Kavitha Krishnamoorthi*,
Srinivasan Jagannathan

Study on the Effects of Perfume on the Mechanical and Colour Properties of Silk Fabrics

DOI: 10.5604/01.3001.0010.5377

Kumaraguru College of Technology,
Department of Fashion Technology,
Coimbatore, Tamil Nadu, India
* E-mail: kavitha.s.ft@kct.ac.in

Abstract
Perfumes are generally used to enhance the attitude of the person. Deodorants and perfumes are designed to be applied directly to the skin. Some people with sensitive skin may find that their skin does get irritated if they use too much perfume and hence apply perfume directly to their clothes. Silk is one of the most luxurious fabrics and is used on all occasions. If perfume is applied directly on fabric, it may cause a stain or discoloration and may spoil a costly garment. Although there is a study on the effect of perfume on cotton fabrics, there is no study about the effect of perfume on silk fabrics in the literature. Therefore this study aims to investigate the effects of perfume on dyed silk fabrics and is the first work on this subject. Mechanical properties like tensile strength, pilling and abrasion resistance were investigated, and the change in colour under washing, dry cleaning and perspiration were recorded.

Key words: *perfume, silk fabric, mechanical properties, colour properties, FTIR.*

Introduction

Since silk filament is produced by a living worm, there will be variation in the physical and mechanical properties of silk from within cocoons as well as between them [1]. Even the major four commercial varieties of silk, namely Mulberry, Tasar, Eri and Muga have principal differences in the physical characteristics and structures due to differences in the chemical composition of these fibres [2].

Silk filament contains amine and carboxylic groups at either end of its chemical structure, which can be dyed with acid dyes, reactive dyes, metal-complex dyes etc. Amongst all of these , acid and metal-complex dyes possess a better affinity to fibre and get easily absorbed by it. Silk is well known for its water absorbency, dyeing affinity, thermal tolerances, insulation properties, and luster. Some properties of silk fibre such as crease recovery, wash and wear properties, photo-yellowing, water and oil staining resistance, dye-ability, and colour fastness are weak and should be improved [3].

Unlike cotton, silk saris and dresses are sensitive to laundering and demand special care during washing and dry cleaning, as well as in the selection of detergents and temperature [4]. Silk will last for many years, as long as it is properly cared for and protected from chemicals and detergents used in washing and drycleaning, pressing heat, sunlight, perspiration etc [5]. The problem of silk is that it loses its strength when wet and therefore requires to be treated gently during the laundering process [6]. Hence only dry cleaning or hand washing is recommended for silk fabric. One of the important silk care instructions is not to spray perfumes or deodorants directly on silk fabric.

From being non-essential and luxury, perfumes have become essentials in everyday life, because of the increasing trend of people's interest in enhancing their appearance and personal care and in boosting their confidence [7]. Although perfume gives the best result when sprayed directly onto the skin, many people apply perfume on clothes not only to cover an unpleasant smell but also to protect themselves from perfumes that are thought to be allergic for the skin and body [8-11]. Being luxurious and lustrous, silk is preferred for special occasions, parties and festivals, and the use of perfumes is also essential in that situation. As it is inevitable to spray perfumes on fabrics directly, understanding the behaviour of silk fabrics with perfumes is necessary. Nowadays a lot of work has been done to impart a durable fragrance finish by different techniques like microencapsulation, the impregnation method, exhaust method, dip-pad-dry method and spray method [12].

But the consumption of perfumes among the young population is escalating because of increasing consumer awareness, people spending more on personal and beauty care products, the availability of perfumes in different price ranges, growing online retail penetration and the promotional strategy by leading brands. Customised perfumes and the use of renewable ingredients are the recent trends in the global perfume market. Perfume manufacturers across the world are also venturing into the production of natural, organic, skin friendly, non-allergic and eco-friendly perfumes to meet the needs of increasing health awareness among consumers.

There are lots of test methods available to test the properties of fabrics under different normal usage conditions, but there is no test method available to test with perfume. Mahmut Kayar, in his work, investigated the effects of perfume on knitted and woven cotton fabrics and reported changes in mechanical and colour properties with less perfume and more amounts of perfumes sprayed. Although perfumes did not change the chemical structure of cotton fabrics, colour properties were altered due to the application of perfumes [13]. Although cotton and silk are natural fibres, they differ in chemical composition and structure. It is possible for any material to reveal different effects on different fabrics. Also as there has been no study showing the effect of perfumes on silk fabric, this paper aims to investigate the effects of perfume on dyed silk fabrics.

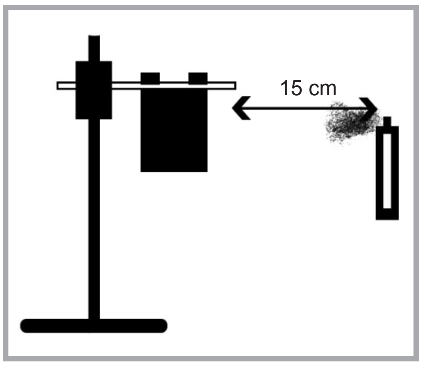

Figure 1. Perfume spraying on the fabric.

Materials and methods

Materials

For the experimental process, 100% mulberry silk fabrics made in plain weave, and dyed with acid dyes representing light, medium and dark shades were chosen. The colours preferred were red, pink and sandal colour, sourced from the Central Silk Board, Bangalore. Properties of the fabric selected are listed in ***Table 1***.

Depending upon the concentration of aromatic compounds, perfumes are classified into different types. Out of that, eau de parfum (EdP), which contains 10-20% of aromatic compounds and eau de toilette (EdT), which contains 5-15% of aromatic compounds, are commonly available in the market. In eau de cologne and body splash, less than 3% of fragrance compounds are added. They are usually formulated with alcohol and water, and the higher the perfume content, the more alcohol must be used for solubilisation. Hence to understand how the chemical contents of perfume interact with very sensitive silk fabrics, one of the best selling perfumes (EdP) was selected and purchased from local stores. Properties of the perfume are listed in ***Table 2***.

Application of perfume on fabric

Although the amount of perfume used by people varies from one another, a constant quantity of perfume was used for testing purposes. A constant amount of 0.25 ml/100 sq.cms was selected to spray on fabric samples subjected to different testing. For this, the amount of perfume released per single spray was measured accurately as 0.092 ml. on average, and hence three sprayings were done. Similar to actual spraying conditions, the perfume was applied onto the fabric by simply spraying from the container at a right angle, as shown in ***Figure 1***, to maintain a uniform condition throughout the study.

Also perfume was sprayed from a 15 cm distance, which is usually the ideal one recommended. This distance is considered sufficient to avoid using too much or too little. The perfume was sprayed onto the fabric two times a day with an eight-hour interval between each spraying.

Table 1. Physical parameters of silk fabrics.

Range	Fabrics	Ends per inch	Picks per inch	Weight, g/m^2	Thickness, mm
Dark	Red	94	90	62	0.20
Medium	Pink	93	81	60	0.18
Light	Sandal	96	91	69	0.19

Table 2. Properties of perfume.

Parameters	Values
Top notes	Citrus
Middle notes	Lily
Base notes	Sandalwood
Flash point	37 °C
Density	0.782 g/m^3
Refractive index	1.4630
pH	6.78
Major ingredients	Denatured Alcohol Benzyl salicylate Butyl phenyl methyl propional Citronellol Eugenol Linalool Ethylhexyl methoxy cinnamate, Hydroxycitronellal Benzophenone-3, Ethy-hexyl salicylate, Butyl methoxy dibenzoylmethane Hydrrxyisohexyl 3-clclohexene Carboxaaldehyde, Gereniol,Isoeugenol, Cinnamyl Alcohol,Limonene, BHT, Propylene glycol, Benzyl alcohol, Benzyl benzoate, Acrylates, Hydrolysed jojoba esters.

Mechanical tests

Tensile strength and elongation

The fabric samples were conditioned under standard conditions of 25±2 °C and 65±2 percent relative humidity for 24 hours before the testing processes began. According to ISO 13934-2:2004 (Grab method), the tensile strength test was carried out for the fabric samples with and without perfume on a Dak System Inc. Universal Testing Machine with a 75 mm gauge length at a 50 mm/min rate of traverse.

Resistance to abrasion and pilling

Resistance to abrasion (ISO 12947-2:1998) and resistance to pilling (ISO 12945-2:2000) tests were performed on a Martindale Pilling and Abrasion Instrument. The weight loss % of the specimens after 5000 cycles of abrasion was noted. The degree of pill formation can be visually assessed by the set of photographic rating standards available for comparing the specimen tested.

Colour fastness tests

Colour fastness to washing

The specimens were tested as per ISO 105-C 10: 2006. The reagent used was neutral soap (0.5 g/l). A test specimen of 10 cm X 4 cm was stitched along with a multifibre sample. Each composite specimen was placed in a container separately and a necessary amount of soap solution was added to it to give a material: liquid ratio of 1:50, which was preheated to (40±2 °C). The composite samples were agitated for 30 minutes in a launderometer at (40±2) rev/min. Then the composite specimen was removed and rinsed in cold water. The composite specimen was then opened and dried in air at room temperature. The change in colour of the treated test specimen and degree of staining were evaluated.

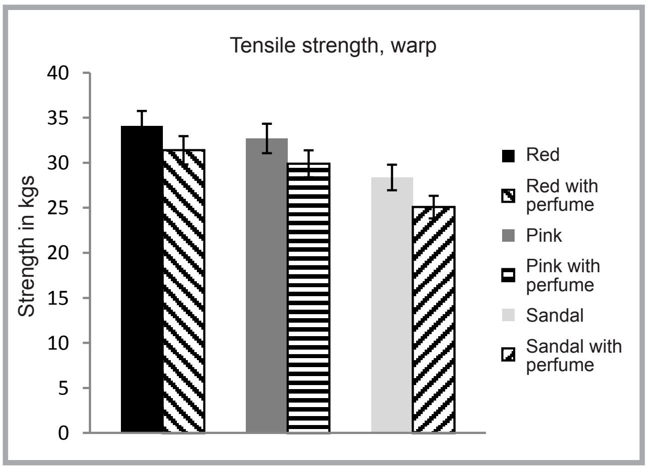

Figure 2. Tensile strength of dyed silk fabrics in warp direction with and without perfume.

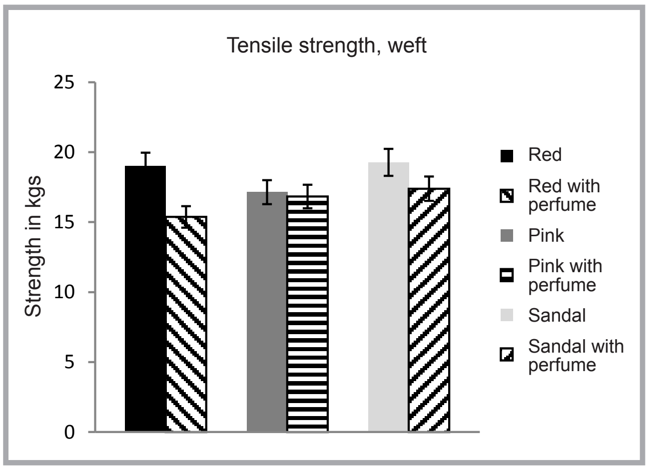

Figure 3. Tensile strength of dyed silk fabrics in weft direction with and without perfume.

Colour fastness to dry cleaning

The ISO 105-D01:2010 method for colour fastness to drycleaning was used where test specimens were agitated in Perchloroethylene for 30 mins together with non-corrodible discs. The samples were then centrifuged and dried in hot air. The change in colour of the specimen was assessed in terms of delta E measured using a spectrophotometer. Staining of the solvent was assessed by comparing the filtered solvent with unused solvent.

Colour fastness to rubbing

Rubbing fastness was evaluated by the ISO 105 X12 -2002 method with Rub XT by means of a MAG Solvics Crock-Meter, which has a finger of 1.6 cm diameter. Fabric of 50 x 140 mm was cut with and without perfume. Dry and wet test cloth of 5 cm x 5 cm was mounted on the rubbing finger with a strength of 9N downwards. After 10 complete cycles, the undyed dry and wet test cloth were removed and evaluated using standard grey scales.

Colour fastness to perspiration

Colour fastness to perspiration was evaluated by the ISO 105-E04:2008 method with artificial perspiration solutions of the acidic and alkaline type made using histidine monohydrochloride monohydrate, sodium chloride and disodium hydrogen orthophosphate. In this method, perfume was sprayed on one set of specimens and another set without perfumes was prepared. Samples of 100 x 40 mm dimensions stitched with multifibre stripes were wetted and soaked in acid and alkali perspiration solutions, and then kept in an oven at 37 ± 2 °C for 4 hours under a pressure of 5 kg. On completion of the test, the samples were taken out and dried slowly. The change in shade on the specimen tested compared to the original and the colour staining of all components on the multifibre were assessed in terms of delta E values.

Spectrophotometer

The colour difference in colour fastness testing is usually assessed using the grey scales. As skill and experience are required for accurate evaluation, instrumental colour measurement of colour fastness test data can be used [14]. The total colour difference between the original sample and those tested was obtained using ***Equation (1)*** using a Reflectance Spectrophotometer (Minolta CM 3600d).

Colour difference

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

where
ΔL = L* before testing – L* after testing
Δa = a* before testing – a* after testing
Δb = b* before testing – b* after testing

Where, L means lightness; a measures redness (+) or greenness (−), and b measures yellowness (+) or blueness (−), respectively. Colour change and colour staining were assessed using delta E values.

Colour fastness scales

Colourfastness results are measured in terms of colour change and colour staining. Colour change denotes the amount of fading or colour alteration of the sample tested when it is subjected to different tests. Colour staining denotes the amount of staining of adjacent materials that occurs when tested along with coloured fabric samples. Two sets of standard grey scales are used to assess the colour fastness of textiles. On visual comparison, the results are given as a standard rating. The grey scale rating ranges from values 1-5, with four intermediate half steps. Spectrophotometers can be used to measure the same colour difference in terms of the delta E value. ***Table 3*** shows the grey scale rating and corresponding delta E value representing the respective colour change or colour staining [15].

Table 3. Standard grey scale rating and delta E value.

Grey scale rating	Corresponding colour difference in delta E	Colour change	Colour staining
5	0	No change	No staining
4-5	0.8		
4	1.7	Slightly changed	Slight staining
3-4	2.5		
3	3.4	Noticeable change	Medium staining
2-3	4.8		
2	6.8	Considerable change	Poor staining
1-2	9.6		
1	13.6	Much change	Very poor staining

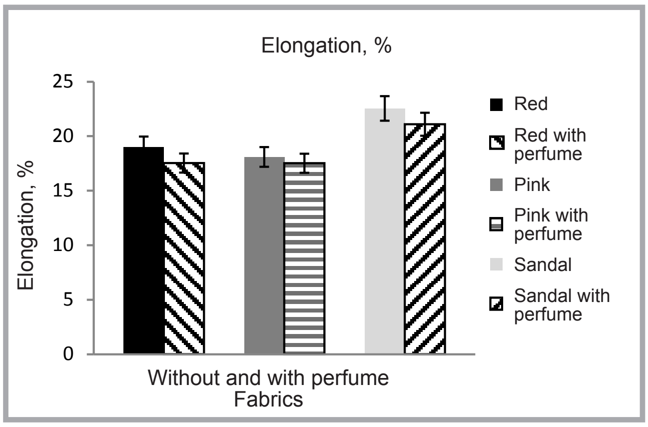

Figure 4. Elongation % of dyed silk fabrics with and without perfume.

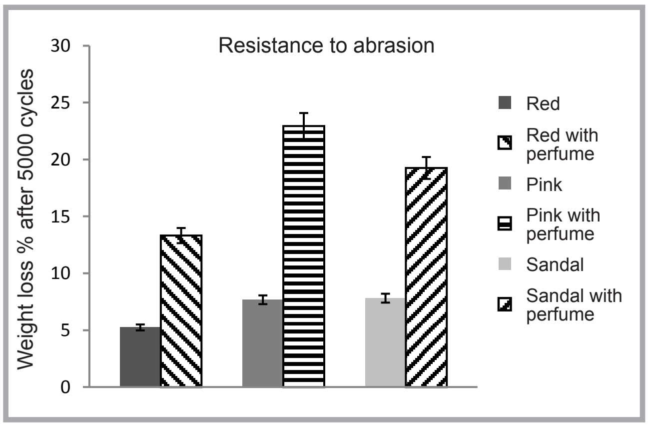

Figure 5. Abrasion resistance values of dyed silk fabrics with and without perfume in terms of weight loss %.

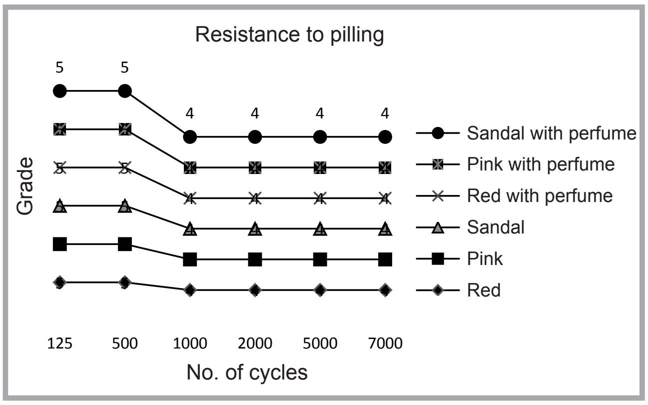

Figure 6. Pilling grade results of dyed silk fabrics with and without perfume.

Figure 7. Change in colour of dyed silk fabrics with and without perfume in the washing fastness test.

FTIR Spectroscopy

Fabric surfaces of samples with and without perfume were also studied by FTIR spectroscopy using a Shimadzu IRAffinity-1S FTIR Spectrophotometer. The mid-infrared region from 400 cm^{-1} to 4000 cm^{-1} was used at a resolution of 2 cm^{-1} with background correction in 350 scans in the ATR mode, and the percentage of transmittance was recorded.

Results and discussion

Mechanical properties

Tensile strength and elongation

Silk is known for its high tensile strength and high elongation at failur e [16].Tensile strength values of red, pink and sandal colour dyed fabrics tested along the warp and weft direction are shown in ***Figure 2*** and ***Figure 3***. According to the figures, it can be said that the strength of the fabric changes slightly when applying perfume both in the warp and weft directions, But the strength reduction is not statistically significant as perfume ingredients do not alter the peptide bonds of fibroins in the semi-crystalline region. Also in all three different colours, the same trend was noticed.

The elongation % tested at a 75 mm gauge length and rate of traverse of 50 mm/min showed a slight decrease in performance when compared to that without perfume in all three colours, as shown in ***Figure 4***.

Resistance to abrasion

Unlike tensile strength, silk has only fair abrasion resistance, and will not stand up to heavy wear. ***Figure 5*** shows the weight loss % after 5000 cycles, and it is inferred that the fabrics applied with perfume have significant changes to abrasion compared with those of the fabrics not applied with perfume. Ethanol and other constituents in perfumes might have changed the surface properties of fibroin by altering the surface energy.

Resistance to pilling

From ***Figure 6***, it is observed that perfume has no influence on fabrics for pill formation, and it shows the same grade as that of fabrics without perfume. It is also observed that pill formation is the consequence of an increase in the number of cycles. Being filament, silk pills less than most other fibres, and hence there were no significant changes.

Colour fastness tests

Acid dyes are usually sodium salts of sulphonic acids or, less frequently, carboxylic acids, and are therefore anionic in aqueous solution. They can dye fibres with cationic sites, which are usually substituted ammonium groups in fibres. These cationic sites are thus available for the acid dye anions to combine with through hydrogen bonding, vander waals forces or ionic bonding. Ethanol used in perfumes is a very polar molecule due to its hydroxyl (OH) group, with the high electronegativity of oxygen allowing hydrogen bonding to take place with other molecules. Hence ethanol may counter acid dyes and affect the fastness property.

Washing fastness

Though it is suggested to dry clean silk fabrics, plain silk fabrics are also washed with water. The change in colour after washing the samples was compared with

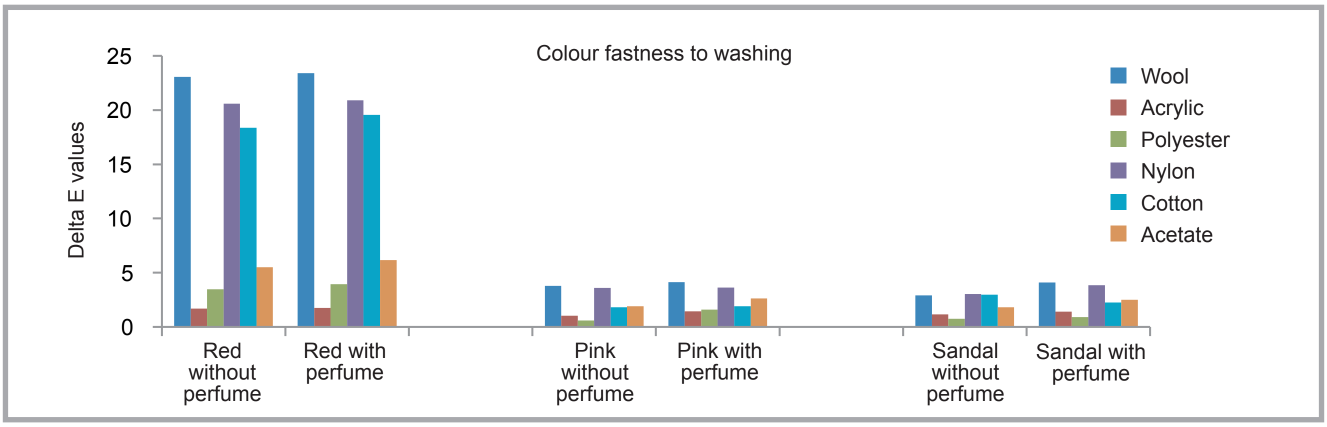

Figure 8. *Colour staining on multifibre adjacent fabric tested along with dyed silk fabrics in washing fastness test.*

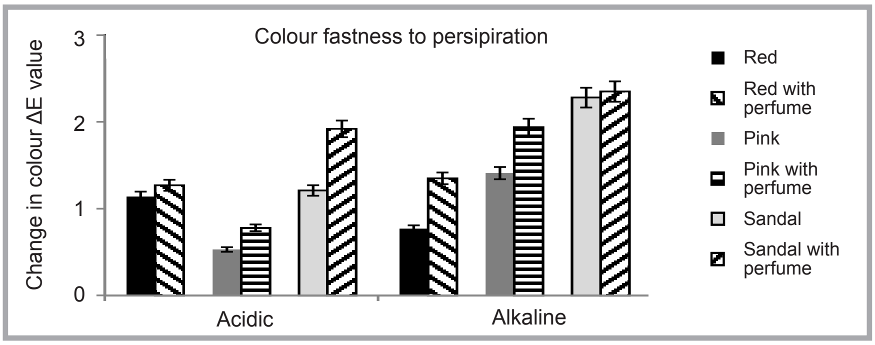

Figure 9. *Change in colour of dyed silk fabrics with and without perfumes in perspiration colour fastness test.*

Figure 10. *Colour staining in multifibre test sample tested with dyed silk fabrics in perspiration fastness testing.*

those treated with perfume and washed in terms of delta E values as measured by the Spectrophotometer. Delta E values up to 1.7 are acceptable, which is equivalent to grey scale rating 4. Here all the values are above 1 even before the application of perfume. After the application of perfume, there is an increasing trend in the colour difference. In the red and pink colour, the colour change is high and similar, whereas in the sandal colour, the colour shift is slightly more.

As expected, multifibre adjacent fabrics were stained more by dark and medium colour than by light colour. The staining level was measured using the spectrophotometer and expressed as delta E to better visualise the staining rate. Wool and nylon were cross stained due to the affinity to acid dyes as compared to other fibre. In cotton, uneven staining was also noticed.

Colour fastness to dry cleaning

Perchloroethylene was used as a solvent in dry cleaning. Samples treated with and without perfume were subjected the dry cleaning test. The results in ***Table 4*** show that the delta E values are below value 1 or nearer to it. Colour fastness is more suited to dry cleaning than to water. But a slight change was noticed due to perfume application. Staining of the solvent is observed more in red dyed fabrics than in the others, which may be due to the poor fastness of dark shades.

Colour fastness to perspiration

As seen in ***Figure 9***, in alkaline and acidic perspiration tests, a slight increase in colour was noticed in perfume applied samples compared to those without perfume. According to the results obtained for the delta E value, there was a noticeable colour change: yellowing can be observed in the sandal colour, which may be due to the alcohol present in perfumes. In all other cases, a colour shift is noticed due to the application of perfumes.

Figure 10 shows the dyed silk samples with multifibre assembly. ***Figures 11*** and ***12*** show delta E values of the multifibre sample tested with and without the perfume treated sample dipped again in acidic and alkaline perspiration solutions. This represents actual wearing conditions.

High staining values were due to the poor fastness of red colour, whereas the pink and sandal colours had good perspiration fastness. When perfume sprayed samples were kept in perspiration solution, the effect of perfume was seen in the red colour only, while in other colours there was no significant change noticed.

More staining in the adjacent multifibre fabric is identified due to acid red dye transfer, especially to cotton, wool and nylon. While in the pink and sandal colour, colour staining is much less. Moreover it is observed that perfume application made a difference in the colour

Table 4. *Delta E values of dyed silk fabrics with and without perfume subjected to dry cleaning.*

	Without perfume			With perfume		
Fabrics	Red	Pink	Sandal	Red	Pink	Sandal
ΔE	0.39	1.49	0.50	0.49	1.74	1.62
Staining of solvent	3	4	4-5	3	4	4

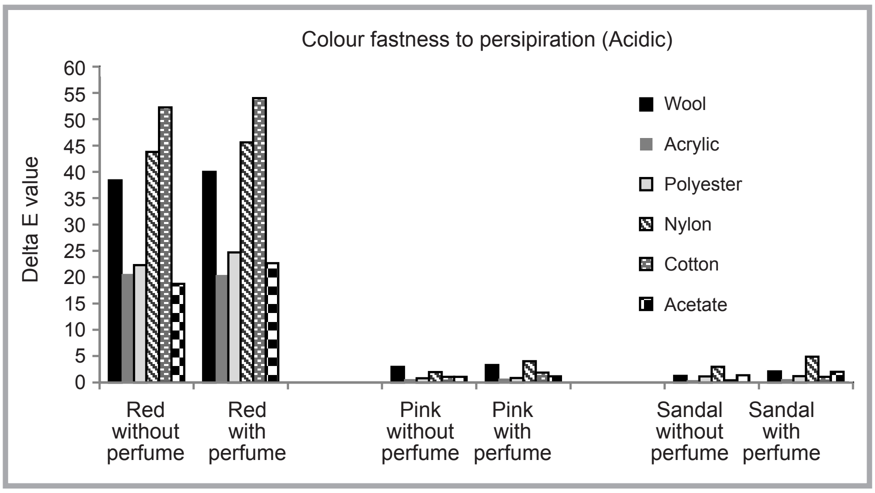

Figure 11. *Delta E value of colour staining on multifibre adjacent fabrics tested along with dyed silk fabrics in acidic perspiration test.*

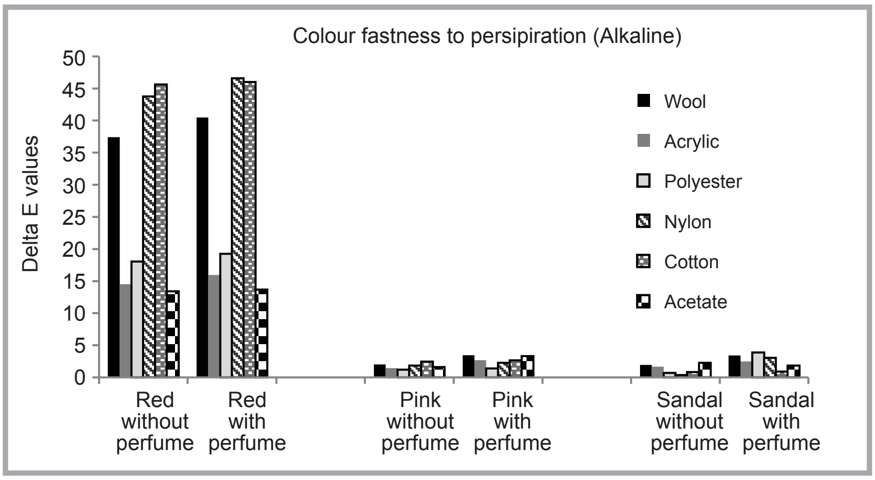

Figure 12. *Delta E value of colour staining on multifibre adjacent fabrics tested along with dyed silk fabrics in alkaline perspiration test.*

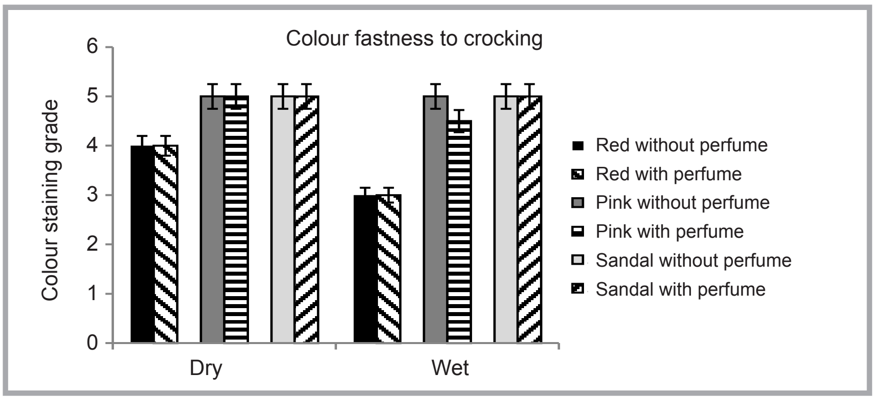

Figure 13. *Grey scale rating of colour staining in crocking fastness test.*

staining of dark colour, especially in alkaline conditions. As acid dyes undergo hydrolysis in alkaline conditions due to ethanol action, dye fastness was affected.

Colour fastness to rubbing

The fabrics with and without perfume treated fabric were rubbed against dry and wet cloth for 10 complete turns with a 9 N force. The colour staining on the white testing square was evaluated and is shown in ***Figure 13***.

Both in dry and wet rubbing, red colour was transferred to the crock square and in the pink colour with the perfume sprayed sample, slightly increased pink colour transfer was noticed. In the sandal colour, no colour transfer had occurred, but looked yellow due to the staining of perfumes.

In the previous study conducted by Kayar [13] on cotton fabrics, it was observed that surface properties like abrasion and pilling resistance and colour properties were altered by perfume whereas strength values were not significantly changed. In a similar way, the tensile strength of silk fabrics was not affected by perfume. But poor abrasion resistance values of silk fabrics were again influenced by the perfumes. As silk is a continuous filament, it has high pilling resistance, which was not altered. However, other colour fastness studies showed that perfume negatively affects the colour change and colour staining values. In dark colours, more staining was observed, whereas, in light and medium shades, colour change was noticed due to the ethanol content in perfumes.

FTIR spectroscopy

The three fabric samples (red, pink, and sandal) show three different spectrums. According to ***Figures 14-16***, FTIR spectra of silk fabrics without perfume and perfume applied fabrics were found similar. There was a slight change in the peak values. For example, the peak value of fabric without perfume is 1219, which shifted to 1249 with the application of perfume. The stretch occurring in this frequency range was the C-O stretch. The peak value noticed at 1033.85 shifted to 1087.5 with the application of perfume due to the C-N stretch. The peak value noticed at 1620.21 shifted to 1612.49 with the application of perfume, and this may be due to the N-H bend. This showed that there were changes in the peak values fabrics with and without perfume, but the changes were compromised within the range of the same frequency, which highlights that there are no major changes in the chemical structure. Since only a small amount of perfume was sprayed and its volatile nature, it only shifted the frequency and affected no change in structure.

Conslusions

This study was aimed at investigating the effects of perfume on the mechanical and colour properties of dyed silk fabrics. Tests of the tensile strength and resistance to abrasion and pilling were

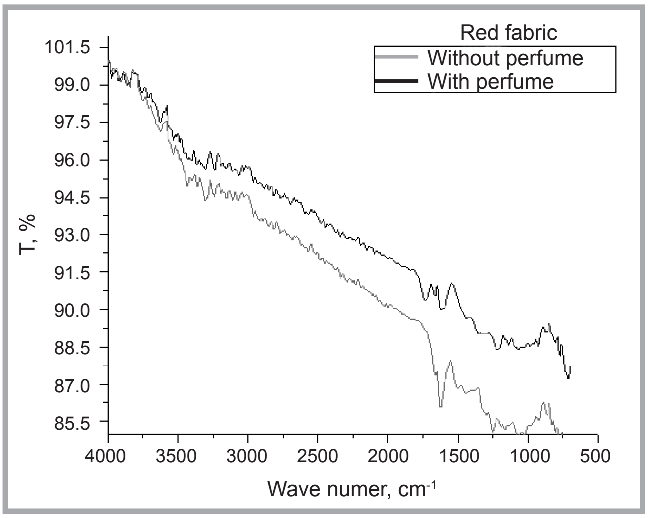

Figure 14. *FTIR graph of red coloured sample with and without perfume.*

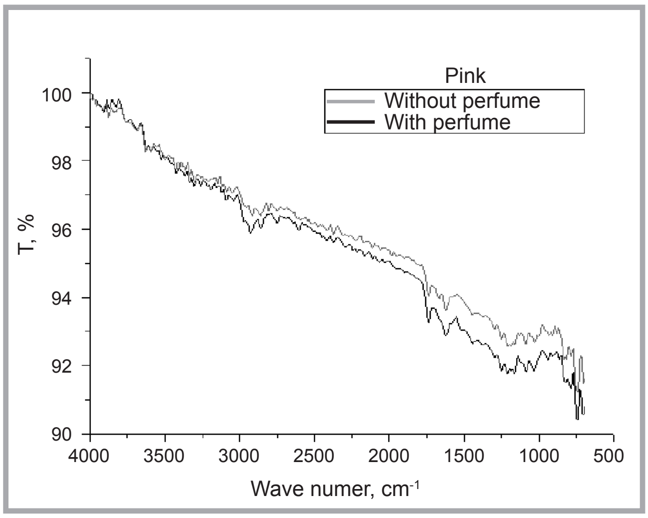

Figure 15. *FTIR graph of pink coloured sample with and without perfume.*

performed, and it is observed that there is a slight reduction in strength as well as an increase in weight loss and no pilling in the fabric applied with perfume, respectively. With the results of colour fastness testing on perfume applied fabrics, it is found that there is a moderate change in colour, and staining occurs due to perfume application. With a small quantity of perfume, being volatile in nature, it did not change the chemical structure of fibroin, but alcohol present in the perfume had an effect on acid dyes attached to the fibre. Thus this study supports Kayar's findings that perfumes do affect colour change and colour shifts, whereas the chemical structure and mechanical properties are least affected. This study also shows that the level of colour fastness to perfume differs for light, medium and dark colour dyed samples.

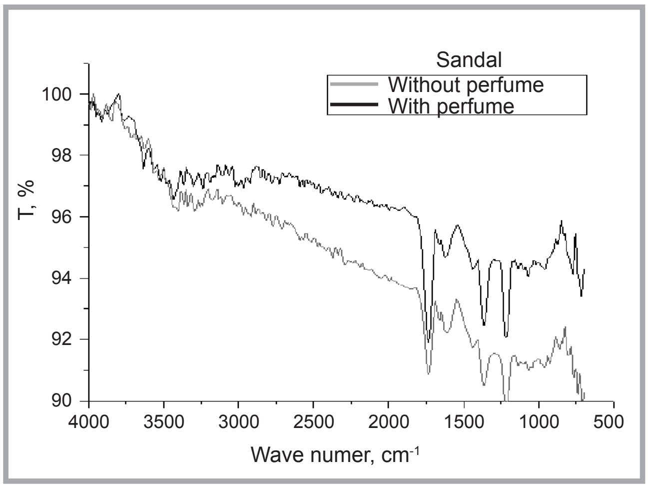

Figure 16. *FTIR graph of sandal coloured sample with and without perfume.*

References

1. Vasumathi BV, ChilakwadS L, Hosur, Hanamanth. Comparative studies on some physical and mechanical properties of silk filament. *Indian J. Fibre Text. Res* 1999; 24(3): 167-171.
2. Gupta V B, Rajkhowa R, Kothari VK. Physical characteristics and structure of Indian silk fibres. *Indian J. Fibre Text.* Res 2000; 25: 14-19.
3. Mehrsa Hussein, Majid Montazer, Rogheih Damerchely, Enhancing Dye-ability and Antibacterial Features of Silk through Pre-treatment with Chitosan. *I Eng FiberFabr*. 2013; 8(3): 102-111.
4. Das S. Wash care Fundamentals for Silk. *Indian Silk J* 2008; 47: 19-21.
5. Swapan Kumar Ghosh, Abir Baran Das , Rajib Bhattacharyya, Care Label Issues of Silk Fabric. *International Journal of Research in Engineering and Technology* 2014; 03(07): 176-179.
6. Fab India, Fabric care, (updated 1999, accessed 16 July 2016) Available from: https://www.fabindia.com/pages/fabric-care/pgid-1124126.aspx\
7. The Global Fragrance Industry: World Markets, Popular Fragrances & Sales Figures, (updated 2014, accessed July 2016) Available from: http://www.kafkaesqueblog. com/2014/02/20/the-global-fragrance-industry-world-markers-popular-fragrances-sales-fi gures/
8. Eagle Marketing Inc, Perfume originals frequently asked questions (updated 2012, accessed July 2016) Available from: http://www.eimi.com/perfumeoriginals/perfumefaq.htm
9. Steilin P, Buttgereit B, Hall L, et al. Skin exposure to deodorants/antiperspirants in aerosol form. *Food Chem. Toxicol* 2012; 50: 2206-2215.
10. A Man's Guide to fragrance: How to choose and wear Colonge (updated 2015 Oct 14; cited Jan 2017) Available from:http://www.artofmanliness.com/ 2015/10/14/guide-to- fragrance.
11. Andreas Natsch. Bacteria and Human (mal)odours. *Flavour Fragr J.* 2013; 28: 199.
12. Hipparagi S A, Srinivasa T, Das B. et al. Studies of application of aromo finish on silk fabrics. *J. Inst. Eng. India Ser. E* 2016; 97: 159. doi:10.1007/s40034-016-0082-8.
13. Mahmut Kayar. Effects of perfume on mechanical and color properties of cotton fabrics, *Int J Cloth Sci Tech*. 2015; 27(1): 6-16.
14. Gulrajani M L. Colour Measurement: Principles, Advances and Industrial Applications. England: Wood head publishing limited; 2010.
15. Asim Kumar Roy Choudhury**.** *Principles of Colour and Appearance Measurement***.** England: Woodhead Publishing; 2014.
16. Raadnui S. Abrasive wear behaviour of a Thai silk fabric. *Int. J. of Applied Mechanics and Engineering* 2006; 11(4), 755-763.

Received 22.03.2017 Reviewed 04.07.2017