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RESEARCH PAPER

Optimization of conditions for dyeing cotton fabric using onion peel

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Abstract: The present experiment was carried out with the objective to optimize the conditions for dyeing cotton fabric with onion peel. The collected onion peel was cleaned, shade dried, crushed into fine powder and stored in bottle to protect from moisture. The aqueous dye solution was prepared and the different per cent concentrations were heated for 15, 30 and 45 minutes separately by constant stirring and then cooled and filtered. The dye concentration and dyeing time was optimized based on K/s value of the dye solution. Cotton fabric was pre-mordanted with three different mordants (Al_2SO_4, $SnCl_2$ and $FeSO_4$) at 3 per cent concentration for 20 minutes and then dyed separately in optimized dye concentration in all pH conditions. Based on the K/s value the dyeing time and pH was optimized for all the mordants separately. The study revealed that, the cotton fabric pre-mordanted with $FeSO_4$ and dyed in onion peel dye showed good colour strength compared to Al_2SO_4 and $SnCl_2$ pre-mordanted fabric. The L* values in all the samples showed the lighter shades of colour, a* value showed colour shade towards red and b* value towards more yellow shade in all samples.

Key words: Cotton fabric, Natural dyeing , Onion peel

Introduction

Colour is one of nature's components that make the world's human life more aesthetic and fascinating. Colours are associated with our life's emotions, human qualities, seasons, festivals, and passion. A dye can generally be described as a coloured substance with an affinity to the substrate it is applied to. It is therefore a fundamental requirement that coloured textiles should be able to withstand the conditions encountered during post-colour processing and subsequent useful life (Gulrajani *et al*., 2001).

The word natural dye encompasses all natural resource-derived colours such as plants, insects and animals. Due to increased environmental awareness, the use of non-allergic, non-toxic and eco-friendly natural textile colours has become a matter of significant importance in order to avoid any dangerous synthetic colours. Natural colours are considered environmentally friendly as they are obtained from renewable resources in comparison with synthetic colours derived from non-renewable petroleum resources. Many natural dyes do not have substantivity for the fibre and it is important to use mordants. Mordants are typically extracted from metal salts, with alum, chromium, stannous chloride, copper sulphate and ferrous sulphate being the widely used metal salts. Mordant's are metal salts that build a connection between dye and fabrics and also improve the properties of dye uptake (Vankar, 2009). Natural colours without mordants have very low speed properties because they have very low fibre and fabric affinity (Ali *et al*., 2007). When used together and in different percentages, it gives different shades (Wanyama, *et al*., 2015). Natural dyes have been used to paint clothing fabrics since the Bronze Age but their applications have been extended in recent years to antimicrobial textile finishing, UV protective clothing, food colouring, cosmetics and pharmaceuticals *etc.* (Adeel *et al*., 2013). Natural dyes contain those colourants that are attained from vegetable and animal matter without applying any chemicals.

Cotton fabric is the world's most widely used textiles, accounting for more than 50 percent of total cellulose consumption. Many types of dyes can be used to dye cellulosic fibres, including vat, direct, reactive, sulfur dyes, different groups varying in factors such as cost, ease of application, speed properties, etc. Characteristically, reactive dyes provide a wide range of shades of good light speed and excellent cellulosic fibre-washing speed. Although reactive dyes are commonly used to dye cotton and other cellulosic fibres for fatigue, however, the dyes suffer the disadvantage that dye-fibre reaction is not 100 per cent effective. This can be due to the dye's incomplete fatigue, the adsorbed dye's incomplete reaction to the fibre and, more significantly, because the dyes will respond to dye hydrolysis not only with the fibre nucleophilic (cellulosate anion) but also with nucleophilic (commonly hydroxyl ions) present in the dye bath .Traditional dyes used in fibre exhaustion are water-soluble and have strong intermolecular fibre interactions. Intermolecular interactions between dye molecules and fibre surfaces serve as a driving force for fibre absorption through diffusion of the dye molecules (Jabar, 2014). In plants, colouring agents are produced from roots, leaves, flowers, barks and fruits. Some important natural colours are pomegranate, eucalyptus, kamala, madder, henna, turmeric, *etc*.

In the food industry, onion peel is considered waste and can cause environmental pollution if not properly discarded. Onions (Allium cepa) have strong characteristic flavors and aromas that have made them important food ingredients. Bioactive compounds have been shown to be present in all areas of the onion bulb. Onion is a potent cardiovascular and anticancer agent whose activity is hypocholesterolemic, antioxidant, antiasthmatic and antithrombotic. Onion is one of the major sources of dietary flavonoids including anthocyanins, which is responsible for the red or purple colour seen in some

varieties, and flavonols (quercetin) which can contribute to the development of yellow and brown compounds found in many onion skins. Thus, the discarded outer skin of the onion is used as dye source for colouring natural textile materials.

Material and methods

The present experiment was carried out at the College of Community Science, University of Agricultural Sciences, Dharwad during 2018-2020.

Fabric sample: Scoured and bleachedcotton fabricof fabric count 62 Ends/inch and 56 picks/inch, 0.290 mm thickness and 0.245g weightcollected from local textile shops was used for dyeing with onion peel dye.

Dye source: Onion peel was collected from APMC and Old Hubli Market. The collected Onion peel was then cleaned, shade dried, crushed into fine powder and stored in bottle to protect from moisture which was further used for dyeing of cotton fabric.

Method of dye extraction: Known quantity of the onion peel was dried under shade, powdered and stored. Five solutions *viz.*, 2g, 4g, 6g, 8g and 10g of dye powder in 100ml of water was prepared separately. These solutions were heated for 15min, 30min and 45 minutes separately by constant stirring, solutions were cooled and filtered (Adeel, 2009). Based on the K/s values, the dye concentration and dye extraction time was standardized for extraction of onion peel dye.

Mordants: Aluminum Sulfate (Al_2SO_4), Stannous Chloride ($SnCl_2$) and Ferrous Sulfate ($FeSO_4$) obtained from the local chemical shop was used as a mordant for the experiment. The scoured and bleached cotton fabric to be dyed with onion peel dye was pre-mordanted with Al_2SO_4, $FeSO_4$ and $SnCl_2$ in 3 per cent concentration separately at 80^0C for 20mins with MLR 1:40. The mordant solution was then allowed to cool and the fabric was rinsed under running water (Managooli, 2009). Based on the K/s values, the dyeing time and pH was standardized separately for all the mordants.

Dyeing of cotton fabric with onion peel dye

Optimized concentration of onion peel dye was used for dyeing of pre-mordanted cotton fabric in acidic, alkaline and neutral conditions. Based on the pH, the solution was brought to acidic or alkaline or neutral by adding acetic acid or NaoH or both respectively during dyeing of cotton fabric. Then the dyed samples were washed and dried under shade. Finally the dyed samples were assessed for colour strength (K/s).

Based on the Colour strength values, dyeing time and pH was optimized for dyeing of pre-mordanted cotton fabric (three mordants) with onion peel dye.

Results and discussion

The onion skin is non edible that consists of dye stuff known as Pelargonidin (3, 5, 7, 4'-tetrahydroxyanthocyanidin), work like acid dyes that can dye the protein fibers at high efficiency. The amount of pelargonidin was found to be 2.25 per cent in certain solvent extraction process using soxhlet apparatus. Onion peel extract showed the presence of hydroxyl, carbonyl C=C, organic sulphanes, tannins, antraquinones, cardiac glycosides, flavonoid and reducing sugar. Due to presence of four hydroxyl groups (Auxochrome groups) pelargonidin exhibits good dyeing properties for dyeing of natural fibers (Mohammad Razamiah *et al.,* 2016). The dyes are having yellow shade. Most of the dyes are derivatives of hydroxyl and methoxy substituted flavones or isoflavones. The chemical structure is as shown below (Jabar, 2014).

Optimization of dye concentration and dye extraction time of Onion peel dye

Table 1 shows the Colour strength (K/s) values of onion peel dye concentrations extracted at different time intervals. The dye concentration and dye extraction time was optimized based on the highest colour strength (K/s) values. It was found that, there was increase in the colour strength values with the increase in the dye concentration and dye extraction time except in 6 per cent dye concentration extracted for 15 mins and 45 mins. But the increase was significant among the dye concentrations extracted for 15 mins. However, the maximum colour strength value was found in 10 per cent concentration of onion peel dye extracted for 45 minutes (1.4280) followed by in the dye extracted for 30 minutes (1.4168). Hence, 10 per cent dye concentration of onion peel dye extracted for 45 minutes was optimized for dye extraction.

Optimization of dyeing time and pH for dyeing of cotton fabric with onion peel dye without mordant

Maximum colour strength was obtained in the fabric sample dyed with 10 per cent onion peel dye (owf) in alkaline pH for 45 minutes (6.302) followed by in neutral condition dyed for 45 minutes (5.60). The cotton fabric dyed with onion peel dye obtained darker shades (L*) at alkaline condition dyed for 45 minutes (58.37) with higher K/s value (6.302). However, with respect to colour coordinates of a* and b* value, it is found that, the dyed fabric showed reddish and yellowish shades when dyed in all pH conditions and at different time intervals. Thus, based on K/s value the dyeing time of 45 minutes in alkaline condition was optimized for dyeing of cotton fabric with 10 per cent onion peel dye concentration without mordant application (Table 2).

Table1. Colour strength (K/s) values of onion peel dye concentrations extracted at different time intervals

Dye	Colour Strength (K/s) Values		
Concentration (%)	15 Min	30 Min	45 Min
2	0.4943	0.7315	0.6930
4	0.7423	0.6885	0.9560
6	0.6133	1.0185	0.6790
8	0.7815	1.2598	1.0933
10	0.9993	1.4168	1.4280

ANOVA

Dyeing Time	S.Em.±	C.D. 5%	CV
15 min	0.131119	0.39771*	14.5%
30 min	0.194633	0.599723^{NS}	
45 min	0.197512	0.608597^{NS}	

* - Significant @5% NS -Non significant

Table 2. Optimization of dyeing time and pH for dyeing of cotton fabric without mordant

pH	Dyeing Time	K/s values	L*	a*	b*
Acidic	15 Min	3.605	69.09	3.82	30.60
	30 Min	4.552	66.87	4.96	32.48
	45 Min	4.417	62.02	8.98	26.94
Neutral	15 Min	4.095	66.86	5.45	31.10
	30 Min	4.778	62.69	8.28	28.04
	45 Min	5.600	66.43	4.78	36.05
Alkaline	15 Min	4.167	65.87	6.43	29.97
	30 Min	4.925	61.32	9.26	30.08
	45 Min	6.302	58.37	0.65	27.76

Optimization of dyeing conditions of cotton fabric pre-mordanted with three per cent Aluminium Sulphate

Cotton fabric pre-mordanted with 3 per cent Al_2SO_4 and dyed with 10 per cent onion peel dye concentration in neutral pH for 45 minutes showed higher colour strength value (6.485) followed by in the sample dyed for 30 minutes (6.107). However, the L* values in all the samples showed the lighter shades, as all the values obtained were above 65.00. Among the samples, a* value of cotton sample pre mordanted with 3 per cent Al_2SO_4 and dyed in neutral condition for 45 minutes showed more redder shade (10.14) followed by in sample dyed for 30 minutes (9.02). The b* value showed more yellower shade in sample pre- mordanted with 3 per cent Al_2SO_4 and dyed in alkaline pH for 45 minutes (29.83) followed by in neutral condition for 30 minutes (29.49). Thus, the dyeing time for dyeing of 3 per cent Al_2SO_4 pre mordanted cotton fabric with 10 per cent onion peel dye concentration was optimized for 45 minutes in neutral condition (Table 3).

Optimization of dyeing conditions of cotton fabric pre-mordanted with 3 per cent Stannous chloride

Cotton fabric pre-mordanted with 3 per cent $SnCl_2$ and dyedwith 10 per cent onion peel dye concentration (owf) in neutral pH for 45 minutes showed higher colour strength value (1.84). However, the L* values in all the samples showed lighter shade (L* value > 70) . Among the samples, a* value of 3 per cent $SnCl_2$ pre-mordanted sample and dyed in alkaline P^H for 45 minutes showed light red shade (7.56) followed by the sample dyed in neutral condition for 45 minutes (7.52). The b* value showed more towards green tint in sample pre-mordanted with $SnCl_2$ and dyed in neutral pH for 45 minutes (10.27)(Table 4).

Thus, the dyeing time for dyeing of 3 per cent $SnCl_2$ pre-mordanted cotton fabric with 10 per cent onion peel dye concentration (on weight of fabric) was optimized for 45 minutes (K/s value:1.84) in neutral pH.

Optimization of dyeing conditions of cotton fabric pre-mordanted with 3 per cent Ferrous sulphate

It is observed from Table 5 that, the cotton fabric pre-mordanted with 3 per cent $FeSo_4$ dyed with 10 per cent onion peel dye concentration in alkaline pH for 30 minutes showed higher colour strength value (10.334) followed by in sample dyed for 45 minutes (10.109). This may be because of the ionization of the hydroxyl group in the dye molecules under alkaline conditions that leads to increase in the K/s value. Also the cotton fabric pre mordanted with 3 per cent $FeSo_4$ and dyed in neutral condition for 45 and 30 minutes showed darker shade (L* value: 6.8 and 7.14 respectively). This is because of mordanting with ferrous sulphate leads to decrease in L* value and increase in K/s (Gawish, 2017). The a* value of samples pre- mordanted with 3 per cent $FeSo_4$ and dyed in neutral condition dyed for 30 minutes showed more towards red tint (12.1) followed by in sample dyed for 45 minutes (11.76) in neutral condition. The b* value showed more yellower tint in sample pre- mordanted with 3 per cent $FeSo_4$ and dyed in neutral pH for 30 minutes (14.05) The colour co-ordinates of the $FeSO_4$ mordanted onion peel dyed cotton fabric showed the colour towards reddish yellow in darker shades.

Thus, the dyeing time of 30 minutes in alkaline pH for dyeing of cotton fabric pre-mordanted with 3 per cent $FeSo_4$ with 10 per cent onion peel dye concentration was optimized based on highest K/s values (10.334). However, 3 per cent $FeSO_4$ pre-mordanted cotton fabric dyed with 10 per cent onion peel dye concentration in alkaline condition for 30 minutes showed higher K/s value compared to fabric pre mordanted with Al_2SO_4 and $SnCl_2$.

Table 3. Optimization of dyeing conditions of cotton fabric pre-mordanted with Aluminium Sulphate (3%)

Spectral value	Acidic pH 3% Al_2SO_4			Neutral pH 3% Al_2SO_4			Alkaline pH 3% Al_2SO_4		
	15 mins	30 mins	45mins	15 mins	30 mins	45mins	15 mins	30 mins	45mins
K/s	5.161	4.4	3.501	5.482	6.107	6.485	4.959	5.244	5.221
L	74.71	72.79	72.55	69.21	66.16	63.33	75.14	73.38	70.85
a*	1.98	5.38	5.53	7.15	9.02	10.14	0.03	0.78	2.60
b*	17.00	20.04	19.11	27.4	29.49	28.99	25.6	28.93	29.83

Table 4. Optimization of dyeing conditions of cotton fabric pre-mordanted with 3 per cent Stannous chloride

Spectral value	Acidic P^H 3% $SnCl_2$			Neutral P^H 3% $SnCl_2$			AlkalineP^H 3% $SnCl_2$		
	15 mins	30 mins	45Mins	15 mins	30 mins	45mins	15 mins	30 mins	45mins
K/s	1.56	1.68	1.65	1.20	1.73	1.84	1.62	1.62	1.68
L	76.61	73.94	72.91	78.99	74.60	72.62	77.03	74.48	72.59
a*	5.69	6.76	7.18	4.78	6.51	7.52	4.82	7.20	7.56
b*	5.03	7.50	7.75	4.22	9.67	10.27	7.23	7.21	8.32

Table 5. Optimization of dyeing conditions of cotton fabric pre-mordanted with 3 per cent Ferrous sulphate

Spectral value	Acidic P^H 3% $FeSo_4$			Neutral P^H 3% $FeSo_4$			Alkaline P^H 3% $FeSo_4$		
	15 mins	30 mins	45Mins	15 mins	30 mins	45mins	15 mins	30 mins	45mins
K/s	5.139	5.337	4.959	5.923	6.968	6.398	9.146	10.334	10.109
L	51.92	52.13	53.86	48.55	7.14	6.8	42.34	39.55	39.51
a*	3.72	3.66	3.53	6.83	12.1	11.76	5.38	5.61	5.35
b*	12.35	12.82	12.57	12.05	14.05	13.58	13.74	13.2	12.57

Compared to $Al_2SO_4$and $SnCl_2$ mordants $FeSo_4$ showed good colour strength because it has good affinity towards cellulosic fibers and also this is because of mordanting with ferrous sulphate which leads to decrease in L* value and increase in K/s (Gawish *et al.,* 2017). This may be because of good affinity of cotton fabric towards alkaline P^H of $FeSO_4$ pre-mordanted cotton fabric dyed in onion peel dye which gave higher K/s value.

In general, all samples showed good colour strength values may be due to the formation of hydrogen bonding between the hydroxyl groups of the tannin formed in onion peel and the hydroxyl group of the cellulose (Kesur *et al.*, 2016) whereas, the L* values in all the samples showed the lighter shades may be because when K/s increased, L value decreased. However, a* value showed colour towards red shade and b* value showed more yellow shade in all samples.

Conclusion

From the results it can be concluded that cotton fabric dyed with onion peel with Al_2SO_4, $SnCl_2$ and $FeSo_4$ mordants showed good colour strength in all the samples due to the formation of hydrogen bonding between the hydroxyl groups of the tannin formed in onion peel and the hydroxyl group of the cellulose. The L* values in all the samples showed the lighter shades because when K/s increased L value decreased. While, a* value showed more colour towards red shade and b* value showed more yellow shade in all samples. However, 10 per cent dye concentration of onion peel extracted for 45 minutes was optimized. Based on K/s values, the dyeing time of 45 minutes in neutral condition was optimized for 3 per cent Al_2SO_4 and $SnCl_2$ pre-mordanted cotton fabric whereas, the dyeing time of 30 minutes in alkaline condition was optimized for dyeing of cotton fabric pre-mordanted with 3 per cent $FeSO_4$ mordant.

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