COLOURFASTNESS PROPERTIES OF NATURAL DYE FROM *TAGETES ERECTA* ON SILK FABRIC USING DIFFERENT DYEING TECHNIQUES

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Abstract

Of late, dyeing fabrics with natural dyes have become an attraction because of its eco-friendly and less threatening disposition towards humankind. In the textile colouration industry, natural dyes play an important role because of the need for replacement synthetic dyes which have a great deal of tension with the environmental issues. This study focuses on the colour shade, colour coordinates, and fastness properties of dyed silk fabric from *tagetes erecta* (Mexican Marigold flower) using the water boiling extraction method. The dyeing was carried out using lemon juice as a natural mordant through the simultaneous mordanting method, using two different dyeing methods: infrared (IR) dyeing and exhaustion dyeing. The shades produced for exhaustion dyed fabric is light-yellow compared to the IR dyed fabric, which is medium-light yellow. These shades were confirmed with the CIELAB colour coordinates, L*a*b* values. The colourfastness to washing, perspiration, rubbing, and light of the fabrics were conducted to investigate the performance of the dye and mordant on the dyed silk fabrics. The colourfastness properties of the dyed silk fabric using infrared (IR) dyeing technique have better performance than using exhaustion dyeing technique.

Keywords: infrared dyeing, natural dye, natural mordant, silk, tagetes erecta

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Introduction

Presently, the tremendous usage of synthetic dyes would release a massive amount of waste and unstable colourants, sparking serious health hazards and upsetting the ecosystem. Further study needs to be directed to select the potential natural dyes source and to study the optimal yield of dye extracted from the natural sources to be practically applied on textile colouration. Most natural dyes are environmentally friendly, making them an alternative to synthetic dyes, which not only harmful to the environment but also to people with allergies skin problems, and other diseases. Many research works on natural dyes from plants and microorganisms have been of interest (Bechtold et al., 2007; Shahid & Mohammad, 2013; Lee et al., 2013; Saxena & Raja, 2014). Natural dyes are mostly derived from natural plants, minerals, animals, and bacterial which have been used since ancient times for textile colouration (Yusuf et al., 2015). Natural dyes often produce a very rare, soothing and soft shades in contrast to synthetic dyes (Arora et al., 2017). On this day, natural dyes are still used alongside mordant, amazingly they can yield bright and dark colours (Vignesh et al., 2014). Although the use of mordants was not essential for substantive natural dyes, it is a must in order to obtain a variety of shades, to increase the dye uptake, and to improve the colourfastness properties. A research from Satpathy et al. (2019) have stated that it has been proven that the efficacy of mordant on colour provides good washability. In this study, *tagetes erecta* (Mexican Marigold flower) was used as the natural source of dye while lemon juice was used as natural mordant. According to Jothi (2008), *tagetes erecta* is one of the primary sources of carotenoids that can be obtained by producing a high colour yield. Lutein pigment consists in *tagetes erecta* carotenoid can create a very unique colour shade such as yellow to orange colour (Shabbir et al., 2018). They have reported from previous studies that the colourant extracted from *tagetes erecta* are free from any toxicity and harmful to the environment (Jothi, 2008; Shabbir et al., 2018). According to Vankar (2017), shades of light yellowish green hue colour were chosen by pure aqueous extracts from *tagetes erecta*. For a successful commercial use of natural dyes, the most recent technology innovation which proper and normalized dyeing techniques should be embraced without scarifying the required quality of dyed textiles materials. Therefore, in this new era, the infrared (IR) dyeing approach needs to be proposed back to obtain newer shades with an appropriate colour fastness behavior and reproducible colour yield. Infrared (IR) dyeing produces heat through electromagnetic radiation where the heat releasing directly to the interaction between the dye and fibre molecules where the absorption happened (Kim & Choi, 2015). According to Gupta et al. (2013), the infrared dyeing machine was designed for fast production with precise temperature control and has very low energy consumption. Since they are made environmentally friendly, this dyeing technique will help reduce the amount of water and chemicals required compare to exhaustion dyeing (Paul et al., 2017). In addition, previous studies have reported that the dyeing technique of IR has better results in colourfastness compared to conventional techniques (Bahlool, 2019; Kale et al., 2018). According to Kale et al. (2018), the higher rate of heat transfer in IR dyeing machines results in increased dye migration from the dyebath to the fibre surface.

Methodology

Materials

Tagetes erecta (Mexican Marigold flower) was used as the dye source as shown in Figure 1 and purchased from a nursery in the state of Negeri Sembilan Malaysia. As for the substrate, 2g of 100% plain silk fabric and lemon juice was used as a natural mordant in this research.

Figure 1. *Tagetes erecta* (Mexican Marigold flower)

Natural Dyes Extraction

The extraction was carried out by the water boiling extraction method. The petals of *tagetes erecta* were first to cut into small pieces and soaked in distilled water. The liquor ratio of 1:20 (weight of materials: volume of distilled water) was prepared for the dye solution and boiled in a beaker for 60 minutes at 100°C.

Dyeing and Mordanting

Exhaustion dyeing and infrared (IR) dyeing (Figure 2) methods were used to dye the silk fabrics. Both dyeing process took 60 minutes at 90°C with liquor ratio of 1:20 (weight of substrate: volume of dyes solution). Simultaneous mordanting method was performed using lemon juice as natural mordant (2% from the weight of fabric).

(a)

(b)

Figure 2. **(a)** Lab IR Dyeing Machine and **(b)** Water Bath Exhaustion Dyeing Machine.

Colour Measurement

The shades of the dyed fabrics were measured by using HunterLab LabScan XE Spectrophotometer and analyzed using EasyMatch QC Software. The percentage of reflectance curves for each dyed fabric was measured by capturing their shades. The colour coordinates values (CIE L*a*b*) were visualized, and the reflectance of the dyed fabrics was measured. The L* value indicates perceived lightness or darkness. A value of 0 indicates black and 100 indicates white. The value of a* indicates red (+a) and green (-a), b* indicates yellow (+b) and blue (-b). While dL*, da* and db* indicates the differences in absolute colour coordinates and referred as Delta (Δ) of L*, a* and b* values.

Colourfastness Properties

The dyed fabrics were assessed in terms of colourfastness to washing, perspiration, light, and rubbing/crocking. The visual evaluation was analysed according to MS ISO Standard as listed in Table 1 below and AATCC Gray Standard. The samples were compared with the Gray Scale and ratings given. The AATCC standard scale and numerical ratings were applied in the testing. The scale for change in colour and staining is from 1 to 5 where the lowest rating is 1 and the highest rating is 5.

Table 1. The Colourfastness Assessments by using Standard Methods

Testing	**Standard Methods**	**Equipment**
Washing	MS ISO 105-C01-2006	Gyrowash
Perspiration	MS ISO 105-E04-2014	Perspirometer
Light	MS ISO 105-B02-2019	Light Fastness Tester
Rubbing	MS ISO 105-X12-2019	Crockmeter
Change in colour	MS ISO 105-A05-2007	Grey scale
Staining	MS ISO 105-A04-2007	Grey scale

Results and Discussion

Shades of the Dyed Fabrics

Table 2 shows the shades obtained from the *tagetes erecta* flower extracted using water boiling extraction method on silk fabric with natural mordant using different dyeing methods. The silk dyed fabrics using IR dyeing with lemon juice mordant produced medium-light yellow shade while fabric dyed with exhaustion dyeing method produced very light-yellow shade.

Table 2. Colour Shades of Dyed Fabrics

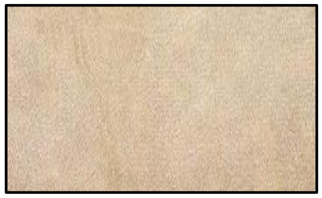
Dyes	Colour Shades Lemon juice Mordant (2%)	
	Infrared Dyeing	**Exhaustion Dyeing**
Tagetes erecta		

Table 3. L*a*b* values of Dyed Fabrics

Dyed Fabrics	**L***	**a***	**b***	**dL***	**da***	**db***
IR Dyeing	67.69	-1.66	21.03	-23.12	-1.50	16.91
Exhaustion Dyeing	64.58	-0.28	20.55	-26.22	-0.12	16.42

The results of depth of shades of dyed silk fabrics with *tagetes erecta* flower using different dyeing techniques are summarised in Table 3. It shows that the values of CIELAB colour coordinates (L*a*b*), and 2D colour plot for the dyed fabrics obtained from the colour prediction computer; LabScan XE processed in this study where L* defines lightness, a* denotes the red/green value and b* the yellow/blue value. From the data shown in the Table 3, it shows that L* value for IR dyed is 67.69 while L* value for exhaustion dyed is 64.58. On the L* plane, the measurement difference of +3.11 shows that *tagetes erecta* dyed silk fabric using IR dyeing technique produced slightly darker shades than exhaustion dyeing technique. However, the b* values for both samples does not showed much difference (+0.48) since both fabrics are in the yellow colour range. This is because the heating source of infrared dyeing is uniform, hence the dye fixation towards fabric leads to have better colour yield absorption compared to exhaustion dyeing technique.

Figure 3 shows that the 2D colour plot graph for the two types of dyeing method on silk fabric with the same type of mordants were towards positive in the yellow colour region above the yellow-blue line axis and high in the L value in the lightness axis, L-axis. As a result, the colour values for both dyed silk fabrics are somehow lighter in colour.

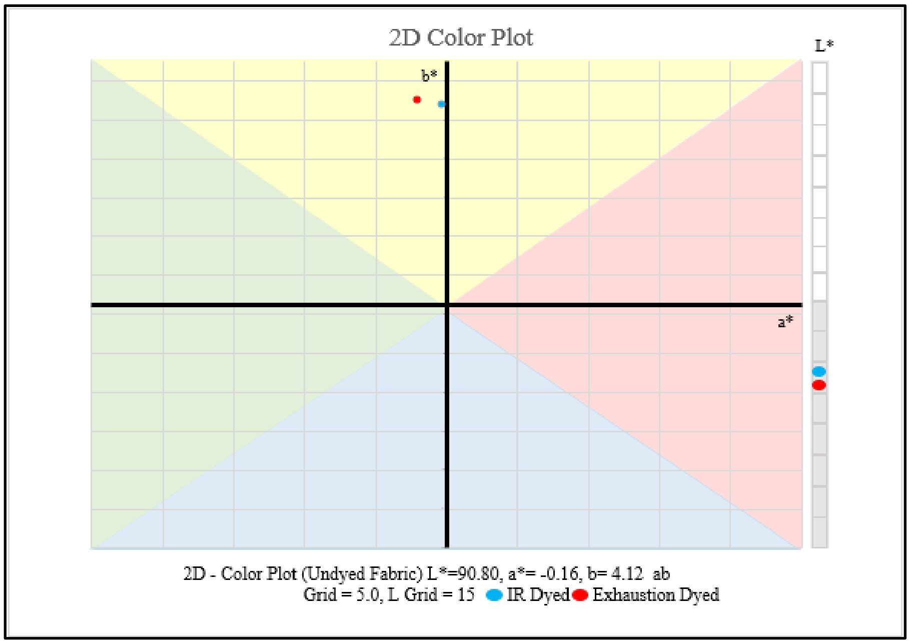


Figure 3. 2D Plot representing the shades of silk fabric with two dyeing techniques

From the analysis graph shown in Figure 4, the value of wavelength (x-axis) is directly proportional with %reflectance (y-axis) for both dyed fabrics. It can be seen that all the dyed silk fabrics showed similar curves because they came from the same sources, *tagetes erecta* dyes and lemon juice mordant.

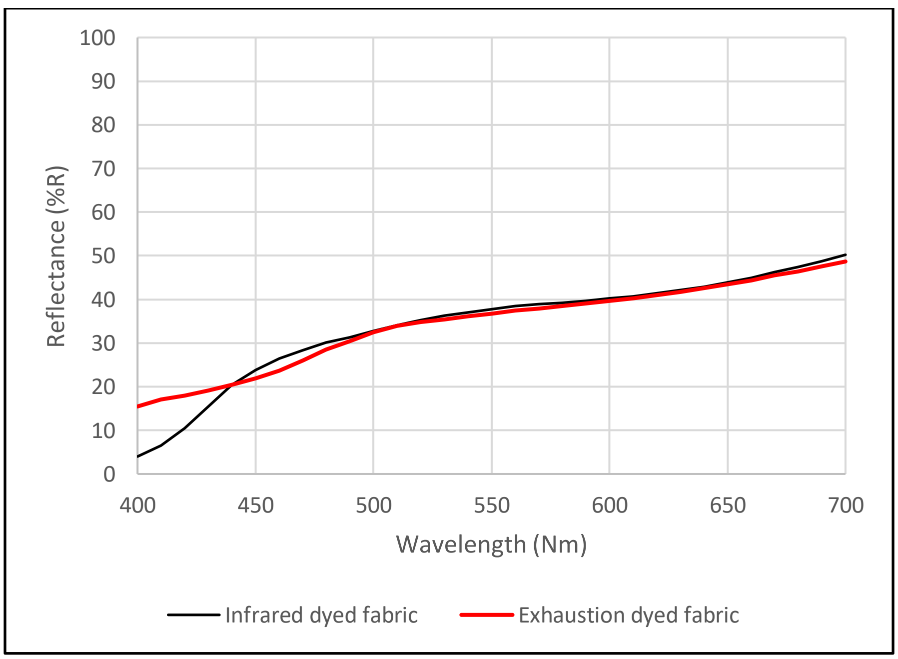


Figure 4. %Percentages reflectance of silk fabric with two dyeing techniques

Colourfastness Properties

Tables 4 shows the results of colourfastness properties of silk fabric dyed with *tagetes erecta* dye in terms of washing, perspiration and light for both dyeing techniques. Silk fabric dyed with *tagetes erecta* dye showed fair to good resistance to colour change due to washing using exhaustion dyeing technique. However, it showed good to excellent resistance to staining in cotton and silk composite fabrics using infrared dyeing technique. Meanwhile, it showed moderate resistance to colour change due to perspiration using infrared dyeing technique. Infrared dyeing techniques showed good resistance to staining and exhaustion dyeing technique showed excellent resistance to staining due to perspiration. In light fastness properties, it showed fair to good resistance to colour change. The blue wool standard was rated at 2 and 4 indicating poor to average light fastness for both dyeing techniques as the samples faded when exposed to light for 72 hours.

Table 4. Colourfastness properties of silk fabric dyed with *tagetes erecta* dye

Dyeing Technique	**Washing**			**Perspiration**			**Light**	
	Change in colour (rating)	**Staining**		**Change in colour (rating)**	**Staining**		**Change in color (rating)**	**Blue wool standard**
		Cotton	**Silk**		**Cotton**	**Silk**		
Infrared	3 (moderate)	4/5 (excellent)	4 (good)	3 (moderate)	4 (good)	4 (good)	3/4 (fair/good)	4
Exhaustion	3/4 (fair/good)	3/4 (fair/good)	4 (good)	2/3 (poor/moderate)	4/5 (excellent)	4/5 (excellent)	3 (moderate)	2 (poor)

Table 5 shows the results of colourfastness to rubbing for both dyeing techniques. Silk fabric dyed with *tagetes erecta* dye for both infrared and exhaustion dyeing techniques showed excellent colourfastness resistance to rubbing in dry and wet conditions.

Table 5. Fastness properties to rubbing

Dyeing method	**Staining**			
	Warp		**Weft**	
	Dry	**Wet**	**Dry**	**Wet**
IR	4/5	5	4/5	5
Exhaustion	4/5	5	4/5	5

Overall, silk fabric dyed with *tagetes erecta* dye using infrared dyeing technique showed moderate resistance to color change due to washing, perspiration and light but the performance is slightly better than using exhaustion dyeing technique. Silk fabric dyed with *tagetes erecta* dye has good to excellent resistance to staining due to washing on cotton and silk composite fabrics using infrared dyeing technique. However, both dyeing techniques showed good to excellent resistance to staining due to perspiration and excellent colourfastness resistance to rubbing.

Conclusion

This study investigated the colorfastness properties of natural dye from *tagetes erecta* on silk fabric using different dyeing techniques which are exhaustion dyeing and infrared dyeing technique. *Tagetes erecta* can be utilized as a natural dye source, which produces yellow shades on silk fabric. Besides the exhaustion dyeing method, infrared dyeing is a good alternative method of dyeing since it is environmentally friendly with great colour yield. IR dyeing with lemon juice mordant produced medium-light yellow shade while fabric dyed with exhaustion dyeing method produced very light yellow shade. The colourfastness properties of the dyed silk fabric using infrared dyeing technique have better performance than using exhaustion dyeing technique.

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