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Indigenous dye plants of the Kingdom of Eswatini, traditional uses and new prospects

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ABSTRACT

Eswatini is rich with a diverse assortment of many indigenous plant species with great potential of economic importance. Natural dye producing plants are among those plants which remain in the wild unexploited, while synthetic dyes used in the textile industries are imported. The aim of this study was to investigate indigenous natural dye producing plants found in Eswatini with potential economic use in the handicraft and textile industries. Plant species were identified with potential to produce natural dyes of economic importance. Important species identified include *Berchemia discolor*, *Syzigium cordatum*, *Kigelia africanum* and *Sclerocarya birrea.* The species, local names, plant parts used and the color produced are presented. Dye extraction, characterization techniques and application technologies are discussed. Coincidentally many dye plants were found to have medicinal properties. This paper attempts to address the environmental concerns possibly arising from exploitation of dye plant species and presenting some recommendations on new prospects.

Keywords: Indigenous plants, natural dyes, medicinal properties, commercial potential, sustainable development goals (SDGs).

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INTRODUCTION

Traditionally certain plants in Eswatini have been used as source of colourants to dye mats, hats, ropes, baskets and other home made handicrafts for a long time. Recently natural dyes of plant origin have gained economic advantage over synthetic dyes because of their non-toxic, non-carcinogenic and biodegradable nature (Bhuyan and Saikia, 2008; Samanta and Agarwal, 2009; Wanyama et al., 2011). There is recognition internationally that commercialization of non-timber forest products is increasing (Arnold, 1995: Cunningham, 2001). Taxonomists and ecologists have been concerned with the impact of non-timber forest products (NTFP) extraction on forest structure, composition and sustainability (Daniels et al., 1996; Murali et al., 1996; Cunningham, 2001). Economists are concerned with benefit/cost analysis of exploitation of forest species. Some of the indigenous species have been used for income, social and food security especially by poor households (Chambers, 1983; Campbell, 1987; Manyatsi et al., 2010; Zwane et al., 2011). Indigenous plants have historically been associated with cultural values, traditions and even religious values. Anthropologists and sociologists have been concerned with tenure, traditions, institutions and rules governing the use of indigenous plant resources (Mukamuri et al., 1998; Manyatsi et al., 2010). Previous studies indicated the institutions and traditional rules have weakened over years (Nhira and Fortman, 1992; Braedt and Standa-Gunda, 1998; Manyatsi et al., 2010).

Dyes from indigenous plants apart from being mostly non-toxic they are bio-degradable and thus environmentally friendly (Mkhonta et al., 2014). There has been promotion on use of natural dye plants species in recent years. Work has been done pertaining to dye color measurements, analysis and structure determination (Deo and Desai, 1999; Bhuyan et al., 2002; Debajit and Tiwari, 2005). Colourimetric and spectroscopic methods have been employed to successfully characterize dyes from plants (Kenneth, 1973; Bhuyan et al., 2002; Young-Hee and Han-Do, 2004). More research has to be done to increase cultivation and awareness of crucial importance of natural dyes, which is why this research was undertaken.

The country is currently facing unprecedented economic challenges. Diversification of the country's industrial base is urgently needed. The economic use of indigenous dye plants for local purposes as well as export of value added products containing indigenous plant dyes or dyes themselves will help alleviate current economic challenges.

METHODOLOGY

Information was obtained from literature review and informal surveys in the various agro-ecological zones of the country.

Site description

Eswatini formerly Swaziland is located in Southern Africa. The country has four agro-ecological zones with distinct topography, geology, soils, vegetation and climatic patterns (Figure 1). In the west is the Highveld, which is mountainous and has a vegetation of mainly commercial forests with the bulk of the land used for subsistence farming (Thompson, 2017; Government of Swaziland, 2007). It experiences a temperature range of 4.5 to 33°C (Table 1) (Dlamini and Lupupa, 1995). It has rivers, waterfalls and gorges with protected natural areas including Malolotsha, Hawane and Phophonyane (Government of Swaziland, 2005). The Middleveld is characterized with temperatures ranging from 2.5 to 37.2°C (Dlamini and Lupupa, 1995). This region has fertile valleys which favour intensive farming. It has the most diversely cultivated and heavily populated area in the country (Thompson, 2017). Protected nature reserve areas include Mantenga and Milwane (Government of Swaziland, 2005). To the east, there is the Lowveld with the largest area of 40% of the country and is drought prone. There is the Western Lowveld which is underlain by sandstone/ claystone and the Eastern Lowveld which is underlain by basalt (Dlamini and Lupupa, 1995). It has a vegetation of shrubs, and mean temperature ranges from 2.6 to 41.8°C with the bulk of commercial farms growing crops under irrigation. The nature reserves in the area are: Mlawula, Hlane, Shewula, Mbuluzi, Simunye and Nisela game reserves (Thompson, 2017; Government of Swaziland, 2007). The fourth region is the escarpment called Lubombo plateau with an altitude of 600 m above sea level and climatic conditions similar to the Middleveld. Only one eighth of the Lubombo plateau land is arable and the rest is for animal grazing (Dlamini and Lupupa, 1995).

FINDINGS

Several dye plants are found in the four agro-ecological zones of the Kingdom of Eswatini (Table 2). It must be emphasized that it is in the natural reserve areas where there is abundancy of dye plants in their natural habitat.

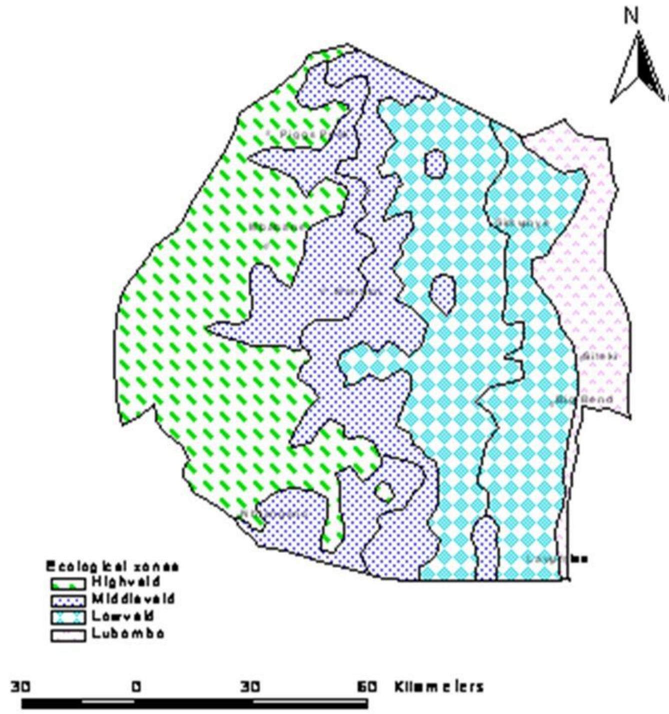

Figure 1. Agro-ecological zones of Eswatini.

Dye extraction

Natural dye extraction conditions, temperature, M:L ratio, time, extraction solvent and pH are critical in maximizing the dye yield and dye strength in all the methods that are employed for extraction. One of the limitations of natural dyes is the use of substantial dye source material to produce a small amount of dye, hence the tinctorial strength of the dye source ought to be considered as trees take longer to replenish. Consequently the use of existing timber byproduct as dyestuff preserves the environmental compared to harvesting trees or tree components for dye material (Doty et al., 2016). The optimum extraction conditions are determined by varying the extraction parameters (Samanta and Konar, 2011). Marigold natural dye colour strength values increase with the increase in temperature from room temperature to boiling point, an increase in extraction time and an increase in the M:L ratio. This is attributed to cell wall ruptures as a result of the high temperature and ultimately more dye release (Farooq et al., 2013; Ahmadi and Houjeghan, 2017). The extraction yields of quercetin increase with an increase in pH due to the effective swelling of the plant material which helps to increase the surface area for solute-solvent contact (Kumar et al., 2014).

Table 1. Characteristics of four agro-ecological zones of Eswatini where dye plants are found.

Agro-ecological zone	Land area (%)	Altitude (m)	Rainfall (mm)	Min and max temp (°C)
Highveld	33	900 - 1400	1000-1200	7 - 30
Middleveld	28	400 - 800	700-1000	9 - 35
Lowveld	31	400 - 450	450-850	12 - 40
Lubombo Plateau	8	550 - 700	550-700	8 - 30

Source: Edge and Ossom (2009).

Table 2. Indigenous dye plants of Eswatini.

Scientific name	Common name	Siswati name	Part used	Colour obtained	Conservation status
Sclerocarya birrea	Marula	*Umganu*	Bark	Red	Least concern
Trichilia emetic	Natal mahogany	*Umkhuhlu*	Bark	Brown	Least concern
Calpurnia aurea	Common calpurnia	*Umphendvulo*	Leaves	Purple	Least concern
Pterocarpus angolensis	Wild teak	*Umvangati*	Bark	Red	Least concern
Tagetes minuta	Khaki weed	*Nukani*	Leaves	Green	Common weed
Sterculia murex	Lowveld chestnut	*Umbhaba*	Bark	Red-Brown	Near Threatened
Syzigium cordatum	Waterberry	*Umcozi*	Bark	Red-Brown	Least concern
Bidens pilosa	Black jack	*Chuchuza*	Leaves	Mustard	Common weed
Rhus dentate	Nana berry	*Inhlangushane*	Fruit	Yellow	Least concern
Ficus glumosa	Mountain rock fig	*Inkhokhokho lemhlophe*	Bark/latex	Brick-red	Least concern
Annona senegalensis	Wild custard apple	*Umtelemba*	Fruit	Yellow/Brown	Least concern
Vangueria cyanescens	Wild medlar	*Umntulwa*	leaves , Bark	yellow, green	Least concern
Ximenia caffra	Large sourplum	*Umtfundvuluka*	Leaves/Roots	Oil imparts dark black to hair	Least concern
Flacourtia indica	Governor's plum	*Umtabhala*	Leaves/Bark/Root	Brown	Least concern
Ozoroa sphaerocarpa	Currant resin tree	*Imfuce lemnyama*	Bark	Pinkish dye	Least concern

Innovative dye extraction methods are being explored and developed to address the substantial use of energy and water in light of global water scarcity which is expected to increase with the rise of global warming. To achieve more sustainable patterns of natural dye extraction requires responsible and efficient use of natural resources, hence the need for more efficient extraction techniques and efficient management of the waste water as articulated by the sustainable development goals. Currently the quantity of plant material required to replace synthetic dyes is high (Kechi et al., 2013). In addition to the commonly used aqueous method, the alkali or acid extraction, microwave and ultrasonic assisted extraction, fermentation, enzymatic extraction, alcoholic or solvent extraction and super critical fluid extraction are used (Grover and Patni, 2011; Prabhu and Bhute, 2012). These emerging approaches and advances are assisting towards the standardization of the extractions processes therefore counteracting the lack of precise technical knowledge on extraction.

The choice of the method of extraction is heavily dependent on the dye plant source as the dye component may be derived from roots, leaf, bark, trunk fruits, or flowers of the selected indigenous plants (Anjali and Deepali, 2012). The barks of *Ficus religiosa* L. easily discharge colour in aqueous extraction (Saravanan and Chandramohan, 2011), natural dye is efficiently extracted from *Madhuca longfolia* leaves at 95°C at pH 10 for 60 min in aqueous extraction (Swamy et al., 2015) gamma ray treatment of 15kGy is an effective absorbed dose for dye extraction from red calico leaves, The natural dye source is dried to reduce the moisture content hence increase shelf life and ground for more surface area during extraction. The challenge with the different extraction methods often employed is to achieve absolute selectivity of the dye component from the extract hence to address this concern solid phase extraction is employed (Kumar et al., 2014).

Characterization techniques for natural dyes

Natural dye extracts usually contain a number of coloured compounds. The characterization of natural dyes involves a combination of techniques, with separation into respective coloured moites done first followed by the characterization of the separated compounds. There are a number of techniques that can be used to identify and characterize natural dyes, and these include chromatographic analysis, ultraviolet visible spectroscopic (Uv-Vis) analysis, Fourier transform infra-red analysis (FTIR), differential scanning calorimetry (DSC), X-ray powder diffraction (XRD) and X-ray fluorescence (XRF) (Samanta and Agarwal, 2009; Vankar, 2017). To better understand new dye extracts these techniques are normally used in combination rather than separately as they characterize different aspects of the dye extract (Alemayehu and Teklemariam, 2014).

Thin layer chromatography (TLC) is one of the techniques that has found wide spread use in natural dye extract characterization. This has been used to isolate and identify various coloured compounds found in natural dye extracts. Singh et al. (2017) characterized a dye extract from *Butea monosperma* (Lam) Kuntze flower petals (palash) using a combination of TLC, FTIR and UV Visible spectroscopic analysis and identified the palash flower dye extract to contain chalcone, butein, orange yellow needles and flavanone, butein and its glycoside butrin. In another study, a combination of spectroscopic and chromatographic analysis was used to characterize dye extracts from a natural mineral dye and TLC showed presence of four different coloured compounds containing aromatic groups as well as Ar-NH2, -CONH2, C=C, C-C and metal-carbon chelate rings, which were confirmed through FTIR and UV Visible analysis (Adebayo et al., 2007).

High performance liquid chromatography (HPLC) is another technique that is used to analyze natural dye extracts (Karapanagiotis et al., 2006). Silva et al. (2018) characterized a dye extract from eucalyptus leaves using HPLC and mass spectrometry. The extract was found to contain a mixture of fourteen characteristic phenolic compounds.

Analysis of dye extracts using UV-Vis spectroscopic analysis results in the identification of the most prevalent dye compounds in a particular dye extract (Kusumawati et al., 2017). Depending on the region that the dye absorbs light important information like the light fastness properties of the dye can also be established. Other important characteristics of dyes like solubility and mordanting power of dyes which are influenced by the chemical constituents as well as functional groups in the coloured compounds can be determined through FTIR analysis, as this is capable of identifying functional groups present in dyes (Samanta and Agarwal, 2009). Sanjay et al. (2018) in their study were able to confirm through FTIR the presence of anthocyanin, carotene and chlorophyll molecules in the dyes extracted from leaves of *Peltophorum pterocarpum* and *Acalypha amentacea* for use as sensitizers for ZnO based dye sensitized solar cells. UV-Visible analysis of both dye extracts further showed intense absorption peaks in the UV-Visible region showing the presence of anthocyanin, carotene and chlorophyll.

Applications of indigenous dye plants

Plants contain colourants used in a number of applications including textile dying (Sava, 2007). In the past, plant dyes were used mainly in the textile and cosmetic industry (Yusuf et al., 2017). Research and Development (R and D) has seen the expansion of the use of plant dyes to other industries like the medical, food, leather and pharmaceuticals (Cardon, 2010; Grover and Patni, 2011; Yusuf et al., 2017; Kunene and Masairambi, 2018). However, the development of organic chemistry in industrialised countries brought about the use of synthetic dyes and pigments obtained from fossil resources: coal-tar and oil which are not only cheaper but have simpler application procedures (Cardon, 2010) than natural dyes. Although other parts of the world retained their knowledge of colouring properties of their indigenous plants, they slowly lost it as they adopted the western lifestyle over the years (Yusuf et al., 2017) which include the use of synthetic dyes. These synthetic dyes are imported into developing countries like the Kingdom of Eswatini for use mainly in the textile industry.

The Sustainable Development Goals (SDGs) on nature conservation advocate for the use of eco-friendly technologies. The increase in the cost of fossil resources, its scarcity as well as the public's awareness on the effects of synthetic materials on the environment, aquatic and ecosystem, has sparked an interest to revive the use of safe natural colorants from indigenous plants as alternative to synthetic dyes (Cardon, 2010; Yusuf et al., 2017). The technological advancement around the world calls for combining the traditional, current and new technologies and techniques in the applications of indigenous dye plants.

Textile applications

The most common use of indigenous dye plants is the extraction of colourants used in textiles. Natural dyes on their own have limitations which include inadequate degree of fixation, low colour fastness and narrow shade range and therefore require the addition of mordants (Yusuf et al., 2017). A good mordant will produce the desired colour yield at minimal cost without altering the fabric properties, producing toxic substances during processing or carcinogenic substances during use (Arora et al., 2017). Effectiveness of the dyeing process and colour shade are influenced by the fibre content of the dyed fabric, mordanting technique and reaction between the dye, the mordant and substrate (Samanta and Argarwal, 2009; Arora et al., 2017). Currently aluminium and iron mordants are the other preferred mordants over metallic ones that result in toxic metal ion residue in waste water which negatively impacts the environment and also cause allergenic reactions to humans (Yusuf et al., 2017). With the shift from the use of environmentally harmful synthetic substances in dyeing, studies on alternative new plant extracts recommend *Aloe vera* and lemon (*Citrus limon*) as comparable alternatives to the conventional mordants (Yusuf et al., 2017; Zubairu and Msheli, 2015). In addition to textile dyeing, plant colorants may also be used to incorporate functional properties in textiles. These include introducing antimicrobial finishes, ultraviolet protection, deodorising finishes and moth and insect repellent finishes (Yusuf et al., 2017).

Textiles retain oxygen, moisture and nutrition which make them susceptible to microbial and dust mite activity. Transmission of micro-organism may occur when the bacteria found in human skin cells are deposited on textiles. Under these conditions together with human perspiration, microorganism may produce odour. This then necessitates the need for anti-microbial and deodorising finishes especially on underwear to inhibit microbial activity and counteract bad odour respectively (Yusuf et al., 2017). Some natural dyes may also have antimicrobial properties which may also be useful in protecting patients and hospital employees from cross transmission of microbes. Natural anti-microbial and deodorizing finishes are preferred over synthetic ones that produce hazardous substances into the environment.

Some natural colorants from plants introduce ultraviolet protection properties on textiles e.g. wool treated with extracts from eucalyptus leaves, silk dyed with natural yellow dyes and indigo dyes used on a number of fabrics. Protein fibers like silk and wool are prone to moth and insect attack. Common chemical moth repellents are harmful to the environment (Yusuf et al., 2017) there is therefore a need to explore indigenous plants for natural colorants with the same effect.

Other prospects of indigenous dye plants

The applications of indigenous dye plants is not only limited to textiles, other uses include natural food colourants that may replace synthetic food colourings due to the many health benefits associated with the use of natural substances and the increased consumer awareness on green consumption (Yusuf et al., 2017). Other future prospects of indigenous dye plants application that may be explored in the Kingdom of Eswatini include their use in leather, cosmetic, pharmaceutical and paint industries.

Indigenous dye plants have medicinal properties

Dyes are secondary products of plant metabolism, by their nature they are often found to have medicinal properties. The same plant part used to extract dyes is usually the same part used to extract medicinal substance. Indigenous dye plants with medicinal properties are shown in Table 3.

Work on indigenous medicinal plants has previously been reported (van Wyk et al., 1997; Adeniji et al., 2000; van Wyk, 2002; Masarirambi et al., 2011; Kunene and Masarirambi, 2018; Kunene et al., 2018). There is need to continue work on indigenous dye plants with medicinal properties to keep pace with modern day technologies.

CONCLUSION AND RECOMMENDATIONS

Indigenous dye plants of the Kingdom of Eswatini and the region have been reviewed. The common names, scientific names, siSwati names, part used colours obtained and conservation, status have been documented. The active ingredients of indigenous plant dye extracts are secondary metabolites most of which apparently have medicinal properties. The indigenous knowledge (IK) pertaining to economically useful yet endangered plant species has been passed on from one generation to another using oral tradition. Oral tradition changes from one generation to another and hence the need for documentation as we go into the future while striving to attain SDGs for the people and the planet. Conservation of biodiversity is crucial for the planet and the people, especially in this era of climate change, severe weather events and uncertainties. It is therefore strongly recommended going forward that all stakeholders do work on indigenous dye plants using modern technologies in order to reach the next upper level of commercialization and to subsequently document that work in leading scientific fora.

It may be concluded that it is important to document indigenous dye species and to raise awareness of local people, governments and industrial entrepreneurs about the species. There is need to protect the wealth so that it

Table 3. Indigenous dye plants with medicinal properties.

Common Name	Siswati name	Scientific name	Traditional medicinal use	Part used
Water berry	*Umncozi*	*Syzigium cordatum*	Edible fruits, bark used for treating diarrhea	Bark
Marula	*Umganu*	*Sclerocarpa birrea*	Treatment of dysentery and diarrhea	Bark
Red ivory	*Umneyi*	*Berchemia zeyheri*	Edible fruit, bark for back pain	Fruit, bark
Wild custard apple	*Umtelemba*	*Annona senegalensis*	Edible fruits diarrhoea	Fruit
Wild medlar	*Umntulwa*	Vangueria cyanescens	Edible fruit, coughs, fevers and wounds	Leaf, bark, fruit
Large sourplum	*Umtfundvuluka*	*Ximenia caffra*	Inflamed eyes, abdominal pain, dysentery and diarrhoea	Leaves, roots
African teak	*Umhlume*	*Breonadia salicina*	Treatment of diarrhoea in children	Bark
Currant resin tree	*Imfuce lemnyama*	*Ozoroa sphaerocarpa*	Treatment of diarrhoea in children	Bark
Mountain rock fig	*Inkhokhokho lemhlophe*	*Ficus glumosa*	Treating diarrhoea and tooth ache, alleviate sprain pains	Bark/latex
Governor's plum	*Umtabhala*	*Flacourtia indica*	Bark and roots for sore throats and rheumatism. Leaf tonic for asthma	Bark, root, leaf
Shepherd's tree	*Ingwavuma*	*Boscia albitrunca*	Leaves and roots used as emetic and epilepsy remedy, bark for vomiting. Also used for haemorrhoids	Leaf, bark

can be utilized by the next generations.

REFERENCES

Adebayo GB, Adekolaand F, Olatunji FA, **2007**. Chromatographic separation and spectro-analytical characterization of a natural African mineral dye. Bull Chem Soc Ethiopia, 21(2): 159-170.

Adeniji KO, Amusan OOG, Dlamini PS, Enow-Orock EG, Gamedze ST, Gbile ZO, Langa AD, Makubu LP, Mahunnah RLA, Mshana RN, Sofowa A, Vilane MJ, **2000**. Traditional medicine and pharmacopoeia contribution to ethnobotanical and floristic studies in Swaziland. Scientific, Technical and Research Commission of the Organization of African Unity (OAU/STRC).

Ahmadi Z, **Houjeghan** FG, **2017**. Evaluation of color sensitivity to dyeing parameters in natural dyeing with anthocyanin. J Textil Polym, 5(2): 97-102.

Alemayehu T, **Teklemariam** Z, **2014**. Application of natural dyes on textile: A review. Int J Res, 2(2): 61–68.

Arnold JEM, **1995**. Socio-economic benefits and issues in non-timber forest products use. Paper for export consultation on non-wood forest products. Yogyakarta, 17-25 January, 1995. FAO, Rome, Italy.

Arora J, Agarwal P, Gupta G, **2017**. Rainbow of natural dyes on textiles using plants extracts: Sustainable and eco-friendly processes. Green Sust Chem, 7: 35-47.

Bhuyan R, **Saikia** CN, **2008**. Isolation of colour components from the roots of *Morinda angustifolia* Roxb and evaluation of its dyeing characteristics. Ind J Fibre Textile Res, 27: 429-433.

Bhuyan R, Saikia, DC, Saikia CN, **2002**. Isolation of color components from the roots of *Morinda angustifolia* Roxb and evaluation of its dyeing characteristics. Ind J Fibre Textile Res, 27: 429-433.

Braedt O, **Standa-Gunda** W, **1998**. The woodcraft industry in Zimbabwe: An overview. IES working paper. Harare, Zimbabwe.

Campbell BM, **1987**. The use of wild fruits in Zimbabwe. Economic Bot, 41: 375-385.

Cardon D, **2010**. Natural dyes, our global heritage of colors. Textiles Society of American Symposium Proceedings.12. http://digitalcommons.unl.edu/tsaconf/12 (Accessed on November 12, 2018).

Chambers R, **1983**. Rural Development: Putting the Last First. Longman, London, UK.

Cunningham AB, **2001**. Applied ethnobotany: People, wild plant use and conservation. Earthscan Publications Ltd, London, UK and Sterling, VA, USA.

Daniels RJR, Gadgil M, Joshi N, **1996**. Impact of human extraction on tropical humid forests in the Western Ghats in Uttara Kannada, South India. J Applied Ecol, 32: 866-874.

Debajit M, **Tiwari** SC, **2005**. Natural dye-yielding plants and indigenous knowledge on dye preparation in Arunachal Pradesh, Northeast India. Curr. Sci, 88(9): 1474-1480.

Deo HT, **Desai** BK, **1999**. Dyeing of cotton and jute with tead as a natural dye. Colouration Technol., 115(7-8): 224-227.

Dlamini GM, **Lupupa** T, **1995**. Swaziland: Country report to the FAO International Technical conference on plant genetic resources. FAO, Rome, Italy.

Doty K, Haar S, Kim J, **2016**. Black walnut, Osage orange and eastern red cedar sawmill waste as natural dyes: Effect of aluminum mordant on color parameters. Fash Text 3: 22.

Farooq A, Ali S, Abbas N, Zahoor N, Ashraf MA, **2013**. Optimization of extraction and dyeing parameters for natural dyeing of cotton fabric using marigold (*Tagetes erecta*). Asian J Chem, 25(11): 5955 – 5959.

Government of Swaziland, **2005**. The Swaziland National Biodiversity Strategy and Action Plan. Government of Swaziland, Mbabane, Swaziland.

Government of Swaziland, **2007**. Swaziland Review. Ministry of Commerce and Industry. Government of Swaziland, Mbabane, Swaziland.

Grover N, **Patni** V, **2011**. Extraction and application of natural dye preparation from the floral parts of *Woodfordia fruiticosa* (Linn.) Kurz. Indian J Nat Prod Resources, 2(4): 403-408.

Karapanagiotis I, De Villemereuil V, Magiatis P, Polychronopoulos P, Vougogiannopoulou K, Skaltsounis AL, **2006**. Identification of the coloring constituents of four natural indigoid dyes. J Liquid Chromat Related Technol, 29(10): 1491–1502. https://doi.org/10.1080/10826070600674935 (Accessed on August 30, 2018).

Kechi A, Chavan RB, Moeckel R, **2013**. Dye yield, color strength and dyeing properties of natural dyes extracted from Ethiopian dye plants. Text Light Ind Sci Technol, 2(3): 137-145.

Kenneth MK, **1973**. Colour characteristics of traditional vegetable dyeing. Textile Res J, 43(7): 404-408.

Kumar B, Smita K, Kumar B, Cumbal L, Rosero G, **2014**. Microwave-assisted extraction and solid-phase separation of quercetin form solid onion (*Allium cepa* L.). Sep Sci Tech, 49: 2502-2509.

Kunene EN, **Masairambi**, MT, **2018**. Role of biotechnology in the conservation of rare threatened and endangered medicinal plant species in the Kingdom of Eswatini. Adv Med Plant Res, 6(3): 26-32.

Kunene EN, Oseni TO, Wahome PK, Masariambi MT, McCubbin MJ, Dlamini PS, Sihlongonyane SA, Zwane MG, **2018**. Effect of plant growth regulators and explant type on the *in vitro* micro-propergation of wild ginger (*Siphonochilus aethinopicus*) (Schweif B.L. Burt.). Adv Med Plant Res, 6(4): 54-63.

Kusumawati N, Santoso AB, Sianita MM, Muslim S, **2017**. Extraction, characterization, and application of natural dyes from the fresh mangosteen (*Garcinia mangostana* L.) peel. Int J Adv Sci, Eng Info Tech, 7(3): 878–884.

Manyatsi AM, Mhazo N, Msibi S, Masarirambi MT, **2010**. Utilization of wetland resources for livelihood in Swaziland: the case of Lobamba

Lomdzala area. Curr Res J Soc Sci, 2(4): 262-268.

Masarirambi MT, Dlamini SO, Manyatsi, AM Nkosi BS, **2011**. Medicinal plants of Manzini, Swaziland: Indigenous medicinal plants, harvesting, processing and use. Proceedings of the 14th Boleswana Symposium. Educational Research and National Development: Opportunities and Challenges. 26-28 July 2011. University of Swaziland, Kwaluseni, Swaziland.

Mkhonta TT, Zwane PE, Thwala JM, Masarirambi MT, **2014**. Post-harvest handling, processing and marketing of sisal fibres and crafts in the Shiselweni district of Swaziland. Curr Res J Soc Sci, 6(2): 39-47.

Mukamuri BB, Campbell BM, Kowero G, **1998**. The impacts of macro-economic changes on rural institutions. Final report for CIFOR. IES, Harare, Zimbabwe.

Murali KS, Uma Shankar R, Uma Shaanker K, Ganeshaiah N, Bura KS, **1996**. Extraction of non-timber forest products of Biligiri Rangan Hills, India. Econ Bot, 50: 252-269.

Nhira C, **Fortmann** L, **1992**. Tenurial niches and woodland management institutions in Zimbabwe. CASS Publications. University of Zimbabwe, Harare, Zimbabwe.

Prabhu KH, **Bhute** AS, **2012**. Plant based natural dyes and mordants: A review. J Nat Prod Plant Resource, 2(6): 649-664.

Samanta AK, **Agarwal** P, **2009**. Application of natural dyes on textxiles. Ind J Fib Tex Res, 34:384-399.

Samanta AK, **Konar** A, **2011**. Dyeing of textiles with natural dyes. Natural Dyes. DOI:10.5772/21341www.intechopen.com. (Accessed on August 30, 2018).

Sanjay P, Deepa K, Madhavan J, Senthil S, **2018**. Optical, spectral and photovoltaic characterization of natural dyes extracted from leaves of Peltophorum pterocarpum and Acalypha amentacea used as sensitizers for ZnO based dye sensitized solar cells. Opt Mat, 83: 192–199.

Saravanan P, **Chandramohan** G, **2011**. Dyeing of silk with ecofriendly natural dye obtained from barks of *Ficus Religiosa* L. Universal J Environ Res Technol, 1(3): 268-273.

Sava R, **2007**. Status of natural dyes and dye-yielding plants in India. Current Sci, 92(7): 916-923.

Silva MG, da Barros MASD, Almeida RTR, de Pilau EJ, Pinto E, Soares G, Santos JG, **2018**. Cleaner production of antimicrobial and anti-UV cotton materials through dyeing with eucalyptus leaves extract. J Cle Prod (199): 807-816.

Singh RP, Agarwal KK, Singh RB, College BSA, Pradesh U, **2017**. Extraction and characterization of *Butea monosperma* (Lam.) Kuntze flower petals dye for its uses in the colouration of food , pharmaceutical and textile industries. Int J Pharm Sci Res, 2(5): 2–4.

Swamy VN, Gowda KNN, Sudhakar R, **2015**. Dyeing of silk using *Madhuca longifolia* as natural dye source. Indian J Fibre Textile Res, (40): 419-424.

Thompson CF, **2017**. Swaziland Business Year Book. Christina Forsyth Thompson, Mbabane, Swaziland.

Van Wyk BE, **2002**. A review of enthonobotanical research in southern Africa. South African J Bot, 68: 1-13.

Van Wyk BE, van Oudtshoorn B, Gerieke N, **1997**. Medicinal Plants of South Africa, Briza Publications, Pretoria, South Africa.

Vankar PS, **2017**. Isolation and characterization of the colorant molecules from each dye plant in Natural Dyes for Textiles, 45–88. Padma Shree Vankar https://doi.org/10.1016/B978-0-08-101274-1.00002-1 (Accessed on August 30, 2018).

Wanyama PAG, Kiremire BT, Ogwok P, Murumu JS, **2011**. Indigenous plants in Uganda as potential sources of textile dyes. Afr J Plant Sci, 5(91): 28-39.

Young-Hee L, **Han-Do** K, **2004**. Dyeing properties and colourfastness of cotton and silk fabrics dyed with *Cassia tora* L extract. Fibres Polym, 5(4): 303-308.

Yusuf M, Shabir M, Mohammad F, **2017**. Natural colourants: Historical, processing and sustainable prospects. Natl Prod Bioprospect, 7(1): 123-145.

Zubairu A, **Msheli** YM, **2015**. Effects of selected mordants on the application of natural dye from onion skin (*Allium cepa*). Sci Technol, 5(2): 26-32.

Zwane PE, Masarirambi MT, Seyoum T, Nkosi BS, **2011**. Natural fibre plant resources of economic value found in wetlands of Swaziland: A review. Afr J Agric Res, 6(4): 774-779.

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