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The Influence of the Treatment Process on the Dyeability of Cotton Fabric using Goldenrod Dye

Vpliv postopka obdelave bombažne tkanine na obarvljivost z barvilom zlate rozge

Abstract

The influence of the treatment process on the dyeability of cotton fabric with a natural dye from goldenrod blooms was studied in this research. The dyeing was performed on untreated and treated cotton samples. The treating of the samples, using mordant ($KAl(SO_4)_2 \times 12\,H_2O$), was performed before and during the dyeing process, whilst treatment with a cationic agent (Denimcol FIX-OS) was performed only before dyeing. The dyeing was carried out at 60 °C in two repetitions in three different concentrations of goldenrod aqueous extract, namely without dilution, and by diluting the extract with distilled water at volume ratios of 1:2 and 1:3. Spectrophotometric measurements were done before and after 1, 5, and 10 washing cycles. Colour fastness to rubbing was visually evaluated using a grey scale. Colour fastness to artificial light was visually evaluated using a blue scale, as well as spectrophotometrically before and after illumination of the dyed samples. The results of the research show that the cationic treatment of cotton fabric essentially influences on higher dye uptake in comparison to treatment using mordant before or during dyeing. Cotton samples that are treated with a cationic agent have the highest colour fastness to washing, rubbing, and light among all of the studied samples.
Keywords: Solidago virgaurea, mordanting, cationic treatment, invasive species

Izvleček

V okviru raziskave je bil preučevan vpliv postopka obdelave bombažne tkanine na obarvljivost z naravnim barvilom, pridobljenim iz socvetja zlate rozge. Barvanje je bilo izvedeno na neobdelanih in obdelanih vzorcih. Obdelava vzorcev s čimžo ($KAl(SO_4)_2 \times 12\,H_2O$) je potekala pred in med barvanjem, obdelava s kationskim sredstvom (Denimcol FIX-OS) pa pred barvanjem. Barvanje je bilo izvedeno v dveh ponovitvah pri 60 °C in pri treh različnih koncentracijah vodnega ekstrakta zlate rozge, in sicer brez redčenja in z redčenjem z destilirano vodo v volumskih razmerjih 1:2 in 1:3. Spektrofotometrične meritve pobarvanih vzorcev so bile izvedene pred in po enem, petih in desetih pranjih. Barvna obstojnost na drgnjenje je bila ocenjena vizualno po sivi skali. Barvna obstojnost na umetni svetlobi je bila ocenjena vizualno po modri skali in spektrofotometrično na pobarvanih vzorcih pred osvetljevanjem in po njem. Rezultati raziskave kažejo, da kationska obdelava bombažne tkanine bistveno izboljša navzemanje barvila zlate rozge iz barvalne kopeli v primerjavi z obdelavo, kjer je potekalo čimžanje pred ali med barvanjem. Kationsko obdelani vzorci so imeli tudi najboljše barvne obstojnosti na pranje, drgnjenje in na svetlobi.
Ključne besede: Solidago virgaurea, čimžanje, kationska obdelava, invazivna vrsta

1 Introduction

Natural dyes are biodegradable and environmentally friendly [1], whilst residues after dyeing can be used as fertilisers in the agriculture industry. The great advantage of natural dyes is their friendliness to the skin. Even if they bleed, they do not stain other textiles, with the exception of turmeric [2]. When

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using natural dyes their numerous deficiencies should be eliminated, especially their low affinity to cellulosic fibres.

Goldenrod (*Solidago*) is a green perennial of the Aberdeen family [3]. The goldenrod comes from North America [4], but it can be found elsewhere in the world, including Europe, where it was brought as a decorative plant at the end of the 17th century [3]. Representatives of both indigenous and invasive Solidago species can be found in Slovenia. The autochthon goldenrod is a common goldenrod (*Solidago virgaurea*), while the invasive are Canadian (Solidago canadensis) and giant (*Solidago gigantea*) goldenrod [3]. Goldenrod represents a major environmental problem on one hand, but it can also be beneficial. Due to its antibacterial activity, it can be used for healing purposes. Today its active substances can be found in many pharmaceutical preparations, especially in diuretics. The goldenrod contains dyes, namely flavonoids, including quercetin, quercitirin, isoquercitrin, rutin, and kaempferol (Figure 1) [5]. All of the above the ground parts of the plant can be used – the stem, leaves, buds, and blooms.

In the studies using goldenrod for dyeing, the researchers studied how the type and concentration of metal salt, dye concentration, the content of total phenols in the dye extract, and the liquor-to-goods ratio influence the dyeability of textiles [5–8]. Exhaust dyeing is one of the most frequently used dyeing processes for dyeing with goldenrod dye found in the literature, where the liquor-to-goods ratio depends on the substrate composition and its form (yarn, fabric) [5–8]. Dyeing is usually performed at boiling temperature and lasts for a maximum of 60 minutes, followed by several rinsings to remove unfixed dye from the textile surface. The use of metal salts before, during, or after dyeing is recommended to improve the colour fastness of textiles dyed with natural dyes. The most often used metal salts are iron (II) chloride ($FeCl_2$), iron (II) sulfate heptahydrate ($FeSO_4 \times 7\ H_2O$), and potassium aluminium sulfate dodecahydrate ($KAl(SO_4)_2 \times 12\ H_2O$) [6, 7]. In one of the studies found that the metal salt types influence the colour shade of the textile dyed with goldenrod extract. Iron salt ($FeSO_4 \times 7\ H_2O$) caused a darkening of the colour in comparison to samples of wool and flex dyed without metal salt. In one-bath dyeing when metal salt (Fe (II) or Al salts) is added into the dyebath during the dyeing process, the economically more acceptable process

a

quercetin

b

quercitirin

c

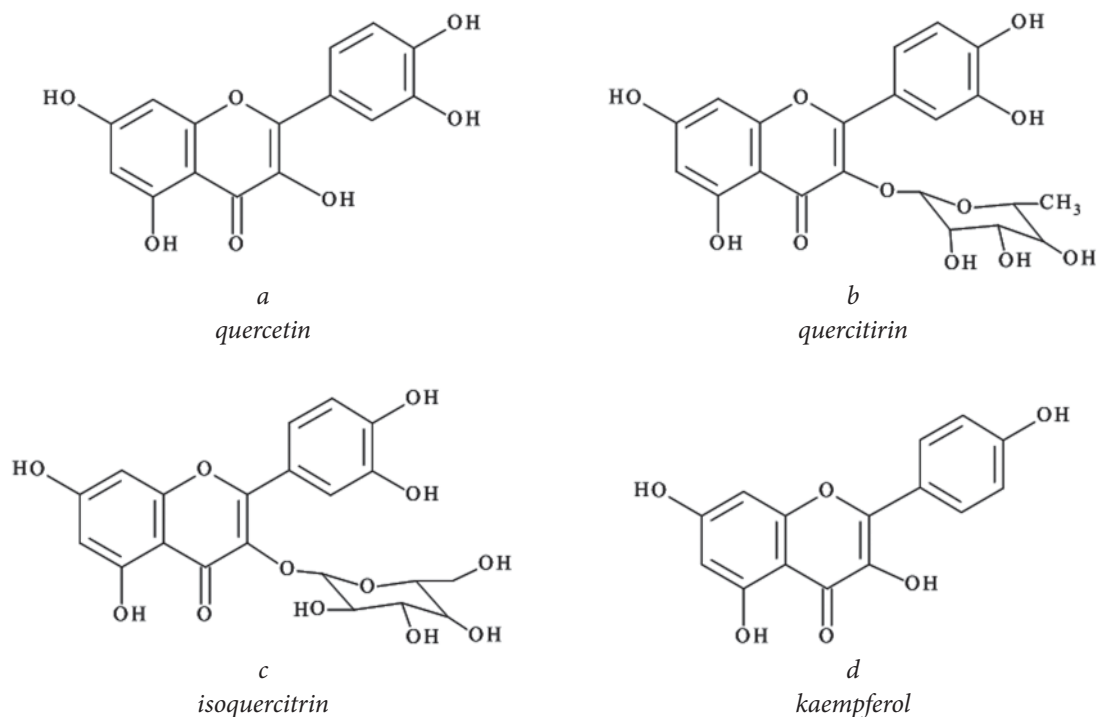*isoquercitrin*

d

kaempferol

Figure 1: Chemical structures of goldenrod dyes

is used due to lower consumption of water in comparison to the two-bath process, which treats the textile with metals salt in the first bath, and then dyeing in the second bath. Moreover, mordants, based upon Co, Sn, or Cr salts, could cause problems with effluents released from the dyeing process because of the waste water limits defined for the concentrations of heavy metals [7].

In the literature no research of the use of a cationic agent to increase the adsorption of goldenrod dye onto cotton fabric can be found. Therefore, the aim of the research was to increase the dyeability of cotton fabric with goldenrod dye from an aqueous extract of fresh flowers of the plant. For that purpose a comparison between the treatment of fabric with a cationic agent and metal salt was performed in the research. Samples of cotton fabric were mordanted using aluminium salt ($KAl(SO_4)_2 \times 12\ H_2O$) before and during the dyeing process, whilst treatment of the cotton fabric with a commercial reactive polyammonium compound (Denimcol FIX-OS) was performed only before dyeing. Colour fastness to rubbing, washing, and light was also carried out. It was assumed that the use of metal salt before or during dyeing contributes to the improvement of the dyeing quality to a lesser extent than chemical modification of cotton fabrics with a reactive polyammonium compound. The latter enables the introduction of cationic sites onto which anionic dyes can be adsorbed more willingly, and to a greater extent due to electrostatic attractive interactions.

2 Experimental

2.1 Fabric

Chemically bleached cotton fabric produced by Tekstina tekstilna industrija Ajdovščina, d. o. o. with the construction parameters, presented in Table 1, was used in the research.

Table 1: Construction parameters of the fabric

Composition	Weave	Mass per unit area [g/m²]	Fabric density [cm⁻¹]	
			warp	weft
100% cotton	plain	124	50	30

2.2 Textile auxiliaries and chemicals

The reactive polyammonium compound Denimcol FIX-OS (CHT, Switzerland), potassium aluminium sulfate dodecahydrate ($KAl(SO_4)_2 \times 12\ H_2O$), sodium hydroxide (NaOH 36°Bé), and acetic acid (CH_3COOH 30 %) were used in the research.

2.3 Preparation of dyeing extract and treatments of cotton fabric

2.3.1 Preparation of aqueous extract from goldenrod plant

Goldenrod flowers were collected in Ljubljana Marshes on 23rd of August 2017. They were freshly frozen. Before use, the flowers were defrosted. An aqueous extract of goldenrod flowers was prepared at LR 20:1 with distilled water. The extract was boiled for 60 minutes and then filtered. Three concentrations of extract were used for dyeing, namely without dilution (C_0) and with a dilution at volume ratios 1:2 (C_1) and 1:3 (C_2) using distilled water. The preparation of the sufficient quantity of the extract enables us to achieve repeatability of all of the dyeings.

2.3.2 Treatments of cotton fabric

Samples of cotton fabric were mordanted before and during dyeing, as well as treated with a cationic agent before dyeing. The mass of each sample was 5 g.

Pre-mordanting

Mordanting of samples before dyeing (CP) was carried out at a temperature of 50 °C for 30 minutes with 3 g/L $KAl(SO_4)_2 \times 12\ H_2O$ at LR = 20:1 in the GyroWash apparatus (James Heal, Great Britain). After mordanting the samples were dyed.

Meta-mordanting

Mordanting of samples during the dyeing process (MP) was performed as follows. After 10 minutes of dyeing samples at 60 °C, 3 g/L $KAl(SO_4)_2 \times 12\ H_2O$ was added into the dyebath and dyeing was continued for a further 50 minutes at the same temperature in the GyroWash apparatus.

Cationic pre-treatment

Prior to dyeing, the samples (KP) were treated at liquid ratio (LR) = 10:1 with 5% Denimcol FIX-OS and 2.75 ml/l NaOH 36°Bé for 20 minutes at 50 °C in the GyroWash apparatus. Then the samples were rinsed in cold (25 °C) distilled water and

neutralised. Neutralisation of the samples with 5 ml/l CH$_3$COOH 30% at LR = 10:1 lasted for 10 minutes. After neutralisation samples were rinsed in cold distilled water. Dyeing of the samples was carried out in an aqueous extract of goldenrod flowers for 60 minutes at 60 °C.

2.3.3 Dyeing
Untreated (BE) and treated (CP, MC, and KP) samples of cotton fabric were dyed for 60 minutes in the GyroWash apparatus at LR = 20:1 at a temperature of 60 °C. The dyeing was carried out at two replicates. After dyeing, the samples were rinsed in warm (40 °C) and cold (25 °C) distilled water to remove unfixed dye from the samples. After rinsing samples were air dried on flat surface at room temperature (24 °C). Before spectrophotometric measurements and different testing methods, the samples were stored in the dark.

2.4 Sample labeling
The labels of samples, used in the research, are collected in Table 2.

2.5 Analytic methods

2.5.1 Spectrophotometric measurements
Spectrophotometric measurements of samples were performed using spectrophotometer Spectraflash 600 PLUS-CT (Datacolor, Switzerland) within a measuring range of 400–700 nm, geometry d/8°, illuminant D65, 10° standard observer, UV-filter off, specular included, 9-mm aperture size, and four layers of the sample. Ten measurements were performed on each sample.

2.5.2 Colour fastness to rubbing
Colour fastness to dry and wet rubbing was performed according to the standard SIST EN ISO 105-X12:2016 [9] on Crockmeter M238BB (SDL Atlas, USA). Colour fastness to rubbing was visually assessed using grey scale.

2.5.3 Colour fastness to domestic and commercial laundering
Colour fastness to domestic and commercial laundering was performed using the standard SIST EN ISO 105-C06:2010 [10] in the GyroWash apparatus with ECE reference detergent without optical brightener. The laundering conditions are collected in Table 3.

After washing, the samples were rinsed twice. Each rinsing, using 100 ml of distilled water, lasted for 1 minute at a temperature of 40 °C. Then, the samples were air-dried on a flat surface at room temperature. Colour fastness to washing was spectrophotometrically evaluated by the determination of colour difference between unwashed and washed samples after the first washing cycle (A1S test method), 5 washing cycles (A1M test method), and 10 washing cycles (the A1M test method was repeated twice).

Table 2: Samples labels and descriptions

Sample	Description of the sample
BE_X	sample dyed in goldenrod extract at different extract concentrations, i.e. X = 0 for C$_0$; 1 for C$_1$ and 2 for C$_2$
CP_X	pre-mordanted and dyed sample at different extract concentrations, i.e. X = 0 for C$_0$; 1 for C$_1$ and 2 for C$_2$
MC_X	meta-mordanted and dyed sample at different extract concentrations, i.e. X = 0 for C$_0$; 1 for C$_1$ and 2 for C$_2$
KP_X	cationic pre-treated and dyed sample at different extract concentrations, i.e. X = 0 for C$_0$; 1 for C$_1$ and 2 for C$_2$

Table 3: Laundering conditions

Test method	$T_{washing}$ [°C]	$t_{washing}$ [min]	$V_{washing}$ [ml]	$c_{detergent}$ [g/l]	Number of stainless steel balls
A1S	40	30	150	4	10
A1M	40	45	150	4	10

2.5.4 Colour fastness to artificial light

Colour fastness to artificial light was performed according to the standard ISO 105-B02:1994 [11] in the Xenotest Alpha (Atlas, USA) apparatus. Colour fastness was evaluated visually using blue scale and spectrophotometrically by determination of colour difference between samples before and after exposure to xenon arc lamp.

3 Results and discussion

In Table 4, the CIELAB colour values, chroma (C_{ab}^*), hue angle (h_{ab}), and colour difference (ΔE_{ab}^*) of dyed samples are collected. In Tables 5–9 the results of colour fastness to rubbing, domestic and commercial laundering, and light are shown.

From Table 4 it can be seen that the CIELAB colour values are dependent on both the dye concentration in the extract and the type of treatment of cotton fabric before or during dyeing process. With the decrease of dye concentration in the dyebath, samples became lighter (values of L^* increased), whilst values of a^* and b^* vary. The samples, dyed with the dye extract (BE) are lighter, greener, and less yellow than the other samples. The samples mordanted before dyeing (CP) are darker, less green, and more yellow than BE samples. The samples mordanted during dyeing (MC) are darker than BE and CP samples, less green, and more

yellow. The samples cationized before dyeing (KP) are the darkest among the studied samples, redder, and less yellow than CP and MC samples, and almost equally yellow as BE samples. From Table 4 it can be also seen that the values of b^* decrease with decreasing of dye concentration in the extract. The same can be observed for a^* values, the exceptions are CP samples where the influence of extract concentration is less perceptible. The levelness of the dyed fabric, expressed with the ΔE_{ab}^* value, showed that KP samples are the most evenly dyed, followed by the MC samples, CP samples, and lastly the BE samples. The highest colour difference calculated between BE samples and other studied samples is observed in KP samples, followed by MC samples, whilst the lowest colour difference can be observed in CP samples.

From Table 5 it can be seen that the samples have very good to excellent colour fastness to dry and wet rubbing (grades 4/5 and 5 on a grey scale) in both directions, warp and weft. Samples are less resistant to wet than dry rubbing. Good colour fastness to rubbing is a consequence of a low concentration of dyestuffs in the dyebath.

It can be seen from Tables 6 to 8 that the CIELAB values of the studied samples changed with the number of washing cycles. Washed samples became lighter, because L^* values increased, irrespective of both the dye concentration in the extract, and the type of treatment of cotton fabric before or during

Table 4: CIELAB colour values, chroma (C_{ab}^*), hue angle (h_{ab}), and colour difference (ΔE_{ab}^*) of studied samples

Extract concentration	Sample treatment	L^*	a^*	b^*	C_{ab}^*	h_{ab} [°]	ΔE_{ab}^* [1]	ΔE_{ab}^* [2]
C_0	BE	86.97	−3.08	33.13	33.28	95.32	2.25	/
	CP	84.30	−2.69	36.86	36.96	94.17	1.53	4.60
	MC	81.45	−1.97	44.99	45.04	92.52	1.23	13.13
	KP	71.99	1.99	29.03	29.10	86.07	0.87	16.34
C_1	BE	88.45	−3.53	27.16	27.38	97.42	1.00	/
	CP	83.37	−2.51	36.74	36.83	93.91	0.75	10.89
	MC	83.58	−2.26	38.55	38.62	93.35	0.68	12.45
	KP	75.83	0.82	30.11	30.12	88.44	0.89	13.67
C_2	BE	89.97	−3.68	24.20	24.48	98.64	0.67	/
	CP	84.69	−2.67	34.54	34.65	94.42	0.79	11.65
	MC	84.60	−2.56	34.95	35.05	94.20	0.70	12.07
	KP	78.63	0.30	28.16	28.16	89.38	0.82	12.65

[1] Colour difference is calculated between the first measurement on the sample (standard) and other measurements on the sample (batch) for determination of dyed sample levelness.
[2] Colour difference is calculated between sample BE and other samples (CP, MC, and KP).

dyeing process. The KP samples are exception, because the L^* value decreases with an increasing number of washing cycles. This means that the samples became darker. After washing BE and CP samples became less green (a^* value increases) and less yellow (b^* value decreases), MC samples became more green (a^* value decreases) and less yellow (b^* value strongly decreases with increasing number of washing cycles), and KP samples became less red (a^* value decreases) and more yellow (b^* value increases) even though the difference in b^* values before

and after washing are less observable. From Figures 2 to 4 it can be also seen that the colour difference increases with an increasing number of washing cycles, irrespective of the dye concentration in the extract. The highest colour difference is achieved in MC samples, and the lowest in KP samples. The increase of colour difference means that the dye is removed from the cotton fabric during washing. Since the lowest colour difference was obtained in KP samples, we conclude that the goldenrod dye makes the strongest binding to cotton fabric. The weakest

Table 5: Visual assessment of colour fastness to dry and wet rubbing using a grey scale

Extract concentration	Sample treatment	Grey scale grade			
		Dry rubbing		Wet rubbing	
		Warp	Weft	Warp	Weft
C_0	BE	5	5	4/5	4/5
	CP	5	5	4/5	4/5
	MC	4/5	4/5	4/5	4/5
	KP	5	5	4/5	4/5
C_1	BE	5	5	5	5
	CP	5	5	5	5
	MC	4/5	4/5	4/5	4/5
	KP	5	5	4/5	4/5
C_2	BE	5	5	5	5
	CP	5	5	4/5	4/5
	MC	4/5	5	4/5	4/5
	KP	4/5	5	5	5

Table 6: CIELAB colour values, chroma (C^*_{ab}) and hue angle (h_{ab}) of dyed samples after first washing cycle

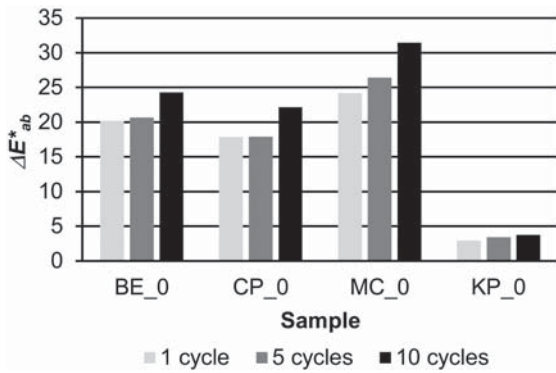| Extract concentration	Sample treatment	L^*	a^*	b^*	C^*_{ab}	h_{ab} [°]
C_0	BE		−1.84	13.31	13.43	97.86
	CP	88.71	−1.52	19.60	19.66	94.44
	MC	89.13	−2.09	22.03	22.13	95.42
	KP	69.60	1.20	30.52	30.55	87.76
C_1	BE	90.70	−1.66	12.53	12.64	97.54
	CP	89.95	−1.96	18.09	18.20	96.18
	MC	91.06	−2.40	17.76	17.93	97.70
	KP	72.92	0.73	31.01	31.02	88.64
C_2	BE	92.19	−1.50	10.19	10.30	98.35
	CP	91.09	−2.11	16.20	16.34	97.42
	MC	91.54	−2.38	15.48	15.67	98.75
	KP	75.87	0.29	29.11	29.12	89.42

Figure 2: Colour difference (ΔE^*_{ab}) between unwashed and washed dyed samples in extract concentration C_0
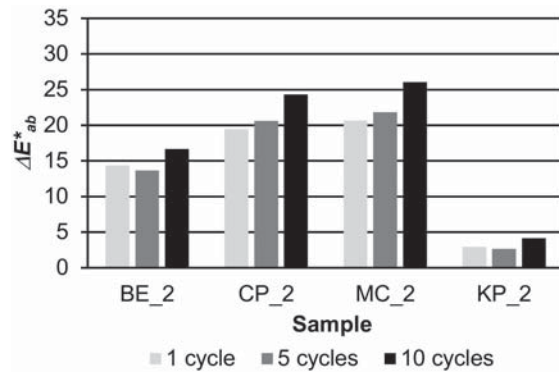

Figure 4: Colour difference (ΔE^*_{ab}) between unwashed and washed dyed samples in extract concentration C_2
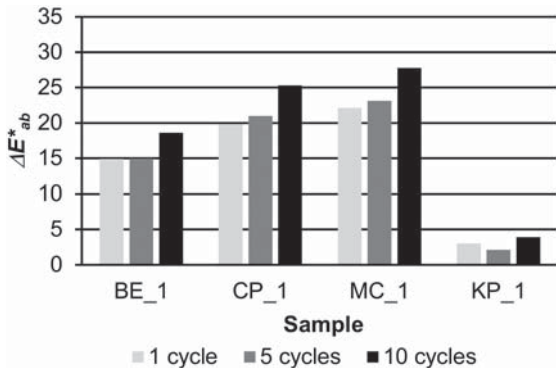

Figure 3: Colour difference (ΔE^*_{ab}) between unwashed and washed dyed samples in extract concentration C_1

dyeing process. In samples dyed with a lower dye concentration, lower colour differences were obtained than in samples dyed with a higher dye concentration. The latter is understandable since the adsorption of dye onto cotton fabric is lower at a lower dye concentration than in a higher dye concentration.

It can be seen from Table 9 that the studied samples have very poor colour fastness to light (grade 1 on a blue scale). Comparison of CIELAB values before and after illumination (Tables 4 and 9) shows that after illumination the samples became lighter (L^* value increases), whilst a^* and b^* values increased or decreased, depending on the treatment of cotton fabric before or during dyeing process. After illumination BE, CP and MC samples became less green and less yellow, while KP samples became redder

binding of goldenrod dye to cotton fabric is observed in MC samples, which were mordanted during

Table 7: CIELAB colour values, chroma (C^*_{ab}), and hue angle (h_{ab}) of dyed samples after 5 washing cycles

Extract concentration	Sample treatment	L^*	a^*	b^*	C^*_{ab}	h_{ab} [°]
C_0	BE	91.16	−1.76	12.91	13.03	97.78
	CP	88.79	−1.79	19.55	19.63	95.24
	MC	89.56	−2.10	19.82	19.93	96.04
	KP	68.85	1.28	30.15	30.18	87.57
C_1	BE	91.36	−1.92	12.61	12.75	98.64
	CP	89.96	−1.87	16.86	19.96	96.34
	MC	90.97	−2.32	16.66	16.82	97.94
	KP	73.94	0.50	29.23	29.23	89.02
C_2	BE	91.95	−1.77	10.81	10.96	99.29
	CP	91.03	−1.98	14.96	15.09	97.56
	MC	91.62	−2.26	14.26	14.44	99.02
	KP	76.07	0.25	28.79	28.79	89.51

Table 8: CIELAB colour values, chroma (C_{ab}^*), and hue angle (h_{ab}) of dyed samples after 10 washing cycles

Extract concentration	Sample treatment	L^*	a^*	b^*	C_{ab}^*	h_{ab} [°]
C_0	BE	91.08	−1.94	9.19	9.39	101.93
	CP	89.09	−2.15	15.23	15.38	98.04
	MC	89.81	−2.33	14.68	14.87	99.04
	KP	68.45	1.12	30.02	30.04	87.86
C_1	BE	91.24	−2.03	8.83	9.06	102.95
	CP	89.99	−2.01	12.33	12.49	99.26
	MC	90.83	−2.38	11.74	11.98	101.44
	KP	72.15	0.45	28.82	28.82	89.12
C_2	BE	91.69	−1.98	7.72	7.97	104.43
	CP	90.70	−1.98	10.98	11.15	100.23
	MC	91.57	−2.27	9.83	10.09	103.02
	KP	74.50	0.05	27.73	27.73	89.89

Table 9: Visual assessment of colour fastness to light using blue scale and CIELAB colour values, chroma (C_{ab}^*), and hue angle (h_{ab}) of the studied samples after illumination

Extract concentration	Sample treatment	Blue scale grade	L^*	a^*	b^*	C_{ab}^*	h_{ab} [°]	ΔE_{ab}^* [1]
C_0	BE	1	89.56	−0.62	13.06	13.08	92.72	20.39
	CP	1	87.59	−0.32	17.73	17.73	91.04	19.55
	MC	1	85.67	0.74	18.53	18.54	87.73	26.93
	KP	1	79.85	2.95	18.25	29.1	86.07	13.38
C_1	BE	1	88.73	−0.53	14.65	14.66	92.06	12.87
	CP	1	89.27	−0.47	14.23	14.24	91.91	23.36
	MC	1	89.51	−0.36	14.61	14.62	91.40	24.74
	KP	1	84.62	1.54	15.27	15.34	84.26	17.26
C_2	BE	1	91.54	−0.91	8.40	8.45	96.17	16.12
	CP	1	90.43	−1.12	12.98	13.02	94.94	22.36
	MC	1	91.17	−0.94	11.84	11.87	94.55	24.08
	KP	1	86.59	1.00	13.79	13.83	85.84	16.44

[1] Colour difference (ΔE_{ab}^*) is calculated between dyed samples before and after illumination

and less yellow. The highest difference in CIELAB values of studied samples before and after illumination is observed in b^* values, which dropped by 10 to 20 units and is dependent on treatment of cotton fabric before or during dyeing process. It can be also seen from ΔE_{ab}^* values (Table 9), that the colour fastness to light of the samples treated with a cationic agent is higher in comparison to BE, CP, and MC samples. Among the studied samples; MC samples have the poorest colour fastness to light.

4 Conclusion

According to the obtained results the following can be pointed out:
• The type of treatment of cotton fabric before or during dyeing with goldenrod extract influences dyeing levelness, CIELAB colour values, and colour fastness to rubbing, washing, and light.
• Cotton fabric dyed with goldenrod extract is the most unevenly dyed among all of studied

samples. It has also very poor colour fastness to washing and light, whilst its colour fastness to dry and wet rubbing is excellent.

- Pre-mordanting of cotton fabric with $KAl(SO_4)_2 \times 12 H_2O$ causes higher dye uptake from the dyebath. Cotton fabric is more evenly dyed and has excellent colour fastness to dry rubbing, and good to wet rubbing. Colour fastness to washing and light are very poor.
- Meta-mordanting of cotton fabric with $KAl(SO_4)_2 \times 12 H_2O$ causes higher dye uptake from the dyebath comparing to pre-mordanted samples. Dyed fabric has good colour fastness to dry and wet rubbing, as well as very poor colour fastness to washing and light.
- Cationization of cotton fabric improved uptake of goldenrod dye from the dyebath. The dyed fabric is the most evenly dyed. The dyed sample has excellent colour fastness to dry and wet rubbing, as well as to washing, whilst its colour fastness to light is very poor, but higher in comparison to other studied samples as can be seen from ΔE_{ab}^{*} values.

According to the above-mentioned facts it can be concluded, that the cationization of cotton fabric proved to be the most suitable treatment of cotton fabric in absorption of goldenrod dye from the dyebath in the studied dyeing conditions. The latter confirmed the grades of colour fastness to rubbing, washing, and light of cationized and dyed fabric.

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