vitellaria paradoxa* (bark), *Prosposis africana* (bark), *Rubia cordifolia* (roots), *Kigelia africana* (bark), *Syzygium guineense* (bark), *Acacia seyal* (bark), *Alchornia cordifolia* (roots), *Psidium guajava* (bark), *Entanda abyssinica* (bark),and *Azadirachta indica* A. Juss (bark) produced medium to fairly dark shades indicating that many of these plants, although not currently being used as source of textile dyes, have the potential to serve as source of dyes

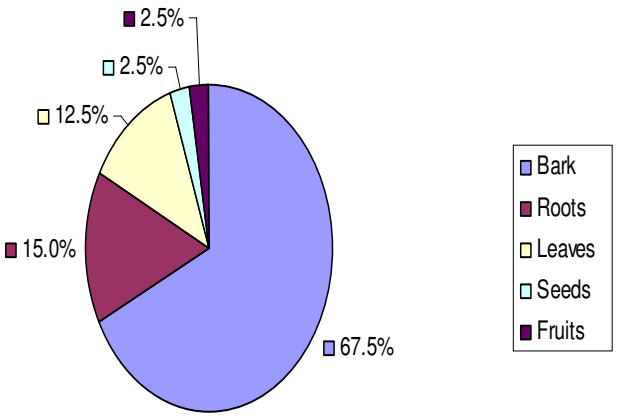

Figure 1. Proportion of plant parts used in dye preparation.

Figure 2. *M. lucida.*

Figure 3. *H. madagascariensis*.

for textile application. Some of the aforementioned indigenous potential dye-yielding plants in Uganda are shown in Figures 2-20. The rest of the plants produced light shades in appearance and of low colour absorption which offer minimum value as textile dyes. The bark was found to have more preponderance of dye than the other parts of the plants tested in the case of *A. coriaria, S. cordatum, Mangifera indica, H. madagascariensis, E. abyssinica, Ficus natalensis and P. guajava* (Table 2). The bark and roots produced colour of more or less similar intensity in the case of *V. paradoxa, M. lucida* and *A.* cor*difolia*. As for *Indigofera arrecta* and *Justicia betonica*, the leaves had more preponderance of dye as compared with the other parts tested for the two plants. The roots were the major source of colour for *C. longa* Linn and *R. cordifolia* dye plants (Table 2). The barks were the overall major source of natural dyes, accounting for 67.5%, followed by the roots (15.0%) and leaves (12.5%), seeds and fruits accounted for about 5% in total (Figure 1). Much as the barks are predominantly used as a major source of the natural dyes, their constant removal from the plants for extraction of dye material is likely to endanger their lives in addition to causing some measure of deforestation. Hence the need to explore greater involvement of the other parts of the plants especially the leaves, seeds and flowers, which are in greater abundance for dye production and prevent massive long time environmental impact and exploitation of plants (Figure 1).

The rest of the plants produced various light shades of brown colour which offer minimum value as textile dyes. The depths of shade developed on the cotton fabrics by the different dye extracts varied from plant to plant.

Variation in dye yield and colour is influenced by growing conditions of plants, geographical location and soil conditions, age, weather and time of harvest (Anna and Christian, 2003; Padma, 2000; Guinot et al., 2007). These factors, singly or collectively, contributed significantly to the depth and type of shade produced by the different plants investigated in this study.

A large plant resource base exists in Uganda, but very little of it has been exploited especially for dye- yielding plants. More detailed studies and scientific investigations are therefore needed to assess the real potential and availability of these plants and propagate some of the species with greater dye content, colour absorption and performance on different textile materials upon exposure to daylight, washing, rubbing and perspiration using test methods standardized for the textile industry (Figures 2 to 20).

Conclusion

This study of natural plant colours is the first one in Uganda to investigate such a large number of dye plants as a useful starting point to choose appropriate species

Table 2. Different parts of selected single plants tested for colour on cotton fabrics.

Species	Plant parts used and colour produced						
	Local names	**Family**	**Bark**	**Stem**	**Stalk**	**Roots**	**Leaves**
M. lucida	Mubajansali	Rubiaceae	Mustard yellow			Raw umber	Flesh tint
A. coriaria	Mugavu	Mimosaceae	Fallow brown			Brown pink	Pale gold
S. cordatum	Kanzironziro	Myrtaceae	Fallow brown			Red brown	Pale gold
I. arrecta	Omusoroza	Papilionoidea		Orangeish white		Very pale orange	Moss green
R. cordifolia	Kasalabakesi	Rubiaceae			Light brownish grey	Pinkish red	Light umberish grey
C.longa L	Binzaali	Zingibaraceae		Orangeish white		Chrome yellow	Very pale umber
J. betonica	Muzukizi	Acanthaceae			Medium grey	Light orange reddish grey	Bluish purple
V. paradoxa	Nakunguli	Sapotaceae	Brown Red			Dark greyish brown red	Moderate orange
M. indica	Muyembe	Anacardiaceae	Yellow green			Pale yellowish green	Yellowish green
E.abyssinica	Jjirikiti	Papilionaceae	Cadmiun yellow			Light Crimsonish grey	Pale greyish umber
H.madagascariensis	Mulilira	Guttiferae	Raw umber			Orange, reddish grey	Yellowish green
F. natalensis	Mutuba	Moraceae	Very pale, orange red			Light Brownish Gray	Light brownish grey
P.americana	Avocado	Lauraceae	Cygnet brown			Umberish grey	Greyish umber
S. cuminii	Jambula	Myrtaceae	Alabaster brown			Greyish brown	Greyish brown
P. guajava	Guava	Myrtaceae	Light-stone brown			Greyish umber	Greyish umber
A. cordifolia	Luzibaziba	Euphorbiaceae	Light-stone brown			Greyish brown	Yellow green

for optimization research and hence encourage the more indigenous use of dye plants. Indigenous knowledge of extraction, processing and practice of using some of these plants among the local communities for herbal medicines and for dyeing local vegetable materials like palm leaves and sisal was found useful in identifying

Figure 4. *R. cordifolia*.

Figure 5. *C. longa* L.

Figure 6. *S. cordatum.*

Figure 7. *A. coriaria*.

Figure 8. *B. orellana* Linn.

Figure 9. *I. arrecta.*

Figure 10. *H. sabdariffa*.

Figure 13. *K. Africana*.

Figure 11. *V. paradoxa*.

Figure 14. *E. abyssinica*.

Figure 12.*M. indica*.

Figure 15. *A. cordifolia*.

Figure 16. *E. abyssinica*.

Figure 19. *P. guajava*.

Figure 17. *J. betonica*.

Figure 20. *A. seyal*.

Figure 18. *S. guineense.*

some of these plants. The majority of these plants which had dye- yielding properties were also known to be commonly used sources of medicine for the local communities.

Application of some of these plants as source of textile dyes was however, very limited and no serious attempts characterization of natural dyes would help in commercialization and promotion of some of the promising indigenous plants as alternative crops for farmers, thereby enhancing their economy.

Projects to promote the cultivation of dye plants with good agronomic potential should be developed in Uganda and across many countries in Africa. *A. coriaria, R. cordifolia, M. indica, M. lucida, V. paradoxa and S. cordatum* are some of the indigenous plants which have

been evaluated with good colourfastness performance values of 3 to 4 on a 5-point grey scale (Wanyama et al., 2010), indicating potential marketability as dyestuffs. Appropriate studies should also be conducted on each of the possible sources of variation in colour consistency and yield so as to produce high quality natural dyes with shades comparable to some of the highly rated synthetic dyes in the textile industry.

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