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Colouring Silk Fabric with Cashew Nut Peel Dye in Combination with Selected Mordants

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ABSTRACT: Different food processing wastes, if used for extraction of dyeing materials, can not only reduce the food processing plant effluents, but also can add to the economics of food processing. Cashew nut peel is one such food processing waste, which can be used as natural dyes. It is important to standardize the dyeing parameters and mordants for its use in dyeing applications. Thus, an attempt was made to determine the colour intensity and fastness of silk fabric treated with five mordants at different concentrations and then dyed with colour extracted from cashew nut peel. The different mordants used were copper sulphate ($CuSO_4$), aluminum sulphate ($Al_2(SO_4)_3$), ferrous sulphate ($FeSO_4$), citric acid ($C_6H_8O_7$) and alum (K_2SO_4, $Al_2(SO_4)_3$, $24H_2O$). The levels of concentrations were taken as 1, 3 and 5%. It was observed that the final shades of colours varied with the different mordants and concentrations thereof. The light fastness of the dyed fabric was achieved up to fairly good level for the $CuSO_4$, $FeSO_4$ and alum at 1-5% levels. Excepting the alum at 1 and 3% levels, all other mordants and levels gave good to excellent ratings for washing fastness test I. The $CuSO_4$, $Al_2(SO_4)_3$ and $FeSO_4$ at 3% and 5% levels gave good to excellent ratings for washing fastness test II. The dry rubbing and wet rubbing conditions were also excellent for all mordanted samples at all levels. The changes in the pore sizes due to the mordanting and dyeing treatments were also studied. In view of the colour fastness, the $CuSO_4$ and $FeSO_4$ mordants at 3% and 5% levels are recommended for application of cashew nut peel dye on silk.

Keywords: Mordanting, dyeing, colour fastness, wash fastness, microstructure, absorbance.

INTRODUCTION

In recent years, there is an increase in interest in natural dyes, which is mainly because of environmental reasons. The dyestuff industry is suffering from the increase in costs of feed stock and energy for dye synthesis and another consideration is the reduction of damage to the environment caused by the production and application processes associated with synthetic colours. The effluent produced are also a matter of concern for maintaining the environmental sustainability. The natural dyes exhibit better biodegradability and generally have higher compatibility with the environment compared with their synthetic counterparts, and thus are important in the above perspective. Kashyap *et al.* (2016) reported that the natural dyes are considered eco-friendly as these are renewable and biodegradable, are skin friendly and may also provide health benefits to the wearer.

Many studies have been attempted to test the feasibility of different natural sources for extraction of dyes and their application on the textiles and other materials (Deshmukh *et al.,* 2013; Shanmathi and Soundri 2016; Sanchiher and Babel 2017; Nawaz, 2019; Alam *et al.,* 2020). In this context, an important source of the natural materials can be the wastes of food processing industries. Proper disposal of the food processing wastes is very important and the cost of disposal is often too high. Therefore, in-plant value addition of these waste materials can not only help the processor to add to his income, but also can prevent the environmental hazards. Preparation of natural dyes from the food processing wastes can be explored both for food and fibre applications (Ohama *et al.,* 2016; Samant and Gaikwad 2020; Singhee, 2020). The cashew nut processing industry has two main by-products, *viz*., the shell and the peel. It is reported that one kg cashew kernel contains about 80 g peel (the red skin covering the nuts). As discussed above, preparation of natural dyes, if possible, from these materials can add to the income of the processor and also reduce the problems of disposal of these products.

In view of the above, the study was conducted to assess the feasibility of using cashew nut peel dye for colouring of silk and to study the shades and colour fastness properties. As the natural dyes are mostly non-substantive and mordants are necessary for acting as bridging material to create substantivity of natural dyes, and because different mordants and their concentrations affect differently on the colour shades and the fastness properties, it was decided to use five different mordants, *viz*., copper sulphate, aluminum sulphate, ferrous sulphate, citric acid and alum, each at three concentrations for studying the colour characteristics. At the same time, Mavilashaw and Krishnamoorthy (2021) have reported that some of the natural dyes could produce better colours on fabrics and could give excellent colour fastness properties without the use of any chemical mordants, which they attributed to the

presence of an appropriate natural mordants (binder for fabrics) in the selected natural dyes. Thus, it was required to find the applicability of natural mordants for cashew nut peel dyes.

MATERIALS AND METHOD

Preparation of dye. The cashew nut peels, received from the industry, were manually examined for the extraneous materials. It was almost dry and the moisture content was found to be within 6 and 7% (wet basis). For the extraction of dye, the method followed by Kumaresan *et al.* (2011); Sahoo *et al.* (2012) was followed. The powdered dye was taken in water in a ratio of 1:10 (w/w basis, i.e.100 g powder in 1 litre water) and was boiled under pressure in a pressure cooker for 1 hour. Thus, it was a 10% stock solution. The liquid was filtered by filter paper (Whatman No. 4) and kept in a refrigerator for further use.

Measurement of absorbance and peak wavelength (λ_{max}). The dye solutions were subjected to UV and visible light to find out the absorbance and the peak wavelength (λ_{max})as per Lasrado *et al.* (2019). A UV-visible spectrophotometer (make: Perkin Elmer Lambda 365 with the software version UV Express-Version 4.1.1) was used for the study in the measurement range of 190-1100 nm. The data interval was 1 nm. The beam type was double normal. The other parameters were threshold AU: 0.088, threshold (%T, %R): 1, and threshold (E): 10.

Collection and degumming of fabric, mordanting and dyeing. White mulberry silk fabric was procured from the Odisha Cooperative Tasar and Silk Federation Limited, Bhubaneswar. The fabric was degummed in a solution prepared by dissolving 5 gpl neutral soap and 1% (w/w) sodium carbonate in water with material liquid ratio of 1:40. The temperature of the bath was gradually raised from normal temperature to 90°C and the process was continued for one hour. Then the silk fabrics were taken out from degumming bath and squeezed to remove the excess liquid and then rinsed under running water to make it free from traces of detergent and other chemicals. Then it was dried under shade having taken enough care for protecting the fibre from sunlight.

The dye was used on the fabric without mordant and with five different mordants *viz.,* copper sulphate ($CuSO_4$), aluminum sulphate ($Al_2(SO_4)_3$), ferrous sulphate ($FeSO_4$), citric acid ($C_6H_8O_7$) and alum (K_2SO_4, $Al_2(SO_4)_3$, $24H_2O$), using different concentrations. Each mordant was used at three concentrations of 1%, 3% and 5% of the weight of farbric. The concentrations were decided on the basis of preliminary experiments. Pre-mordanting as per the method suggested by Gulrajani and Gupta (1992); Sahoo *et al.* (2014) was used. Known quantity of mordant was added to distilled water to get the M:L ratio of 1:40. The degummed silk was kept in the mordant solution initially at normal temperature, after which the temperature was raised up to 90°C for 30 minutes. The mordant solution was allowed to cool and the sample was dried inside the laboratory by normal air circulation.

The fabric samples were dyed using open dye beaker baths with material liquid ratio of 1:40 at 90°C temperature for one hour. The dyed samples were allowed to cool up to 50°C and then washed by running water to remove the superficially deposited or unfixed dye particles or unreacted mordanting residues from the surface. The samples were dried within the laboratory by normal air circulation.

Measurement of colour. The colour values of the samples were measured in the Hunter Lab coloriometer in the L, a and b scale (the changes from the control, i.e. undyed fabric was denoted by ΔL, Δa and Δb) (Merdan *et al.*, 2012; Teklemedhin and Gopalakrishnan 2018; Aung *et al.,* 2020). The total colour difference ΔE was calculated as follows, which was a single value that takes into account the differences between the L, a and b of the sample and control (undyed fabric).

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

The change in chroma value was also calculated as follows.

$$\Delta C = \sqrt{\Delta a^2 + \Delta b^2} \quad (2)$$

Determination of colour fastness. Colour fastness of the dyed samples was assessed for washing, rubbing and exposure to sunlight (Waheed and Alam 2004; Kittinaovarat, 2004; Sati and Jahan 2006). The colour fastness to washing Test-1, which is designed to determine the effect of washing on the colour fastness of the textiles, was tested as per IS/ISO 105-C10 (BIS, 2006). The reagent used was neutral soap (05 g/l). The test specimen of 10 cm × 4 cm was placed in between the two adjacent, undyed test cloth pieces and stitched along all four sides to form a composite specimen. Each composite specimen was placed in the container separately and necessary amount of soap solution was added to it to give a M:L ratio of 1:50, which was preheated (40±2°C). The composite samples were agitated for 30 min in launderometer (digiWash SS^{TM}) with 40±2 rev/min. Then the composite specimen was removed and rinsed in cold water. The stitches were ripped out along the two long sides and one short side. The composite specimen was opened and dried in air at room temperature. The change in color of the treated test specimen and the degree of staining of the two pieces of adjacent fabrics was evaluated with the help of SDC Grey scale (Make: Paramount) as per ISO 105 A02 (BIS, 2021) and the rating was assigned.

In the colour fastness to washing Test -2 the temperature was maintained at 50±2°C and the time was 45 min. The reagent used was neutral soap (05 g/l).

The colour fastness of the dyed fabric today light is of considerable importance to the consumer. The test for colour fastness for sun light was done as per IS test method: 686:1985 (BIS, 2016). The test specimen (1cm × 6 cm) was placed along with the standard blue wool patterns (1 to 8), which denote light fastness ratings, where 1 is very poor and 8 is outstanding. One third portions of the test specimen and blue wool standards were covered with the help of opaque card sheet, and exposed to sunlight from 9 am to 4 pm for 48 hours. The fastness was assessed by comparing the fading of the

specimen with that of blue wool patterns Mavilashaw and Krishnamoorthy (2021) have used similar scores for assessing the colour fastness of dyes.

The test for colour fastness to rubbing/ crocking is designed for determining the degree of colour, which may be transferred from the surface of coloured textile materials to other surfaces by rubbing in wet and dry state. The specimens were tested as per ISO 105-X12:2001 (BIS 2019). For the dry crocking test, two test specimen were placed on the base of the crock meter (Make: Paramount) so that it rests flat (on the abrasive cloth) with its long dimension in the direction of rubbing. The 5 cm × 5 cm of dry undyed test cloth was mounted over the end of the finger which projects downward from the weighed sliding arm. A spherical spiral wire clip held the test cloth in place. The finger was covered onto the test specimen and it was crocked back and forth 20 times by making 10 complete turns. The undyed test cloth was removed and evaluated. For the wet crocking test, the undyed (white colour) test cloth was thoroughly wet out in distilled water and squeezed out, and then mounted on the finger. The remaining procedure was same as that of dry crocking test.

To assess the colour change and the staining, SDC grey scale was used (BIS, 1996).

Analysis of microstructure and change in pore size. The mordanted as well as the dyed samples were put under the scanning electron microscope (Make *Hitachi S3400N*) to know about the changes in pore sizes after the mordanting and dyeing treatments. The equipment provides detailed high resolution images from 10X to 300,000X magnification of the sample surface. An Energy Dispersive X-ray Spectrometry (EDS) attached with this system is used for elemental identification and quantitative compositional information. The area of the pores was the mean average of 10 random pores (L× B) observed in one field under Scanning Electron Microscope.

RESULTS AND DISCUSSION

Measurement of absorbance and peak wavelength (λ_{max}) of dyes. The absorbance of the dyes at three different concentrations, viz. 10%, 20% and 30% were obtained from the spectrophotometer. As mentioned above, 190-1100 nm wavelength was used in a UV-Vis spectrophotometer to find out the absorbance values and the peak wavelength. The lamp change was at 400 nm. A sample curve obtained from the spectrophotometer is shown in Fig. 1 and the absorbance values of the cashew nut peel dye at 3 levels of concentrations (10%, 20% and 30%) are given in Table 1.

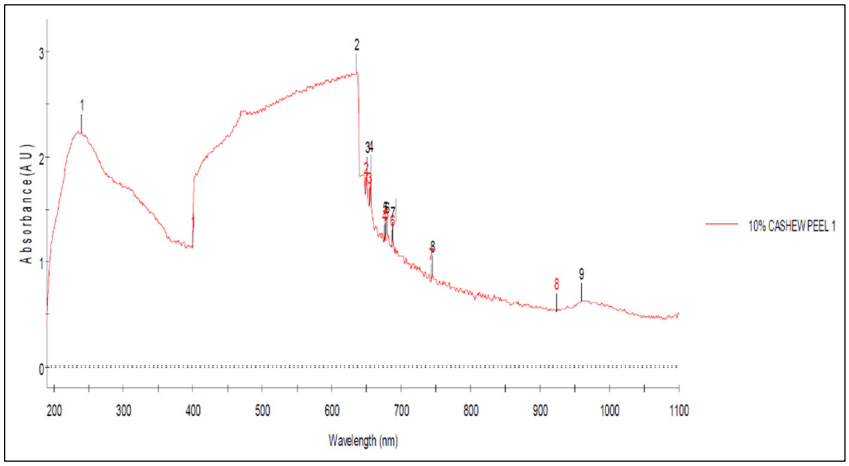


Fig. 1. Absorption spectra for 10% cashewnut peel dye.

Table 1: Absorbance values of the different dyes.

Dye	Concentration	UV range		Visible range	
		Peak wavelength, nm	Peak AU	Peak wavelength, nm	Peak AU
Cashew nut peel	10%	240.40	2.2373	636.15	2.8029
	20%	239.20	2.2346	644.85	2.8180
	30%	235.50	2.2436	664.75	3.0342

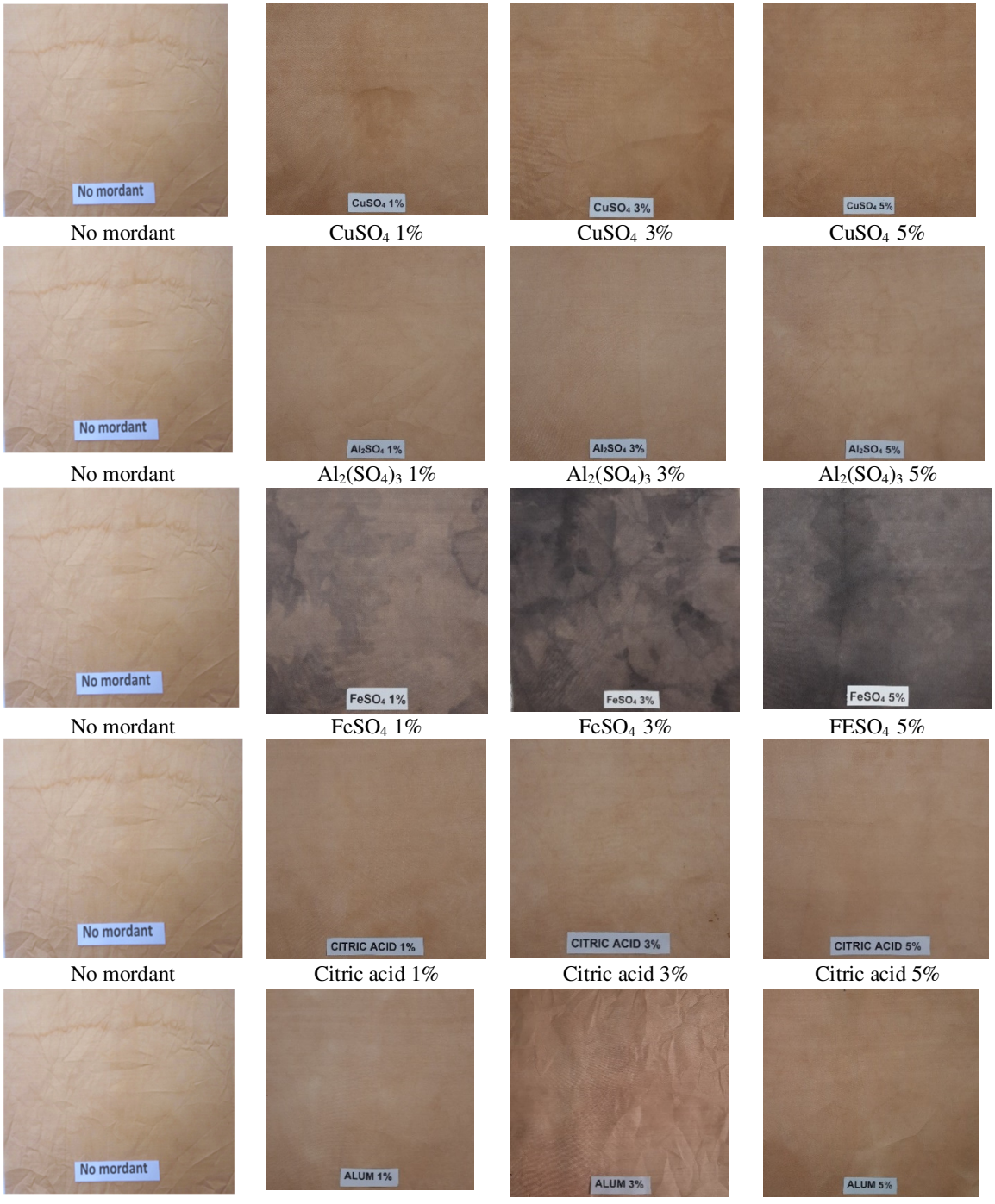
It was observed that the peak AU remained between 2.2373 to 2.2436 in the UV range and between 2.8029 and 3.0342 in the visible range for the dye. The peak wavelengths (λ_{max}) ranged between 235 to 240 nm for the UV range and 636 to 664 nm for the visible range for the dye.

Colour of dyed silk fabrics. The silk fabric samples were coloured with the dye. Before that the samples were also treated with five different mordants, as mentioned above, each at concentrations of 1%, 3% and 5%.

The different shades obtained on the fabric samples are shown in Fig. 2. It was observed that the colours had different intensities and shades depending on the type of mordant and its concentration.

The L, a and b values along with the change in colour (ΔE) and the chroma value (ΔC) of the silk fabric

samples dyed with cashew nut peel with different mordants are given in Table 2. The colour parameters of undyed silk fabric was observed to be L: 90.14± 0.215, a: 1.2 ± 0.089 and b: 1.26 ± 0.53. The reduced values of L as compared to the undyed sample indicate that the samples became darker after the treatment.



No mordant | $CuSO_4$ 1% | $CuSO_4$ 3% | $CuSO_4$ 5%

No mordant | $Al_2(SO_4)_3$ 1% | $Al_2(SO_4)_3$ 3% | $Al_2(SO_4)_3$ 5%

No mordant | $FeSO_4$ 1% | $FeSO_4$ 3% | $FESO_4$ 5%

No mordant | Citric acid 1% | Citric acid 3% | Citric acid 5%

No mordant | Alum 1% | Alum 3% | Alum 5%

Fig. 2. Colours of silk fabric treated with different mordants and dyed with cashew nut peel.

Table 2: Colour values of the silk fabric dyed with cashew nut peel dyes.

Mordant types	Levels, %	L	a	b	ΔC	ΔE
$CuSO_4$	1	53.3 ± 0.88	16.38 ± 0.13	24.4 ±0.1	27.67 ± 0.11	46.07 ± 0.71
	3	52.08 ± 0.88	17.46 ± 0.43	24.96 ± 0.28	28.74 ± 0.45	47.69 ± 0.77
	5	53.12 ± 0.8	17.94 ± 0.38	25.12 ± 0.37	29.14 ± 0.18	47.12 ± 0.65
$Al_2(SO_4)_3$	1	65.82 ± 0.28	15.82 ± 0.23	24 ±0.1	27.03 ± 0.18	36.36 ± 0.3
	3	64.28 ± 0.72	15.26 ± 0.26	22.6 ± 0.23	25.55 ± 0.33	36.35 ± 0.7
	5	63.7 ± 0.6	15.66 ± 0.15	23.26 ± 0.11	26.32 ± 0.13	37.31 ± 0.48
$FeSO_4$	1	47.5 ± 0.57	7.94 ± 0.36	9.02 ± 0.96	10.28 ± 0.97	43.87 ± 0.37
	3	38.4 ± 1.95	5.52 ± 0.33	3.1 ±0.53	4.7 ±0.5	51.95 ± 1.9
	5	37.16 ± 1.18	5.34 ± 0.23	2.44 ± 0.51	4.32 ± 0.32	53.15 ± 1.16
CA (%)	1	65.06 ± 0.58	15.92 ± 0.24	23.66 ± 0.18	26.8 ± 0.27	36.7 ± 0.58
	3	67.72 ± 0.64	14.94 ± 0.16	23.26 ± 0.21	25.93 ± 0.24	34.28 ± 0.53
	5	67.1 ± 0.76	15 ±0.2	23.14 ± 0.13	25.86 ± 0.19	34.64 ± 0.58
Alum (%)	1	66.98 ± 1.04	14.44 ± 0.3	22.46 ± 0.32	24.99 ± 0.39	34.07 ± 0.95
	3	65.52 ± 1.33	13.96 ± 0.45	21.76 ± 0.34	24.14 ± 0.5	34.49 ± 1.06
	5	65.62 ± 1.29	14.38 ± 0.33	22.84 ± 0.25	25.28 ± 0.34	35.22 ± 1.11
Undyed silk sample		90.14 ± 0.215	1.2 ± 0.089	1.26 ± 0.53		

The effect of the different mordants and the concentrations in terms of change in colour for the silk are also presented in Figs. 3 and 4. As it can be observed, the different types of mordants induced different colours for the fabric. In general, the ΔL values increased with the increase in the level of concentration of mordants, though deviations from this trend was observed for $CuSO_4$ and citric acid mordanted samples. In the case of $CuSO_4$, the maximum ΔL was for the 3% mordanted sample and for citric acid the minimum ΔL was for the 3% mordanted ones. The observations and the statistical analysis of the changes in L values indicated maximum change in L value with the $FeSO_4$ at 5% level (52.98 ± 1.19), though it was not significantly different from the $FeSO_4$ at 3% level. The minimum ΔL value was for the citric acid 3% level (22.42±0.64) though it was not different from the citric acid at 5% level, $Al_2(SO_4)_3$ at 1% level and alum at all levels.

The maximum changes in Δa and Δb values were for $CuSO_4$ treated samples and the minimum for the $FeSO_4$ treated ones. The statistical analysis also revealed that the $CuSO_4$ at 5% gave the maximum change in a value (16.74 ± 0.38), though this value was not significantly different from the $CuSO_4$ at 3% level. There was no significant difference between the $FeSO_4$ at 3% and 5% levels. The statistical analysis of the Δb values also revealed that $CuSO_4$ at 5% gave the maximum change in b value (23.86 ± 1.19), and it was not significantly different from the $CuSO_4$ at 1% and 3% levels. There was no significant difference between the $FeSO_4$ at 3% and at 5% levels, the latter of which showed the least change in b values (1.18±0.513). In other words, the a and b values changed in similar pattern.

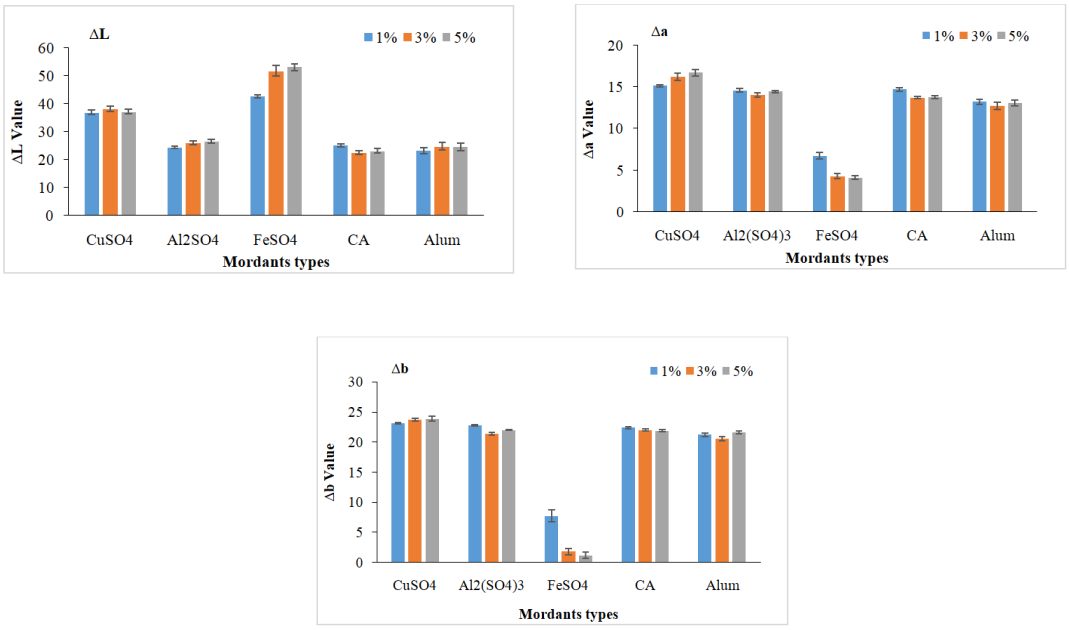


Fig. 3. Changes in the colour parameters (ΔL, Δa and Δb) of the silk treated with cashew nut peel dye.

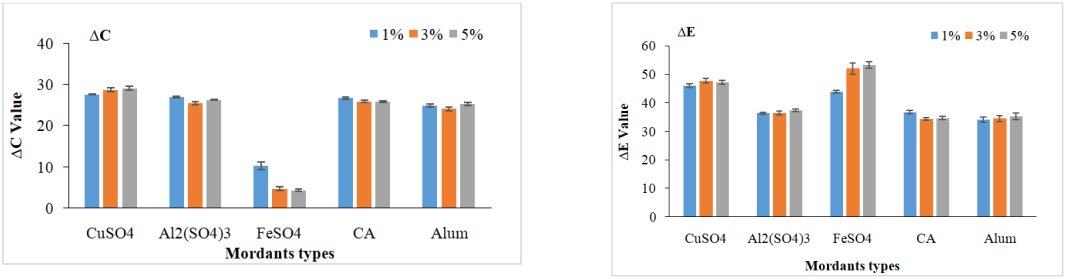


Fig. 4. Chroma value and change in colour of the silk treated with cashew nut peel dye.

The analysis of chroma value, which is a composite character comprising of changes in a and b values, indicated maximum change for the $CuSO_4$ samples followed by the $Al_2(SO_4)_3$ treated samples. The minimum chroma values were for $FeSO_4$. The statistical analysis also revealed the maximum chroma value for $CuSO_4$ at 5% (29.147±0.51), which was not different significantly from 3% level and the minimum chroma value for $FeSO_4$ 5% level (4.324 ± 0.33), which was at par with $FeSO_4$ at 3% level.

The change in colour (ΔE) was maximum for the $FeSO_4$ treated samples. It was observed that the maximum change in colour was for the $FeSO_4$ 5% sample (53.157 ± 1.17) and it was not significantly different from the 3% level of the same mordant. The minimum change in colour in general was for alum and citric acid treated samples.

In view of the above analysis, it is inferred that the shades of the colour will be dependent on the mordants and their concentrations. Samanta and Agarwal (2009) also reported that the final colour, their brilliance and colour fastness properties were not only dependant on the dye itself, but were also determined by varying concentration and skillful manipulation of the mordants. As the consumers will be having different preferences for fabric colours, different types of mordants and different concentrations can be used to prepare the variety of shades.

Colour fastness test of dyed fabrics. Table 3 presents the effect of washing, rubbing and exposure to sunlight on colour fastness of the dyed material. As observed from the table, in general, the mordanted specimen exhibited better colour fastness compared to samples on which no mordant was applied. The light fastness was moderate for $Al_2(SO_4)_3$ and citric acid mordanted samples. The $CuSO_4$, $FeSO_4$ and alum mordanted samples showed fairly good fastness to sunlight.

The observations on colour fastness to washing (Test 1) show that the samples mordanted with copper sulphate, aluminium sulphate, ferrous sulphate and citric acid showed good to excellent fastness, whereas alum showed good fastness. There was negligible change for staining on cotton and silk including no-mordanted samples. In the test of colour fastness to washing (Test 2), the alum and citric acid showed good fastness, including 1% $CuSO_4$ and 1% $Al_2(SO_4)_3$ mordanted samples. The $CuSO_4$ and $Al_2(SO_4)_3$ both at 3% and 5% levels showed good to excellent fastness.

Table 3: Colour fastness of silk samples dyed with cashew peel.

Name of Mordant	Mordant concentration	Light fastness	Colour fastness to washing (Test 1)			Colour fastness to washing (Test 2)			Rubbing fastness Test	
			Change in colour	Stain on cotton	Stain on silk	Change in colour	Stain on cotton	Stain on silk	Dry rubbing	Wet rubbing
No mordant		2	3/4	5	5	3	5	4	4	4
$CuSO_4$	1%	4	4/5	5	5	4	5	5	4/5	4/5
	3%	4	4/5	5	5	4/5	5	4/5	4/5	4/5
	5%	4	4/5	5	5	4/5	5	4/5	4/5	4/5
$Al_2(SO_4)_3$	1%	3	4/5	5	5	4	5	5	4/5	4/5
	3%	3	4/5	5	5	4/5	5	5	4/5	4/5
	5%	3	4/5	5	5	4/5	5	5	4/5	4/5
$FeSO_4$	1%	4	4/5	5	5	4	5	5	4/5	4/5
	3%	4	4/5	5	5	4/5	5	5	4/5	4/5
	5%	4	4/5	5	5	4/5	5	5	4/5	4/5
Citric acid	1%	3	4/5	5	5	4	5	5	4/5	4/5
	3%	3	4/5	5	5	4	5	5	4/5	4/5
	5%	3	4/5	5	5	4	5	5	4/5	4/5
Alum	1%	4	4	5	5	4	5	5	4/5	4/5
	3%	4	4	5	5	4	5	5	4/5	4/5
	5%	4	4/5	5	5	4	5	5	4/5	4/5

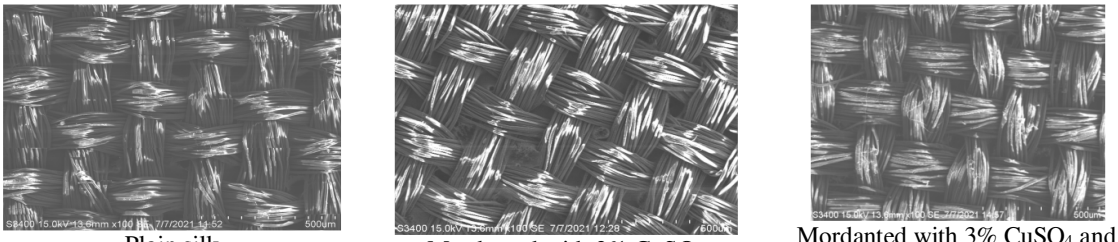
Scores for washing and rubbing fastness tests: 5-Excellent; 4-Good, 3- Fair 2-Poor, 1-Very poor
Scores for staining: 1-Much change, 2-Considerable change, 3-Noticeable change, 4-Slight change and 5-Negligible change
Score for light fastness test: 1- very poor; 2- poor; 3- moderate; 4- fairly good; 5- good; 6- very good; 7- excellent; 8- outstanding
Parameters for colour fastness to washing (Test 1): Temperature 40±2°C, agitation time 30 min with (40±2) rev/min
Parameters for colour fastness to washing (Test 2): Temperature 50±2°C, agitation time 45 min with (40±2) rev/min

Staining on undyed cotton samples including no mordanted samples showed negligible change. However, during staining, it was observed that there was slight or negligible change for $CuSO_4$ 3% and 5% mordanted

samples. The $CuSO_4$ 1% as well as all other levels of different mordants yielded negligible change during staining. The dry and wet rubbing fastness were found to be good to excellent for all mordanted samples, whereas no mordanted samples showed good crocking fastness.

As per the above observations, the light fastness was achieved up to fairly good level for the $CuSO_4$, $FeSO_4$ and alum at all the three levels of 1-5%. Excepting the alum at 1 and 3% levels, all other mordants and levels gave good to excellent ratings for washing fastness test I. The $CuSO_4$, $Al_2(SO_4)_3$ and $FeSO_4$ at 3% and 5% levels gave good to excellent ratings for washing fastness test II. The dry rubbing and wet rubbing conditions were excellent for all mordanted samples at all levels. In view of the above, the $CuSO_4$, $FeSO_4$ mordants at 3% and 5% levels are recommended for application of cashew nut peel dye on silk.

Analysis of microstructure with Scanning Electron Microscope. The dyed samples were put under the scanning electron microscope to know about the changes in pore sizes after the mordanting and dyeing treatments. Some sample images are shown in Fig. 5. The areas of the pores were studied, which was the mean average of 10 random pores (L×B) observed in one field under Scanning Electron Microscope. The observations are shown in Fig. 6.



Plain silk | Mordanted with 3% $CuSO_4$ | Mordanted with 3% $CuSO_4$ and dyed with cashew nut peel

Fig. 5. SEM images for silk fabric during stages of dyeing.

It may be observed that in general for the silk fabric, mordanting reduced the size of the pores, which could be due to further shrinkage of the fabric or the partial filling of the pores due to the deposition of the chemical mordant. Different mordants exhibited different changes in size of pores. After dyeing, the size of the pores changed, however, no uniformity in pattern of changes was observed.

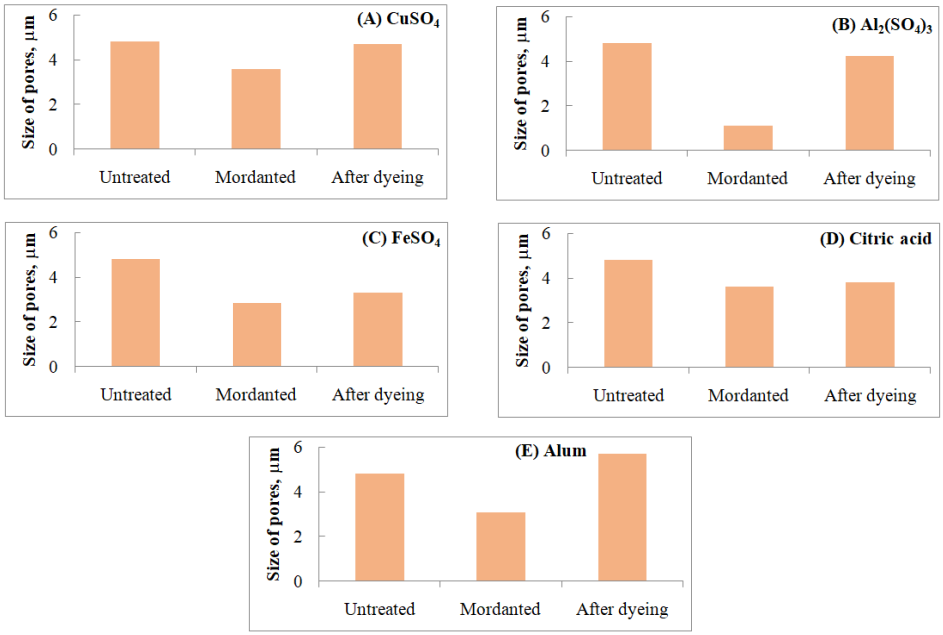


Fig. 6. Changes in pores of silk due to mordanting with different mordants and dyeing.

In view of the above studies, it is concluded that the cashew nut peel can be used for extraction of dyes for application on silk. Different mordants with different concentrations can be used for obtaining various colours and intensities of the colour. However, the colour fastness to sunlight, washing and rubbing depend on the mordants and their concentrations. In view of the colour fastness, the $CuSO_4$, $FeSO_4$ mordants at 3% and 5% levels are recommended for application of cashew nut peel dye on silk.

CONCLUSIONS

Based on the above study, it can be concluded that the cashew nut peel can be used as a dyeing material for the

silk with the application of different mordants and the final colours will depend on the different types of mordants and their concentrations. The maximum change in colour (ΔE) was for the $FeSO_4$ mordant at 5%, however it was not significantly different from the 3% level of the same mordant. The minimum change in colour was for alum and citric acid mordanted samples. The light fastness of the dyed fabric was achieved up to fairly good level for the $CuSO_4$, $FeSO_4$ and alum at 1-5% levels. Excepting the alum at 1 and 3% levels, all other mordants and levels gave good to excellent ratings for washing fastness test I. The $CuSO_4$, $Al_2(SO_4)_3$ and $FeSO_4$ at 3% and 5% levels gave good to excellent ratings for washing fastness test II. The dry rubbing and wet rubbing conditions were excellent for all mordanted samples at all levels. In view of the above, the $CuSO_4$, $FeSO_4$ mordants at 3% and 5% levels are recommended for application of cashew nut peel dye on silk.

FUTURE SCOPE

The method of extraction of dye from cashew nut peel and mordanting process need to be standardized. The colour fastness of the dye need to be further improved for the wider adoption of this technology on commercial basis.

Conflict of Interests. None.

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