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Stability of Colorants and Application of Natural Dye in Cotton Fabric Extracted from *Tectona grandis* L. Leaves

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A B S T R A C T

The demand for natural dyes in the modern world is increasing day by day in every field. The potentially ruinous effects of some synthetic dyes, there is an increasing demand for natural colorants. Natural dyes find use in the colouring of textiles, drugs, cosmetics, food colouring agents and pharmaceuticals etc., owing to their non- toxic effects. In the present investigation, natural dye was extracted from *Tectona grandis* L., belongs to the family Verbinaceae. For the extraction of Natural dye water bath method was used. Similarly aqueous used as a solvent. The results revealed that extraction of volatile fraction from *T. grandis* was maximum exhibited in (480 mg/g) water bath method. The results revealed showed that increasing in pH, exposure to sunlight is able to spoil the dye molecule. Aqueous extract of *T. grandis* Leaves of Pre, Post and Simultaneous method were used. $CuSO_4$, $FeSO_4$, $ZnCL_2$ used as a chemical Mordant and colour lightness, wash fastness and rubbing properties were also analyzed. The present investigation revealed that the dye extracted from *T. grandis* is a potential agent for dyeing in cotton fabric.

***Key words*:** *Tectona grandis*, Natural Dye, colour stability, Textiles, Cotton fabric

The use of non-toxic and ecofriendly natural dyes on textiles has become a matter of significant importance because of the increased environmental awareness in order to avoid some hazardous synthetic dyes. However, worldwide the use of natural dyes for the colouration of textiles has mainly been confined to craftsman, small scale dyers and printers as well as small scale exporters and producers dealing with high valued ecofriendly textile production and sales [1]. Moreover, the global consumption of textiles is estimated at around 30 million tonnes, which is expected to grow at the rate of 3% per annum. The colouration of this huge quantity of textiles needs around 700,000 tonnes of dyes which causes release of a vast amount of unused and unfixed synthetic colourants into the environment [2]. Dyeing is the application of dyes or pigments on textile materials such as fibers, yarns and fabrics ith the goal of achieving colour with desired colour fastness. Dyeing is normally done in a special solution containg dyes and particular chemical material. Dye molecules are fixed to the fiber by absorbtion, diffusion, bonding with temperature and time being key controlling factors. The bond between dye molecule and fiber may be strong or weak, depending on the dye used. Dyeing and printing are different applications; in printing, colour is applied to a localized area with desired patterns. In dyeing, it is applied to the entire textile [3].

This led to the use of different types of natural colouring matters to dye clothes prepared from different natural fibres such as cotton, Linen, Wool, and Silk etc. He observed that some dyes, which produce intense action on woollen fabrics, did not even stain cotton clothes. A new class of dyes had to be used to dye cotton. Indigo, cutch, logwood, tyrian purple and henna were some of the natural dyestuff used for dyeing cotton fabrics [4]. Natural dyes comprise those colourants (dyes and pigments) that are obtained from plants, animal or vegetable matter without chemical processing [5]. Research has shown that the natural dyes are quite safe and environment friendly [6]. The aim of the present investigation was carried out in colour stability and dyeing in Cotton fabric of *Tectona grandis* leaves dye extract.

MATERIALS AND METHODS

Collection of plant materials

The *Tectona grandis* leaves were collected from the Thennamanadu village in Thanjavur district, Tamil Nadu, India, during December 2020. The collected leaves were washed several times with distilled water to remove the traces of impurities from the leaves. Then examined carefully, old infected and fungus damaged portion of the leaves were removed. Healthy leaves were dried in room temperature and grind using grinder mixture. The powder was stored for further analysis.

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Extraction of dye from plant Powder [7]

The plant powder material used for extraction of dye. 10 g leaf powder was taken and 200 ml of water solvent was introduced in a conical flask to immerse the leaves in to the solvent fully were put into three neck round flask then put inside the water bath. The extraction of volatile fraction from *Tectona grandis* was performed using water bath for quick extraction. Extraction process was done at temperature 60 °C atmospheric pressure, 200 ml of solvent, 20Hz frequency and 20 mins. Extraction process will be stopped when the extraction time was completed. The solution was then double filtered and used to further study.

Stability of colorants [8]

Determination of pH stability of Tectona grandis Linn.

Tectona grandis colorants were prepared at pH 2.0, 4.0, 6.0, 7.0, 8.0, 10.0 and 12.00 by adjusting the pH of extracts using 0.1 N HCl and 0.1N NaOH. The effect of pH on colorant stability was performed immediately after preparing the extract at different pH values.

Determination of sunlight stability of Tectona grandis Linn.

To study the degradation of colorants under the influence of sunlight, sample solution containing glass tubes were exposed to natural light outdoor (sunlight). At appropriate time intervals, the samples were taken out to measure the absorbance at its λmax.

Application of natural dye extraction from Tectona grandis leaves in cotton cloth

Material

Cotton fabric were purchased from local market at Thanjavur. It was used after bleaching for application.

Experimental methods

$CuSO_4$, $FeSO_4$ and $SnCl_2$ were used as mordants. For light shade, the cotton fabric is kept in the dye bath in short time and dark shade kept it for overnight and change the proportion.

Mordanting dyeing Techniques [9]

Pre-mordanting dyeing

In dyeing with pre-mordanting method, the pretreated cotton fabrics were soaked in a solution containing 10 % on weight of fabrics (cotton) of a mordant, at 50 °C for 45 min with material-to liquor ratio of 50:1. The fabrics samples soaked with mordant solutions were then dyed.

Simultaneous mordanting dyeing

Dyeing with simultaneous mordanting method was done by putting the pretreated fabrics in a beaker (250 cm^3) containing 10% on weight of fabric (cotton) of mordant, at 50 °C for 45 min. A material to liquor ratio (LR) of 50:1 was used in all dyeing. This was done separately using each of the selected mordants.

Post mordant dyeing

The material is dyed and then treated with a mordant. In post-mordanting dyeing of cotton fabrics, the pretreated fabrics were dipped in a dye bath (250 cm^3) and after 10 minutes, 10% on weight of fabric (cotton). The dyed samples were removed from dye bath and squeezed to remove excess dye. The dyed fabrics were then soaked in a mordant solution at 50 °C for 45 minutes with material to liquor ratio of 50:1.

Pantone matching system [10]

The Pantone Matching System (PMS) has become the leading color reference system for "selecting, specifying, matching and controlling ink color" in the graphic arts and printing industries. The dyed cotton fabric were compared with reference standard Pantone matching system (PMS).

Types of colour fastness

Colour fastness of textile materials can be classified into different way like as:

- Light fastness
- Washing fastness
- Rubbing fastness
- Perspiration fastness
- Water fastness
- Colour fastness to bleaches and chemicals

In this current analysis light fastness, washing fastness and rubbing fastness were analyzed.

Dyeing recipe for cotton fabric

Dyeing recipe	Amount
Tectona grandis aqueous extract	1%
Temperature	50 °C
Time	45 mins
M:L	50:1

Method of wash fastness [11]

As the sample to be tested is in cotton fabric form a piece measuring 10cm width by 4cm length was cut from each of the cotton fabric. The pieces of the undyed cloth enable the degree of staining during test to assess. The sample was washed with 5g/l of soap in a solution with liquor ratio 50:1, at a temperature of 50 °C, for 45mins followed by rinsing and drying. The change in colour of the tested specimen and the staining of the adjacent undyed cloths were assessed with the appropriate grey scales.

Method of light fastness

The artificial light source method of determination of light fastness was used in this study. The specimens were exposed behind a glass and inserted into the light fastness testing machine. Exposure was carried out for 45 mins. Exposure was terminated after the contrast between the exposed and the unexposed portion of the specimen is equal to the grades on the grey scale, for assessing change in colour. Change in colour was assessed by comparing the tested cotton fabric under a white light with standard as reference.

Colour fastness to rubbing

Rubbing fastness is determined by the equipment called AATCC crock meter. Grey scale for staining also used for this. The rubbing fastness tester checks the colour transferred from the surface of a coloured textile material to other surface by rubbing in dry and wet condition. It is applicable to textiles made from all fiber in the form of yarn or fabrics whether dyed or printed or otherwise coloured. The crock meter is been used to determine the colour fastness to rubbing or crocking.

Aqueous extracted dyeing with *Tectona grandis* dye on cotton fabric, colour fastness to rubbing was tested according to [12] (ISO 105 – X12 2001) method. A coloured test specimen is rubbed with white crock test cloth under controlled conditioning. The test was determined using a AATCC Crock meter, during which the dyed fabric was subjected to rubbing treatment with a sample of standard undyed cotton. Rubbing was carried out, wetted cotton fabric. The sample was rubbed with 5 g/l of soap in a solution with liquor ratio 50:1, at a

temperature of 50 °C, for 45mins followed by rinsing and drying. The extent of colour transfer was assessed based on the greyscale rating (1–5) where 1 and 5 represent poor and excellent, respectively. Colour transferred to the white cloth is assumed by a comparison with grey scale for staining and a grade is assigned.

RESULTS AND DISCUSSION

Extraction

In current analysis *Tectona grandis* leaves extract was carried out water bath in aqueous solvent. Have also been the subjects of increased attention in recent years due to their high extraction yields, selectivity, stability of the target extracts and process safety merits. Extracted with water solvent in water bath (4.8g). Similarly, the optimum yield of teak leaves extraction with methanol solvent in pH3 was 42,79% at 20 minutes. Meanwhile, the optimum yield of teak leaves extract was decreasing after reach the optimum condition [13].

Stability of colourants

The stability of colorants was studied using spectrophotometer at different pH, and under sunlight conditions. Their absorption spectra were found to be very stabled during stability study for 90 days. Effect of stability in pH and sun light color of *Tectona grandis*. The stability of colourants was influenced by several factors such as pH, sun light etc., similarly, studied the effects of pH, number of storage days, and temperature, light and dark conditions on the stability of anthocyanin extracted from *Tibouchina semidecandra* flowers at different developmental stages were evaluated [14].

Determination of pH stability of Tectona grandis Linn

In this current inquiry pH were investigated in *Tectona grandis* Leaves. Based on the analysis show that dye is red at low (In pH 2,4 acidic conditions), the higher the pH value of dye will provide color fading of colorless, yellow, pink and purple (In pH 6, 7, 8, 10 and 12). Dye was stable at low pH. UV-visible spectra were recorded between 200-700nm on UV–visible spectrophotometer (Fig 1-2). It becomes less stable when exposed to heat, causing a loss of color and browning. As a result, high temperature increased sugar level, pH, and ascorbic acid can affect the rate of destruction. In solution, anthocyanins molecules are present in equilibrium between the colored cationic form and the colorless pseudo base. This equilibrium is directly influenced by pH. pH is very important for the color of dye, some anthocyanins are red in acid solutions, pink in neutral solutions and purple in alkaline pH. As a result, *Tectona grandis* can be stable colorant with variation pH.

Fig 1 Stability of colourants in water leaf extract of *Tectona grandis* Linn. at different pH

Determination of sunlight stability of Tectona grandis Linn

In this present study different nm were analyzed such as 420nm, 495nm, 495nm colourants from *Tectona grandis* leaves dye extract are sensitive to sunlight. They underwent degradation after 8hrs of sunlight exposure (Fig 3).

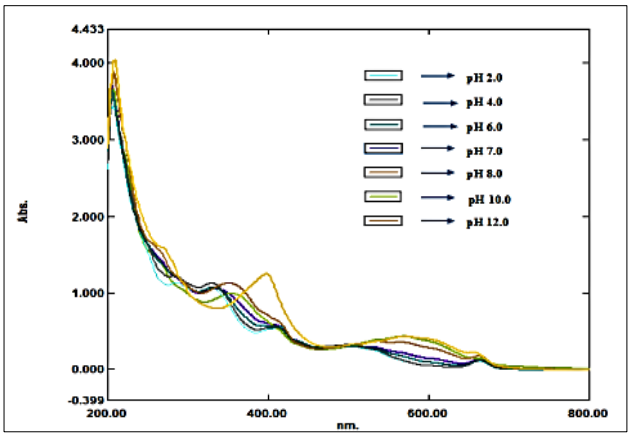


Fig 2 UV-Visible overlay spectra of *Tectona grandis* Linn. water leaves extract at pH 2.0, 4.0, 6.0, 7.0, 8.0, 10.0 and 12.0

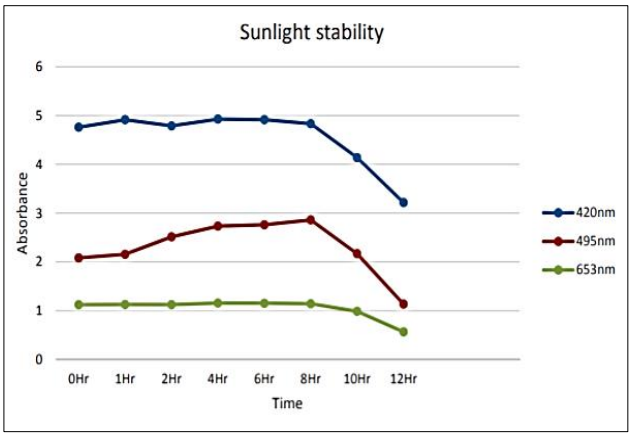


Fig 3 Sunlight stability of *Tectona grandis* aqueous leaf extracts

Application of different mordants as PM, SM, and POM on cotton fabric

In current analysis the strength of colour depends upon the use of pre- mordant, simultaneous mordant, post-mordant and these are metal sources to form a coordinate bond with dye and cotton fabric. From the results, it was observed that *Tectona grandis* leaves showed better colour strength values. Mordant can help the dyestuffs achieve a strong and bright colour on cellulose fibers (Table 1). From the results, it was observed that *Tectona grandis* leaves showed better colour strength values. In all the three dyeing methods, premordantning method gave excellent results as compared with normal cotton fabric. In all the three methods of dyeing, the mordants copper sulphate, ferrous sulphate and stannous chloride showed excellent colour strength values. Similarly, they combine with the dyestuff and are then permanently fixed onto the fibre. Intensity of the hue and the fastness of the resultant colour can be improved [15].

Light fastness

Light fastness testing is a specific type of colour fastness, light fastness testing is a fundamental part of quality control present study light fastness of cotton fabrics dye was measured light fastness grade method followed and represent in (Table 2). In pre-mordant the light fastness grade was 6 indicating as slight fading, light fastness grade was 5 indicating as moderate fading in simultaneous mordant while light fastness grade was 7

indicating very slight fading in post mordant for chemical mordant as $CuSO_4$ when compared to normal (without mordant) light fastness grade was 5 indicating as moderate fading. In Pre-mordant the light fastness grade was 5 indicating as moderate fading, light fastness grade was 5 indicating as moderate fading in simultaneous mordant while light fastness grade was 5 indicating moderate fading in post mordant for chemical mordant as $FeSO_4$ when compared to normal (without mordant) light fastness grade was 5 indicating as moderate fading. In pre-mordant the light fastness grade was 7 indicating as very slight fading, light fastness grade was 7 indicating as very slight fading in Simultaneous mordant while light fastness grade was 6 indicating slight fading in post mordant for chemical mordant as $SnCl_2$ when compared to normal (without mordant) light fastness grade was 5 indicating as moderate fading. Among the various mordant, pre and post-mordant has prevent the colour lightness followed by meta- mordant. The stannous chloride mordant has retained the colour as compared to copper and ferrous sulphate chemical mordant (Table 3). Analogously, the metal mordant stannous chloride used in the present study protects the dye from photolytic degradation, thereby giving excellent light fastness than copper and ferrous sulphate mordant [12].

Table 1 Colour produced by different mordants as PM, SM, and POM on cotton fabric by conventional method, dyed with leaves dye extract of *Tectona grandis*

Chemical mordant	Colour shades obtained in cotton fabric			
	Pre-mordant (PM)	Simultaneous mordant (SM)	Post-mordant (POM)	Normal dye (Without Mordant)
$CuSO_4$	PMS – 197	PMS–17-1522TCX	PMS-197	
$FeSO_4$	PMS – D38895	PMS – DD6BA7	PMS - 197	PMS – B91655
$SnCl_2$	PMS- 696C	PMS – 696C	PMS – 695C	

Table 2 Colour fastness properties grade

Grade	Degree of fading	Colour fastness type
8	No fading	Outstanding
7	Very slight fading	Excellent
6	Slight fading	Very good
5	Moderate fading	Good
4	Appreciable fading	Moderate
3	Significant fading	Fair
2	Extensive fading	Poor
1	Very Extensive fading	Very poor

Wash fastness – water shaking bath

The resistance to the loss of colour of any dyed or printed material to washing is preferred to as its wash fastness. Present study wash fastness of cotton fabric dye was measured wash fastness grade as excellent, very good, good, moderate and poor. (Table 4) shows the wash fastness of after PM, SM, and POM on textile as cloth. In pre-mordant the wash fastness grade was 6 indicating as slight fading, light fastness grade was 4 indicating as appreciable fading in simultaneous mordant while wash fastness grade was 5 indicating good in post mordant for chemical mordant as $CuSO_4$ when compared to normal (without mordant) wash fastness grade was 4 indicating as moderate. In pre-mordant the wash fastness grade was 6 indicating as very good, wash fastness grade was 6 indicating as very good in simultaneous mordant while wash fastness grade was 4 indicating moderate in post mordant for chemical mordant as $FeSO_4$ when compared to normal (without mordant) wash fastness grade was 4 indicating as moderate.

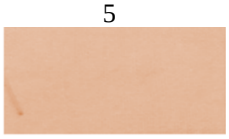
Table 3 Colour lightness after PM, SM, and POM on cotton fabric

Chemical mordant	Colour lightness after PM, SM, and POM on cotton fabric			
	Pre-mordant (PM)	Simultaneous mordant (SM)	Post-mordant (POM)	Normal dye (Without Mordant)
$CuSO_4$	6	5	7	
$FeSO_4$	5	5	5	5
$SnCl_2$	7	7	6	

Table 4 Wash fastness after PM, SM, and POM on cotton fabric

Chemical mordant	Wash fastness			
	Pre-mordant (PM)	Simultaneous mordant (SM)	Post-mordant (POM)	Normal dye (Without Mordant)
$CuSO_4$	6 	4 	5 	
$FeSO_4$	6 	6 	4 	4 
$SnCl_2$	7 	6 	7 	

Table 5 Wet Rubbing after PM, SM, and POM on cotton fabric

Chemical mordant	Wash fastness			
	Pre-mordant (PM)	Simultaneous mordant (SM)	Post-mordant (POM)	Normal dye (Without Mordant)
$CuSO_4$	6 	6 	5 	
$FeSO_4$	5 	5 	7 	5 
$SnCl_2$	7 	7 	6 	

In Pre-mordant the wash fastness grade was 7 indicating as excellent, wash fastness grade was 6 indicating as very good in Simultaneous mordant while wash fastness grade was 7 indicating excellent in post mordant for chemical mordant as $SnCl_2$ when compared to normal (without mordant) wash fastness grade was 4 indicating as moderate. Among the various mordant, premordant has prevent the wash fastness followed by post and simultaneous mordant. The stannous chloride mordant has wash fastness the colour as compared to copper and ferrous sulphate chemical mordant. Similarly, If the number of groups which is capable of forming hydrogen bonding and metal complex is higher, the magnitude of dye removal will be lower [16]. In current analysis, the cotton cloth premordanted with stannous chloride have given relatively very good wash fastness.

Table 6 The dyed cotton fabric with Pantone matching system (PMS)

Chemical mordant	Colour shades obtained in cotton fabric			
	Pre-mordant (PM)	Simultaneous mordant (SM)	Post-mordant (POM)	Normal (Without Mordant)
		Colour lightness		
$CuSO_4$	PMS 16-1520 TCX	PMS 1895	PMS 17-1522 TCX	
$FeSO_4$	PMS 14-1909 TCX	PMS 16-1520 TCX	PMS 14-1909 TCX	PMS 19005
$SnCl_2$	PMS 17-1831TCX	PMS 17-1831TCX	PMS 17-1522 TCX	
		Wash fastness		
$CuSO_4$	PMS 1905 C	PMS 0521C	PMS 1905C	
$FeSO_4$	PMS 16-1520 TCX	PMS 189C	PMS 1909 TCX	PMS 211
$SnCl_2$	PMS 696C	PMS 245	PMS 17-1831 TCX	
		Rubbing fastness		
$CuSO_4$	PMS 1905C	PMS 189C	PMS 1905C	
$FeSO_4$	PMS 14-1909 TCX	PMS 0521C	PMS 16-1520 TCX	PMS 211
$SnCl_2$	PMS 171831 TCX	PMS 245	PMS 14-1909 TCX	

Rubbing fastness method

The (Table 5) shows the result of the rubbing fastness properties of the colourant on dyed and mordanted cotton fabrics. It was observed that the unmordanted cotton fabric wet rubbing fastness of grade 5. However, the introduction of $SnCl_2$, $FeSO_4$ and $CuSO_4$ as mordants increased the results to grade 7. Present study rubbing fastness of cloth dye was measured rubbing grade as excellent very good, good, moderate and poor. In pre-mordant the rubbing fastness grade was 6 indicating as slight fading, rubbing fastness grade was 6 indicating as slight fading in Simultaneous mordant while rubbing fastness grade was 5 indicating moderate fading in post mordant for chemical mordant as $CuSO_4$ when compared to normal (without mordant) rub fastness grade was 5 indicating as moderate fading. In pre-mordant the rubbing fastness grade was 6 indicating as slight fading, rub fastness grade was 5indicating as moderate fading in simultaneous mordant while rub fastness grade was 7 indicating very slight fading in post mordant for chemical mordant as $FeSO_4$ when compared to normal (without mordant) rub fastness grade was 5 indicating as moderate fading. In pre-mordant the rub fastness grade was 7 indicating as very slight fading, rub fastness grade was 7 indicating as very slight fading in simultaneous mordant while rub fastness grade was 6 indicating slight fading in post mordant for chemical mordant as $SnCl_2$ when compared to normal (without mordant) wash fastness grade was 5 indicating as moderate fading. Among the various mordant, premordant has prevent the rub fastness followed by post and simultaneous mordant. The stannous chloride mordant has rubbing fastness the colour as compared to copper and ferrous sulphate chemical mordant. Similarly, If the number of groups which is capable of forming hydrogen bonding and metal complex is higher, the magnitude of dye removal will be lower [16]. In Current studies, the cotton cloth premordanted with stannous chloride have given relatively very good wet rubbing fastness.

CONCLUSION

The use of natural dyes has increased during the last couple of years. This awareness grows to different side of the user's viz. designers, traditional art dyers and printers, and academic institute etc., We know that synthetic dyes commonly used to dyeing of fabric but it is earlier found associated with environmental hazards, pollutants and having azo groups which provide the harmful effect the skin, lungs and respiratory system etc. It has been noticed that many communities who have engaged in this traditional method, now they shifted to other profession. Overall, it can be concluded that the dye was prepared from *Tectona grandis* aqueous extract has possessed potential dyeing capability to cotton fabric.

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LITERATURE CITED

1. Vankar PS. 2007. Handbook on natural dyes for industrial applications, New Delhi. National Institute of Industrial Research. pp 432.
2. Samanta AK, Agarwal P. 2009. Application of natural dyes on textiles. *Indian Journal of Fibre and Textile Research* 34: 384-399.
3. Balter M. 2009. Clothes Make the (Hu) Man. *National Library of Medicine* 325(5946): 1329.
4. Shenai VA, Saraf NM. 1991. *Principles and Practice of Dyeing*. Sevak Publications, Mumbai. pp 7-12.
5. Gulrajani ML, Gupta D. 1992. *Natural Dyes and Application to Textiles*. Department of Textile Technology, Indian Institute of Technology. pp 7.
6. Mohanta D, Tiwari SC. 2005. Natural dye yielding plants indigenous knowledge on dye preparation in Arunachal Pradesh, Northeast India. *Current Science* 88(9): 1474-1480.
7. Reddy GA, Joy JM, Mitra T, Shabnam S, Shilpa T. 2012. Nano silver – a review. *International Journal Advice Pharmacology* 2(1): 09-15.
8. Younsook S, Dong II Y. 2012. Storage stability and colour reproducibility of yellow and red dyes extracted from *Carthamus tinctorius*. *Textile Coloration and Finishing* 24: 3.
9. Kumaresan M, Palnisamy PN, Kumar PE. 2011. Application of ecofriendly natural dye obtained from flower of spathodea Campanulata on silk. *European Journal of Scientific Research* 52(3): 306-312.
10. Pantone announces uncoated version of new Pantone Goe System 2008. May 29, Retrieved from ProQuest Newsstand, Creative ProQuest.
11. Hu J. 2008. Fabric testing. *Research Journal of Textiles and Apparel.* pp 424.
12. ISO 105-X12. 2001. Textiles: Tests for colour fastness. Part X12: Colour fastness to rubbing, Basel: ISO.
13. Lailatul Q, Mahfud M, Endah S, Swastika P. 2018. natural dye extraction from teak leaves (*Tectona Grandis*) using ultrasound assisted extraction method for dyeing on cotton fabric. *MATEC Web of Conferences* 156: 05004.
14. Abdullah Saad Al-Abdullah, Roula, Al-Bounni, Mohammad Al-Omari. 2006. Color stability of tetric N-ceram bulk fill restorative composite resin after immersion in different drinks. *Journal of Advanced Oral Research* 8(1/2): 34-41.
15. Dably G. 1992. Natural dyes for vegetable fibres. Somerset: *Ashill Publications.* pp 93.
16. Ali NF, El-Mohamedy RSR. 2011. Eco-friendly and protective natural dye from red prickly pear (Opuntia Lasiacantha Pfeiffer) plant. *Journal of Saudi Chemical Society* 15: 257-261.