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The Influence of Mordanting on the Dyeability of Cotton Dyed with Turmeric Extract
Vpliv čimžanja na obarvljivost bombaža z ekstraktom kurkume

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Abstract
The dyeability of cotton fabric with turmeric extract in two concentrations (pale and dark dyeing) was studied using four different mordants in low concentration (0.2 g/l). As mordants three metal salts were used as mordants (ferrous sulphate, aluminium sulphate and zinc chloride), and organic mordant tannin. The mordanting of cotton was performed before, during and after dyeing, namely by pre-, meta-, and post-mordanting application methods. Colour fastness of dyed samples to repetitive washing and hot pressing was also performed. The colour values of the dyed samples were measured on a reflectance spectrophotometer. The results showed that the dyeability of the cotton with turmeric extract is greatly influenced by the used mordant and its application method. The highest dyeing uptake (dyeability) was achieved by pre-mordanting with aluminium sulphate. All the mordanted samples had improved colour fastness, especially those samples meta-mordanted with ferrous sulphate.
Keywords: cotton, turmeric, curcuma, mordant, natural dyeing, dyeability

Izvleček
V raziskavi je bil proučevan vpliv čimžanja z uporabo štirih čimž v nizki koncentraciji (0,2 g/l) na obarvljivost bombažne tkanine z ekstraktom kurkume v dveh koncentracijah (za svetlo in temno obarvanje). Uporabljene čimže so bile tri kovinske soli (železov sulfat, aluminijev sulfat in cinkov klorid) in organska čimža tanin. Čimžanje je potekalo pred barvanjem, med njim in po njem oziroma pre-, meta- in postčimžanje. Določene so bile tudi barvne obstojnosti na večkratno pranje in vroče likanje. Barvne vrednosti barvanih vzorcev so bile določene z uporabo refleksijskega spektrofotometra. Raziskava je pokazala, da je obarvljivost bombaža z ekstraktom kurkume močno odvisna od uporabljene čimže in načina čimžanja. Najgloblje obarvanje je bilo doseženo pri bombažu, barvanem z višjo koncentracijo ekstrakta kurkume, ki je bil čimžan z aluminijevim sulfatom pred barvanjem. Barvne obstojnosti na pranje in vroče likanje so se z uporabo čimž na splošno izboljšale, najbolj za vzorec, metačimžan z železovim sulfatom.
Ključne besede: bombaž, kurkuma, čimža, barvanje z naravnimi barvili, obarvljivost

1 Introduction

Textile materials are usually dyed using synthetic dyes. Synthetic dyes are used in order to facilitate the high demands of the costumers and the added-value of the textile material [1]. The high usage of synthetic dyes in textile dyeing is also due to their ready-to-use form for fast and easier handling and repeatability of dyeing. Over recent years we have witnessed an immense shift towards the usages of natural dyes and pigments during the dyeing and printing of textile materials due to, again, costumer

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demand. Costumers are becoming more and more conscious about the hazardous threats and potential health issues in conjunction with the textiles they are using. Most of the commercial textile dyers have responded to the trend towards using natural dyes and started looking towards the maximum possibilities of using natural dyes for the dyeing and printing of different textile materials [1, 2]. For a successful commercial use of natural dyes for any type of textile, the appropriate and standardised techniques of dyeing need to be adopted [1]. The word 'natural dye' covers all those dyes derived from natural sources such as plants, animals, and minerals [3]. Natural dyes produce very lustrous, soft and soothing shades as compared to synthetic dyes [1]. Natural dyes are more eco-friendly, can perform better biodegradability and generally have a higher compatibility with the environment. Furthermore, natural dyed textiles also have good UV-protection and antibacterial activity [4, 2].

Turmeric is the most popular natural dye in textile dyeing [1]. Turmeric is a rich source of phenolic compounds called curcuminoids [5]. The active colouring ingredient in turmeric rhizome is *Curcumin*, which is also known as Natural Yellow 3 (C.I. 75300). Its general formula is given in Figure 1.

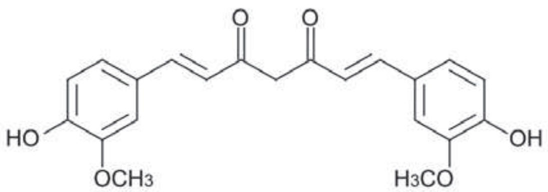

Figure 1: Chemical structure of turmeric (keto form) [5]

Turmeric is the brightest yellow natural dye, which belongs to the diaroylmethane group named diferuloylemethane [5]. It is also well-known for its anti-carcinogenic, anti-inflammatory, anti-microbial, anti-parasitic, anti-mutagenic and anti-inceptive properties, as well as for the formation of sunscreen products [6–8]. Natural dyes such as turmeric dye are mostly non-substantive and must be applied on textiles with the help of mordants, usually a metallic salt, having an affinity for both the dye and the fibre [9].

Metallic mordants are generally metal salts of aluminium, iron, copper, chromium and tin [1]. The metallic mordants are of two types. Brightening and dulling mordants. Amongst all types of aluminium, potash aluminium is a cheap, easily available and safe to use mordant. It usually produces pale versions of the prevailing dye colour in the plant.

Chrome is also referred to as red chromate but it is relatively more expensive. However it is considered to be harmful for human skin. Copper is known as blue vitriol, it is readily soluble in water and easy to apply. It gives some special effects in shades that otherwise cannot be obtained. However, copper beyond a certain limit is also under the eco-standard norms as objectionable heavy metals. Iron is also known as green vitriol and is readily soluble in water. It is used for darkening, browning and blackening of the colours / shades. It is easily available and one of the older mordants known. It is extensively used to get grey to black shades. Tanin is not a metal salt but it gives brighter colours than any other mordant. However, the tannin mordant is oxidised on exposure to air and imparts a stiff hand to the fabric if used in high concentration [1]. Zinc is a slightly acid mordant of white powder or silver-grey metallic granules with a 4.5 pH, easily clumped by humidity; found naturally, known since at least around 15th century. Natural and man-made fibres can be dyed with turmeric extract dye. Turmeric extract can be applied onto cotton, silk, polyamide and acrylic fibres [1, 2, 6, 10, 11]. Different mordants on acrylic fibres not only cause difference in hue and changes in K/S values but also changes in colour characteristic when dyed with turmeric extract [6]. Hydroxylamine hydrochloride and ammonium acetate were used for providing higher concentration of the nitrogen on the surfaces of acrylic fibres. The K/S values of the dyed samples were higher due to the increased nitrogen content on the fibres. The washing, perspiration, and rubbing fastness properties for the dyed samples were enhanced by application of alum as pre-mordant. A man-made fibre that also contains nitrogen in its structure is polyamide [11]. Polyamide samples were pre-mordanted with potassium aluminium sulphate, cupric sulphate, ferric sulphate and dyed with turmeric extract at 100°C. The results showed that using mordants leads to higher K/S values, for example ferric sulphate mordant gave the highest K/S value [11]. Another nitrogen containing fibre is silk, which is a natural protein fibre and was dyed with turmeric after mordanting with copper sulphate, ferrous sulphate and potassium aluminium sulphate [10]. The results showed that pre-mordanting of silk imparted deeper shades compared to the fabrics dyed without mordants. Cotton is also a natural fibre, however it

does not contain nitrogen within its structure and for the purpose of dyeing with natural dyes needs to be mordanted. Pre- and post-mordanting with iron and aluminium improves the light fastness and washing fastness of turmeric dye on cotton [12].
In previous studies of dyeing textiles with turmeric dye, mordants were applied onto textiles mostly before dyeing (pre-mordanting) and at high concentrations. The purpose of our research was to dye cotton fabric with turmeric extract, using low concentrations of different mordants and different mordanting application methods, i.e. mordanting prior, during and after dyeing, and to evaluate which mordanting technique gives higher dyeability with turmeric.

2 Experimental

Material
100% bleached cotton plain weaved fabric (Tekstina, Ajdovščina) was used for the research.

Mordanting
Ferrous sulphate ($FeSO_4$), aluminium sulphate ($Al_2(SO_4)_3$, zinc chloride ($ZnCl_2$) and tannin were used as mordants. The application methods of mordanting were pre-mordanting (mordanting before dyeing), meta-mordanting (mordanting during dyeing) and post-mordanting (mordanting after dyeing). The concentration of mordant was 0.2 g/l. Pre- and post-mordanting was performed at goods to liquor ratio 1:40 for 10 min at room temperature. The samples were then dried in the oven at 130°C, for 5 min. Meta-mordanting was performed during dyeing.

Extraction of turmeric dye
The dye was prepared by extracting turmeric powder from deionised water at neutral pH, at 95°C for 1.5 hours. Two concentrations of turmeric powder were used, i.e. 2 g/l and 20 g /l. The obtained *Curcuma Longa* extract solution (dye solution) had a yellowish colour.

Dyeing
Dyeing of cotton was performed in stainless-steal beakers, at goods to liquor ratio 1:40, at 60°C, for 60 min. After dyeing, rinsing of samples was performed in warm and cold deionised water. The samples were air-dried at room temperature.

Wash-fastness
The dyed samples were washed in the Launderometer Laboratory apparatus according to EN ISO 105-C06 standard. The size of the sample was 100 x 40 mm, the wash bath contained 4 g/l ECE phosphate reference detergent B, the volume of the bath was 150 ml, the temperature of the bath was 40°C and time of washing 45 minutes. Ten stainless steel globules were added into each bath to perform washing, which corresponds to five domestic washings. After washing, the samples were rinsed twice in deionised water and air dried at room temperature.

Fastness to hot pressing
Hot pressing of dyed samples was performed according to EN ISO 105-X11standard. The test specimen and adjacent fabric were soaked in distilled water and squeezed. The wet specimen and adjacent fabric were placed on the top of dry adjacent fabric. The specimen was put into a heating device for 15 s at 200 ± 2°C. Fastness was evaluated according to the Grey Scale test (standards EN ISO 105-A05 and EN ISO 105-A04).

Colour measurements
CIE $L^*a^*b^*$ colour values and reflectance (R) of samples were measured using a reflectance spectrophotometer Spectraflash 600 PLUS-CT (Datacolor). From the CIE $L^*a^*b^*$ colour values, colour differences were calculated according to equation 1:

$$\Delta E_{ab}^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}, \tag{1}$$

where ΔL^* is the lightness difference, Δa^* is the red/green difference and Δb^* is the yellow/blue difference between standard and batch.
From the reflectance measurements, K/S values were calculated according to equation 2:

$$\frac{K}{S} = \frac{(1 - R)}{2R} \tag{2}$$

where R is the reflectance, K is absorbance and S is the scattering.

3 Results and discussion

The CIE $L^*a^*b^*$ colour values of the non-dyed non-mordanted sample (UN) and samples mordanted with $FeSO_4$ (Fe), $Al_2(SO_4)_3$ (Al), $ZnCl_2$ (Zn) and tannin (Tan) are presented in Table 1. The results show that mordanting with $FeSO_4$ caused the non-dyed sample to be darker, redder and yellower compared to the non-mordanted non-dyed sample. Mordanting with $Al_2(SO_4)_3$ and $ZnCl_2$ caused the samples to be greener and yellower compared to the non-mordanted sample. Mordanting with tannin caused the sample to be darker, greener and e yellower compared to the non-treated sample. From the results of colour differences (ΔE^*ab) between non-mordanted and mordanted non-dyed samples (Figure 2) it is clear that mordanting with $Al_2(SO_4)_3$ and $ZnCl_2$ does not induce colour changes. The ΔE^*ab values were lower than 1, meaning that colour change was undetectable (there was no visible colour difference between the samples) [13]. Mordanting with $FeSO_4$ and tannin gave the ΔE^*ab values 8.45 and 3.52, respectively, meaning that the colour change was detectable.

Table 1: CIEL a*b* colour values of non-mordanted (UN) and mordanted non-dyed samples*

Sample	*L**	*a**	*b**
UN	95.37	–0.21	1.84
Fe	91.98	0.05	9.58
Zn	95.30	–0.45	2.24
Al	95.24	–0.41	2.17
Tan	93.82	–0.49	4.99

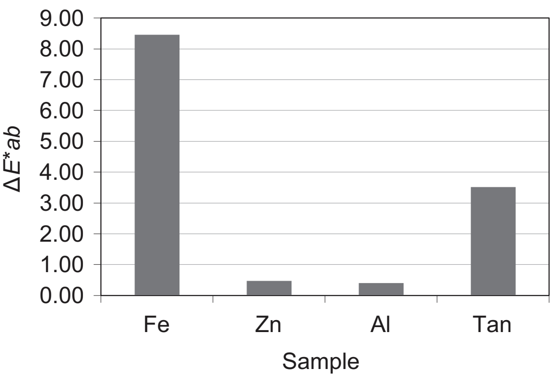

Figure 2: Colour differences (ΔE^*ab) between non-mordanted and mordanted non-dyed samples

From the results of mordanting non-dyed cotton it could be assumed how mordanting would affect dyeing with turmeric extract, i.e. mordanting with $FeSO_4$ and tannin would give predominantly darker, redder (or greener) and yellower dyeing and that mordanting with $Al_2(SO_4)_3$ and $ZnCl_2$ would not affect the colour differences significantly. However, the results of cotton dyed with turmeric extract show a different trend. In Table 2, the results of CIE $L^*a^*b^*$ values are presented for cotton samples dyed with 2 g/l of turmeric extract. Mordanting with $FeSO_4$ indeed caused the dyed samples to be darker, however the samples were less yellow (Table 2). Furthermore, the mordanting application method with $FeSO_4$ had a great influence on the final colour values of the dyed samples. For example, pre-mordanting gave darker, less green and less yellow dyeing while meta and post-mordanting gave darker, redder and less yellow dyeing compared to the non-mordanted dyed sample. The mordanting application method also influenced when other mordants are used (Table 2). The meta-mordanted $ZnCl_2$ samples were yellower compared to the non-mordanted sample. The pre- and post-mordanted $ZnCl_2$ samples were lighter, greener and yellower than the non-mordanted dyed sample. Pre-mordanting with $Al_2(SO_4)_3$ gave lighter, greener and less yellow dyeing, meta-mordanting gave lighter, less green and yellower dyeing and post-mordanting gave lighter, greener and yellower dyeing compared to the non-mordanted dyed sample. Dyeing of samples mordanted with tannin gave similar CIE $L^*a^*b^*$ colour values

*Table 2: CIE L*a*b* colour values of non-mordanted (UN) and mordanted samples dyed with 2 g/l of turmeric extract*

Sample	*L**	*a**	*b**
UN	90.98	–5.32	61.64
Pre_Fe	84.11	–1.28	46.17
Meta_Fe	83.22	0.50	32.03
Post_Fe	82.10	1.90	45.81
Pre_Zn	91.48	–5.71	62.90
Meta_Zn	90.19	–4.77	64.64
Post_Zn	92.06	–6.30	62.74
Pre_Al	91.34	–6.36	57.12
Meta_Al	91.08	–4.52	61.93
Post_Al	91.74	–6.60	64.23
Pre_Tan	90.35	–5.36	62.82
Meta_Tan	90.00	–5.76	62.33
Post_Tan	90.82	–5.91	61.74

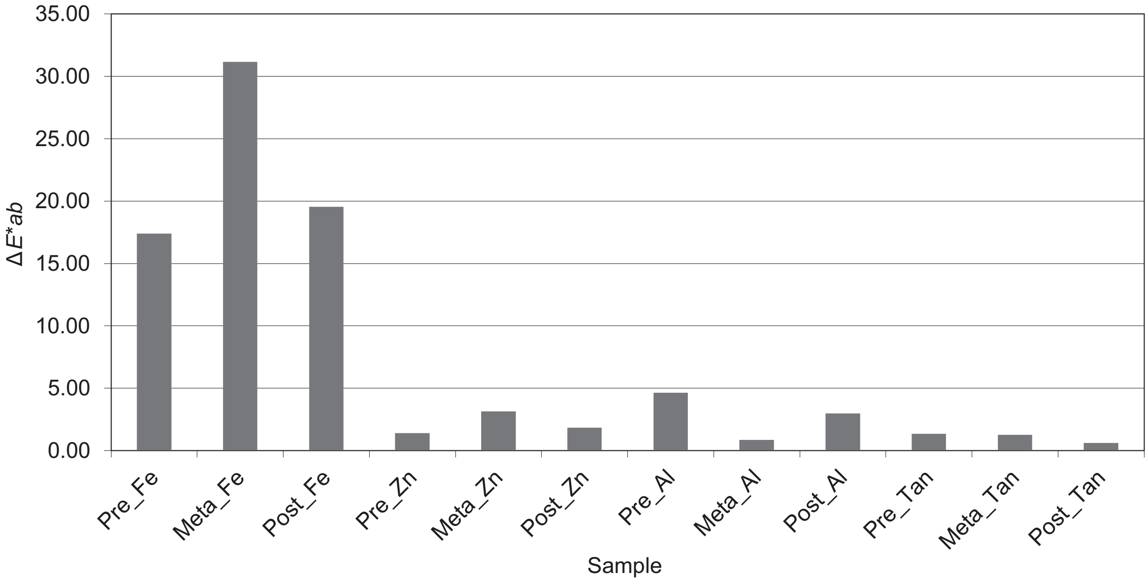

*Figure 3: Colour differences (ΔE*ab) between non-mordanted and mordanted samples dyed with 2 g/l of turmeric extract*

as the dyeing of the non-mordanted sample. From the results of the colour differences (Figure 3) it can be observed that mordanting with tannin did not influence the colour change compared to the non-mordanted sample (ΔE^*ab values were lower than 1). ΔE^*ab values lower than 1 were also calculated for the dyed sample which was meta-mordanted with $Al_2\,(SO_4)_3$. ΔE^*ab values between 1 and 2 were calculated for the following samples: *Pre_Zn, Post_Zn, Pre_Tan* and *Meta_Tan*. A significant colour change was calculated for samples mordanted with $FeSO_4$, regardless of the mordanting application method (pre-, meta- or post-). The ΔE^*ab values for those samples were higher than 17.

Dyeing cotton with higher concentration of turmeric extract, i.e. 20 g/l, generally gives darker, redder and more yellow dyeing (Table 3) than dyeing with lower concentration of turmeric extract, i.e. 2 g/l (Table 2). The correlation between lower or higher concentration of turmeric extract is noticeable when samples are post-mordanted with $FeSO_4$. The samples in both cases are darker, redder and less yellow compared to the non-mordanted dyed samples (Table 2 and 3). Correlation between higher and lower concentration of turmeric exctract, except decreased CIE L^* values (darker) does not apply for pre- and meta-mordanting with $FeSO_4$. There are no correlations between higher and lower concentration of turmeric exctract when using other mordants. When other mordants (i.e. Al, Zn, Tan) are used for dyeing with 20 g/l of turmeric extract, regardless of a mordant used, the samples are lighter, less red and less yellow, except samples *Post_Zn* and *Pre_Al*, which are more yellow compared to the non-mordanted sample (Table 3). The colour changes between non-mordanted and

*Table 3: CIE L*a*b* colour values of non mordanted (UN) and mordanted samples dyed with 20 g/l of turmeric extract*

Sample	L^*	a^*	b^*
UN	79.23	10.04	83.43
Pre_Fe	60.43	9.83	53.96
Meta_Fe	77.18	2.86	51.27
Post_Fe	61.05	10.26	42.30
Pre_Zn	80.73	7.59	82.67
Meta_Zn	85.79	3.29	82.91
Post_Zn	82.12	8.26	85.02
Pre_Al	79.59	8.43	84.59
Meta_Al	85.75	1.61	77.24
Post_Al	83.55	5.30	83.86
Pre_Tan	82.44	6.10	81.40
Meta_Tan	84.49	3.35	82.24
Post_Tan	84.91	3.29	81.65

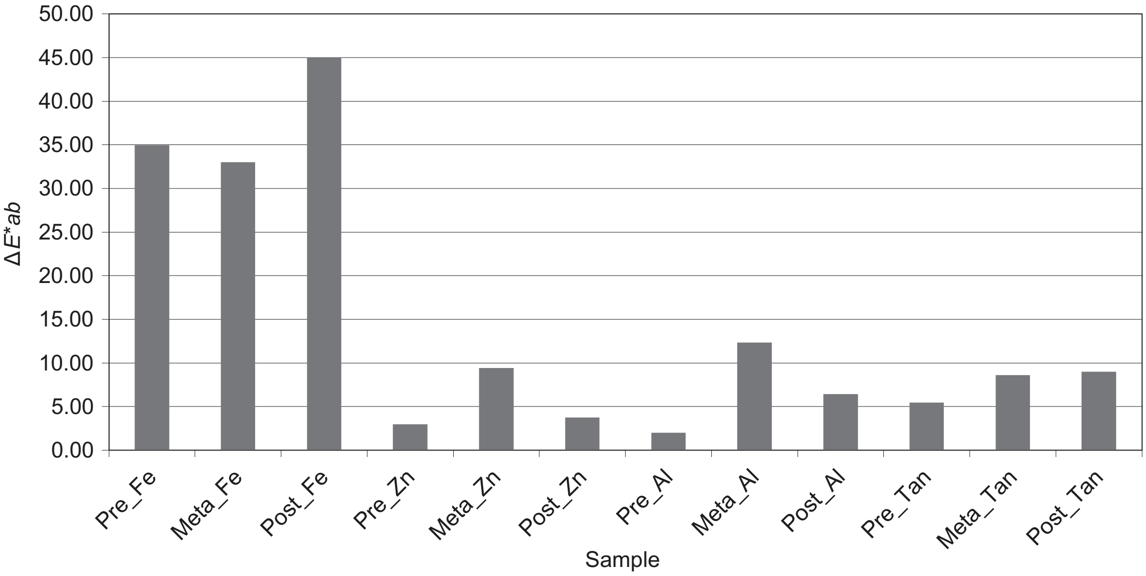

Figure 4: Colour differences (ΔE^*ab) between non-mordanted and mordanted samples dyed with 20 g/l of turmeric extract

mordanted samples are detectable, since ΔE^*ab values are higher than 2 (Figure 4). The highest ΔE^*ab value was calculated for sample post-mordanted with $FeSO_4$ (ΔE^*ab = 44.97). The lowest ΔE^*ab value was calculated for samples pre-mordanted with $Al_2(SO_4)_3$ (ΔE^*ab = 2.02).

According to Kubelka-Munk theory, the higher K/S value, the more the dye uptake will be [14]. The K/S values for non-mordanted and mordanted samples dyed with 2 g/l and 20 g/l of turmeric extract are presented in Figure 5. The *K*/*S* values of metal mordanted samples are not in accordance to CIE L^* values (Table 2 and 3), where on the other hand *K*/*S* values of samples mordanted with tannin are in accordance with CIE L^* values. Mordanting with tannin when dyeing with 2 g/l of turmeric extract has no significant influence on change in CIE L^* values (Table 2) compared to non-mordanted dyed sample,

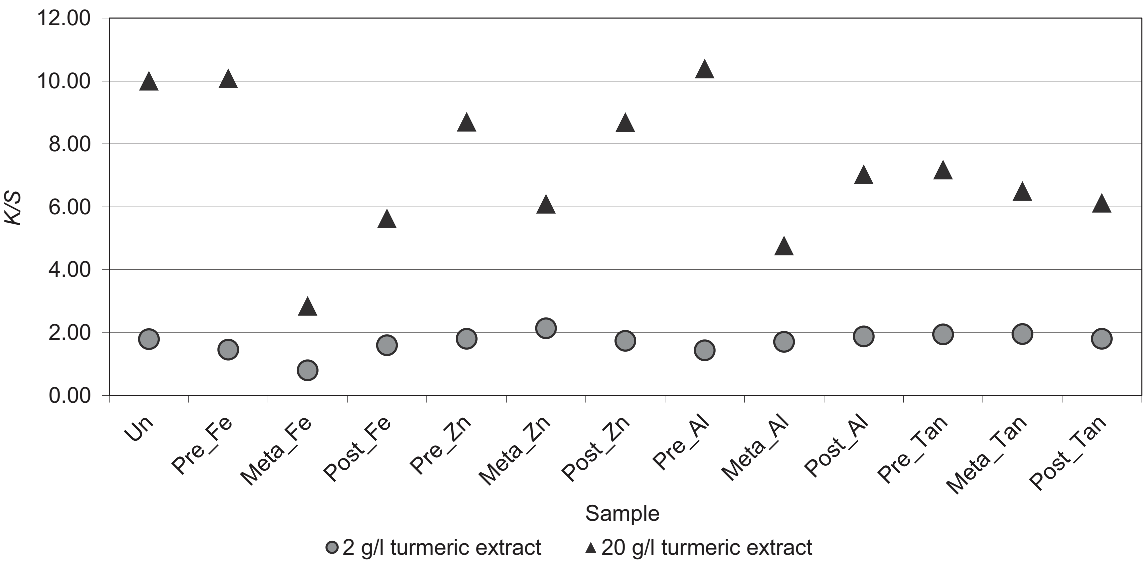

Figure 5: K/S values of non-mordanted and mordantented samples dyed with 2 g/l and 20 g/l of turmeric extract

which also apply for *K/S* values (Figure 5). In case of dyeing with 20 g/l of turmeric extract, samples mordanted with tannin have higher CIE *L** values (Table 3) and lower K/S values. Tannin is not a metal salt, actually it is a water-soluble phenolic compound that has been used on textiles for several hundred years both as a pre-treatment and post-treatment agent to increase wash fastness and light fastness of cotton fabric [15]. When metal salts are used as mordants, the turmeric extract and metal salts react forming strong complexes. The structure and physical properties of these complexes depend on the nature of the metal ion. Furthermore, turmeric has hydrophobic molecule and is almost insoluble in water [16]. The reason that CIE *L** values and *K/S* values do not comply when dyeing with 20 g/l turmeric extract is in the chemical structure of turmeric and the nature of the metal ion. For example, when mordanting is performed as meta-mordanting, the *K/S* values are the lowest (Figure 5). The reason is that metal ion and turmeric react in forming a complex before dye can be adsorbed onto the cotton. Lower *K/S* values indicate lower dye uptake [14]. Pre-mordanting with metal salts induced the highest dye uptake, which can be observed as high *K/S* values (Figure 5). The highest *K/S* value was calculated for sample pre-mordanted with $Al_2(SO_4)_3$ and dyed with 20 g/l of turmeric extract, meaning that pre-mordanting with $Al_2(SO_4)_3$ influences higher uptake of turmeric dye onto cotton fabric.

Turmeric dyed textiles have poor wash-fastness [4]. However it is indicated that mordanting increases wash-fastness of natural dyes [1]. In Table 4 and 5 the CIE *L*a*b** values of washed samples are presented. The samples dyed with 2 g/l of turmeric extract are lighter and less yellow after washing (Table 4). The samples dyed with 20 g/l of turmeric extract are lighter, greener and less yellow after washing. The colour differences (Figures 6 and 7) between unwashed and washed samples are very high (ΔE^*ab values are higher than 15), meaning that fastness to washing is very poor and that mordanting did not significantly increased the wash-fastness. Nevertheless, the best results on fastness to washing were found for dyed samples that were mordanted with $FeSO_4$, regardless of the dyeing concentration. The fastness to washing for samples dyed with 2 g/l of turmeric extract increased in following order: post-Al < non-mordanted < pre- and meta-Al < Zn < tannin < Fe. The fastness to washing for samples dyed with 20 g/l of turmeric extract increased in following order: post-Zn < non-mordanted < pre- and meta-Zn < Al < tannin < Fe. In both cases mordanting with FeSO4 and tannin improved wash fastness.

*Table 4: CIE L*a*b* colour values of non-mordanted (UN_w) and mordanted samples dyed with 2 g/l of turmeric extract after washing (w)*

Sample	*L**	*a**	*b**
UN_w	92.71	–5.41	36.24
Pre_Fe_w	90.38	–3.68	31.33
Meta_Fe_w	86.71	0.51	24.51
Post_Fe_w	89.89	–2.85	34.17
Pre_Zn_w	92.91	–5.79	40.92
Meta_Zn_w	92.93	–6.23	42.11
Post_Zn_w	92.90	–5.93	39.25
Pre_Al_w	93.11	–6.05	36.89
Meta_Al_w	92.74	–6.06	40.33
Post_Al_w	92.88	–5.84	37.71
Pre_Tan_w	91.79	–5.63	39.53
Meta_Tan_w	91.55	–5.62	39.72
Post_Tan_w	91.94	–5.76	37.36

*Table 5: CIE L*a*b* colour values of non-mordanted (UN_w) and mordanted samples dyed with 20 g/l of turmeric extract after washing (w)*

Sample	*L**	*a**	*b**
UN_w	87.56	–1.51	53.87
Pre_Fe_w	63.36	7.58	36.59
Meta_Fe_w	84.87	–0.32	36.46
Post_Fe_w	78.28	2.54	40.44
Pre_Zn_w	87.66	–1.96	55.63
Meta_Zn_w	89.78	–3.49	53.48
Post_Zn_w	88.31	–2.82	53.45
Pre_Al_w	85.86	–0.57	54.10
Meta_Al_w	89.42	–3.08	53.94
Post_Al_w	88.47	–2.44	54.80
Pre_Tan_w	88.06	–2.95	54.09
Meta_Tan_w	88.55	–3.28	54.19
Post_Tan_w	88.40	–2.68	55.57

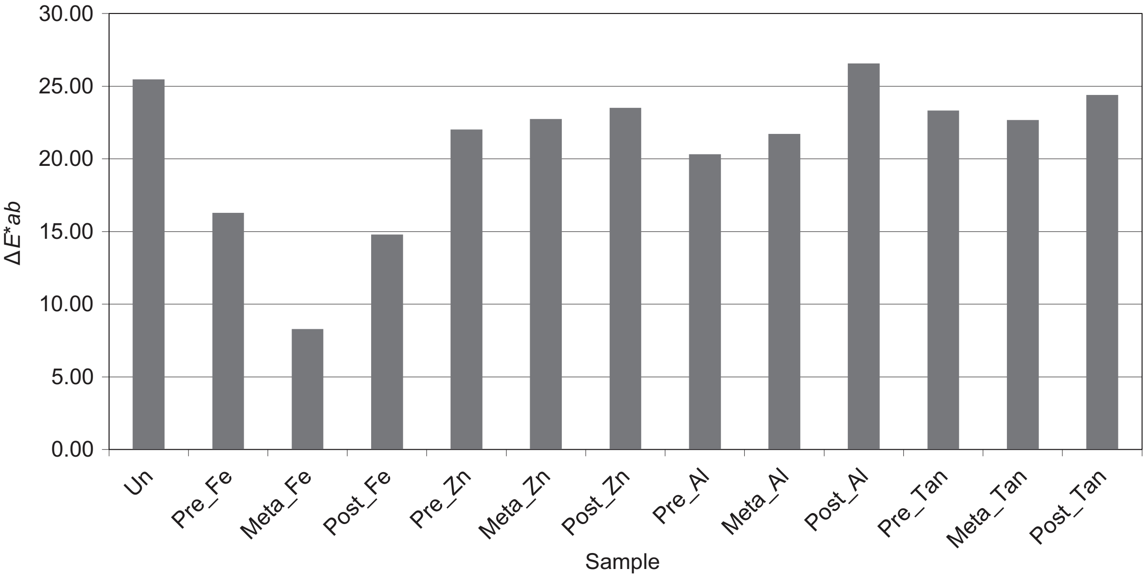

*Figure 6: Colour differences (ΔE*ab) between non-washed and washed samples dyed with 2 g/l of turmeric extracttract*

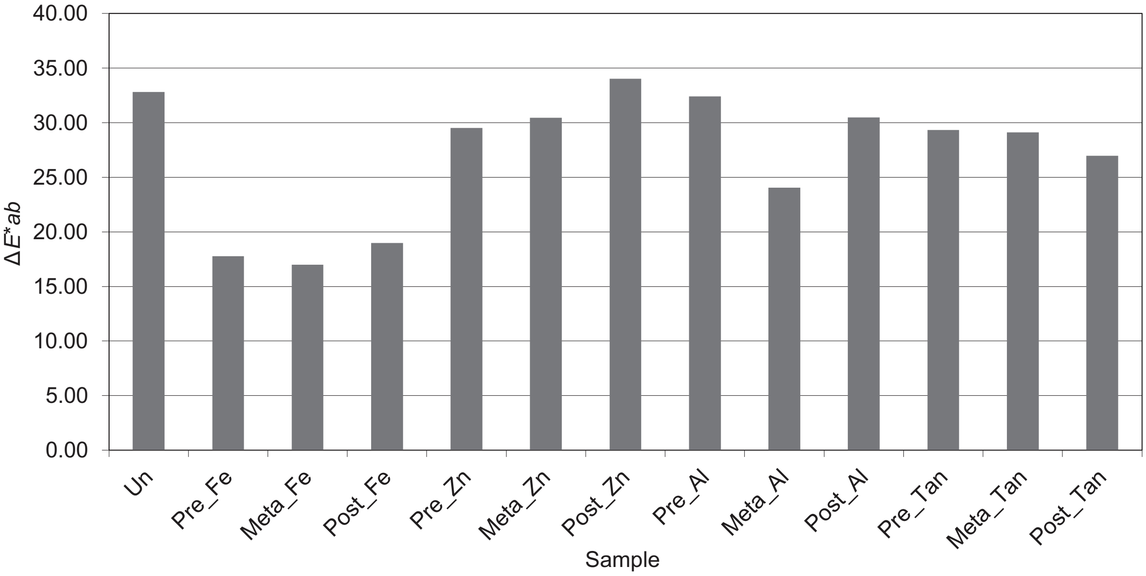

*Figure 7: Colour differences (ΔE*ab) between non-washed and washed samples dyed with 20 g/l of turmeric extract*

The results of colour fastness to hot pressing of samples dyed with 2 g/l of turmeric extract are presented in Table 6. The results indicate that general rating according to grey scale test of change in colour is the same for all samples, except for *Pre_Fe, Post_Fe, Pre_Tan* and *Post_Tan* samples, where the rating is lower than for untreated sample. Wet accompanying fabrics of mordanted samples have in general higher ratings according to grey scale test than unmordanted sample, while dry accompanying fabrics of mordanted samples have the same ratings as unmordanted sample.

For samples dyed with 20 g/l of turmeric extract the general rating according to grey scale test of change in colour is the same for all samples, except for *Meta_Fe, Post_Fe* and *Pre_Tan,* where the rating is

Table 6: Colour fastness to hot pressing of samples dyed with 2 g/l of turmeric extract according to grey scale

Sample	Grey scale test		
	Accompanying fabric (wet)	Accompanying fabric (dry)	Change in colour
UN	3–4	4–5	4–5
Pre_Fe	4–5	5	2
Meta_Fe	4	4–5	4–5
Post_Fe	2	4–5	4
Pre_Zn	4	4–5	4–5
Meta_Zn	3–4	3	4–5
Post_Zn	4	4–5	4–5
Pre_Al	4–5	5	4–5
Meta_Al	4	4–5	4–5
Post_Al	4	4–5	4–5
Pre_Tan	4	4–5	4
Meta_Tan	4–5	5	4–5
Post_Tan	4	4–5	4

Table 7: Colour fastness to hot pressing of samples dyed with 20 g/l of turmeric extract according to grey scale

Sample	Grey scale test		
	Accompanying fabric (wet)	Accompanying fabric (dry)	Change in colour
UN	1–2	2	4–5
Pre_Fe	1–2	2–3	4–5
Meta_Fe	3–4	4–5	4
Post_Fe	4	4	4
Pre_Zn	2	2–3	4–5
Meta_Zn	3–4	3–4	4–5
Post_Zn	2	3	4–5
Pre_Al	1–2	2–3	4–5
Meta_Al	4	4–5	4–5
Post_Al	3	4	4–5
Pre_Tan	2	3	2–3
Meta_Tan	2	3–4	4–5
Post_Tan	2	3–4	4–5

lower than for untreated sample. Wet and dry accompanying fabrics of mordanted samples have higher ratings according to grey scale test than non-mordanted sample, meaning that mordanting did increase the colour fastness to hot pressing.

4 Conclusion

Mordanting application method and the used mordant greatly influence the dyeability of cotton with turmeric extract. Mordant such as ferrous sulphate in general gives significantly darker and redder dyeings than other mordants. Samples mordanted using ferrous sulphate and dyed are visibly not yellow as they are in other cases. In order to obtain yellow dyeing of cotton, mordanting should be performed using aluminium sulphate, zinc chloride and tannin, or by not using mordant at all. However, mordanting improves colour fastness. Increased colour fastness to washing and hot pressing was achieved for dyed cotton samples mordanted with ferrous sulphate, aluminium sulphate and tannin. To achieve higher dye uptake, mordanting (regardless of used mordant) should be performed before dyeing (pre-mordanting). The results showed that mordanting should not be performed during dyeing (meta-mordanting) due to the formation of dye-mordant complex, which prevents dye to be adsorbed onto substrate. At higher dyeing concentration this effect is even more pronounced. The best result of increased dyeability with turmeric extract was achieved by pre-mordanting with aluminium sulphate. Colour fastness of dyed samples was in general improved by mordanting, however the highest colour fastness was found for samples meta-mordanted with ferrous sulphate.

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