Aloe Vera Skin: A New Bio Material for the Coloration of Silk Fabric and Evaluation of Fastness and Color Strength

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Abstract:

In this study, silk fabric was dyed with aloe veras skin, a process that may pose environmental risks where dyeing process was done without Mordanting. Aloe veras skin was used as the source of natural dyes (both in liquid form and powder form). Extracted dyes were applied on 100% scoured & bleached silk fabric in two different methods. One is dry method (dyes are in powder form) and another is liquid method (dyes are in solution form). In dry method 5%, 10%, 15% and 20% shade were applied on silk fabric and in liquid method we made the juice 20%, 30%, 40% and 50% applied on silk fabric. The colour strength (K/S), light, washing and rubbing fastness levels of the dyed fabrics were investigated. The samples dyeing with the above recipe showed superior rubbing fastness, wash fastness and light fastness with a standard colour yield. The most important point is that two colors (one is golden yellow and another one is green) were found by using aloe veras skin. Although every natural dyes gives only one color but here we have successfully found two colors. Finally dyeing of silk with natural dyes from waste aloe veras skin could be a sustainable and economical substitute for synthetic dyeing.

Keywords:

Aloe Veras Skin, Silk Fabric, Eco Friendly, Wastewater, Natural Dyeing

1. Introduction

The current aim is to develop environment-friendly and sustainable technologies for the production of goods, making it possible for future generations to inherit a clean and safe world. Researchers have the opportunity to introduce natural dyes as an alternative to the synthetic dyes known to pose health hazards due to their allergenic and carcinogenic effects of serious environmental pollution [1-3]. The use of non-allergic, non-toxic, antimicrobial and eco-friendly natural dyes on textiles has become a matter of significant importance [4-6]. The consumers, the world over have realized the importance of eco-friendly, biodegradable natural dyes which are being encouraged and preferred by everyone. Natural dyes have no health hazards or

disposal problems but on the contrary act as a health care. Benefits of using natural dyes and finishes for textiles can be numerous [7].

Today, dyeing is a complex, specialized science. Nearly all dyestuffs are now produced from synthetic compounds. This means that costs have been greatly reduced and certain application and wear characteristics have been greatly enhanced. But many practitioners of the craft of natural dyeing maintain that natural dyes have a far superior aesthetic quality which is much more pleasing to the eye. On the other hand, many commercial practitioners feel that natural dyes are non-viable on grounds of both quality and economics [8]. Silk fibre is an amino fibre of animal origin, with a predominance of –COOH and NH2 groups associated with the silk fibroin. Silk is an animal fiber [9]. But instead of being grown in the form of hair, it is produced by insects as a handy material with which to build their webs, cocoons and climbing ropes. Silk is so versatile that it is woven and knitted into a wide variety of fabrics [10]. Bangladesh has a great number of Aloe versa trees that possess nutritious components. However, only the inside part of the Aloe veras leaf is used as a nutrient, while the rest of it is waste [11]. This study suggests that the waste parts of the Aloe veras leaf could be used as a natural dye for dyeing textile fabrics. The experimental natural dyeing results indicate that waste Aloe veras leaf based products can be used as a natural dye for textile coloration.

Aloe barbadensis Miller (AV) leaves consist of two layers, a hard green outer rind including the vascular bundle and an inner jelly-like colourless parenchyma known as ‘AV gel’. AV leaves contain polysaccharides in the parenchyma cells, which the plant uses for its energy. The gel consists of about 99–99.5% water, with the remaining 0.5–1% of solid material containing a range of compounds along with polysaccharides, including carbohydrate, amino acids, minerals, enzymes, phenolic compounds, and organic acids, but polysaccharides make up most of the dry matter of the AV parenchyma and hence the inner gel [12-13]. Aloe gel is widely used for various applications in the food, pharmaceutical, and cosmetic industries, but remaining skins are discharge into the environment without any use. In this research work AV skins are used for the coloration of textile materials. Dyeing was carried out with mordanting and without mordanring but with mordanting no extra result was obtained without loss of chemicals and this is time consuming process. Dyes are applied in two methods like as Aloe Veras Skin Dry dyes (AVSD) and Aloe Veras Skin Solution dyes (AVSS).

2. Materials and Methods

2.1 Materials

The Aloe veras skin used in this study was collected from the local juice seller as waste materials. 100% scoured and bleached Silk Fabric, Acetic acid, sodium carbonate and Instruments (Electric balance, Scissor, Beaker, Measuring cylinder, Pipette, Steel pot, pH checking paper, Burner, Match stick, Thermometer, Steel rod, Watch, Dryer, Iron) were taken from the laboratory of Southeast University.

2.2 Natural dye preparation

As already mentioned Dyes are applied in two methods like as Aloe Veras Skin Dry dyes (AVSD) and Aloe versa skin Solution dyes (AVSS). For AVSD after collecting AVS from juice seller washed AVS by tap water and chopped AVS very carefully. Then placed chopped AVS under the sun light until it become dry with no moisture

remaining. When it became totally dry we took it from the sunlight and made it powder form by grinding. Then fine particles were separated for dyeing. For AVSS after collecting AVS from juice seller washed AVS by tap water and chopped AVS very carefully. After that we made it paste form by blender machine. Then we took juice from it by squeezing. Here squeezing and filtering were done at same time. Finally we took pure liquid color for dyeing. Preparations of dyes from AVS are shown in the Figure1 and Figure2.

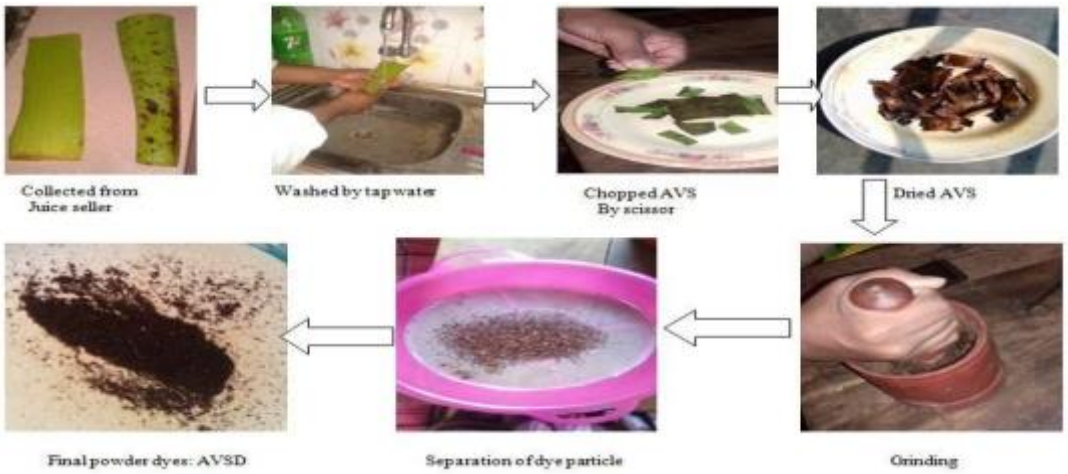

Figure 1. *Procedure for the preparation of solid dyes (AVSD)*

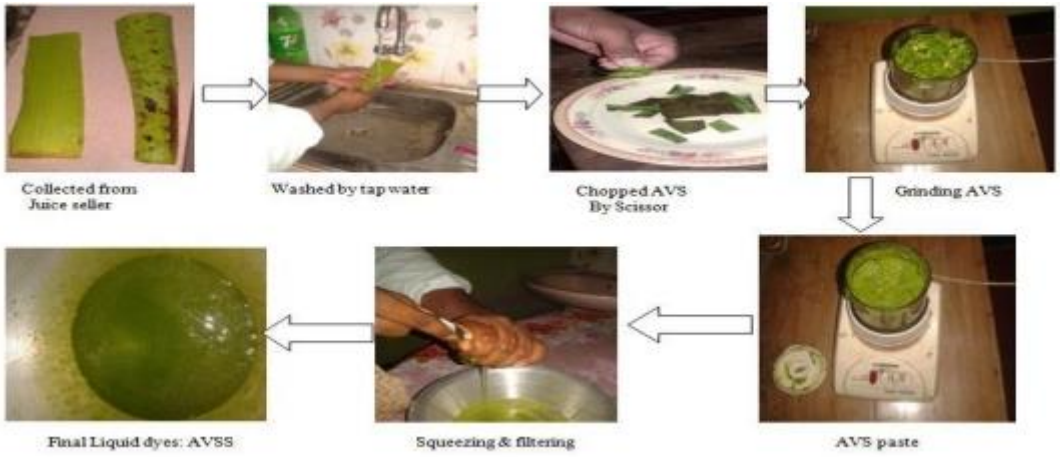

Figure 2. *Procedure for the preparation of Liquid dyes (AVSS)*

2.3 Dyeing with natural dyes

2.3.1 Direct dyeing

According to the recipe placed in the Table 1 direct dyeing was done for both AVSD and AVSS method. After completing dyeing fabrics were neutralized with the help of sodium carbonate. To obtain the optimum time, temperature and pH dyeing was carried out at different time, temperature and pH. Finally maximum color yield was found by the following recipe (Table 1).

2.3.2 Dyeing after extraction

At first extract the dye molecule from the AVSD and AVSS with boiling. Then extracted dyes were applied on the fabric at different time, temperature and pH to obtain the optimum time, temperature and pH. But there is no any advantages were obtained from the direct dyeing method without the loss of time.

2.3.3 Premordant dyeing

Silk fabric (1.5 g) was pretreated in a bath containing 0.4 g mordant at a material/liquor ratio of 1:50 at 60^0C for 30 min. After the pretreated sample was rinsed with cold water and dried in a vacuum oven, it was dyed with the recipe placed in Table 1.

2.3.4 Metamordant dyeing

Silk fabric (1.5 g) was added to a bath containing the above shade% and 0.4 g mordant at a material/liquor ratio of 1:50 at 80^0C. Dyeing was maintained for 60 min at a desired pH value (adjusted using acetic acid).

2.3.5 Postmordant dyeing

Silk fabric was dyed with the following recipe. The dyed silk fabric was gently rinsed with cold water and then added to a bath containing 0.4 g mordant with a material/liquor ratio of 1:50 at 60^0C for a 30 min treatment.

Table 1. *Recipe used for dyeing*

Method	Shade% applied	Concentration of liquid used
AVSD	5%, 10%, 15%, 20%	
AVSS		20%, 30%, 40%,50%

M: L= 1:50, pH=4.5, fabric weight=1.5 gm, CH3COOH= 1g/L, Time= 60 minutes, Temperature=80 ℃, Na2CO3=1g/L (these parameters were used for all shades).

2.4 Measurements and analysis

2.4.1 Colour strength

The maximum wavelength of absorbency (λ_{max}) on the reflectance curves was also used for calculating the colour strength (K/S) of the samples using the Kubelka–Munk equation: [14, 15]

$$K/S = \frac{(1-R)^2}{2R} \quad (1)$$

Where R is the observed reflectance, K is the absorption coefficient, and S is the light scattering coefficient.

2.4.2 Color Fastness to Rubbing

ISO standards ISO105X12:1993 method was followed for rubbing fastness test. At first locked the dyed sample of 14cm X 5cm onto the base of the crock meter. Using the spiral spring clip, rubbing cloth of 5cmX 5cm was set to the finger. After that hand crank was turned at the ratio of 10x10s. Finally removed the rubbing cloth and color transfer was evaluated by using grey scale for staining [15].

2.4.3 Color Fastness to Wash

ISO standards 105-C10 method was followed for wash fastness test. A specimen of 10×4 cm was attached with a multi-fiber fabric strip. Washing solution containing 5 g/L detergent was taken in the laboratory dyeing machine with a liquor ratio of 1: 50. The specimen was treated for 45 minutes at 50±2^{o}C. The specimen was then removed and rinsed in normal water and dried in shadow. The change in color and degree of staining was evaluated visually using grey scale for changing and grey scale for staining [16].

2.4.4 Color Fastness to Light

Light fastness tests were carried out according to AATCC method 16-1994 [17].

3. Results and Discussion

3.1 Effect of color fastness

3.1.1 Direct dyeing

Effects of color fastness to rubbing, wash and light on silk are shown in the Table 2, Figure 3 and Figure 4. It was observed that color fastness to rubbing for AVSD method is excellent in dry condition because the entire grade is 5 for all the shade, whereas in wet condition, 10% and 15% shade result is excellent but 5% and 20% shade is good to excellent. Effect of color fastness to rubbing in AVSS method is excellent in dry condition because the entire grade is 5 for every concentration and in wet condition most of the concentration result is good to excellent but 30% concentration result is excellent.

Color fastness to wash was observed from the Table 2 and Figure 3 that Color staining results are excellent for Acetate, Polyamide and Polyacrylic. Only a few amount of color is stain to cotton and polyester. Here color stains more to wool. For 5%, 10% and 15% results are fair and 20% result is poor. Changing color results are fair for 5% and 10% shade and poor to fair for 15% and 20% shade. In case of AVSS method it was observed that Color staining results are excellent for Acetate, Polyamide and Polyacrylic. Only a few amount of color is stain to cotton and polyester. Here color stains more to wool. For 20% and 30% results are fair and 40% and 50% result is poor. Changing color results are fair for 20%, 30% and 40% concentration and poor to fair for 20% concentration. The light fastness value of the dyed samples in the AVSD method is 6-7 and AVSS method is 5-6.

3.1.2 Dyeing with extraction

Effects of color fastness to rubbing, wash and light are shown in the Table 3. Color fastness to rubbing for AVSD and AVSS method is excellent in dry condition but in wet condition AVSS result is very good in compare to AVSS method. Color staining results are excellent for most of the fibre instead of wool. In AVSD method, better light fastness results were obtained in compare to AVSS method.

3.1.3 Dyeing with pre-mordanting

pre-mordanting, meta mordanting and post mordanting methods were applied for dyeing silk fabric but better results were obtained by pre-mordanting, for that reason pre mordanting results were placed in Table 4. From this table it was observed that all the fastness properties are slightly lower than direct dyeing method instead of mordanting method.

Table 2. *Rubbing, washing, Light fastness of the dyed samples (Direct dyeing)*

Method	Shade%/ Conc.	Rubbing fastness		Wash fastness							Light fastness
						Color staining				Color change	
	Shade%/	Dry	Wet	CA	Co	PA	PET	PAN	Wo		
	5%	5	4-5	5	5	5	5	5	3	3	6
	10%	5	5	5	5	5	4-5	5	3	3	6
AVSD	15%	5	5	5	5	5	5	5	3	2-3	6-7
	20%	5	4-5	5	4-5	5	4-5	5	2-3	2-3	6-7
	Conc.										
	20%	5	4-5	5	5	5	5	5	3	3	6
AVSS	30%	5	5	5	5	5	5	5	3	3	6
	40%	5	4-5	5	4-5	5	5	5	2-3	3	5-6
	50%	5	4-5	5	4-5	5	4-5	5	2-3	2-3	5-6

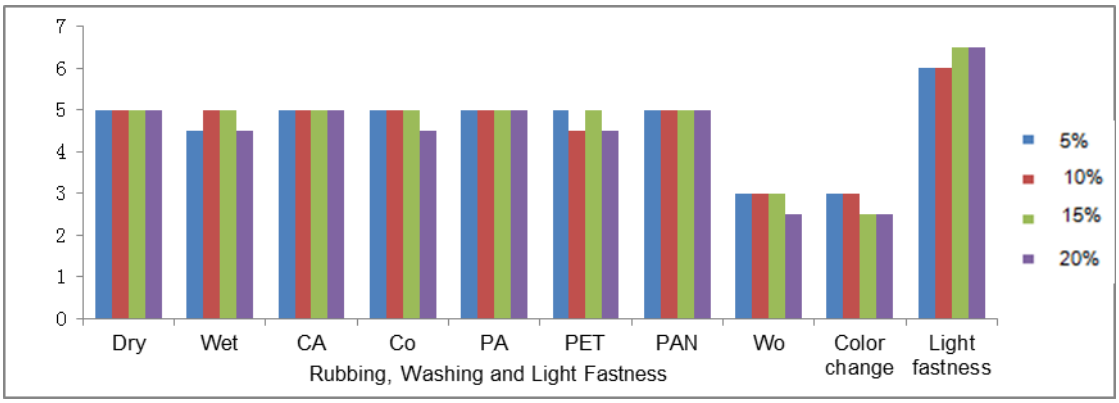

Figure 3. *Effect of color fastness (AVSD method)*

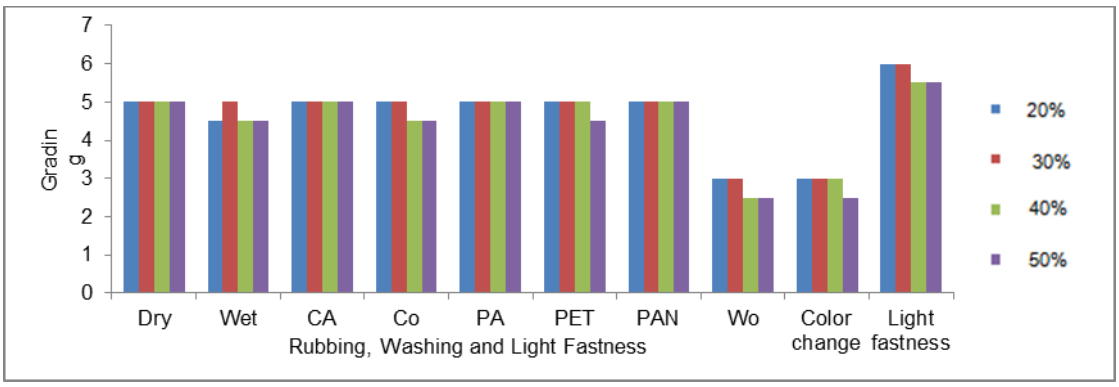

Figure 4*. Effect of color fastness (AVSS method)*

Table 3. *Rubbing, washing, Light fastness of the dyed samples (dyeing after extraction)*

Method	Shade%/ Conc.	Rubbing fastness		Wash fastness							Light fastness
						Color staining				Color change	
	Shade%/	Dry	Wet	CA	Co	PA	PET	PAN	Wo		
	5%	5	4-5	5	5	5	5	5	3	3	6
	10%	5	5	5	5	5	4-5	5	3	3	6

AVSD	15%	5	5	5	5	5	5	5	3	2-3	6-7
	20%	5	4-5	5	4-5	5	4-5	5	2-3	2-3	6-7
	Conc.										
	20%	5	4-5	5	5	5	5	5	3	3	6
AVSS	30%	5	5	5	5	5	5	5	3	3	6
	40%	5	4-5	5	4-5	5	5	5	2-3	3	5-6
	50%	5	4-5	5	4-5	5	4-5	5	2-3	2-3	5-6

Table 4. *Rubbing, washing, Light fastness of the dyed samples (dyeing with pre-mordanting)*

						Wash fastness					
Method	**Shade%/ Conc.**	**Rubbing fastness**				**Color staining**				**Color change**	**Light fastness**
	Shade%/	**Dry**	**Wet**	**CA**	**Co**	**PA**	**PET**	**PAN**	**Wo**		
	5%	5	4-5	5	5	5	5	5	3	3	6
	10%	5	5	5	5	5	4-5	5	3	3	6
AVSD	15%	5	5	5	5	5	5	5	3	2-3	6-7
	20%	5	4-5	5	4-5	5	4-5	5	2-3	2-3	6-7
	Conc.										
	20%	5	4-5	5	5	5	5	5	3	3	6
AVSS	30%	5	5	5	5	5	5	5	3	3	6
	40%	5	4-5	5	4-5	5	5	5	2-3	3	5-6
	50%	5	4-5	5	4-5	5	4-5	5	2-3	2-3	5-6

3.2 Effects of Colour strength

3.2.1 Effect of pH on colour strength

Natural dyes generally have unsaturated aromatic bonds with or without ligands, which are responsible for reaction with metallic mordants and functional groups of fibrous polymer. Ligands are sensitive to change in pH and so pH plays a major role in the formation of final color from natural colorants [19]. Effects of pH of the dyeing solution on colour strength of dyed samples are shown in Table 5 as well as Effects of pH on colour strength by AVSD andAVSS method are shown in Figure 5 and Figure 6 respectly. It was observed that depth of the color increases by both AVSD and AVSS method with the increase of the pH of the dyeing solution and maximum color strength was obtained at pH 4.5.

Table 5. *Effect of pH on colour strength*

Method	**pH values**	**K/S values (400 nm)**		
		Direct dyeing	**Dyeing with extraction**	**Dyeing with mordanting**
	3.5	15.7	13.4	12.8
	4	20.4	16.6	15.6
AVSD	4.5	22.5	20.5	19.75
	5	21	19.05	19
	5.5	20.5	17.04	16.2
	3.5	9.5	8.75	9.01
	4	13.3	15.6	14.3
AVSS	4.5	18.5	17.02	16.5
	5	18.02	16.09	15.2
	5.5	16	15	14

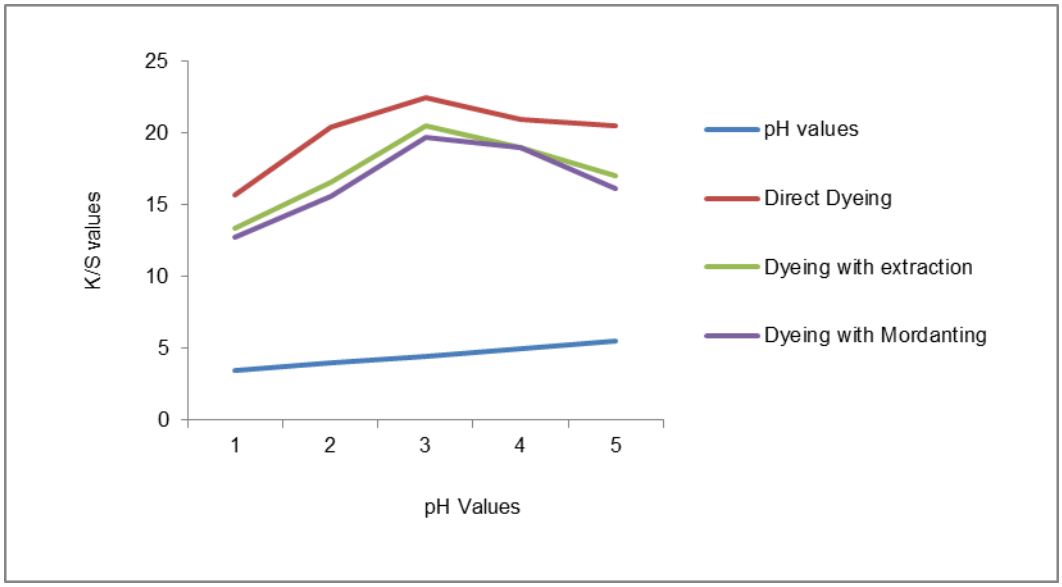

Figure 5. *Effect of color strength on pH (AVSD method)*

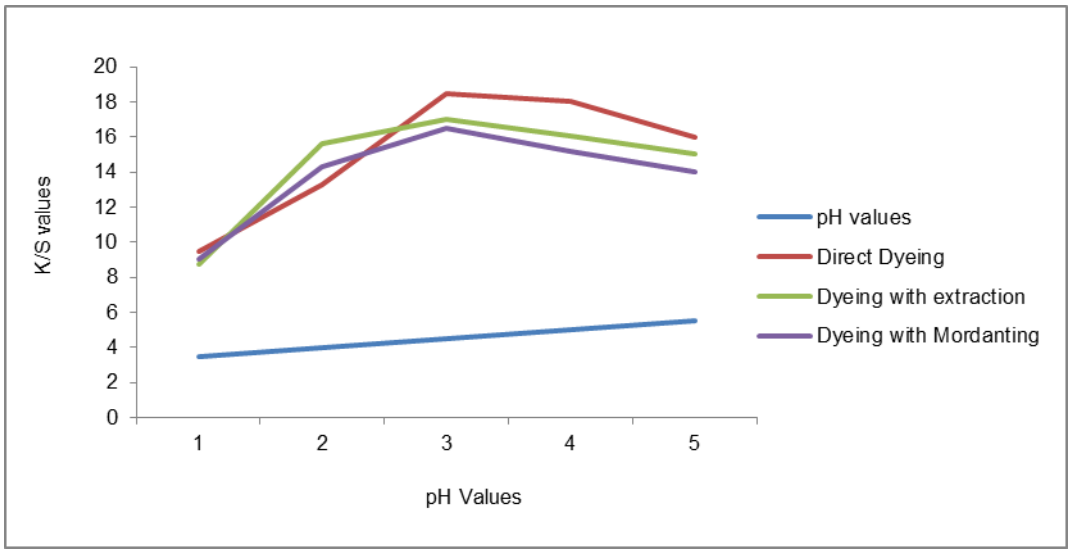

Figure 6. *Effect of color strength on pH (AVSS method)*

3.2.2. Effect of Temperature on colour strength

Effects of Temperature on colour strength of dyed samples are shown in Table 6 as well as Effects of Temperature on colour strength by AVSD and AVSS method are shown in Figure 7 and Figure 8 respectfully. It was observed that depth of the color increases by both AVSD and AVSS method with the increase of the Temperature of the dyeing solution and maximum color strength was obtained at Temperature 80^0C.

Table 6: *Effect of Temperature on colour strength*

Method	Temp. ^{0}C	K/S values (400 nm)		
		Direct dyeing	Dyeing with extraction	Dyeing with mordanting
	60	13.1	12.5	11.9
	65	14.02	13.04	12.4
AVSD	70	16.1	14.9	14.6
	75	21.5	18.5	17.2
	80	23.1	20.5	19.8
	85	20.1	18.04	16.4

	60	9.5	8.75	8.51
	65	13.3	12.6	11.3
AVSS	70	17.5	15.02	14.5
	75	18.02	16.9	15.2
	80	18.8	17.1	16.3
	85	16.2	15.3	14.4

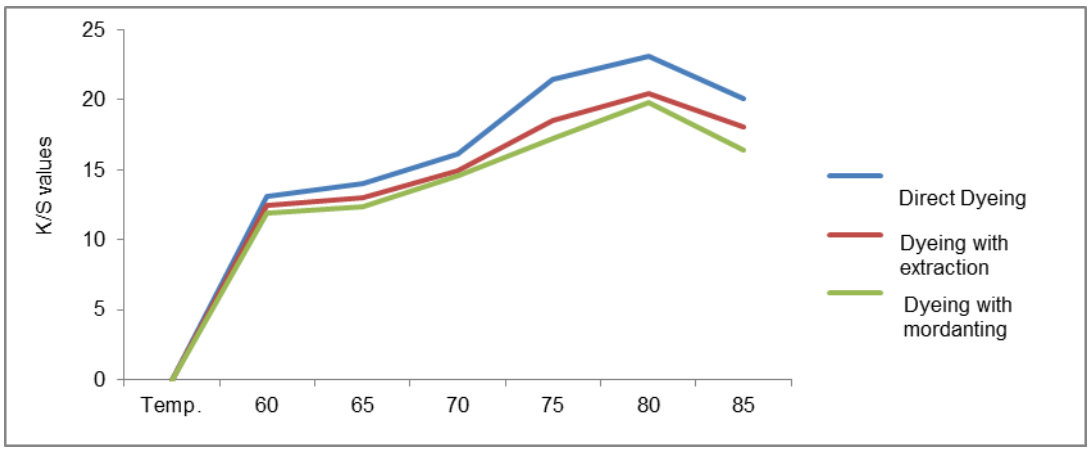

Figure 7. *Effect of Temperature on colour strength (AVSD method)*

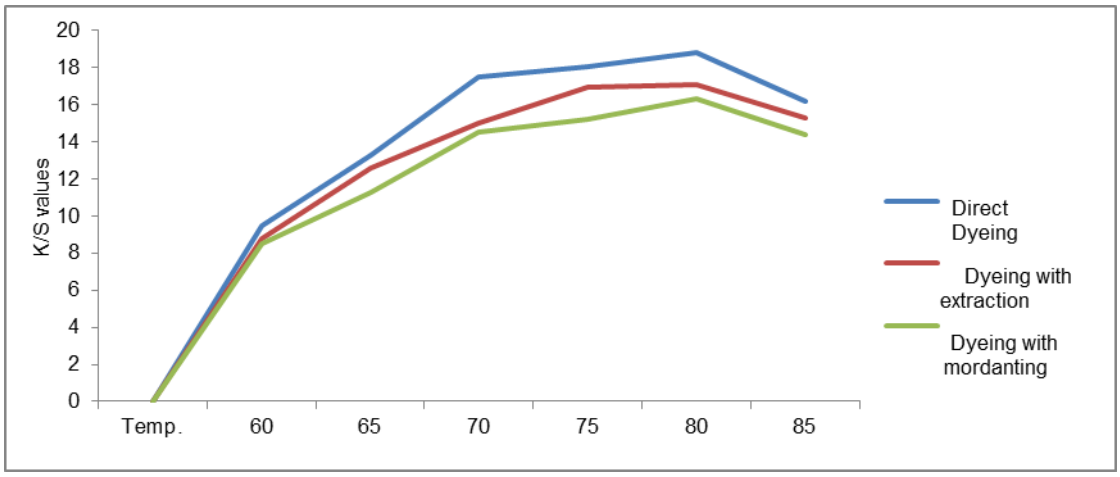

Figure 8. *Effect of Temperature on colour strength (AVSS method)*

4. Conclusions

A significant conclusion drawn from this work is that the invention of a new biodegradable natural dye for the coloration of silk fabric by Aloe Veras Skin and even eliminates the environmental problem. In this research work it has been observed that, how different methods can be applied using aloe veras skin on silk fabric as a natural dye and how cost can be minimized. So to achieve this goal, we have done different procedures forapplying aloe veras skin on silk fabric. Both AVSD and AVSS method were applied on silk fabric where dyeing carried out at direct dyeing, dyeing with extract and dyeing with mordanting. But the result was not up to the mark by dyeing with extract and dyeing with mordanting.

Different fastness properties and color strength of the dyed samples were analyzed. It was found that, with the increment of shade %, color fastness properties are affected. Again it was also observed with the increment of shade %

a considerable change on depth of color was found for both AVSD and AVSS method. Effects of pH and Temperature on color strength were also observed to get the maximum color yield. Besides this AVS is biodegradable materials and there is no any bad impact on environment. On the basis of experimental results of different tests on samples dyed with varying parameters it can be concluded that, silk fabric can be dyed with two colors (golden yellow and green) without mordanring.

Conflicts of Interest

The author declares that there is no conflict of interests regarding the publication of this paper.

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