American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

Color Performance and Cost Effectiveness Evaluation of Acid and Basic Dyed Silk Fabric

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Abstract

Silk, the natural protein fiber has a great importance in textile clothing, apparel and home decoration due to its definite lustrous appearance, peach like softness and draping qualities. Fine fibrillar structure and orientation of fiber molecules control its dyeing nature covering almost the entire spectrum of colors and hues. Silk is mainly used for value added premium quality products, so this research work is carried out to find out the economical dyestuff for silk along with required end customer performance. Shade strength measurement using data color is also another technical aspect of this research.

Keywords: Silk dyeing; color performance; costing; economical.

1. Introduction

Silk is an animal fiber, and therefore, like all animal fibers, mechanism of dyeing silk is dependent mainly on free amino and carboxyl groups.

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Anionic dyes such as acid, metal complex, reactive and selected direct dyes are suitable for dyeing silk as it is slightly cationic with iso-electric point at above pH 5 [1]. Silk offers a wide coloration possibility covering almost the entire spectrum of colors. But the main objective of coloration of a textile fiber is that the permanency of the color and should not allow damage of natural abstract of fiber. This implies that it should not destroy its color during processing following coloration, dyeing and subsequent useful life (i.e. washing, light, rubbing and perspiration). So whatever dyestuff we use for silk dyeing it is very essential to have permanency of that dyestuff [2]. Sericin, a group of soluble glycoprotein, normally present in the silk, which essential to be removed from silk before dyeing it by degumming process. During dyeing, anionic dyestuffs namely acid and cationic dyes namely basic dyes form a 'Dye-Fiber' complex by electrostatic and hydrogen bonds [3]. This mechanism requires an acidic medium to be activated. Exhaustion of dye from the bath requires a proper controlling of the specified and recommended dyeing parameter. 15 sample were prepared for silk dyeing both by acid dye and basic dye according to the dyeing method specified the dyes manufacturer. Acid dyes were applied on silk at 98C for 60 min while for basic dyes 80C temperature for 40 min is maintained. Dyeing procedures of basic dyes were almost similar to the dyeing procedures of acid dyes. Fixation treatment sometimes carried out on colored silk with a view to increase its fastness behavior.

2. Experiment and Methodology

2.1 Materials

2.1.1 Substrate

The raw silk fabric, that is collected from the Sopura silk mills Ltd., Dhanmondi. The fabric is plain woven with the weight of 60 GSM.

2.1.2 Chemicals

Enlisted important chemicals are used in subsequent processes-

Table 1: Important chemicals used for silk pretreatment and dyeing.

Name	**Brand Name**	**Used in**
Synthetic Detergent	Nonyl Phenol Ethoxylate	Degumming
Sequestering agent	SQ-117CA	Degumming
Wetting agent	KS-10	Degumming
Acid dyes	Erionyl	Dyeing
Basic Dyes	Taiacryl	Dyeing
Buffer	Albatex AB 45	Acid dyeing
Levelling Agent	Albagal SET	Acid and Basic dyeing
Soaping agent	Eriopon OS	After treatment
Fixing agent	Erional FRN	After treatment

2.1.3 Equipment

Enlisted machineries are used in subsequent processes-

Table 2: Machineries used for silk pretreatment and dyeing.

Name	**Brand name**	**Process**
Lab Dyeing m/c	IR Dyer	Degumming, coloration
CCMS/ Data color	650	K/S value measurement
Washing machine	Labtec	Wash Fastness Test
Crock meter	Crockmaster	Rubbing Fastness Test
Xenon light box	Q-sun	Light Fastness Test
Incubator	Labtec	Perspiration fastness test

2.2 Methods of silk dyeing

2.2.1 Degumming of silk

Degumming of silk with synthetic detergents (Non-ionic product) is carried out as pretreatment of silk.

Table 3: Recipe for silk degumming with synthetic detergent

Synthetic Detergent (Nonyl Phenol Ethoxylate)	3g/l
Wetting agent (KS-10)	2.5 g/L
Sequestering agent (SQ-117CA)	0.5 g/l
Soda ash	2 g/l
pH	11.5
M: L	1:10
Dyeing Temperature	95^0 C
Dyeing Time	40min

The bath was set with substrate at room temperature and KS-10 (wetting agent), SQ-117CA (Sequestering agent) and detergent was added to it. Then temperature was raised at 2°C /min to 80°C and then pH was maintained to 11.5 by adding soda ash. After that, temperature was raised to 95°C and ran for 40 minutes for optimum removal of sericin gum. The bath was cooled down to 60°C and then the bath was dropped. At last, it was washed with warm and cold water successively.

2.2.2 Silk dyeing with acid dyes and basic dyes

In this experiment, total 15 samples were dyed in red, blue and yellow color by acid and basic dyes respectively. For each color, we dyed sample in 0.5%, 1%, 2%, 3% and 5% shade range.

Table 4: Recipe for silk dyeing with acid and basic dyes (for 4 gm silk fabric)

Acid Dyes (Erionyl)	3% (owf)		Basic dyes (Taiacryl)	3% (owf)
Albatex AB 45	1.0 g/l		Albagal SET (Leveling Agent)	1 %
Albagal SET (Levelling Agent)	1.0 %		Glauber Salt (Na_2SO_4.10 H_2O)	10 g/l
M: L	1:10		Acetic Acid (pH=4.5)	0.07 ml
Temperature	98°C		M: L	1:10
Time	60min		Time x Temperature	40 min x 80º C

For dyeing with acid dyes, Albagal SET (Leveling agent) was taken into the dye pots and dye solution for shade 0.5%, 1%, 2%, 3%, 4% respectively were added into the dye pots. Then, Albatex AB 45 (buffer solution) was added to maintain pH 4.5 and subsequently silk fabric were taken into the pots. Dye bath was prepared to 50^0C temperature and ran the bath for 10 minute at 50^0C. Temperature was raised to 98^0C at 1^0 C/ min rate and Dye bath was run for 60 min. Finally, bath was dropped to 60°C at 1.5°C /min rate [2]. For dyeing with basic dyes, dyeing process is similar except adding Glauber salt with Ablagal SET and dye solution in dye pot. In this process, bath was prepared to 40^0C for 10 min. Temperature was then raised to 80^0C at 1.5^0 C/ min rate. Dye bath was run for 40 min and finally dropped to 60°C at 1.5°C /min rate.

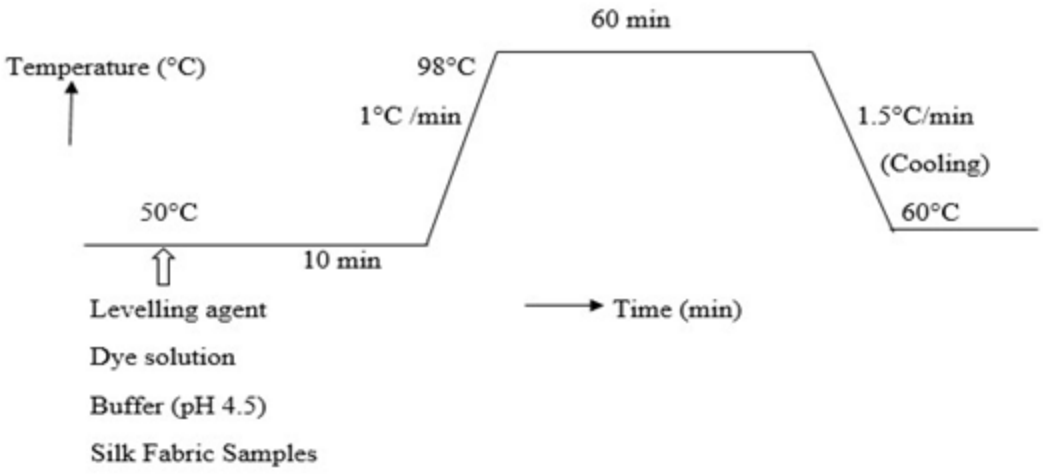

Figure 1: Dyeing curve of acid dye on silk [2].

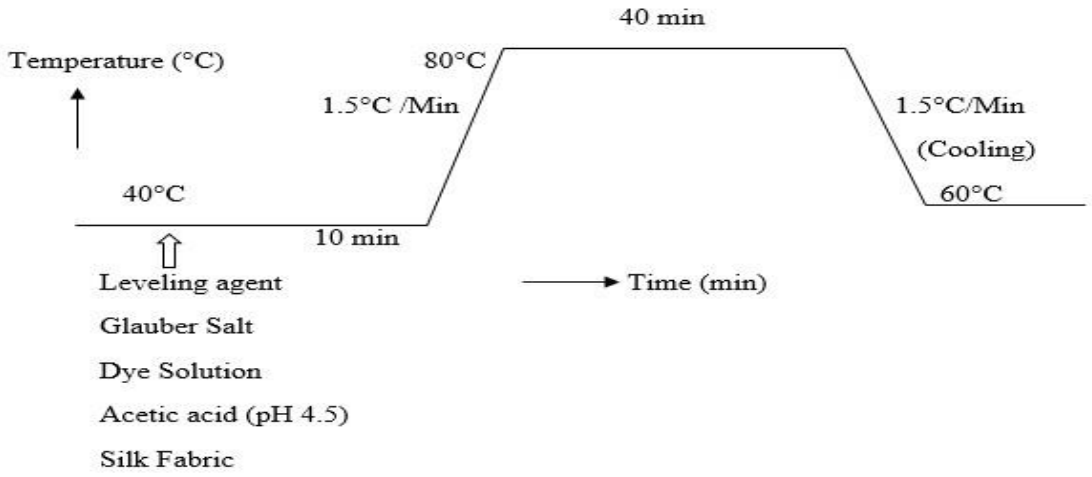

Figure 2: Dyeing curve of basic dye on silk.

Acid and basic silk samples were rinsed with cold water, washed at 80°C for 5 min with soaping agent Eriopon OS 1.0 g/l and then these were rinsed again in cold water. Fixing was done only on acid dyed samples with Erional FRN 3.0% at pH 4.5 (with Albatex AB 45) at 80°C for 30 minutes. Then they were rinsed again with cold water. At last the samples were dried in dryer.

3. Result and Discussion

Comparing criteria of this work are shade strength, color performace properties and last one is costing between acid and basic dyed silk fabric.

3.1 Effect of hue on color strength

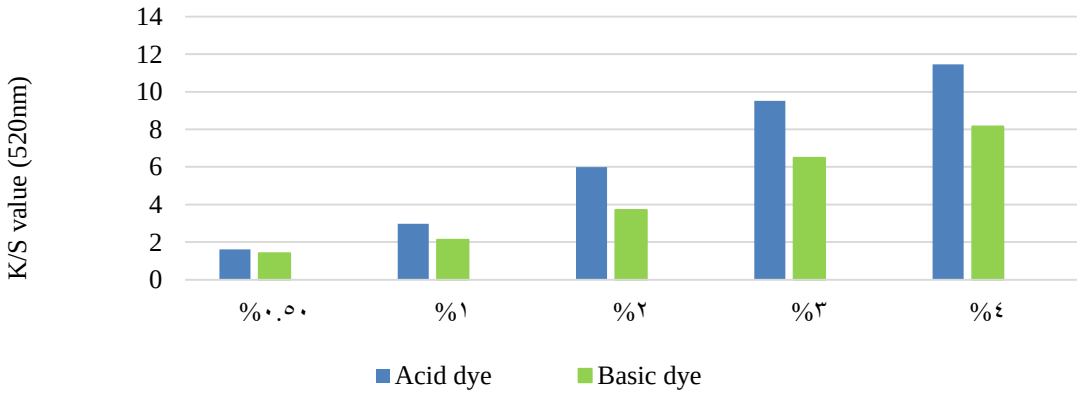

Figure 3: K/S value of acid and basic dyed silk samples (Red shade)

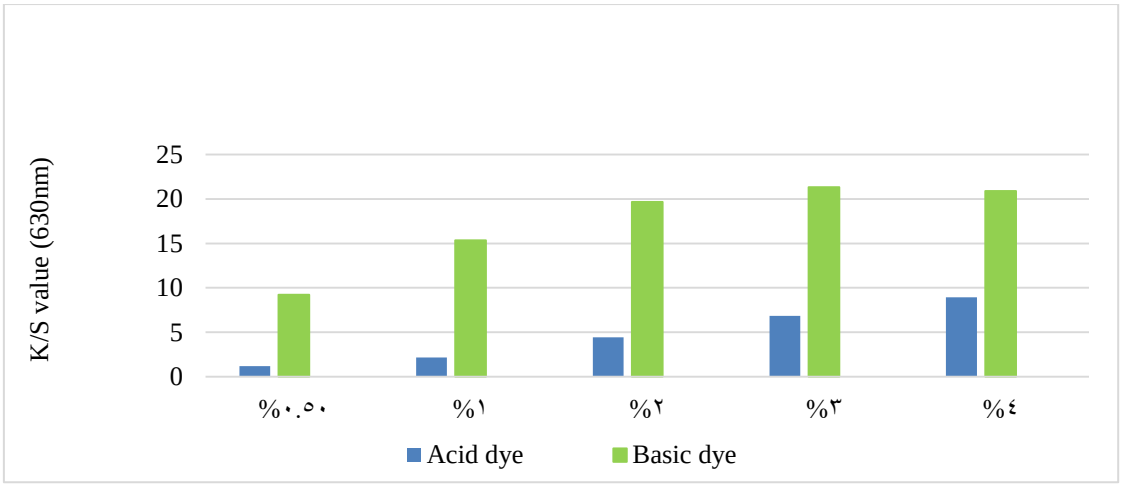

Figure 4: K/S value of acid and basic dyed silk samples (Blue shade)

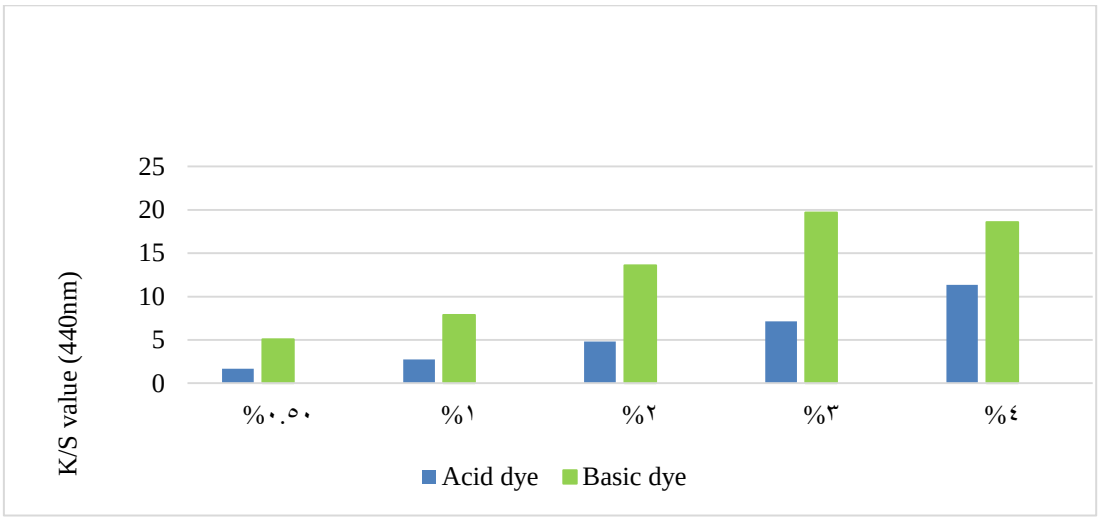

Figure 4: K/S value of acid and basic dyed silk samples (Blue shade)

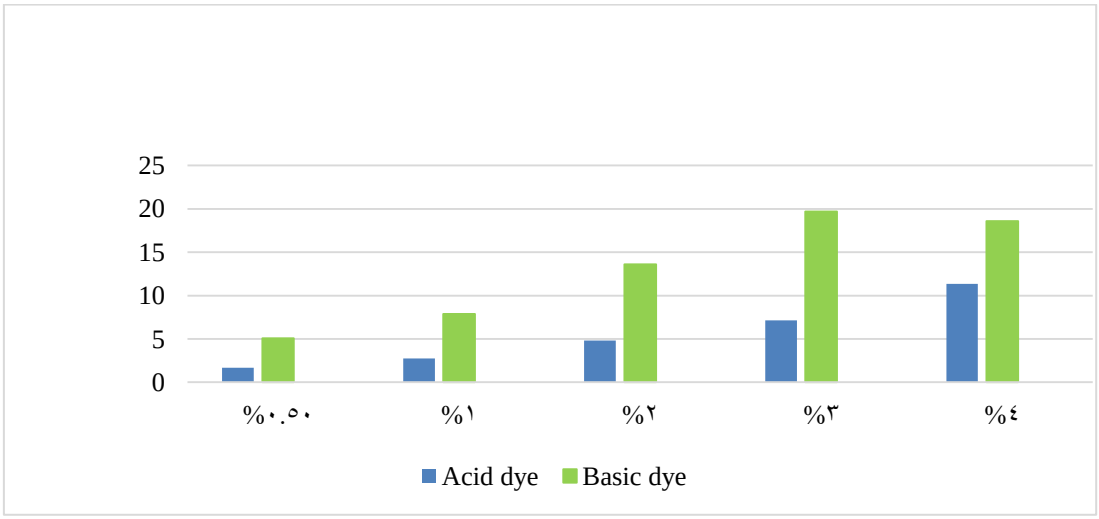

Figure 5: K/S value of acid and basic dyed silk samples (Yellow shade)

Above bar diagram (**Figure 3, 4 and 5**) represents that for acid dyes, K/S value is higher for red shade, so higher dye take up for red shades. For Basic dye, higher K/S value for blue and yellow shade, so higher dye take up for blue and yellow shades.

3.2 Color fastness of differently dyed silk fabric

3.2.1 Color fastness to light

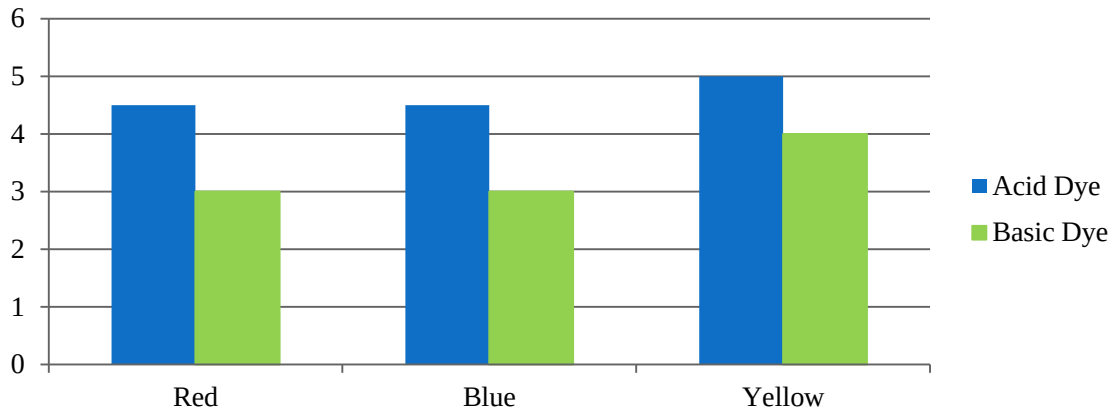

Figure 6: Color fastness to light (for 3% Shade)

From **Figure 6**, it is found that, acid dyed silk sample shows better color fastness to light than basic dyed silk. It is also obvious that fastness to yellow color for both dyes is comparatively better than red and blue color.

3.2.2 Color fastness to wash

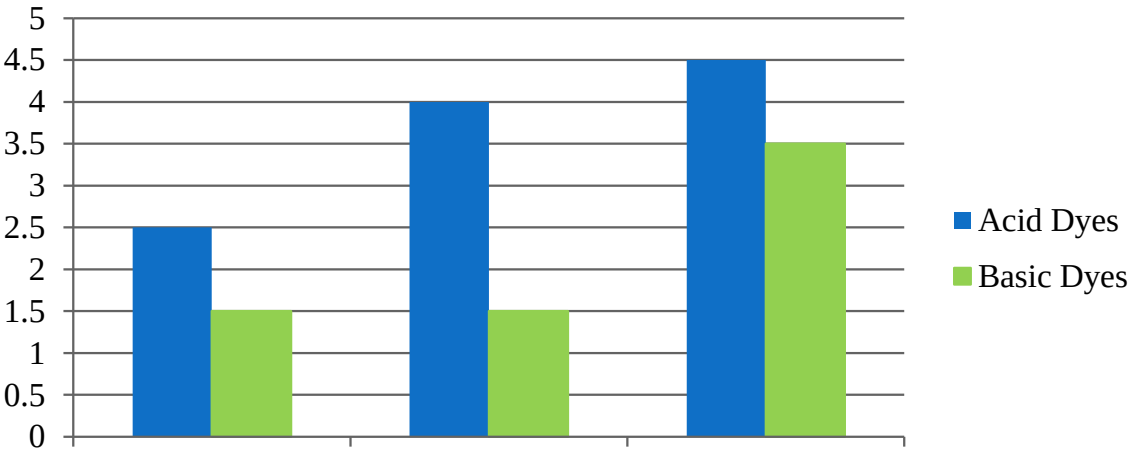

Figure 7: Color fastness to washing (color fading for 3% shade)

Fig 7 represents that acid dyed silk sample shows better resistance color fading against the action of washing. It is also visible that fastness to yellow color for both dyes is comparatively better than red and blue color.

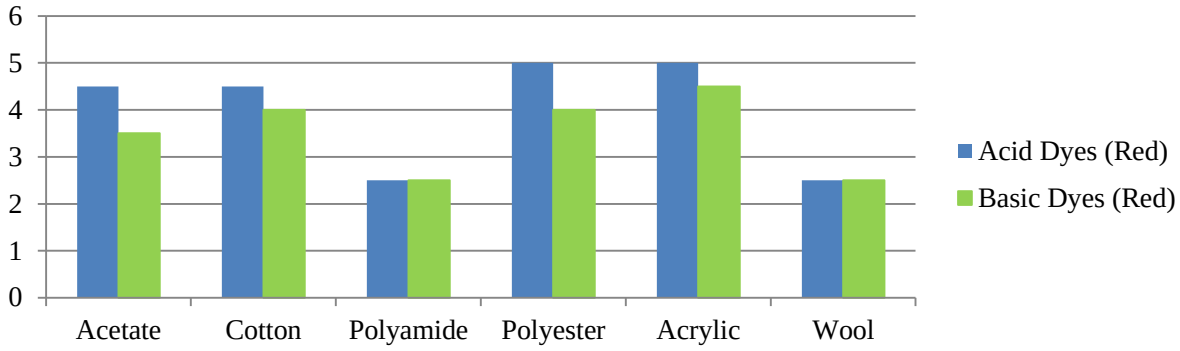

Figure 8: Color fastness to washing (color staining) (3% shade of Red)

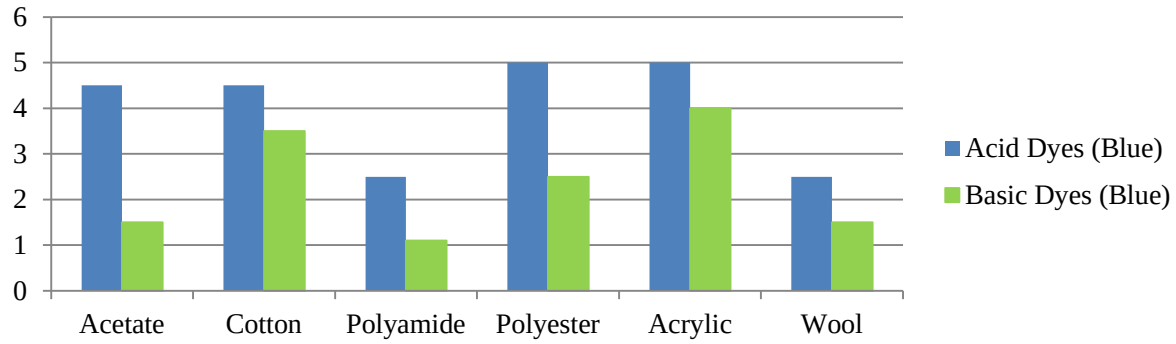

Figure 9: Color fastness to washing (color staining) (3% shade of Blue)

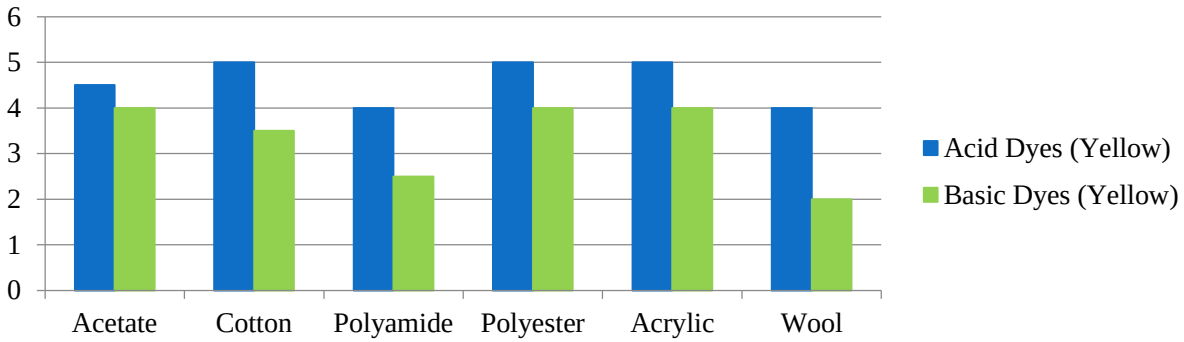

Figure 10: Color fastness to washing (color staining) (3% shade of Yellow)

From **Figure 8, 9 and 10**, it is intuitively obvious that, acid dyed silk sample shows much better performance in case of color staining than basic dyed silk.

3.2.3 Color fastness to rubbing

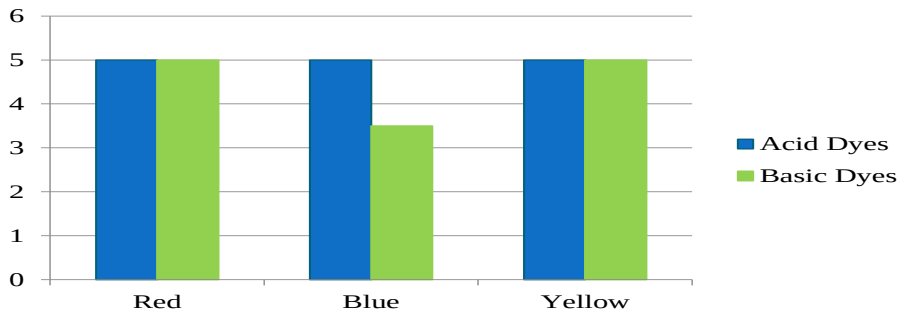

Figure 11: Color fastness to dry rubbing (for 3% Shade)

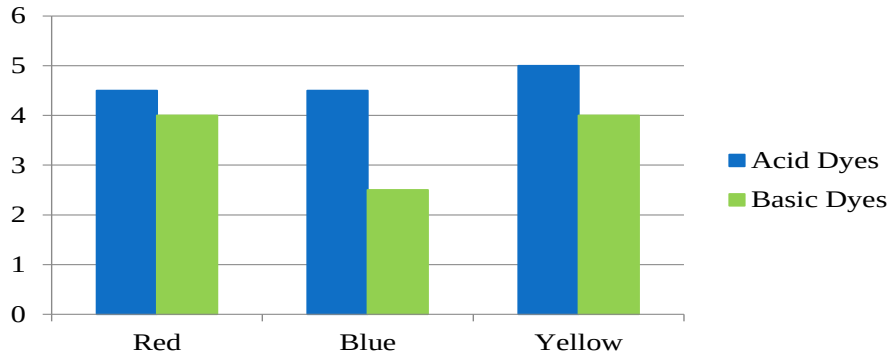

Figure 12: Color fastness to wet rubbing (for 3% Shade)

Figure 11 represents that, fastness performance of acid dyed silk is almost same as the basic dyed silk for red and yellow shade, in case of blue shade, fastness performance of acid dyed silk is comparatively better than basic dyed silk. **Figure 12** represents that, color fastness performance of acid dyed silk is better than the basic dyed silk fabric in case of wet rubbing.

3.2.4 Color fastness to perspiration

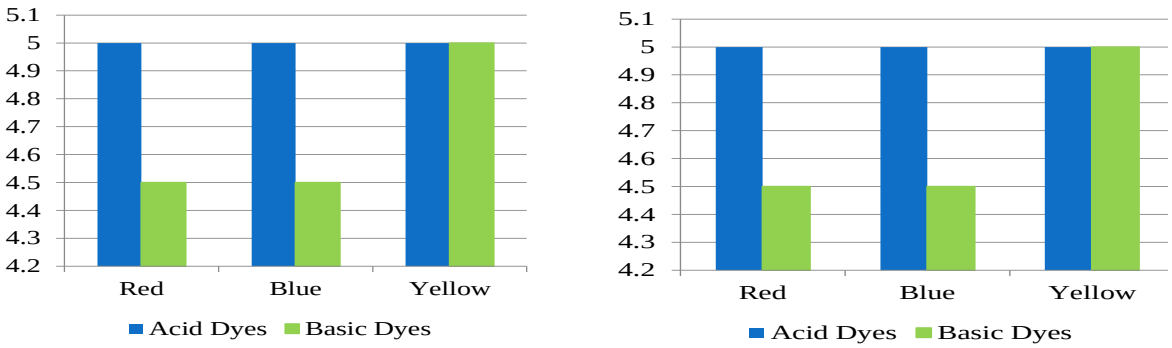

Figure 13 and 14: Color Fastness to acidic and alkaline perspiration respectively (color fading for 3% shade)

Figure 13 represents that, resistance to color fading against the action of acidic perspiration of acid dyed silk is much better than the basic dyed silk fabric in case of red and blue shade while in case of yellow shade, color fastness of acid dyed silk is almost same as the basic dyed silk. **Figure 14** represents that, resistance to color fading against the action of alkaline perspiration of acid dyed silk is much better than the basic dyed silk fabric in case of red shade while in case of blue and yellow shade, color fastness of acid dyed silk is almost same as the basic dyed silk.

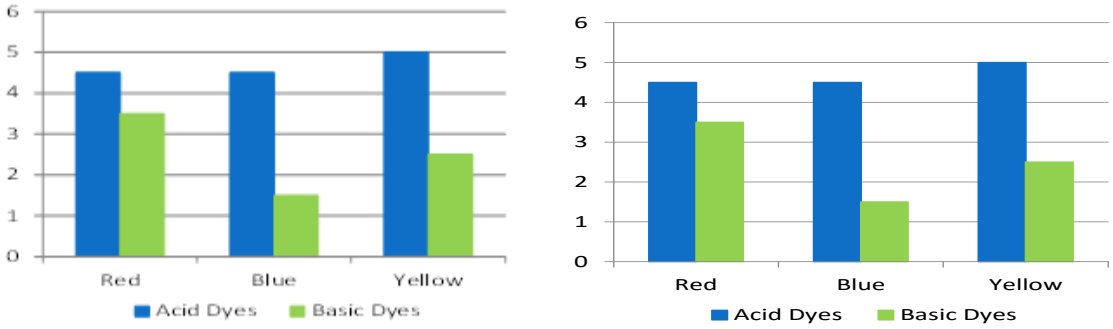

Figure 15 and 16: Staining performance to acidic and alkaline perspiration (for 3% Shade)

Figure 15 and 16 represent that, staining performance of acid dyed silk is very much better than the basic dyed silk fabric for both acidic and alkaline perspiration. Yellow color shows comparatively better staining than rest two color in case of acid dyed silk and red color's staining is comparatively better in case of basic dyed silk.

3.3 Cost effectiveness of silk dyeing

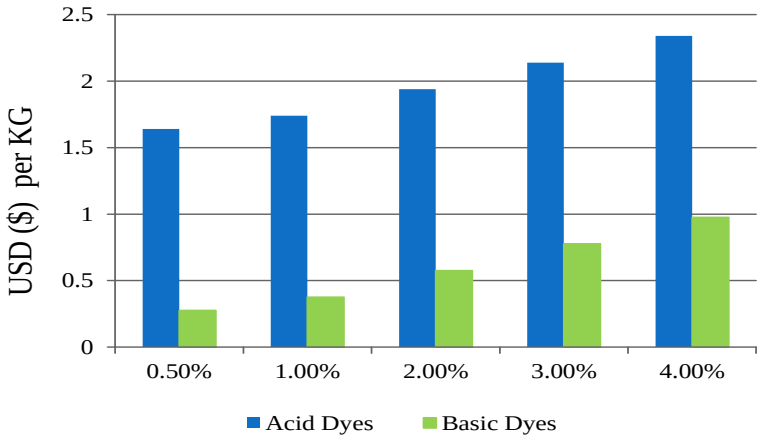

Figure 17: Cost in USD for 1kg silk fabric dyeing.

Table 5: Costing for 1kg silk fabric dyeing by acid and basic dyes

Dyes	**Total cost in USD for 1 kg fabric dyeing**				
	0.5% conc. (owf)	1% conc. (owf)	2% conc. (owf)	3% conc. (owf)	4% conc. (owf)
Acid dye (Red, Blue, Yellow)	1.642	1.74	1.94	2.14	2.34
Basic dye (Red, Blue, Yellow)	0.276	0.376	0.576	0.776	0.976

The above data represents that silk dyeing with acid dyes is costlier than dyeing with basic dyes (at M: L ratio 1:10). One of the main reason behind this is the use of fixing agent during silk dyeing with acid dyes while no fixing agent is used in case of basic dye. It is also clear that the cost increases with the increase of dye concentration. As degumming is same for both process, so cost of degumming is not considered here for cost calculation.

Costing calculation for dyeing 1Kg silk fabric with 0.5% acid dye

Table 6

Ingredient	Quantity (gm)	Rate of Price (per /kg)	Cost(USD)
Acid Dyes	5	$20	$0.1
Levelling Agent (Albagal Set)	10	$4.50	$0.052
Buffer (Albatex AB 45)	25	$2.20	$0.05
Soaping Agent (Eriopon OS)	20	$4.50	$0.09
Fixing Agent (Erional FRN)	300	$4.50	$1.35
		Total	**$ 1.642**

Costing calculation for dyeing 1Kg silk fabric with 0.5% basic dye

Table 7

Ingredient	Quantity (gm)	Rate of Price (per /kg)	Cost
Basic Dyes	5	$ 20	$0.1
Levelling Agent (Albagal Set)	10	$4.50	$0.045
Glauber salt	5	$2.20	$0.011
Acetic Acid	30	$1.0	$0.03
Soaping Agent (Eriopon OS)	20	$4.50	$0.09
		Total	**$0.276**

4. Conclusion

This research work is done to find out suitable cost effective dyes for dyeing silk between acid dyes and basic dyes. This study suggests that silk dyeing with acid dyes is more suitable from the point of view of color performance properties as the data shows good result. On the other hand, basic dyes are suitable from economical point of view. The fastness properties of basic dyes can be increased by mordanting in further research.

4.1 Limitations

The color fastness to wash method we have chosen here for silk, ISO-105/ C06-C2S which is done in alkaline medium. As acid dyed silk structure is as like Fibre-$NH3^{+}$Dye-SO_3^{-}, the dye-fibre bond is often broken down when it is given to alkaline test medium by producing water (H^{+} from the fibre reacts with the OH^{-} of Alkaline medium to form water).The samples are dried in normal dryer instead of stenter. Use of stenter may further increase the performance.

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