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Effects of pre-treatment and microwave assisted extraction on natural dye from marigold (*Tagetes erecta* L.) and nasturtium (*Tropiolum majus* L.) for fabric colouration

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Abstract
The present study demonstrated dyeing of silk and cotton fabric with the pigment extracted through various methods from two ornamentals, marigold (*Tagetes erecta* L.) and nasturtium (*Tropeolum majus* L.) Marigold creates the colour range from yellow to orange whereas for nasturtium off white to purple. The yield of extracted dye was found to be superior (6.24% and 4.48%) in pre-treatment of marigold and nasturtium petal respectively, with Ethanol 50% and under 6 min of microwave interval. To perform the dyeing process two different types of colourless mordants have been used viz. alum and stannous chloride. After scouring, mordanting and dyeing the fabrics were evaluated for colour measurements in HunterlabD25LT Chroma Meter for L* a* and b* values. The L* value were found to be superior when the fabrics were treated with alum. The highest L* value (85.78) was obtained in T15 i.e., pre-treatment of 70% HCl, 6 minute MW interval time and alum mordant in marigold. In nasturtium dyed silk fabric highest L*value (72.84) was found with the T16 treatment (70% EtOH + 6 min MW interval time + stannous chloride).The increased a* value was found with stannous chloride mordant. Through the strip test the tensile strength has been analysed. The highest streanth (412.16 g/m^2 and 194.66 g/m2) was found in T1 (EtOH 50% + 4 min MW interval + alum) in marigold dyed silk and cotton fabric respectively. The stability of colour hue for the dyed sample after washing with standard soap with manual rubbing showed good in fastness properties and a little colour loss.

Keywords: *Tagetes erecta* L., *Tropiolum majus* L., dye, alum, stannous chloride, fastness

Introduction
India is enriched with its diversity of plant kingdom irrespective of edible and non-edible flora and certainly it is indeed treasure house related to plant based organic product. The natural dye is one of them. The dyeing of textile with these natural dyes is an age old practice. After 19th Century arrived synthetic dye naming 'Mauve' by W.H. Perkin 1856, raised over the natural one in production and application (Bhattacharya and Shah 2000) [3]. The gigantic application of these synthetic dyes has escalated environment pollution and health hazards (Bechtold *et al*. 2003) [2]. Therefore, green minded consumers are back to natural and biodegradable alternatives. The sources of natural dye could be mainly three types like animals, plants and minerals (Jha *et al*. 2015) [8]. There are 500 dye bearing plants in existence among them the edible ornamental crops like African marigold (*Tagetes erecta* L.) and nasturtium (*Tropiolum majus* L.) are acknowledged (Jha *et al*. 2015, Niizu & Rodriguez-Amaya, 2005) [5]. They are also valued for aesthetics and medicinal uses. The country like India where 40% of marigold produces goes wasted every year this study is directed towards the diversified use of marigold and nasturtium to avoid market glut and exploitation of these two crop for revenue generation. Moreover, attention has been implied to develop the most efficient extraction technique for dye extraction along with the primitive one. Microwave-assisted extraction has recently become extremely popular and claimed to increase organic reaction by providing high heat efficiency, remarkable rate enhancement and dramatic reduction in reaction times (Mansour *et al.* 2011) [9]. Therefore, the present study was fabricated to use Microwave assisted extraction and extraction in pre treated i.e., with ethanol and carbonate and acid in two different fabrics of silk and cotton.

The effects of various mordants has been examined through stability and colour shades.

Materials and Methods

The present study was carried out in Directorate of Floricultural Research, Pune and Division of Post Harvest Technology, IARI, New Delhi during 2013-2014. The African marigold and nasturtium with bright orange coloured flowers were selected for the study. Flowers were harvested in the early morning when they were fully turgid. The fabric of silk and cotton were bought from Nalli®, India. All chemicals used were of analytical grade, Ethanol (EtOH), Hydrochloric acid (HCl), carbonate (Na_2CO_3) were procured from Merck (Darmstadt, Germany). The mordants (alum and stannous chloride) were purchased from HiMedia (Mumbai). The dyeing method was carried out stepwise i.e., pre-treatment of flower petals, extraction of dye, mordanting and dyeing of fabric and colour fastness test.

Fig 1: Marigold petals,

Fig 2: Nasturtium petals

Pre-treatment and extraction of dye

The 5 gm flower petals were crushed in a blender and further homogenised. The crushed samples were transferred into conical flasks for different pre-treatments viz. 50% EtOH (Ethanol-Water mixture of 50:30 v/v), 70% conc. HCl (Hydrochloric acid – Water mixture of 70:30 v/v) and 0.5g/l Na_2Co_3 in a ratio of 1:20 (w/v). The samples were kept under room temperature (24 ^{0}C with 1600 lux light intensity) for one hour. For rapid dye extraction microwave (MW) oven (Samsung, Korea) assisted method was undertaken. The MW time interval was set in 4, 6 and 8 minute with the constant power of 300 W. After the extraction process was over in microwave the samples were then cooled down and the dye was separated with filter paper (1.0 µm membrane Whatmann ashless filter paper). All the filtrated dye was kept under dark condition prior to apply them on fabric. The combinations in, pre-treatment microwave (MW) interval time and mordants are presented in the Table 1.

Table 1: Treatment combinations of pre-treatment, microwave interval time (minutes) and with any either flower sample (marigold/nasturtium)

Sl No.	Treatment combinations
T1	EtOH 50% + 4 min MW interval time + alum
T2	EtOH 50% + 4 min MW interval time + stannous chloride
T3	EtOH 50% + 6 min MW interval time + alum
T4	EtOH 50% + 6 min MW interval time + stannous chloride
T5	EtOH 50% + 8 min MW interval time + alum
T6	EtOH 50% + 8 min MW interval time + stannous chloride
T7	Na_2Co_3 0.5 g/l + 4 min MW interval time + alum
T8	Na_2Co_3 0.5 g/l + 4 min MW interval time + stannous chloride
T9	Na_2Co_3 0.5 g/l + 6 min MW interval time + alum
T10	Na_2Co_3 0.5 g/l + 6 min MW interval time + stannous chloride
T11	Na_2Co_3 0.5 g/l + 8 min MW interval time + alum
T12	Na_2Co_3 0.5 g/l + 8 min MW interval time + stannous chloride
T13	HCl 70% + 4 min MW interval time + alum
T14	HCl 70% + 4 min MW interval time + stannous chloride
T15	HCl 70% + 6 min MW interval time + alum
T16	HCl 70% + 6 min MW interval time + stannous chloride
T17	HCl 70% + 8 min MW interval time + alum
T18	HCl 70% + 8 min MW interval time + stannous chloride

Yield of natural colorant

The gravimetric method was used to determine the yield of natural colourant in each flower (Shivkumar *et al*. 2009) [16]. The dye filtrates from the extraction procedure were dried in cabinet dryer at 70 ^{0}C, for 16 hr until no water remains. The dye samples were then cooled under desiccator and yield of natural colorant was calculated using the following formula (Zulrushdi *et al* 2016) [18]:

$$\% \text{ Yield of natural colourant} = \frac{\text{Natural dye extract obtained}}{\text{Weight of sample used}} \times 100$$

Mordanting and dyeing of fabric

The fabrics (silk and cotton) were washed in 2 g/L nonionic detergent solution in waterbath, keeping the temperature at 60 ºC for 30 min, while the fabric : liquor ration was 1:40(w/v). Scoured fabrics were thoroughly washed with distilled water and dried at room temperature. Then the fabrics were pre-soaked in distilled water before mordanting. For mordanting the fabrics were weighed accurately equal of 5 g. The mordants like alum and stannous chloride are metallic salts, which were 2% (owf) dissolved to deionised water in 1:40 ratio inside a beaker. The fabrics were then poured into the mordant solutions. The beakers were kept over a waterbath keeping temperature at 80 ºC for half an hour. After heating the samples they were left for cooling for half an hour under room temperature (24 ^{0}C).

The mordanted fabrics were thoroughly rinsed with distilled water and then squeezed and dried. The mordanted fabrics were then immediately taken for dyeing avoiding exposure to light and temperature variation.

The cotton and silk samples were dyed with dye extract, keeping M:L ratio as 1:40; while dying the silk the pH was maintained at 4 by adding acetic acid buffer solution. For dying, the fabrics were dipped in dye and kept under water bath in 80-85 ^{0}C for 1 hr. The fabrics were twisted several times inside the dye solution while dying. After dying the fabrics were washed in cold water to remove excess dye.

Colour measurement

The colorimetric evaluation was done for each fabric after dying. Colour parameters of the fabrics was analysed by a HunterlabD25LT Chroma Meter (Virginia, USA) in 'L', 'a', 'b' colour scales. The instrument was calibrated against a white standard. The total colour difference ΔE* was calculated through the average colour values (Jha *et al*. 2016) of the samples.

$$\Delta E = (\Delta L^2 + \Delta a^{*2} + \Delta b^{*2})^{1/2}$$

The Kulbelka- Munk K/S equation (Salikhov and Idriskhodzhaev, 1978) [14] indicates the fabric colour strength i.e., the production of reflected light which involves absorption and scattering. It is based on the % reflectance (R), K/S can be calculated by the following formula (Toussirot *et al.* 2014) [8]. Here K is the absorption coefficient and S is the Scattering coefficient

$$K/S = (1-R)^2/2R$$

Fabric tensile strength test

The test was performed to find out the fabric strength affected after dyeing. The fabric of each treatment was cut into 8' in length and 2" in width. The Llyod Food Analyzer (Ametek®, USA) was used to identify the maximum load that a material can support without fracture when being stretched according to standard test of ASTM 5035-95C (Seiman *et al*. 2014) [13]. The specimen was mounted centrally, securely gripped along the full width to prevent slipping. The load is applied uniformly across the full specimen width. The load was measured in g/m^2.

Fabric fastness test

The fastness test of two different fabric viz. silk and cotton while dyeing with marigold and nasturtium has been done in this study. The fastness tests which were followed were i) light fastness and ii) wash and rubbing fastness. For light fastness, the fabrics were exposed to direct sunlight for 2 days (12+12 hr). Then the colour fastness was evaluated comparing the colour changed due to sunlight exposure with unexposed or control fabrics. The colour fastness to light was evaluated by comparison of colour change of the exposed portion to the unexposed original material (Samanta and Agarwal 2009) [15].

For washing and rubbing fastness, the dyed samples were sandwiched in between two undyed fabric sample and then they were placed with preheated washing solution (Surf, at 60 ^{0}C) in a ratio of 1:50 (washing solution: water). 1.0 g of sandwiched fabric were put inside it for 30 minutes and rubbed manually. They were rinsed in cold water and dried in room temperature. The wash and rubbing fastness was measured by the presence of colour in un-dyed sample (Samanta and Agarwal 2009, Kanchana *et al*. 2013) [15, 7].

Results and Discussions

Yield of natural colorant

Dye content in the petals of marigold and nasturtium are presented in Table 2. It was found out that, marigold produces higher dye yield (6.24%) while extracting with 50% EtOH for 6 minutes MW interval time followed by 70% HCl 6 minutes MW interval time (5.97%). In nasturtium similar type of results have been shown i.e., 4.48% and 4.12% through with 50% Ethanol and 70% HCl for 6 minutes MW interval time respectively. Marigold comes under Asteraceae family. In marigold, the major pigment for colouring is lutein, which is a fat soluble carotene. It is responsible for yellow or orange pigments. And nasturtium has mostly anthocyanins in its petals which is a water soluble pigment. It might be due to these pigments are more dissolvable in organic solvent and acid solution they give more yield content in alcohol and hydrochloric acid (Padma *et al*. 1997, Kanchana *et al*. 2013) [7].

Table 2: Effect of pre treatment and microwave interval time on yield of natural dye

Flower sample	Pre treatments	Microwave interval time (min)	Yield of natural colorant (%)
Marigold	EtOH 50%	4	5.33±0.03b
		6	6.24±0.04a
		8	3.69±0.09d
	HCl 70%	4	4.13±0.03c
		6	5.97±0.12a
		8	2.45±0.05fg
	Na_2Co_3 0.5g/l	4	2.02±0.02h
		6	3.24±0.04e
		8	2.18±0.53fg
Nasturtium	EtOH 50%	4	3.90±0.57d
		6	4.48±0.08c
		8	2.39±0.09fg
	HCL70%	4	2.40±0.20fg
		6	4.12±0.02c
		8	2.09±0.09gh
	Na_2Co_3 0.5g/l	4	1.90±0.40h
		6	2.55±0.05f
		8	2.18±0.13fgh
LSD at 0.05			0.37

Colour measurements

It can be observed in Table 3, the effect of alum over the dye extracted from marigold and nasturtium showed brighter colour effect than stannous chloride. The hue (L*) value of marigold and nasturtium changed a little with alum. In case of silk fabric the L* value was superior (85.78) while the dye

was extracted through the treatment combination of T15 viz. 70% HCl + 6 minute MW interval time + alum followed by (83.86) T13 (70% HCl + 4 minute MW interval time + alum). The highest L*value (72.84) in nasturtium dyed silk fabric was found with the T16 treatment, combination of 70% EtOH + 6 min MW interval time + stannous chloride. The a* value (redness) was superior where the silk fabric was treated with stannous chloride. It was shown in Table 3, that the highest a* value (19.65) was obtained in silk fabric from marigold dye with T12 treatment (0.5 g/l Carbonate+ 8 min MW interval + stanous chloride). For nasturtium dye, the highest a* value (5.07) was observed in T14 (0.5 g/l Carbonate + 4 min MW interval + stannous chloride). According to Table 3, the K/S value is found to be the highest (107.18) in marigold dye with the T1 treatment in combinations of 50% EtOH+ 4 min MW interval + alum. Jyothi (2008) showed that the effect of alum and stannous chloride mordant on marigold dye and found the alum gave superior L* and a* value over stannous chloride.

In case of cotton fabric the effect of the marigold and nasturtium dye has been presented over Table 4. The L* value is again found to be superior in alum over stannous chloride with marigold dye. The highest L* value (107.17) was found out in T1 treatment in combination of 50% EtOH + 4 min MW interval + alum. In Nasturtium dye, it was 74.32 with T7 treatment (0.5g/l Carbonate + 4 min MW interval + alum). The highest a* value (12.36) was obtained with T16 (70% HCl + 6 min MW interval + stannous chloride).

Table 3: Effects of pre-treatments, drying conditions and mordants over colour measurements in silk fabric

Flower sample	Mordants	Colour measurement			
		L*	a*	b*	K/S value
Marigold	T1	72.84±0.02 ef	10.89±0.02 f	77.84±0.10 a	107.18±0.39 a
	T2	75.28±0.20 d	3.52±0.20 n	42.15±3.12 c	86.37±0.14 fg
	T3	76.48 ±0.89 c	4.69±0.89 lm	24.19±0.1 e	91.25±2.34 e
	T4	72.67±1.0 efg	4.48±1.00 m	40.32±0.10	83.24±0.85 g
	T5	70.85±0.28 k	6.92±0.28 i	66.86±0.40 b	97.75±0.37 d
	T6	72.39±0.20 fgh	3.52±0.20 n	42.15±2.00 c	84.18±0.74 g
	T7	71.50±0.1 ijk	5.51±0.01 k	66.67±0.03 b	97.80±0.19 d
	T8	68.34±0.14 nop	19.24±0.14 b	23.33±0.03 e	74.74±0.12 h
	T9	68.06±0.06 nop	9.96±0.06 g	75.36±0.17a	102.02±0.04 bc
	T10	68.85±0.40 mn	13.65±0.40 e	70.17±0.20 ab	99.29±0.35 bcd
	T11	69.48±0.28 lm	8.04±0.28 h	75.49±0.20 a	102.86±0.13 b
	T12	67.68±0.08 p	19.65±0.08 a	23.30±0.17 e	74.21±0.08 h
	T13	83.86±0.16 b	4.76±0.03 lm	34.67±0.17 cd	92.67±0.06 e
	T14	68.85±0.05 mn	13.65±0.05 e	70.17±0.10 ab	99.29±0.05 bd
	T15	85.78±0.03 a	6.11±0.16 j	31.58±0.10 cd	89.83±0.17 ef
	T16	68.52±0.02 no	15.18±0.02 d	69.91±0.10 ab	99.08±0.17 cd
	T17	84.09±0.09 b	6.30±0.09 j	31.52±0.20 cd	90.03±0.09 ef
	T18	66.52±0.07 q	16.01±0.07c	69.91±0.10 ab	97.87±0.08 hijk
Nasturtium	T1	71.48±0.10 ijk	2.33±0.10 p	12.54±0.10 f	72.61±0.11 hij
	T2	72.10±1.0 ghi	0.93±1.0 rst	3.83±0.02 ghi	72.21±1.00 hij
	T3	70.04±0.04 l	2.85±0.40 o	14.12±0.09 f	71.51±0.07 hijk
	T4	70.85±0.39 k	1.36±0.39 q	3.79±0.13 hi	70.96±0.39 jkl
	T5	68.94±0.20 mn	1.17±0.20 qr	13.26±0.09 f	70.22±0.20 hijk
	T6	71.36±0.48 jk	1.36±0.47q	3.79±0.10 ghi	71.48±0.47 hijk
	T7	73.37±0.54 e	0.61±0.54 stu	11.75±0.75 fgh	74.31±0.53 h
	T8	72.23±0.23 fgh	0.59±0.23ut	6.37±0.24 fghi	72.51±0.18 hij
	T9	72.00±0.50 hij	0.30±0.50 uv	12.28±0.60 fg	73.04±0.52 ihj
	T10	67.70±0.70 p	0.79±0.70 rst	6.77±0.30 fghi	68.06±0.66 kl
	T11	68.90±0.98 mn	1.01±0.98 qrs	12.41±0.02 f	70.04±0.93 jkl
	T12	71.88±0.10 hij	4.43±0.10 m	6.62±0.03 fghi	72.18±0.10 hij
	T13	68.64±0.10 no	0.13±0.10 uv	10.41±0.20 fghi	69.56±0.11 jkl
	T14	72.24±0.10 fgh	5.07±0.90 l u	2.70±0.10 i	72.33±0.10 hij
	T15	69.90±0.9 l	2.42±0.10 p	9.61±0.10 fghi	70.74±0.90 ijkl
	T16	72.84±0.40 ef	2.53±0.40 op	3.48±0.20 hi	72.97±0.40 hij
	T17	66.12±0.02 q	3.39±0.03 n	10.94±0.09 fghi	67.16±0.04 l
	T18	71.16±0.06 k	2.73±0.06 op	3.29±0.20	71.28±0.06 hijk
LSD at 0.05		0.7051	0.4027	6.48	3.68

Table 4: Effects of pre-treatments, drying conditions and mordants over colour measurements in cotton fabric

Flower sample	Treatment combinations	Colour measurement			
		L*	a*	b*	K/S value
Marigold	T1	107.17±0.03 a	4.80±0.05 g	52.10±0.06 i	88.68±0.24 c
	T2	86.36±0.14 f	7.90±0.40 d	54.32±0.02 e	79.96±0.07 h
	T3	91.24±3.30 e	5.10±0.10 g	53.06±0.06 gh	88.08±0.01 d
	T4	83.24±0.83 g	8.77±0.07 c	54.17±0.07 e	79.85±0.11 h
	T5	97.75±0.37 d	5.66±0.06 f	53.76±0.06 f	89.50±0.10 b
	T6	84.18±0.74 g	6.92±0.07 e	50.69±0.09 j	77.58±0.09 c k
	T7	97.80±0.19 d	3.13±0.20 lmn	48.14±0.04 k	89.05±0.04 bc
	T8	74.73±0.12 h	7.85±0.05 d	82.00±0.50 a	102.32±0.29 a
	T9	102.02±0.04 bc	1.64±0.10 r	42.11±0.11 l	84.38±0.10 e
	T10	99.28±0.35 bcd	8.23±0.10 d	52.76±0.06 h	79.37±0.59 i
	T11	102.86±0.13 b	1.79±0.09 r	41.57±0.07 m	84.19±0.81 e
	T12	74.20±0.08 hi	8.76±0.06 c	53.37±0.07 g	79.88±0.08
	T13	92.66±0.06 e	0.92±0.10 s	36.96±0.06 o	78.23±0.10 j
	T14	99.29±0.05 bcd	11.30±0.03 b	56.56±0.73 c	80.14±0.56 h
	T15	89.83±0.17 ef	1.41±0.10 r	34.34±0.10 p	77.68±0.11 k
	T16	99.08±0.17 cd	12.36±1.00 a	58.18±0.80 b	82.12±0.05 f
	T17	90.03±0.09 ef	0.57±0.07 s	40.53±0.03 n	79.77±0.47 hi
	T18	97.87±0.08 d	11.93±0.45 a	55.51±0.10 d	81.13±0.17 g
Nasturtium	T1	72.61±0.11 hij	3.86±0.06 hij	14.50±0.04 t	72.94±0.09 p
	T2	72.21±1.00 hij	2.49±0.10 pq	10.88±0.10 zy	66.02±0.07 v
	T3	71.51±0.07 hijk	3.54±0.01 jkl	18.44±0.10 q	77.75±0.11 k
	T4	70.96±0.39 ijk	2.64±0.04 opq	11.78±0.05 w	65.66±0.06 vw
	T5	70.22±0.20 jkl	3.68±0.03 j	15.59±0.09 s	77.97±0.98 jk
	T6	71.48±0.47 hijk	2.37±0.07 q	10.73±0.10 z	65.22±0.08 w
	T7	74.32±0.53 hi	3.06±1.00 mno	9.77±0.07 b	74.75±0.08 n
	T8	72.51±0.18 hij	3.48±0.08 jklm	12.21±0.01 v	67.97±0.07 sr
	T9	73.04±0.52 hij	3.22±0.02 klmn	10.17±0.07 a	72.93±0.04 p
	T10	68.06±0.66 kl	3.69±0.09 ij	12.75±0.25 u	67.77±0.06 rst
	T11	70.04±0.94 jkl	3.16±0.06 lmn	8.78±0.08 c	73.43±0.03 o
	T12	72.18±0.10 hij	3.55±0.05 jkl	12.57±0.56 u	67.35±0.08 t
	T13	69.56±0.11 jkl	4.12±0.12 hi	16.94±0.10 r	75.47±0.65 m
	T14	72.33±0.10 hij	3.60±0.10 jk	11.19±0.04 xy	67.51±0.10 st
	T15	70.74±0.90 ijk	4.16±0.04 h	8.86±0.06 c	71.22±0.04 q
	T16	72.97±0.40 hij	3.12±0.02 lmn	11.62±0.02 w	68.00±0.03 r
	T17	67.12±0.04 l	4.25±0.05 h	10.30±0.20 a	76.46±0.05 l
	T18	71.29±0.06 hijk	2.82±0.02 nop	11.43±0.09 wx	66.64±0.09 u
LSD at 0.05		3.6843	0.4342	0.356	0.4683

Fabric strip test

The strength which was put to tear the strip of silk fabric has been presented in fig. 3. According to it the highest strength (412.16 g/m^2) to tear has been found out with the T1 treatment (EtOH 50% + 4 min MW interval + alum) in marigold tinted silk fabric. Whereas, the lowest strength (58.68 g/m^2) was seen in T18 treatment in marigold dyed silk (70% HCl + 8 min MW interval + stannous chloride). In case of Nasturtium dye (fig. 3) the maximum strength (296.23 g/m^2) for silk fabric was found out with the T1 treatment (EtOH 50% + 4 min MW interval + alum). It has been found out that the effect of alum gives better strength to fabric compared to stannous chloride for silk fabric. For cotton fabric similar kind of strength application has been seen like silk fabric i.e.., alum proved to be a better strength provided for fabric than stannous chloride. The highest strength (194.66 g/m^2) to the cotton strip was found in (T1) Ethanol 50% + 4 minutes MW interval + alum. The marigold dyed cotton showed better strength affects than the nasturtium. The highest strength in nasturtium (90.07 g/m^2) was found in (T1) Ethanol 50% + 4 minutes MW interval + alum. In case of silk, the fabric breaking strength was less with acid treatments. This was probably due to intense acid activity at higher temperature condition (Nakpathm, 2014) [10]. Fabric breakage can be expressed in terms of elongation capacity. In other words, breaking elongation gives the measure of the resistance of the material to elongate and finally break. It means how much the fibre will extend or elongate which subjected to stretching. This was showed in cotton fibre by Hosseinali 2012.

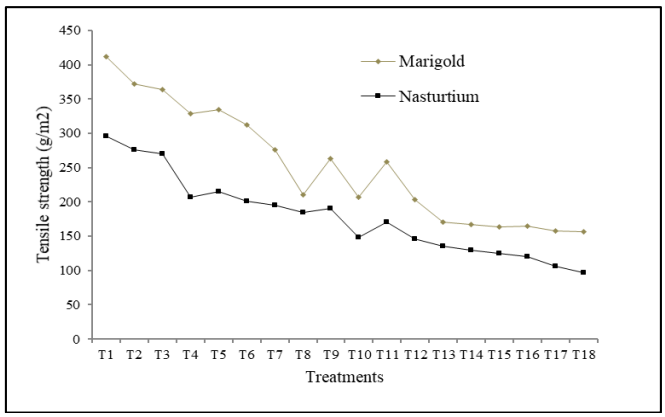

Fig 3: Effect of dyeing over the silk fabric strength (g/m^2), LSD=6.7718

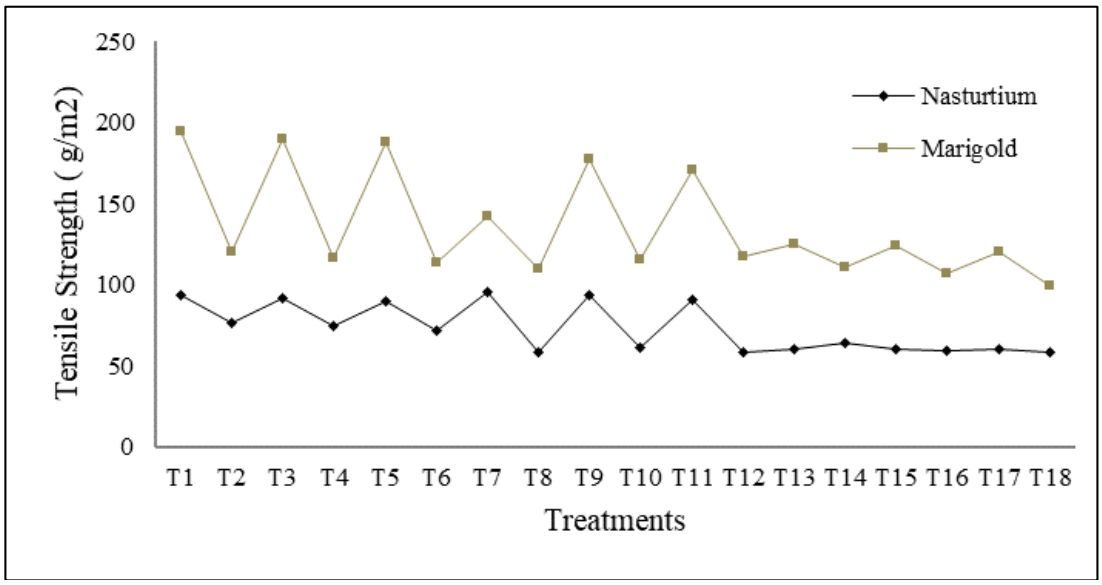

Fig 4: Effect of dyeing over the cotton fabric strength (g/m^2), LDS= 1.9601

Fastness test of fabric

In light fastness tests of marigold and nasturtium over silk (Fig. 4&5) and cotton (Fig. 8&9) fabric for the colour variation has been observed. This may be due to formation of a complex with the metal salts which protects the chromatophore to minimum photolytic degradation (Ali *et al.* 2009) [1]. For lightfastness, the substitution pattern of dyes seems to play an important role for colour determination. The increase or decrease of electron density through the substituent may accelerate oxidation otherwise reduction reaction of molecules. Which can be seen that the marigold lutein has two hydroxyl group gives good fastness (Ali *et al.* 2009, Kanchana *et al.* 2013) [1, 7].

Washing and rubbing fastness (Fig. 6&7 for silk and Fig. 10&11 for cotton) of the dye is influenced by the rate of diffusion of the dye and state of the dye inside the fibre by the rate of diffusion of the dye and state of the dye inside the fibre (Jyothi, 2008). Marigold and nasturtium extracted dye exhibit good wash and rubbing fastness. With mordant it complexes and create the dye an insolubilizing effect to make the colour fast. (Raja *et al.* 2010) [12]. Fabric samples dyed in marigold and nasturtium pigment with alum as a mordant have resulted in good wash fastness along with good rub fastness. Similar result was seen by Kanchana *et al.* 2013 [7] and Jothi 2008 [6].

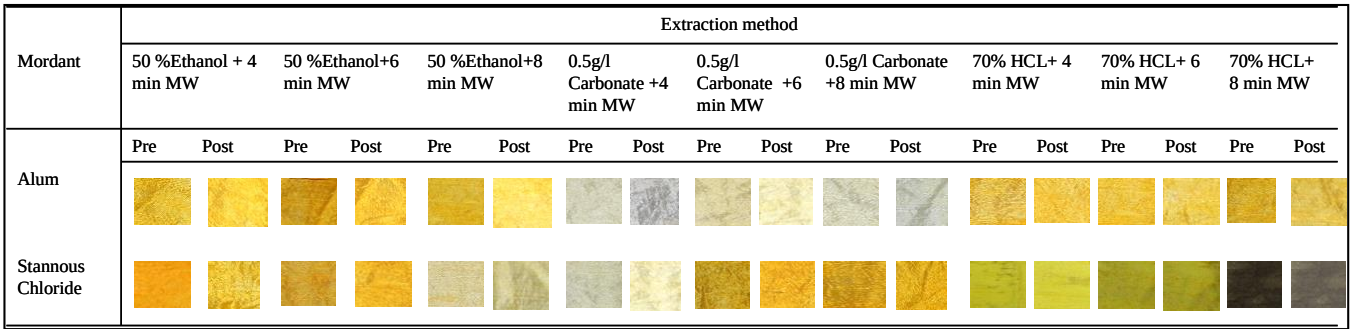

Fig 5: light fastness test on silk fabric dyed with marigold pigment

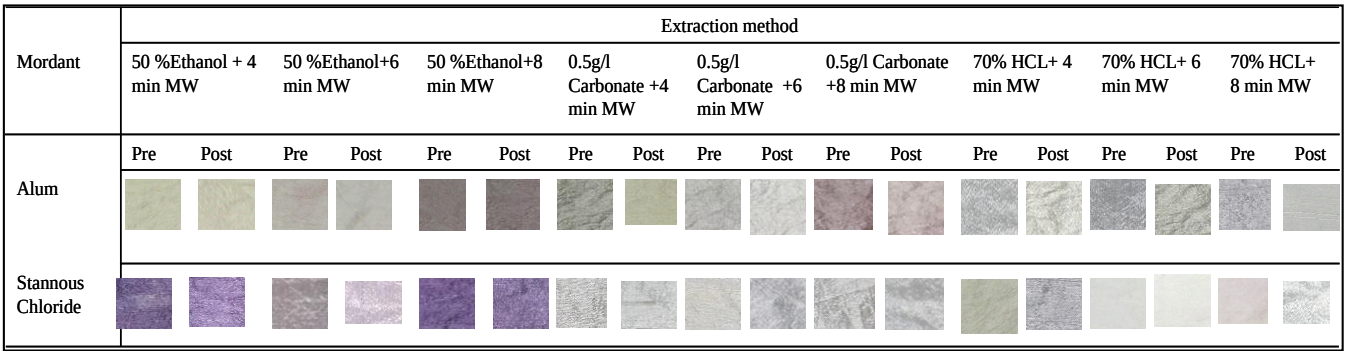

Fig 6: Light fastness test on silk fabric dyed with nasturtium pigment

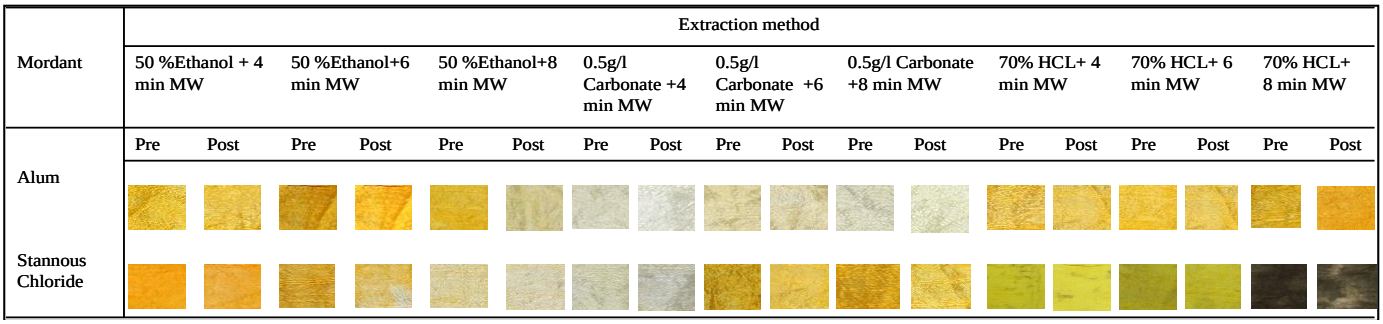

Fig 7: Wash and rubbing fastness test on silk fabric dyed with marigold pigment

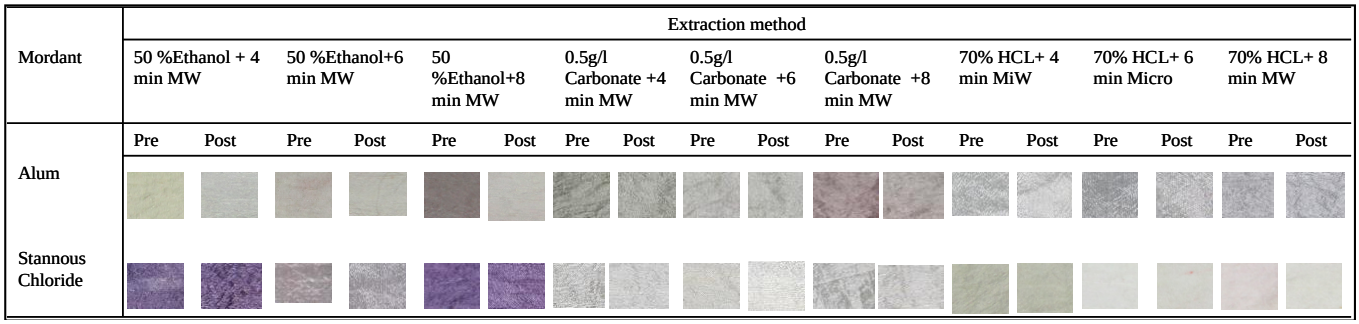

Fig 8: Wash and rubbing fastness test on silk fabric dyed with nasturtium pigment

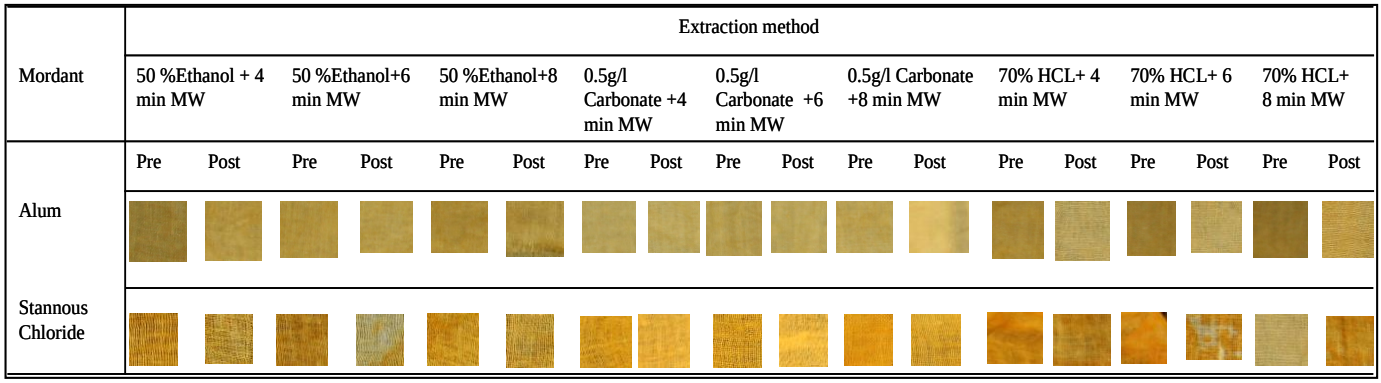

Fig 9: Light fastness test on cotton fabric dyed with marigold pigment

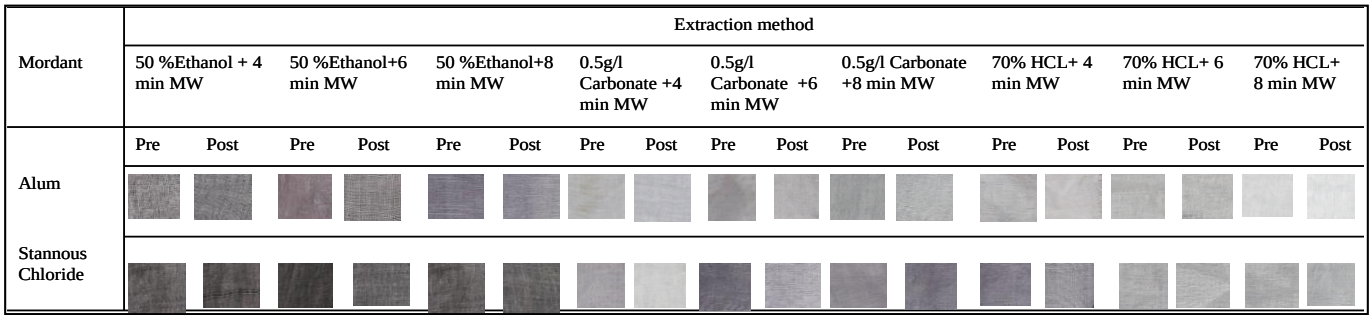

Fig 10: Light fastness test on cotton fabric dyed with nasturtium pigment

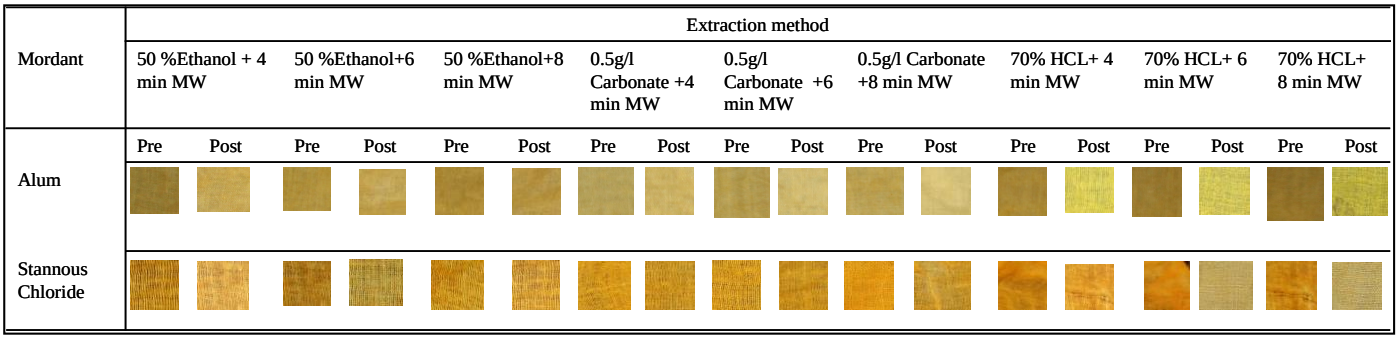

Fig 11: Wash and rubbing fastness test on cotton fabric dyed with marigold pigment

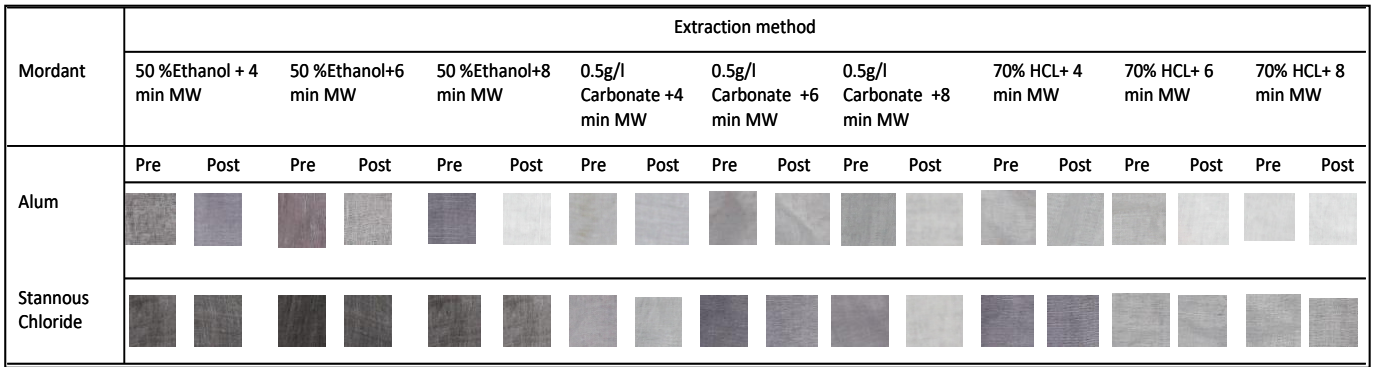

Fig 12: Wash and rubbing fastness test on cotton fabric dyed with nasturtium pigment

The whole process of extraction and dyeing is ecologically safe. The obtained results have shown the dyeing potential of all three natural plant sources as source for dyeing. There is need for proper knowledge, documentation and assessment of dye- yielding plants as well as the dying techniques so as to increase the use of natural dyes.

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