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Ecofriendly approach for the extraction of dyes from bark of kikar after chemical treatment

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Abstract

The idea of extracting dyes from plant (natural) sources is to avoid the environmental pollution and water pollution. Present days with global concern over the use of eco-friendly and biodegradable materials, considerable research work is being undertaken around the world on the application of natural dyes in textile industry. Dyes derived from natural sources have emerged as an important alternative to synthetic dyes. In present work the bark of *Acacia Arabica* (kikar) was used for extraction of dyes highlighting the importance of ecofriendly approach. The dyes extracted from bark of *Acacia* were used on four types of different fabrics such as cotton, khaddar, silk and wool and tested for their color fastness to washing properties. The best color and washing fastness were observed on a fabric which was dyed with alkaline extract. The analytical studies such as UV-Visible and IR spectrophotometry were also performed on the extracts. Moreover, the dyes obtained from the plant are used in effective manner because these are mostly eco-friendly, biodegradable, less toxic, and less allergenic as compared to synthetic dyes. It is suggested and recommended that with financial aid and problem based cooperation of textile industries, application of natural dyes can be explored in better way.

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Introduction

A dye is a substance which has ability to color the fabric and other products and easily dissolve in water or any solvent. Dyes consist of the main groups of chemicals apart from pharmaceuticals, petrochemicals and fertilizers. Currently there are some dyes which are naturally obtained from plants, fruit peels, and bark of trees, insects and minerals (Broadbent, 2001). In natural environment there are products which contains chemical such as in plants the chemicals may be present in their roots, leaves, bark, flowers and in stamens. Artificial dyes are hard to dissolve in water or solvent and they give sharper color and stay for longer time as compared to natural ones (Kumaresan *et al.,* 2011).

Synthetic dyes are consisting of some harmful chemicals that are toxic to humans and animals. The manufacturing and use of dyes has released huge amount of waste and detached colors that create problematic issue to health of humans and environment. The use of synthetic dyes can cause lots of problems to sensitive peoples and cause allergic reactions, toxic and may be carcinogenic. Natural dyes are mostly eco-friendly, biodegradable, less toxic, and less allergenic as compared to synthetic dyes (Purrohit A, 2007). Natural dyes produce remarkable variety of colorants which enhance the quality. *Acacia Arabica* or Babul is known for its strength to very long hard summer seasons and in water logged areas. This tree is present where saline water is present. This plant has ability to suck water from deeper layer to fulfill their requirements. (Mohammad *et al.,* 2014).

Pakistan is rich in natural resources and there are wide scopes to explore and revive application of natural dyes on textile, having more and more scientific knowledge base available. In spite of better performance of synthetic dyes, recently the use of natural dyes on textile materials has been attracting more and more scientist for study on this due to following reasons:

- The large amount of natural dyes present and have great ability.
- The procedure and knowledge about characterization of dyes and colorants for purification and extraction are easily available.
- The information and utilization about natural dyes are widely available in different textiles. (Samanta *et al.,* 2001).

The present research work was conducted with an aim to use green chemistry approaches to resolution of issues related with water pollution. It also focused on utilization of plant waste as bark of *Acacia* as a useful commodity for the production of natural dyes.

Material and methods

Research work presented here was conducted in Department Environmental science. It was subdivided into three steps.

1. Extraction of dye from Acacia Arabica under various conditions.
2. Dyeing of different types of fabric with above extracts.
3. Characterization of extracts as well as dyed fabrics

Materials and Chemical used

- Powder of Acacia bark
- Sodium hydroxide
- Hydrochloric acid
- Sodium chloride
- Soap solution (1%)
- Raw cotton, khaddar, silk, wool yarn used for dyeing (obtained from local market)

Equipment

- UV/Visible Spectrophotometer (U-2800 Hitachi)
- Spectra flash
- Fourier transform infrared spectrophotometer (IR prestige-21 shimadzu)

Collection and processing of sample

A bark of Acacia was collected from commercial garden. Bark was cut into small pieces and then ground into fine powder form by using grinder and this powder was used in extraction procedure.

Optimization of extraction conditions

- Extraction was carried out using water as solvent in various conditions like variable temperature, time and solid to liquid ratio, alkaline and acidic medium so as get optimum condition.

Dyeing

All the dye extracts obtained from the experiments for Acacia were used to dye raw cotton fabric, silk; khaddar fabric and wool yarn separately using standard dyeing protocol.

- After dyeing all samples were checked for color fastness and washing fastness.

Chemical characterization of Dye Extract

Randomly selected dye extracts were run through spectroscope analysis (UV-Visible spectroscopy (Model: UV-2800 Hitachi) and Fourier transforms infrared spectroscopy (Model: IR prestige-21, shimadzu) (Hussain, *et al.,* 2009).

Results and discussion

A study on bark of *Acacia Arabica* as a source of natural dye was carried out. The effect of molar to liquor ratio on the dye ability of the all fabrics was conducted at M: L (2:10, 4:10 and 6:10) ratios. Aqueous extraction was traditionally used to extract the dye from plants.

The experiments were performed with aqueous extraction the washing fastness and color fastness was good but in alkaline extraction medium the dyed fabrics were showing more better result than the aqueous medium it gives excellent washing and color fastness because alkaline medium is more suitable and contain phenolic groups as they are soluble in alkali, which improves the dye yield. The samples extracted with different alkaline condition (1g and 2g NaOH) indicated that all samples were in the range of brighter and dark to light brown colors than the wool and silk. The experiments were conducted in acidic medium (10ml HCl and 20ml HCl), the results of color strength was not so much good than the alkaline medium. The experiments with HCl were effective for protein fibers such as silk and wool. These increase solubility in water, and give the dye molecules a negative charge and the colorfastness of the dyed samples to acidic solution was found much better than the alkaline solution (Rawat *et al.,* 2001).

Table: 2

Dyed fabric of Khaddar and Cotton with Aqueous extracts

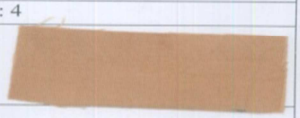
Fabric Name : Khaddar	Fabric Name : Cotton
Experiment 1 	Experiment 1 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing Fastness: 4
Experiment 2 	Experiment 2 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4
Experiment 3 	Experiment 3 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4
Experiment 4 	Experiment 4 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4
Experiment 5 	Experiment 5 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4
Experiment 6 	Experiment 6 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5

Table: 3

Dyed fabric of Khaddar and Cotton with Alkaline extracts (1gNaOH)

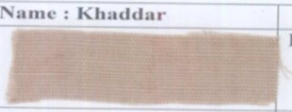
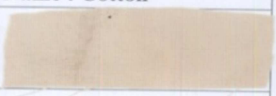
Fabric Name : Khaddar	Fabric Name : Cotton
Experiment 7 	Experiment 7 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 8 	Experiment 8 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness:
Experiment 9 	Experiment 9 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 10 	Experiment 10 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 11 	Experiment 11 
Color Fastness: 5	Color fastness: 5
Washing Fastness: 5	Washing Fastness: 5
Experiment 12 	Experiment 12 
Color Fastness: 5	Color fastness: 5
Washing Fastness: 5	Washing Fastness: 5

Table: 4

Dyed fabric of Khaddar and Cotton with Alkaline extracts (2g NaOH)

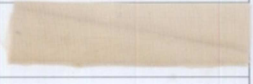
Fabric Name : Khaddar	Fabric Name : Cotton
Experiment 13 	Experiment 13 
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing Fastness: 6
Experiment 14 	Experiment 14 
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6
Experiment 15 	Experiment 15 
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6
Experiment 16 	Experiment 16 
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6
Experiment 17 	Experiment 17 
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6
Experiment 18 	Experiment 18 
Color Fastness: 6	Color Fastness : 6
Washing fastness: 6	Washing fastness:6

Table: 5

Dyed fabric of Khaddar and Cotton with Acidic extracts (10ml HCl)

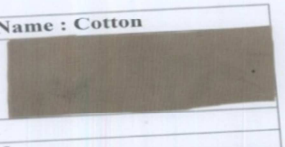
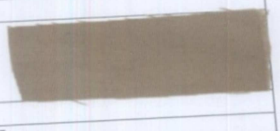
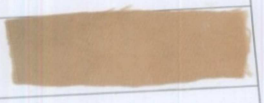
Fabric Name : Khaddar	Fabric Name : Cotton
Experiment 19 	Experiment 19 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing Fastness: 5
Experiment 20 	Experiment 20 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 21 	Experiment 21 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 22 	Experiment 22 
Color Fastness: 5	Color Fastness: 5
Washing fastness:	Washing fastness: 5
Experiment 23 	Experiment 23 
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 24 	Experiment 24 
Color Fastness:5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5

Table: 6

Dyed fabric of Khaddar and Cotton with Acidic extracts (20ml HCl)

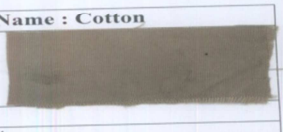
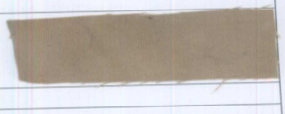
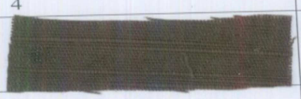
Fabric Name : Khaddar	Fabric Name : Cotton
Experiment 25 	Experiment 25 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing Fastness: 4
Experiment 26 	Experiment 26 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4
Experiment 27 	Experiment 27 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4
Experiment 28 	Experiment 28 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4
Experiment 29 	Experiment 29 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4
Experiment 30 	Experiment 30 
Color Fastness: 4	Color Fastness: 4
Washing fastness: 4	Washing fastness: 4

Table: 7

Dyed fabric of Silk and Wool with Aqueous extracts

Fabric Name : Silk	Fabric Name : Wool
Experiment 1	Experiment 1
Color Fastness: 5 Washing fastness: 5	Color Fastness: 5 Washing Fastness: 5
Experiment 2	Experiment 2
Color Fastness: 5 Washing fastness: 5	Color Fastness: 5 Washing fastness: 5
Experiment 3	Experiment 3
Color Fastness: 5 Washing fastness: 5	Color Fastness: 5 Washing fastness: 5
Experiment 4	Experiment 4
Color Fastness: 5 Washing fastness: 5	Color Fastness: 5 Washing fastness: 5
Experiment 5	Experiment 5
Color Fastness: 6 Washing fastness: 6	Color Fastness: 6 Washing fastness: 6
Experiment 6	Experiment 6
Color Fastness: 6 Washing fastness: 6	Color Fastness: 6 Washing fastness: 6

Table: 8

Dyed fabric of Silk and Wool with Alkaline extracts (1g NaOH)

Fabric Name : Silk	Fabric Name : Wool
Experiment 7	Experiment 7
Color Fastness: 6 Washing fastness: 6	Color Fastness: 6 Washing fastness: 6
Experiment 8	Experiment 8
Color Fastness: 6 Washing fastness: 6	Color Fastness: 6 Washing fastness: 6
Experiment 9	Experiment 9
Color Fastness: 6 Washing fastness: 6	Color Fastness: 6 Washing fastness: 6
Experiment 10	Experiment 10
Color Fastness: 6 Washing fastness: 6	Color Fastness: 6 Washing fastness: 6
Experiment 11	Experiment 11
Color Fastness: 6 Washing Fastness: 6	Color fastness: 6 Washing Fastness: 6
Experiment 12	Experiment 12
Color Fastness: 6 Washing Fastness: 6	Color fastness: 6 Washing Fastness: 6

Table: 9

Dyed fabric of Silk and Wool with Alkaline extracts (2g NaOH)

Fabric Name : Silk	Fabric N[illegible] Wool
Experiment 13	Experiment 13
Color Fastness: 7 Washing fastness: 7	Color Fastness: 7 Washing Fastness:
Experiment 14	Experiment 14
Color Fastness: 7 Washing fastness:7	Color Fastness: 7 Washing fastness: 7
Experiment 15	Experiment 15
Color Fastness: 7 Washing fastness: 7	Color Fastness: 7 Washing fastness: 7
Experiment 16	Experiment 16
Color Fastness: 7 Washing fastness: 7	Color Fastness: 7 Washing fastness: 7
Experiment 17	Experiment 17
Color Fastness: 7 Washing fastness: 7	Color Fastness: Washing fastness:
Experiment 18	Experiment 18
Color Fastness: 7 Washing fastness: 7	Color Fastness: 7 Washing fastness: 7

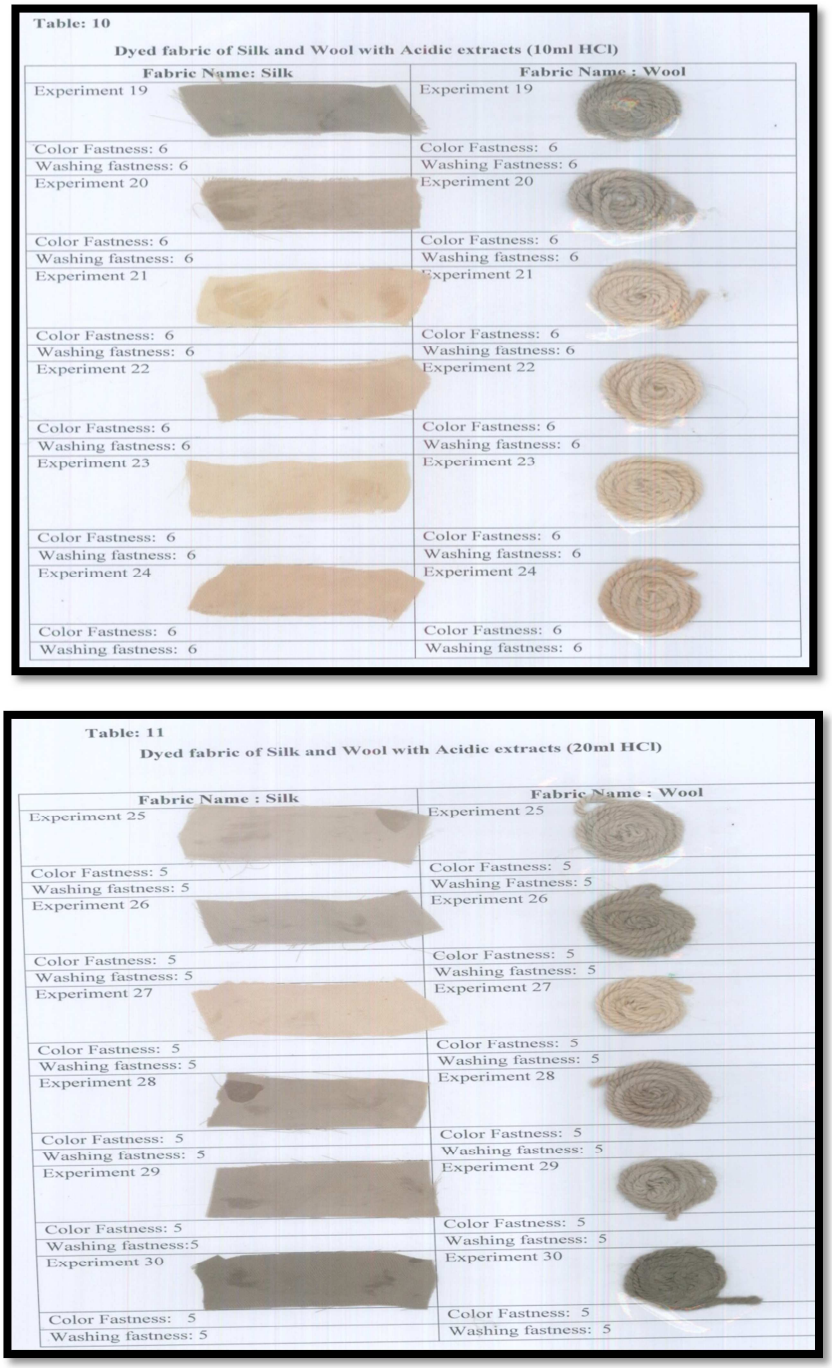


Table: 10

Dyed fabric of Silk and Wool with Acidic extracts (10ml HCl)

Fabric Name: Silk	Fabric Name : Wool
Experiment 19	Experiment 19
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing Fastness: 6
Experiment 20	Experiment 20
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6
Experiment 21	Experiment 21
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6
Experiment 22	Experiment 22
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6
Experiment 23	Experiment 23
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6
Experiment 24	Experiment 24
Color Fastness: 6	Color Fastness: 6
Washing fastness: 6	Washing fastness: 6

Table: 11

Dyed fabric of Silk and Wool with Acidic extracts (20ml HCl)

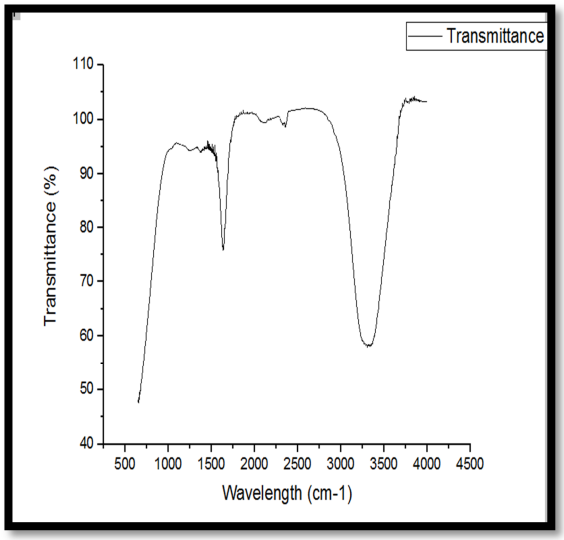
Fabric Name : Silk	Fabric Name : Wool
Experiment 25	Experiment 25
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing Fastness: 5
Experiment 26	Experiment 26
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 27	Experiment 27
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 28	Experiment 28
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5
Experiment 29	Experiment 29
Color Fastness: 5	Color Fastness: 5
Washing fastness:5	Washing fastness: 5
Experiment 30	Experiment 30
Color Fastness: 5	Color Fastness: 5
Washing fastness: 5	Washing fastness: 5

Fig. 1. Dyed fabrics of cotton, khaddar, silk and wool with Acacia extract.

UV-Visible and FTIR Analysis

UV-Vis spectral analysis of aqueous, alkaline and acidic solution of Acacia dye was done that indicating peaks and troughs in different wave length shows its main color, absorption etc. These peaks were compared with the peaks of Gallic acid and Catechin that showed both substances were present in all dye extracts. The FTIR spectrums for aqueous, alkaline and acidic extract were compared with spectrum of Gallic acid and Catechin which showed that these chemicals were present in all dye extracts along with some other components. As Gallic acid and Catechin are major coloring components present in bark of *Acacia*.

It is clear that all extracts are showing peaks between 3000-4000cm-^{1}as well as in region 1000-1500cm-^{1} overlapping the peaks of functional groups of Catechin and Gallic acid. This confirms extraction of Gallic acid and Catechin under applied extraction conditions responsible for dyeing of fabric.



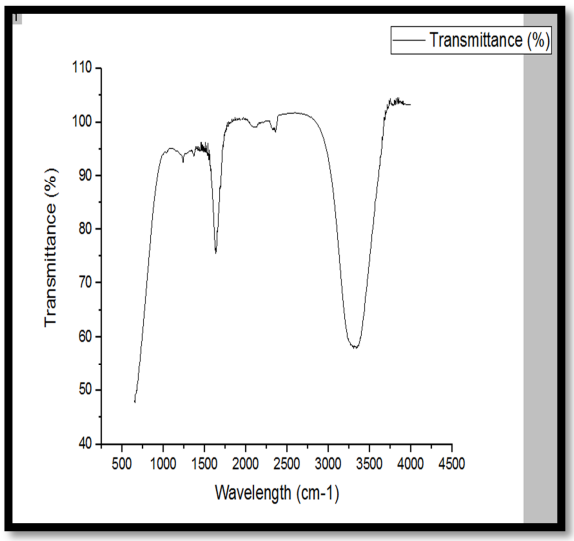


Fig. 2 & 3. FTIR spectrum for Gallic acid &Catechin (Alkaline and acidic extracts).

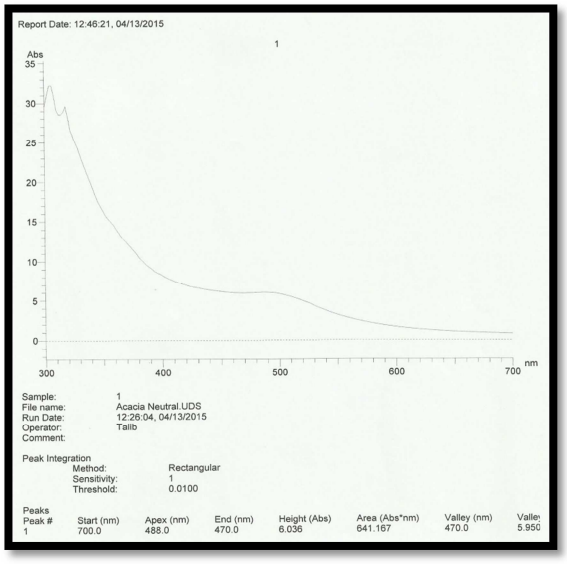


Fig. 4. UV-Visible absorption spectra for Gallic acid & Catechin (Aqueous extracts).

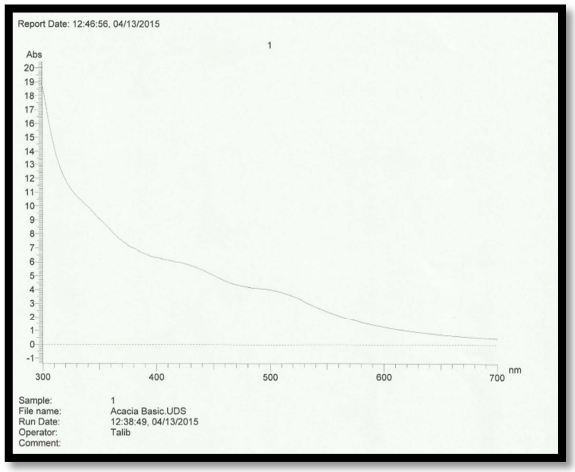


Fig. 5. UV-Visible absorption spectra for Gallic acid & Catechin (Alkaline extracts).

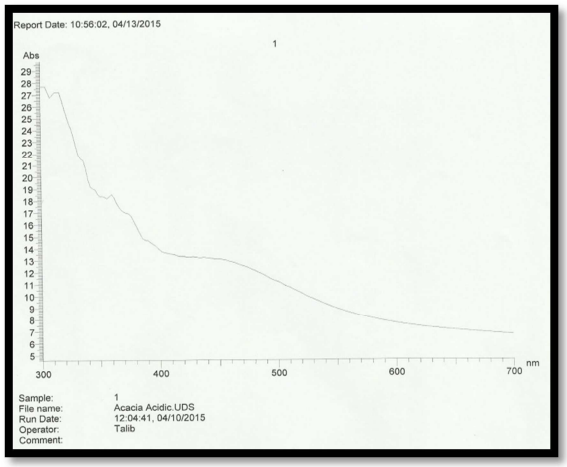


Fig. 6. UV-Visible absorption spectra for Gallic acid & Catechin.

Conclusion

The present work shows that, barks of *Acacia Arabica* can be used as dye for coloring different fabrics. These trees are grown throughout Pakistan and it is easily available plant. Different shades of color can be obtained at different conditions. The washing and light fastness of all dyeing fabrics were quite good. The best results were obtained with alkaline extraction medium. The dye has good scope in the commercial dyeing of cotton, khaddar, wool and silk fabrics. It is concluded that dyeing with *Acacia Arabica* has huge advantages as the textile wastewater is much more biodegradable than the textile wastewater generated with synthetic dyes. Natural dyes, generally supposed to be cheap, non-toxic, renewable and sustainable resource with minimal environmental impact, have attracted the

attention of the scientific community to use them in a variety of traditional and newly discovered application disciplines. It is suggested and recommended that with financial aid and problem based cooperation of textile industries, application of natural dyes can be explored in better way.

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