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# Mango kernel starch: A bio-thickener for natural printing on fabric

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**Abstract**
Printing designs and colours form an artistic expression to establish the fabric. The craft of printing occupies a unique place in Indian civilization. The thickener is the crucial component of print paste. Thickeners used in textile printing are high molecular weight compounds giving viscous pastes in water. Mango kernel is a rich source of starch content. Annually aproximately 0.13 million tones of starch can be isolated from mago kernel. The starch is eco friendly, low cost, non – conventional starch and has good pasting property therfore in present study it used for printing on cotton and silk fabrics using marigold dye source as pigment. The results revealed that 2 percent mango kernel starch exhibited good to better light fastness, very good fastness rating to washing, rubbing and perspiration on both cotton and silk fabrics. Hence it can be concluded that mango kernel starch can be used as indigenous and natural thickener for textile printing.

**Keywords:** Cotton, colourfastness mango kernel, printing, starch, thickener

## Introduction
The textile dyeing and printing industry plays an important role in the economical growth as well as in the environmental sectors of any country. The use of non-toxic and eco-friendly natural dyes on textiles has become a matter of significant importance because of the increased environmental awareness in order to avoid some hazardous synthetic dyes (Kumar 2015) [15].
The concept of textile printing was developed in India few centuries before the birth of Christ. Printing is an art and science probably as old as the art of weaving of textiles (Prayag, 1990) [13]. The process of printing textiles can be considered as localized dyeing in which colour is applied in the form a viscous paste of a designed pattern (Dixit, 2000) [6].
India has a rich and diverse tradition in the field of textiles. The printing and decorating technique in India is rather extensive. Rajasthan, Gujarat and Masulipatnam are famous for the block printing techniques used to beautify the cloth material. Block printing on textiles is done with wooden blocks by craftsmen to create beautiful designs (Meena B, 2014).
Printing is a form of dyeing in which the color is applied to specified area. The resulting multicolored patterns have attractive and artistic effects which enhance the value of fabric. To resist the coloring matter to the design area, it is pasted with thickening agent which may be natural or synthetic polymer. Plant products are attractive alternatives to synthetic products because of biocompatibility, low toxicity, environmental "friendliness" and low price compared to synthetic products. Natural products are also generally non-polluting renewable sources for the sustainable supply (Babel & Gupta, 2015) [2, 3].
The thickener is the crucial component of printing paste. Thickeners used in textile printing are high molecular weight compounds giving viscous pastes in water. These impart stickiness and plasticity to the printing paste so that it can be applied to a fabric surface without spreading and are capable of maintaining the design outlines even under high pressure (Solangi *et al*, 2014) [16]. There is a wide range of thickener materials available including alginates, natural vegetable gums, synthetic polymers, or even foams. The synthetic thickening agents used is generally extremely high-molecular weight polymers capable of developing a very high viscosity at a relatively low concentration. However, the paste or thickening agents are difficult to dispose off as it creates sedimentation in the water during its waste disposal. An increasing awareness about the realization that the intermediates and chemical used in synthetic dyes being toxic and hazardous to human health as well as to the environment, has led to the revival of interest in the non-toxic eco-friendly materials (Babel *et al.*, 2015) [2, 3].
Mango (*Mangifera indica*) is an important fruit crop cultivated in tropical regions, belongs to *Anarcaiaceae* family. India is the largest producer of mangoes in the world.

The kernel obtained after decortications of mango seeds can be utilized as a supplement to wheat flour or for extraction of edible oils (Kaur *et al.,* 2004) [9]. Besides its use in animal feed, mango kernel flour can be utilized for edible purposes. After industrial processing of mango and extraction of oil from mango kernel, considerable amounts of mango kernels are discarded as waste, usually termed as total waste, has sufficient amount starch. Approximately 40-60% waste is generated during processing of mango, out of which peel and kernel constitute 12-15% and 15-20%, respectively (Nilani P. *et al.,* 2010) [12].

Depending upon the variety, mango kernels contain 6% protein, 11% fat, 77% carbohydrate, 2% crude fibre and 2% ash, based on the dry weight average (Puravankara *et al.,* 2000). As mango kernel contain larger amount of carbohydrate hence are rich source of starch content. Annually aproximately 0.13 million tones of starch can be isolated from mago kernel. Mango kernel starch is eco friendly, low cost, non – conventional starch and has good pasting property (Nilani P. *et al.,* 2010) [12]. Extraction and physicochemical properties studies revealed that the mango seed kernel is a good source of starch and can be utilized for industrial purposes (Sonthalia M & Sikdar D. C., 2015) [17]. In the present study, an attempt was made to printing silk fabric with marigold dye using a natural thickener – mango kernel starch.

## Material and methods

### Fabric

Silk fabric was used for the present study. Silk fabric was procured from the Khadi gramogyoga. Before printing the silk fabric was degummed, to remove sizing material present in the fabric that hinders the absorption. Degummed fabric was pre- treated with one per cent myrobolan (*Terminalia chebula*).

### Dyes and mordents

Marigold flower (*Tagetes erecta*) is one of the most popularly used flowers for decoration in any Indian festival. Research findings showed that the marigold flower can serve as a potential source of natural colorant which can be used in textile for dyeing and printing purpose (Kumar *et al.* 2015) [10]. Six percent of marigold powder was soaked in one liter amount of water. The dye solution was boiled for 40-45 mins for extraction of dye. The extracted dye solution was made in to concentrated form by boiling so that 100 ml dye solution was reduced to 5ml. Studies showed that dye extract can be made in more concentrated form, the print will be obtained in darker shades (Bahtiyari *et al*, 2013) [5]. Metallic salts such as copper sulphate, ferrous sulphate and stannous chloride were used as mordants.

### Thickener

The thickeners give sharp print and good penetration in the cloth. Mango kernel starch of 1 & 2 per cent powder were used for printing process.

### Printing

Printing process was carried out on silk fabric using wooden blocks and screens. After printing the fabrics were shade dried for 24hrs.

### After treatment

Dried printed samples were subjected to steaming. Steamed silk samples were treated with 5gpl silk with 5gpl citric acid and finally washed, squeezed and dried in shade.

### Visual Assessment

Silk samples printed with marigold pigment using mango kernal starch as thickener was assessed through visual analysis by twenty respondents using five point rating scale for depth of colour, evenness of print, sharpness of print and overall appearance of the print and statistically analyzed by paired t- test.

### Colour fastness

Colour fastness of the printed fabrics to light, perspiration (acidic & alkaline) and washing was assessed by standard test procedures of IS: 2454 – 1985, IS: 971 – 1983 and IS: 687 – 1979 methods respectively. Ratings as per blue wool standard were assigned for light fastness and grey scale ratings were assigned for perspiration and wash fastness.

## Results and Discussions

### I. Visual Assessment of Printed Samples

### A. Silk samples printed using 1 per cent mango kernel starch

Table 1 indicates the visual evaluation of silk samples printed with marigold pigment containing 1 per cent mango kernel starch the details are as below.

### Depth of colour

Samples screen printed using 2.5 per cent Cassia seed gum concentration and CS+FS mordant were rated higher (4.15) than SC (3.95) mordanted ones. Among the block printed samples, CS+FS mordanted samples exhibited higher (3.15) Weight Mean Score followed by SC (2.15) with respect to depth of colour. Control samples without mordant expressed very less Weight Mean Score than the mordant treated samples.

### Evenness of print

Silk samples Screen printed with marigold pigment containing 2.5 per cent cassia gum and CS+FS mordant were rated higher scores (4.30) followed by SC (4.10) mordant with respect to evenness of print. The block printed samples using 2.5 per cent cassia gum concentration exhibited higher Weight Mean Score for CS+FS mordant (2.25) than SC (2.20) mordent.

### Sharpness of print

Data presented in Table 1 explains that the screen printed silk samples exhibited maximum Weight Mean Score with 2.5 per cent cassia gum in the marigold pigment and CS+FS mordant (4.40) than SC (4.15) mordant. On the other hand block printed silk samples exhibited poorer weighted mean score (1.85) score for 2.5 per cent cassia gum with SC and CS+FS mordants respectively.

### Overall appearance

Screen printed samples with 2.5 per cent cassia gum concentration and CS+FS mordant combination in the Pigment recorded higher (4.45) Weight Mean Score followed by stannous chloride (4.35) mordant. Similarly the silk samples block printed using 2.5 per cent cassia gum and CS + FS mordant were found to have higher (2.15) Weight Mean Score than SC (1.55) mordanted ones.

**B. Silk samples printed using 5 per cent *Cassia tora* seed gum:** Table 2 represents data on visual evaluation of silk samples printed using 5 percent *Cassia tora* gum in the marigold pigment. Details of the print quality parameters are explained herewith separately.

**Depth of colour**
Silk samples block printed with marigold pigment containing SC and CS+FS mordant combination and using 5 per cent Cassia gum exhibited 4.60 and 4.45 Weight Mean Score values respectively. However, the screen printed silk samples with CS+FS mordant and 5 per cent cassia gum scored the highest Weight Mean Score 4.15 than SC (4.05) mordant with respect to depth of colour.

**Evenness of print**
Silk screen printed samples using 5 per cent cassia gum concentration and CS+FS mordants recorded highest (4.40) Weight Mean Score followed by SC (4.15) with respect to evenness of print. Among the block printed samples CS+FS mordant and 5 per cent Cassia gum recorded maximum Weighted Mean Score (4.25) followed by stannous chloride (3.85)and control samples without mordant (2.10) respectively.

**Sharpness of print**
Five per cent Cassia gum with CS+FS mordant combination in the marigold pigment when screen printed scored highest Weight Mean Score (4.45) with respect to sharpness of print than SC mordant (4.25). Similarly the block printed samples using 5 per cent cassia gum concentration and CS+FS mordant recorded (3.15) Weight Mean Score rates followed by SC (3.80) mordant. However, the control samples were rated lower than the mordanted ones.

**Overall appearance**
Screen printed silk samples using 5 per cent gum concentration and CS+FS mordant revealed to score higher Weighted Mean Score (4.50) followed by SC (4.40) mordant. Likewise block printed samples with CS+FS mordant and 5 per cent Cassia gum were rated higher (4.15)than SC mordanted (4.00) ones with respect to overall appearance.
Screen printed silk samples were more acceptable than the block printed silk samples due to evenness of print, appreciable sharpness of print and less manual errors. Whereas, block printing has produced uneven deposition of the pigment that has got washed off on subsequent after treatment, producing lighter shade. Evenness of prints dependent upon the type of design, consistency of pigment, age and type of block, pressure applied in printing and as well more number of manual errors.
Thus, it can be concluded that use of 5% *Cassia tora* gum has imparted good consistence to the printing paste to achieve excellent colour penetration, evenness and sharpness of print as well good appeal with respect to both screen and block printed silk samples.

**Silk samples printed using 2 percent mango kernel starch**
Table 4 represents the colour fastness of silk samples printed with marigold dye using 2 per cent mango kernel starch.

**Light fastness**
Samples block and screen printed with 2 per cent mango kernel starch and mordanted with stannous chloride exhibited better (5) light fastness. Whereas, CS+FS mordanted samples reported good to better (4-5) light fastness. The control screen printed samples indicated fair to good (2-3) light fastness and good (3) fastness for block printing.

**Wash fastness**
Silk samples block printed using 2 per cent mango kernel starch and mordanted with stannous chloride exhibited very good (4) wash fastness and the screen printed samples had good to very good (3-4) fastness. On the other hand samples screen printed with marigold dye using 2 per cent mango kernel starch and CS+FS mordant reported to have very good (4) wash fastness and good fastness for block printing. However both block and screen printed control samples had good (3) wash fastness.

**Rubbing fastness**
Dry rubbing fastness of silk samples printed with marigold dye using 2 per cent mango kernel starch and stannous chloride mordant exhibited very good (4) fastness for block printing and good to very good (3-4) fastness for screen printing. Similarly block and screen printed silk samples mordant with CS+FS reported to have good to very good (3-4) dry rubbing fastness. Block and screen printed control samples had fair (2) dry rubbing fastness. Silk samples block printed with marigold dye using 2 per cent mango kernel starch and SC mordant showed good (3) wet rubbing fastness and the screen printed samples were fair to good (2-3). On the other hand fair to good (2-3) fastness was observed for screen printed and fair (2) fastness for block printed silk samples mordanted with CS+FS mordant. Control block and screen printed samples had fair (2) wet rubbing fastness.

**Perspiration fastness**
Fastness of block and screen printed samples with marigold pigment using 2 per cent mango kernel starch and stannous chloride mordant reported to be very good (4) for acidic perspiration. Similarly silk samples screen printed using 2 per cent mango starch and CS+FS mordant exhibited very good to excellent (4-5) perspiration fastness and good (3) for block printing. Block and screen printed control samples using 2 per cent starch and without mordanted indicated fair (2) perspiration fastness in acidic media.
Block and screen printed samples with marigold pigment using 2 per cent mango kernel starch and stannous chloride mordant exhibited good to very good (3-4) alkaline perspiration fastness. In the same way screen printed samples using 2 per cent mango kernel starch reported to have very good (4) alkaline perspiration fastness when mordanted with CS+FS and the block printed samples were good(3). The block and screen printed control samples printed without mordants, with 2 per cent starch showed fair (2) perspiration fastness in alkaline media.
In a similar study screen print on silk fabric with *Butea monosperma* flower dye extract using mango kernel starch with two mordants copper sulphate and ferrous sulphate was carried out. Results of silk screen printed samples with both the mordant exhibited very good to excellent fastness rating for light, washing, rubbing and perspirations (Babel and Gupta, 2016) [4]. Similarly Yadav & Gaba, 2016 used mango kernel starch for screen printing on silk fabric with *Kachnar* bark dye extract and printed fabric exhibited good to excellent colour fastness properties towards sunlight, washing dry and wet rubbing, and acidic and alkaline.

**Plate 1:** Cotton printed with marigold pigment and SC mordant

**Plate 2:** Silk printed with marigold pigment and CS+FS mordant

**Table 1:** Visual evaluation of silk printed samples with marigold dye using (1%) mango Kernal starch N=20

| Printing | DP | EP | SP | OA | Average |
|---|---|---|---|---|---|
| **Control (without mordant)** | | | | | |
| Block | 0.90 | 1.12 | 1.20 | 1.50 | 1.18 |
| Screen | 0.95 | 1.20 | 1.50 | 1.60 | 1.31 |
| **Mordant 1 (SC)** | | | | | |
| Block | 2.15 | 2.20 | 1.85 | 2.00 | 2.04 |
| Screen | 3.15 | 2.25 | 1.85 | 2.15 | 2.35 |
| **Mordant 2 (CS+FS)** | | | | | |
| Block | 3.15 | 3.25 | 3.20 | 3.15 | 3.19 |
| Screen | 3.25 | 3.35 | 3.45 | 3.50 | 3.39 |

DP- Depth of colour
SC- Stannous chloride
EP – Evenness of colour
CS+FS – Copper sulphate + Stannous chloride
SP – Sharpness of colour
OA – Overall appearance

**Table 2:** Visual evaluation of silk printed samples with natural dye using mango kernel starch (2%) N=20

| Printing | DP | EP | SP | OA | Average |
|---|---|---|---|---|---|
| **Control (without mordant)** | | | | | |
| Block | 1.55 | 1.70 | 1.65 | 1.75 | 1.66 |
| Screen | 1.60 | 1.75 | 1.85 | 1.80 | 1.75 |
| **Mordant 1 (SC)** | | | | | |
| Block | 3.45 | 2.85 | 2.80 | 3.10 | 3.05 |
| Screen | 3.05 | 3.15 | 3.25 | 3.40 | 3.21 |
| **Mordant 2 (CS+FS)** | | | | | |
| Block | 3.95 | 4.10 | 4.15 | 4.35 | 4.14 |
| Screen | 4.15 | 4.30 | 4.40 | 4.45 | 4.33 |

DP- Depth of colour
SC- Stannous chloride
EP – Evenness of colour
CS+FS – Copper sulphate + Stannous chloride
SP – Sharpness of colour
OA – Overall appearance

**Table 3:** Colourfastness of silk samples printed with 1% mango kernel starch

| Mordant conc. (%) | Colour fastness grades | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Light | Washing | | | Rubbing | | | | Perspiration | | | | | |
| | | | | | Dry | | Wet | | Acidic | | | Alkaline | | |
| | | cc | w | c | cc | cs | cc | cs | cc | sw | sc | cc | sw | sc |
| **Control (without mordant)** | | | | | | | | | | | | | | |
| Block | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Screen | 2/3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 |
| **Stannous Chloride** | | | | | | | | | | | | | | |
| Block | 5 | 3 | 4/5 | 4/5 | 4 | 4/5 | 3 | 3/4 | 4 | 4 | 4/5 | 4 | 3 | 3/4 |
| Screen | 4/5 | 1/2 | 4/5 | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 2/3 | 3 | 3/4 |
| **Copper Sulphate +Ferrous Sulphate** | | | | | | | | | | | | | | |
| Block | 4/5 | 2/3 | 4 | 4 | 3 | 3/4 | 3 | 3 | 3 | 4 | 4 | 2/3 | 3 | 3/4 |
| Screen | 4/5 | 3/4 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 3 | 3/4 |

CC –Change in colour SC - Stain on cotton SW – stain on wool
Light fatness Rating 1-poor, 2-fair, 3-moderate, 4- good, 5-better, 6-very good, 7- best &8-excellent
Wash, rubbing and perspiration rating1-poor, 2-fair, 3-good, 4-very good & 5-excellent

**Table 4:** Colourfastness of silk samples printed with 2 per cent mango kernel starch

| Mordant conc. (%) | Colour fastness grades | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Light | Washing | | | Rubbing | | | | Perspiration | | | | | |
| | | | | | Dry | | Wet | | Acidic | | | Alkaline | | |
| | | Cc | W | C | Cc | Cs | Cc | Cs | Cc | Sw | Sc | Cc | Sw | Sc |
| **Control (without mordant)** | | | | | | | | | | | | | | |
| Block | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Screen | 2/3 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 |
| Stannous Chloride | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Block | 5 | 3/4 | 4 | 4 | 3 | 4 | 3 | 3 | 3/4 | 4 | 4 | 3/4 | 3 | 3/4 |
| Screen | 5 | 3/4 | 4 | 3/4 | 3 | 3/4 | 2 | 2/3 | 4 | 4 | 4 | 4/5 | 3/4 | 3/4 |
| Copper Sulphate +Ferrous Sulphate | | | | | | | | | | | | | | |
| Block | 5 | 3 | 3 | 2/3 | 3 | 3/4 | 2 | 2 | 3/4 | 3 | 3 | 2/3 | 3 | 3 |
| Screen | 5 | 2/3 | 4 | 4 | 3 | 3/4 | 2 | 2/3 | 4/5 | 4 | 4 | 4 | 3/4 | 3/4 |

CC –Change in colour SC - Stain on cotton SW – stain on wool
Light fatness Rating 1-poor, 2-fair, 3-moderate, 4- good, 5-better, 6-very good, 7- best &8-excellent
Wash, rubbing and perspiration rating1-poor, 2-fair, 3-good, 4-very good & 5-excellent

## Conclusion

The present study proved that cotton and silk fabrics can be block and screen printed using marigold dye source and natural thickener mango kernel starch. Printed samples were assessed for colour fastness to light, wash, rubbing and perspiration. The results revealed that 2 percent mango kernel starch exhibited good to better lightfastness, very good fastness rating to washing, rubbing and perspiration on both cotton and silk fabrics. It has been concluded that mango kernel starch can be safely used for block and screen printing and can be used as indigenous natural thickener.

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