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Leather Dyeing with Plants Dyes: A Review

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Abstract

The paper reviewed the application of natural dyes on leather. The analysis of reviewed articles showed that different colours were obtained with the use of common and traditional mordants such as copper sulphate, ferrous sulphate and potash alum. From the results of earlier articles, it can be concluded that plant based dyes exhibited fair to good application on leather. Furthermore, the quality and durability of natural dyes in terms of colour fastness to light, washing, rubbing, and perspiration were also inferred from reviewed studies. This review article will help local dyers, researchers and leather merchants who seek information for leather dyeing using natural dyes. Furthermore, this study will also provide an insight regarding the available plant resources which can be used for the production of precious dyes.

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Introduction

In the human civilization, biodiversity provides a strong plant-human association for livelihood (Nadeem *et al.*, 2013). Plants were used not only to fulfill the basic needs of life such as food, fabric, fuel, medicines and shelter but also significantly contribute to obtain different products (Shah, 2005; Pahnwar and Abro, 2007; Zareen *et al.*, 2013) including natural dye.

Natural dyes preparation and application was one of the human favourite activities in the classical era. Natural dyes were used by people to paint caves, decorating shells, coloring feathers, hides and celebrating religious festivals. Primitive men used colours for symbolic and magical powers to get success in war and believed that colours defend them from evil spirits. The historical evidences of dyeing materials were found in the Indus Valley Civilization at Mohenjo-daro and Harappa ruins. Archaeologists reported that Egyptian mummies were wrapped in dyed clothes using *Carthamus Tinctorius* dye Evidences of dyeing materials were also found by excavation at archaeological sites where ancient fabrics were unearthed. The use of natural dye "saffron" is also mentioned in the Holy Book "Bible" (Siva, 2007; Savvidis *et al.*, 2013).

However, the real breakthroughs in the history of natural dyes came in 1856 when a teenager William Perkins an English chemist accidently discovered a synthetic colouring compound called 'mauveine'. The advent of synthetics dyes reduced the consumption of natural dyes (Chengaiah *et al.*, 2010; Saravanan and Chandramohan, 2011; Shahid *et al.*, 2013; Srivastava and Gautam, 2014) which were consumed largely in leather and textile industries till the middle of 19th century.

The application of man-made synthetic dyes is widespread in leather industry which possesses several negative effects. Synthetic dyes are produced from petroleum and coal-tar sources (Siva, 2007; Devi *et al.*, 2013) which not only destroy the environment (Carneiro *et al.*, 2010; Ferrero and Periolatto, 2012) during their synthesis but also discharge effluents into water bodies after dyeing process (Zaharia *et al.*, 2012; Gupta *et al.*, 2013).

Synthetic dyes effluents are difficult to treat through conventional waste water treatment process as they are highly soluble in water (Suzuki *et al.*, 2001; Padhi, 2012). They are hazardous for human health (Kamel *et al.*, 2005; Elsalam *et al.*, 2008; Thiyagarajan *et al.*, 2015), penetrate into the human skin (Sudha *et al.,* 2014), destroy ecosystem (Kant, 2012) and toxic to aquatic biodiversity (Danazumi and Bichi, 2010). Owing to mutagenic and teratogenic impacts of synthetic dyes (Abramian and El-Rassy, 2009) Germany, France, Turkey, Holland and India imposed ban on carcinogenic dyes (Nadigera, 2001; Kadolph, 2008; Sankat and Siddique, 2008). Due to the consequences of synthetic dyes and the strict environmental standards (Purohit *et al.*, 2007), the demand of natural dyes increased rapidly in the 21st century (Bechtold *et al.*, 2006; Bose, 2012). Nowadays nature lovers (Borah and Phukon, 2009), health conscious and green minded people started to emphasize natural dyes over synthetic colorants (Karaboyaci, 2014; Upadhyay and Choudhary, 2014). Therefore, keeping in view the consequence of synthetic dyes, this study was carried out to review the studies on natural dyes which were conducted on leather dyeing. The aim of this study was to review the application of natural dyes on leather with and without mordants in different era and also the colour fastness properties of dyed leather specimens.

Significance of natural dyes

Characteristically, natural dyes reported manifold advantages. They have wide variety, non-carcinogenic, non-poisonous, biodegradable, and non-hazardous to life (Saravanan *et al.*, 2013; Thiyagarajan *et al.*, 2015). Unlike synthetic dyes, the natural dyes are renewable, non-toxic, sustainable, and well known to create soft, subtle, pastel, soothing (Onal *et al.*, 2005; Samantaa and Agarwal, 2009; Kulkarni *et al.*, 2011; Pervaiz *et al.*, 2016) and vibrant colours (Srivastava and Gautam, 2014). Natural dyes are neither harmful for human beings nor hazardous for environment (Shahid and Muhammad, 2013). Plant based dyes are reported economical (Jadhao and Rathod, 2013; Pervaiz *et al.,* 2016), easy to handle, render fragrance in the dyed substrate (Pervaiz *et al.,* 2016),

promote green revolution (Agarwal *et al.,* 1992), enrich with aesthetic properties (Vankar *et al.*, 2007), helpful to generate employment, safe for ecology (Mahanta *et al.,* 2005), provide economic benefits through sustainable yield and harvest of dye bearing plants (Saravanan *et al.,* 2013). On the other side, commercialization of natural dye can help to boost up the economy of the country (Ghorpade *et al.*, 2000; Saravanan *et al.*, 2013; Upadhyay and Choudhary, 2014; Belemkar and Ramachandran, 2015) and have an opportunity to earn carbon credits by reducing consumption of petroleum based synthetic dyes (Aishwarya and Devi, 2014).

Leather dyeing with natural dyes

Source-wise almost whole plant parts such as roots, stems, barks, leaves, fruit, seeds, berries and flowers were used to prepare dyes (Angelini *et al.,* 2003; Adeel *et al.*, 2009). Several studies of natural dyes were also reported to dye leather, for instance *Parkia biglobasa* bark and pods' husk extract were used to dye leather (Campbell-Platt, 1980). In Hellenistic period, kermes dye was evaluated on leather (Koren, 1993). Rhubarb (*Rheum rhabarbarum*) dye was found suitable for dyeing leather (Schellenberg *et al.,* 1999) and *Tangetus erecta* extract was analyzed on sheep leather (Karolia and Dilawar, 2004).

Adem (1996) selected the onion's skin for dye extraction which is well known for its good dye component. The dye extraction was made using distilled n-hexane and resultant colourant was evaluated on feathered leather, woolen strips and cotton using pre-mordanting and post-mordanting techniques. Results of the study demonstrated that onion's skin dye is effectively and commercially viable for the leather industry.

Okwuchi (2006) examined the *Khaya senegalensis* (Savanna mahogany), *Bixa Orellea* (Annatto), *Alluim cepa* (Red Onion), *Mangnifera indica* (Mango) and *Hibiscus sabdariffa* (Zobo) natural colourant. Dye was extracted using different solvents such as acetone, ethanol, methanol, water and chloroform. Results of the study showed that the obtained extracts possess colour impacting chromophores and can be successfully used for leather dyeing. Findings of the study indicated the absence of microbial activities in the extracted dye of zobo. With reference to colour fastness to rubbing, the results showed good application of dye on the leather. The percentage of dye adsorption and the yield of dye extracted using different solvents had also reported good results.

Sivakumar *et al.* (2009) carried out a study to extract natural dye from beetroot and evaluated its dye potential on leather and paper. The ultrasound technique was used to extract dye and has shown significant efficiency to extract dye from beetroot whereas the best dye yield was obtained using 1:1 ethanol–water mixture. Based upon the results it was noticed that 80W ultrasonic power for three hours contact time produced better dye yield. Results of study concluded that obtained natural dye from beetroot was found eco-friendly and potentially viable in 'Green Chemistry.'

Velmurugan *et al.* (2010) studied the dyeing effects of fungal pigment on wet blue goat leather. They evaluated fungi which have been an important source of anthrquinone, anthraquinone carboxylic acids, and pre-anthraquinones. For the analysis, five different water-soluble pigments were extracted *from Monascus purpureus*, *Isaria* spp., *Emericella* spp., *Fusarium* spp. and *Penicillium* spp. which were used for dyeing afterwards. They also studied the different parameters such as pH, temperature, exhaustion of dye and colour intensity. The results of their study inferred that fungal pigments can be used as natural dye and would be helpful to reduce the pollution of leather dyeing process.

In another study of (Pervaiz *et al.*, 2016), four different varieties of flowers were selected for dye extraction. They analyzed the application of *Celosia cristata*, *Lantana camara*, *Rosa damascena* and *Tagetes erecta* dyes on goat leather. Eco-friendly dyeing procedure was adopted for dye extraction.

Forty shades were developed with ten different mordants using pre-mordanting method and four shades were obtained without mordants. The colour coordinates (CIEL* a* b*) of dyed leather specimens were also studied using spectrophotometer (Spectra-flash SF-650X). The results of their study showed that soft and dark shades were obtained with and without mordants. Findings of the study revealed that floral dyes have remarkable potential in leather dyeing and also an opportunity to promote sustainable fashion development.

Colour fastness properties of naturally dyed leather

Musa *et al.* (2009) analyzed the *Lawsonia ineremis* dye application on leather substrate. *Lawsonia ineremis* is known as henna in subcontinent and belong to the most prominent class of natural colorants which contain (2-hydroxy 1, 4 naphthaquinone and alpha–hydroxylnaphthaquinone).

In their study, different shades were produced with the henna dye using aluminium sulphate ferrous sulphate and zinc sulphate mordants. The results of study described that deep shades on leather can be obtained by increasing the amount of henna. However, different shades on leather were obtained with different mordants. The colour fastness to rubbing (dry & wet) and perspiration have shown good results whereas colour fastness to light inferred satisfactory results.

Extraction of natural dye from eucalyptus bark, tea leaves, turmeric rhizomes and walnut bark were studied by Inayat *et al.*, (2010). The extracted dye efficiency was assessed on goat leather. Acetic acid, citric acid and oxalic acid mordants were used to increase the colour fastness of dyed leather using post-mordanting technique. The study of Inayat *et al.,* (2010) concluded that leather dyed with oxalic acid mordant has shown best colour fastness properties in terms of washing, rubbing, and perspiration.

Boahin *et al.* (2011) evaluated the suede dye on leather sheets which is the local dyestuff of Ghana. For the study purpose, they made three trials of experiments. In the first trial, they examined the suede dye and salt (sodium chloride) results on leather sheet. In the second experiment of study, dye and alum were dissolved in warm water and leather immersed in the solution.

In the third trial, two different dyes were mixed separately with alum in warm water and used on leather sheet. In all the trials, leather sheets were immersed left in solutions for 15 minutes for the penetration of dyes. From the results of their study, it has been found that natural dyestuff has good light fastness and can be used for leather dyeing.

Bordingnon *et al.* (2011) analyzed the dyeing capacity of two natural dyes on wet white (chrome free) and wet blue leather. Urucum (*Bixa orellana* L.) and cochineal carmine (*Dactylopius coccus*) were used for dye extraction. It has been observed from the results that leather dyed with selected dyes exhibited good surface coating on leather. Moreover, the dye penetration and exhaustion were also found good with the used dyes. Furthermore, the colour fastness properties of dyed samples exhibited satisfactory results. Findings of the study concluded that natural dyes produced good results on wet blue leather than wet white (chrome free) leather.

Onem *et al.* (2011) studied the 5 year old *Rubia tinctorum* plant roots for dye extraction. The application of dye was tested on chrome and vegetable tanned Iranian sheep leather. Different mordants were used for dyeing analysis viz. potassium aluminium sulphate, copper sulphate and ferrous sulphate. Results of study concluded that chrome tanned leather rendered good colour fastness results as compared to vegetable tanned leather. The study analysis also described that extracted dye was found antioxidant, sustainable, environment friendly and helpful to reduce aquatic pollution.

In 2012, Erisen and his fellows studied the colouring ability of onion skins (*Allium cepa*) on chrome tanned leather. In this research, mordants viz. aluminium sulphate copper sulphate and ferrous sulphate have been used to obtain various colours and to increase the fastness value of dyed leathers. For color measurements, Konica Minolta (CM-3600d) spectrophotometer was used and dyestuff exhaustions have been analyzed by using Shimadzu (UV-1601 PC) UV-Visible spectrophotometer. Colour fastness to rubbing was performed in accordance to TS EN ISO 11640, colour fastness to perspiration was evaluated by TS EN ISO 11641 and colour fastness to light was measured by ISO 105-B02. Findings of the study concluded that colour fastness and dyestuff exhaustion values were varied by mordant type and results of all fastness gave satisfactory output.

Pant and Gahlot (2012) studied the natural colourant of cutuch (*Acacia catechu)* for dyeing chrome tanned sheep crust leather. Aqueous medium was employed for the extraction of dye. They studied the optimum dye extraction time, dyeing and mordanting time and mordants ratio. For comparative analysis, they used natural and synthetic mordants for mordanting leather. Results of their study concluded that different variation of brown shades can be obtained using cutuch dye with synthetic and natural mordants. The colour fastness results were also reported fair to good with the used dye.

A comprehensive study was conducted by Mughal *et al.*, (2012) using three different plants for the extraction of natural colourants. Aqueous medium was applied for dye extractions from *Mangifera indica*, *Syzygium cumini* and *Eucalyptus camaldulensis*. The goat leather was used for the assessment of extracted dyes. For the detailed evaluation of dyes, four different mordants *viz.* copper sulphate, ferrous sulphate, potassium permanganate and potash alum were selected. These mordants were used to improve the colour fastness of dyes and for the good dye uptake. Results of their study revealed that excellent colour fastness of dyes was obtained in terms of washing, rubbing, day light and heat with the selected dyes.

Their study also concluded that natural extract with mordants can be successfully applied on leather to get different pleasing shades.

Selvi *et al.* (2013) selected the *Bixa orellana* seeds for the evaluation of natural dye. The dye extraction was carried out using water as solvent. The application of extracted colourant was evaluated on chrome tanned wet blue sheep skins. Results of their study have shown that extracted dye of annatto seeds exhibited uniform shades on grain and flesh side of leather. Moreover, the colour fastness to rubbing (dry & wet) has bestowed good results. Findings of the study concluded that annatto dye has significant characteristics and can be used commercially to replace the hazardous synthetic dyes.

Abba *et al.* (2013) studied the dyeing and colour fastness efficiency of henna and kolanut plants leaves. Dye extraction was carried out using chloroform, acetone and sulphonated and chlorosulphoic acid. The application of sulphonated dyes were evaluated on chrome tanned leather. In their study, they assessed the dye exhaustion, evenness, penetration, fixation of dyes. Comparative analysis of henna and kolanut dyes revealed that better colour fastness results of the sulphonated dyes were observed with henna dye. Results of the study have proved that the use of sulphonation increased the affinity of dyes on leather.

Amarnath and Radhika (2015) studied leaves of *Indigo tinctoria* L. leaves (Indigo), *Haematoxylon campechianum* L wood of (Logwood) for dye extraction. Application of two different natural dyes was evaluated on wet blue cow leather. Pre-mordanting method was adopted using metallic mordants such as alum, chromium, and ferrous sulphate to improve the colour fastness. The selected raw material was found good source to produce variety of shades such as green, red, brown, and orange on leather. Findings of the study suggested that obtained shades on leather have viable option to promote eco-friendly natural dyes.

Paschal *et al.* (2015) dyed leather, cotton and wool substrates with the extract of *Justicia carner hooker*. The dye was extracted with water and methanol using soxhlet apparatus. Results of the study indicated that the good dye application was observed on all selected substrates. Results also demonstrated that good dye yield *i.e.* 92.8 % obtained with coupled dye. Hence, the results of colour fastness of coupled dye were recorded viable for leather dyeing.

In 2015, Sundari extracted the natural colourant from *Mucuna pruriens* and analyzed its colouring ability on chrome tanned wet blue goat leather. Ethanolic medium was used for dye extraction. In addition, the dyed leather samples were evaluated by leather experts and they found the satisfactory dye application in terms of dye uniformity. Results of study demonstrated that satisfactory colour fastness properties were obtained with *Mucuna pruriens* dye. Findings of study inferred that several fashion shades were achieved using mordants. Results of study also illustrated that toxic, non-carcinogenic synthetic dyes can be avoided using environment friendly natural dye.

Pervaiz *et al.* (2016) extracted the dye from waste petals of *Rosa damascena* (rose) and used to dye chrome tanned goat crust leather. Conventional, eco-friendly aqueous method was adopted for dye extraction. Two different methods of mordanting *i.e.* pre-mordanting and post-mordanting were used to dye leather. Results of the study inferred that rose petals have good potential to dye leather with and without mordants. Findings of their study indicated good to very good colour fastness of rubbing whereas colour fastness to light was observed satisfactory. They also performed the cost analysis of dye extraction and results of their study concluded that natural dye obtained from waste rose petals was cost efficient, environmental friendly and viable for industrial application.

Pervaiz *et al.* (2016) selected the conventional aqueous method for dye extraction using fifteen different plants parts such as araucaria leaves, banana tree bark, banyan tree bark and aerial roots, black plum tree bark, blood leaf leaves, bottle brush flowers and leaves, drumstick leaves, false ashoka leaves, mango bark, mulberry leaves, oleandar flower, strawberry leaves and pomegranate fruit peel. The goat crust leather was dyed with liquid extracts, keeping M:L ratio 1:10. Pre-mordanting technique was used for dyeing of leather with oxalic acid. The rubbing and light fastness properties of dyed leather specimens were found in the range of good to very good. They also studied the dye yield of selected plants and maximum yield of dyes were recorded with strawberry leaves and pomegranate fruit peel whereas aerial roots of banyan tree rendered low yield. However, the deep dark shades were obtained with banyan tree's bark dye. From the results of their study, it was concluded that natural dyes have good tendency for dyeing leather and commercial-lization of green dyes can help to strengthen the economy of Pakistan.

Conclusion

It can be concluded from reviewed articles that natural dyes are found environment friendly, low cost, non-carcinogenic, non- hazardous and very useful for leather dyeing. The results of leather dyeing with natural dyes by using different mordants were found encouraging in terms of their colour fastness to light, rubbing, washing and perspiration properties. Therefore, there is a good scope for Pakistan's leather industry to use natural dyes to meet the fundamental requirement of European Union, to earn carbon credits by reducing the use of synthetic dyes and to improve the socio-economic condition of farmers by yielding and harvesting dye bearing plants. Therefore, the role of the government should be to encourage the use of natural dyes by providing soft loans and financial support to farmers for the cultivation of dye bearing plants. In addition, government can provide assistance in marketing of natural dyes and reward the environment friendly leather industries. Moreover, detailed studies and technical investigations of natural dyes are yet to be made from the same plants available in different regions of the world and propagate the plant species having maximum dye yield for dyeing of leather.

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