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Sodium alginate: An alternative source for printing of cotton fabric with arecanut slurry

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Abstract

Synthetic thickeners, prevail in the printing of pigments due to their low solids content. They moreover offer advantages in quick and easy paste preparation, adjustment of viscosity adjustment and consistency of quality and supply. The print quality was assessed in terms of sharpness ranking, washing fastness and rubbing fastness. Experimental observations showed that sodium alginate gum can be successfully used in textile printing of cotton fabrics as indigenous thickener which is found to be eco-friendly. Eco-printed cotton samples with $FeSO_4$ mordant using 0.5 per cent *kokilaksha* gum concentration exhibited higher depth of colour, evenness of print, sharpness of print and overall appearance compared to other concentrations (0.1 – 0.4%). All the samples printed with 50:50 and 75:25 arecanut:myrobolan (with $FeSO_4$) as mordant exhibited good (3) to very good (3/4) colour fastness properties compared to samples printed without mordant.

Keywords: Sodium alginate, alternative, cotton fabric, arecanut slurry

Introduction

Every colour has its own significance and the design whether mythological natural, human or floral, has its hidden meaning. The tradition of using natural dyes could only survive only in certain isolated pockets. A dye is a coloured substance that has an affinity to the substrate to which it is being applied. In printing dye is generally applied with gum to fabric in definite patterns. Which are made from synthetic resources such as petroleum by products and earth minerals. Presently, there is an excessive use of synthetic dyes, estimated at around one crore tonnes per annum, the production and application which release vast amounts of waste and unfixed colourants, causing serious health hazards and disturbing eco-balance of nature. Textile printing is a term which is used to indicate the patterning of cloth by means of printing, dyeing or painting. Sodium alginate, as a salt of alginic acid (carbohydrate component of brown sea weeds), possesses a unique position among all thickeners producing soft and brilliant prints especially when reactive dyes are used (Shenai, 2003) [11]. Sodium alginates are readily soluble and the extent of interaction with the reactive dyes is negligible. With excessive use of reactive dyes in textile printing, sodium alginate has now become scarce and expensive. High price, scarceness of natural thickeners and the increase demand of thickeners stimulate the search of locally available materials suitable to use as an alternative to the traditional thickeners. The main objective of this study was to explore the possibility of sodium alginate to be used as thickener in printing process and assess the colourfastness properties.

Material and Methods

Desizing of Cotton: The fabric was treated in 5 gpl detergent solution with material liquor ratio (MLR) of 1:40 for 40-45 min to wash off the sizing agents and other impurities. The fabric was squeezed as well as rinsed in running water to make it free from traces of detergent and dried up.

Pre-treatment agent: In the present study arecanut dye powder and myrobolan powder were combined in 100:0, 50:50 and 75:25 proportions.

Preparation of dye concentrate: Two per cent areca dye powder was soaked for 8 hours in 100 ml water. The solution was boiled 30 mins for extraction of dye. The extracted dye solution was made into concentrated form by boiling it until the volume of the dye liquor reduced to 10 ml.

Preparation of gum: For the present experiment, 0.1 percent to 0.5 percent sodium alginate was used. Calculated amount of gum was mixed in 10 ml of water and added to the condensed dye solution

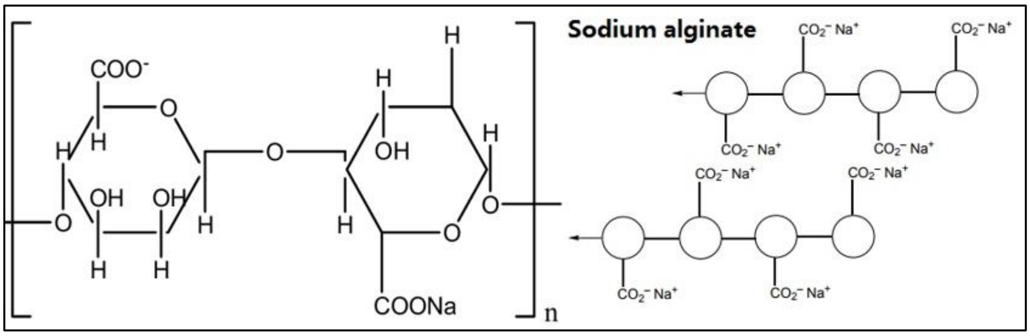

Fig 1: Molecular stucture of sodium alginate

(Figure 1 shows the schematic representation of sodium alginate molecule ($C_6H_7O_6Na)_n$). Carbohydrate polymers such as alginate have been effect of Lecithin and Calcium Chloride Solution. Sodium alginate molecule preferably used in various food applications. Alginates in guluronic acid form stronger and more compact gels in the presence of Ca2+, but at the same time more sensitive to fluctuations in calcium concentration and more stable at high-mannuronic acid alginate gels. The alginate matrix stays structurally stable in low acid environments, however, as pH is lowered below the pka values of mannuronic and guluronic acid (3.6 and 3.7, respectively) alginate is converted to alginic acid with release of calcium ions and the formation of a more dense gel due to water loss (Homayouni *et al*., 2007) [4].

Mordanting: Ferrous sulphate mordant was selected for printing experiments. In the present study 0.1 per cent of ferrous sulphate was mixed in 5 ml water and then added to the printing paste (10ml)

Preparation of printing paste

Printing recipe

Arecanut:myrobolan ratio - 100:0, 50:50, 75:25

Gum - Sodium alginate

Gum concentration - 0.1%, 0.2%, 0.3%, 0.4%, and 0.5%

Mordant - Without mordant and with ferrous sulphate mordant

Printing procedure: Once the printing paste was ready, the process was carried out on cotton fabrics using screen printing. After printing the fabrics were shade dried for 24 hrs.

Visual evaluation of printed samples: Samples printed with arecanut slurry dye using varied concentration of sodium alginate was assessed through visual analysis by thirty respondents using appropriate questionnaire with five point rating scale. Based on the outcome of the survey, two best dye ratios; one best gum concentration was selected for further studies. Based on the visual analysis best 2 samples were selected for the further experiment.

Steaming and curing: Steaming swells the fibres and ensures better penetration of the dye and improves colour fastness properties. After printing samples were shade dried for 24 hours they were steamed. The samples were rolled in cotton fabric and kept in 20 ltr steel cooker container and steamed for 30 min. After removal of steam from cooker, samples were removed and dried for some time

Assessment of colourfastness properties of printed samples: Colour fastness is the resistance of a material to change any of its colour characteristics or an extent to transfer the colour to its adjacent white materials. The colour fastness is usually rated either by loss of depth of colour in original sample or it is also expressed by discolouration scale, *i.e*., the accompanying, white material gets tinted or stained by the colour of the original fabric. However among all types of colour fastness, light fastness, wash fastness, perspiration and rubbing fastness are considered specifically for textiles (Alemayehu and Teklemariam, 2014) [1].

Table 1: Gray scale for Evaluation

Rating for Change in Colour	Rating for Colour Staining
5- Negligible or no change	5- Negligible or no staining
4- Slightly Changed	4- Slightly stained
3- Noticeable Changed	3- Noticeable stained
2- Considerably Changed	2- Considerably stained
1- Much Changed	1- Heavily Stained

3. Result and Discussion

Visual evaluation of cotton samples screen printed with different concentrations of arecanut: myrobolan (without mordant) for optimization of the sodium alginate (Table 1)

Cotton screen printed samples with cent per cent arecanut dye concentration using 0.5 per cent sodium alginate gum concentration exhibited highest (3.81) weighted mean score followed by 0.4 per cent sodium alginate gum concentration (3.61). Whereas, cotton samples screen printed with 50:50 arecanut:myrobolan dye concentration at 0.5 per cent sodium alginate gum concentration depicted greater (3.85) weighted mean score values followed by 0.4 per cent sodium alginate gum concentration (3.56). Similarly samples printed with 75:25 arecanut:myrobolan dye using 0.5 per cent gum concentration printed cotton samples showed maximum (3.56) weighted mean score and least was the 0.1 percent gum concentration. Sodium alginate with medium viscosity is acceptable for screen printing because of its rheological behaviour. They imparts good bonding of the printing paste onto the fabric surface arecanut:myrobolan have good tannin content, that gives polarity on fabric surface and in turn leads to good adsorption of dye molecules on the surface of fabric.

The paired t-test, exhibited a non-significant difference between the weighted mean score of the samples printed with various concentration of arecanut and myrobolan.

Table 2: Visual evaluation of cotton samples screen printed with different concentrations of arecanut: myrobolan pigment (Without mordant) for optimization of the sodium alginate gum concentration N = 30

Gum Conc. (%)	100% Arecanut	Arecanut:myrobolan (50:50)	Arecanut:myrobolan (75:25)
	Weighted mean score (WMS)		
0.1	2.80	3.06	2.75
0.2	3.13	3.51	2.78
0.3	3.36	3.53	3.03
0.4	3.61	3.56	3.23
0.5	3.81	3.85	3.56

Paired t-test

Arecanut:myrobolan ratio	Mean ± SD	Mean ± SD	t-value
100:0 and 50:50	3.34 ± 0.39	3.50 ± 0.28	1.36 NS
100:0 and 75:25	3.34 ± 0.39	3.07 ± 0.33	1.42 NS
50:50 and 75:25	3.50 ± 0.28	3.07 ± 0.33	0.085 NS

DC-Depth of colour, EP-Evenness of print, SP-Sharpness of print, OA- Overall appearance
WMS – weighted mean score
Significant at 0.05 level of significance
NS- Non-significant
N – Significance

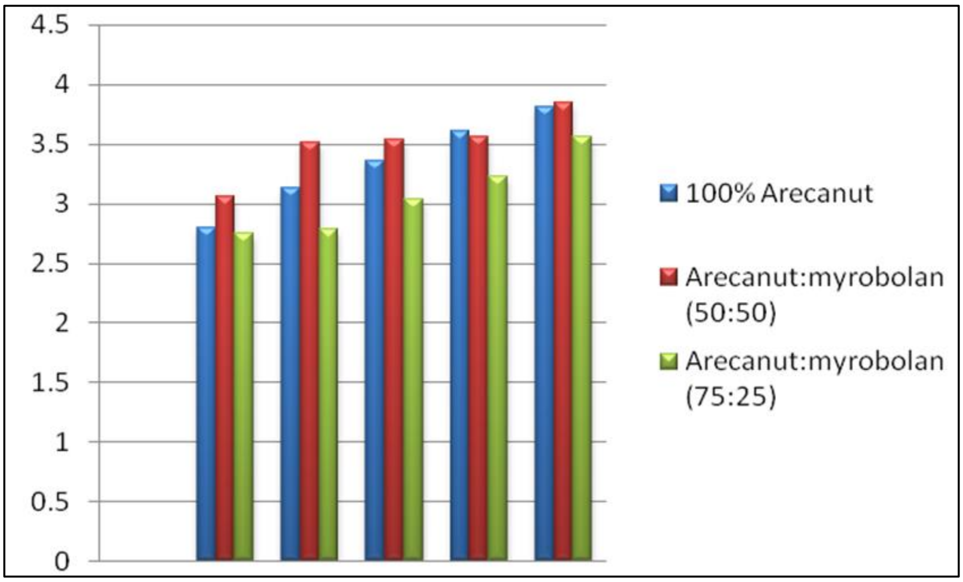

Fig 2: Visual evaluation of cotton samples printed with arecanut slurry using sodium alginate gum (without mordant)

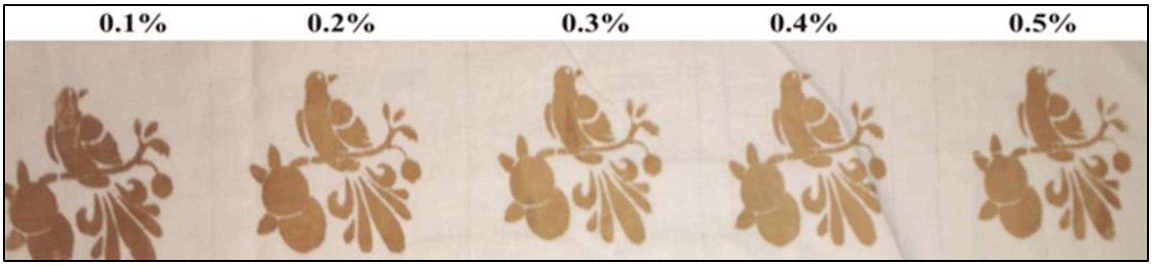

Plate 1: Visual evaluation of samples printed without mordant using sodium alginate gum and arecanut slurry

Visual evaluation of cotton samples screen printed with different concentrations of Arecanut: myrobolan (with $FeSO_4$) for optimization of the sodium alginate (Table 2)

Samples printed with 100 per cent arecanut dye concentration using 0.5 per cent sodium alginate gum concentration exhibited highest (3.76) weighted mean score followed by 0.4 per cent sodium alginate gum concentration (3.43). Whereas, cotton samples screen printed with 50:50 arecanut: myrobolan dye concentration at 0.5 per cent sodium alginate gum concentration depicted higher (3.74) weighted mean score values followed by 0.4 per cent sodium alginate gum concentration (3.44). Similarly samples printed with 75:25 arecanut: myrobolan dye using 0.5 per cent gum concentration printed cotton samples showed maximum (3.75) weighted mean score and least was the 0.1 percent gum concentration. In printing, the thickener is the crucial component of printing paste. The purpose of the thickener is to give proper viscosity to printing paste and helps in uniform and even colour application (Vastrad and Sanganavar, 2017) [14]. Further statistically, it was observed that there was no significant difference formed between all printed samples *viz.*, 100 per cent, 50:50 and 75:25 arecanut and myrobolan proportions.

Majority of natural dyes need a mordant in the form of a metallic salt. The effect of the mordant was to assist the absorption and fixation of colour and promote good bonding of colour with fibre. An almost complete range of colours can be obtained by appropriate combination of various natural dyes and mordants (Salem, 2012). Further, the mordant in the present study ferrous sulphate was added directly into the printing paste, which was an additional auxiliary that improved the consistency of the paste. Therefore proportion of myrobolan is reduced that has produced good quality prints.

It was observed that the consistency of the printing paste using 100 percent areca slurry was inappropriate and watery even after adding the gum of respective concentrations. Further mixing arecanut with myrobolan in various combinations imparted desirable consistency to the paste that made it suitable for screen printing.

Table 3: Visual evaluation (WMS) of cotton samples screen printed with different concentrations of arecanut: myrobolan pigment (With $FeSO_4$ mordant) for optimization of the sodium alginate gum concentration N = 30

Gum Conc. (%)	100% Arecanut	Arecanut: myrobolan (50:50)	Arecanut: myrobolan (75:25)
	Weighted mean score (WMS)		
0.1	2.69	2.40	2.41
0.2	2.72	2.95	2.88
0.3	2.95	3.24	3.15
0.4	3.43	3.44	3.54
0.5	3.76	3.74	3.75

Paired t-test

Arecanut: myrobolan ratio	Mean ± SD	Mean ± SD	t-value
100:0 and 50:50	3.14 ± 0.215	3.21 ± 0.26	0.37 NS
100:0 and 75:25	3.14 ± 0.215	3.15 ± 0.38	0.045 NS
50:50 and 75:25	3.21 ± 0.26	3.15 ± 0.38	0.78 NS

DC-Depth of colour, EP-Evenness of print, SP-Sharpness of print, OA- Overall appearance
WMS – Weighted mean score
Significant at 0.05 level of significance, NS- Non-significant, N – Significant

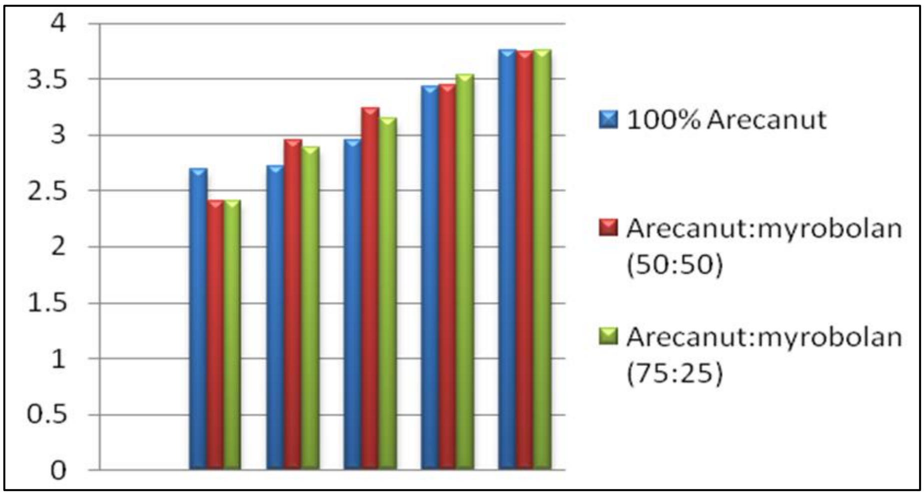

Fig 2: Visual evaluation of cotton samples printed with arecanut slurry using sodium alginate gum (with $FeSO_4$ mordant)

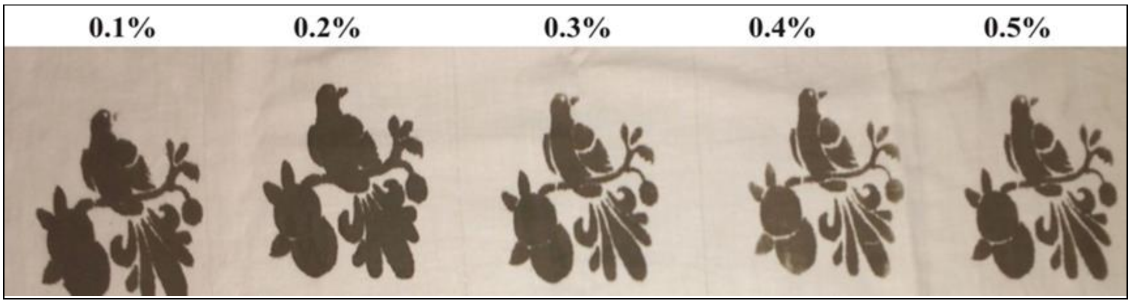

Plate 1: Visual evaluation of samples printed without mordant using sodium alginate gum and arecanut slurry. Colour fastness properties of cotton samples screen printed with arecanut: myrobolan using sodium alginate pigment (0.50%), after treated with 5 gpl salt solution (Table 3)

Light fastness: Cotton fabric printed with 50:50 and 75:25 arecanut: myrobolan concentration, without mordant showed average (3) light fastness properties respectively on curing, steaming and soaking in 5 gpl salt solution. Wherein, rather average (3) scores were obtained in presence of ferrous sulphate mordant and both the dye concentration (50:50 and 75:25 arecanut: myrobolan), 0.5 per cent natural gum and soaking in salt solution.

Wash fastness: Cotton screen printed fabric with 50:50 and 75:25 each arecanut: myrobolan, combination 0.5 per cent natural gum and both in absence and presence of ferrous sulphate mordant exhibited good (3) change in colour with respect to wash fastness after curing, steaming and soaking in 5 gpl salt solution. There was slight colour staining observed on the adjacent fabric because without mordant, dye molecules easily hydrolysis while washing on the adjacent fabrics. Samples printed with ferrous sulphate mordant showed good light and wash fastness properties which may be due to the property of the mordants to help in better absorption of dye molecules on the surface of fabric. There was slight colour staining on the adjacent fabrics. Mordant increase interaction of respective metal ion because of their higher co-ordinating ability with fibre and dye molecules (Shabbir *et al.*, 2016) [9].

Perspiration: Screen printed fabric with 50:50 and 75:25 ratio each of arecanut: myrobolan, 0.5 per cent gum and in absence of mordant demonstrated good to very good (3/4) and good (3) fastness to acidic perspiration. Whereas, colourfastness to alkaline perspiration was good (3) for fabric printed with 50:50 and 75:25 each arecanut: myrobolan, without mordant and after treated with 5 gpl salt solution. Perspiration grades of 50:50 and 75:25 arecanut myrobolan concentration printed samples with mordant recorded good to very good (3/4) than 50:50 and 75:25 arecanut: myrobolan printed samples without mordant which indicates that the dye and fibre bonding without mordant is strong enough for better colouration. The extent of rubbing may be influenced by the moisture as many textiles transfers more colour when wet (Babel and Gupta, 2016) [2].

Rubbing fastness: Results from the table 3 highlights on dry and wet rubbing fastness properties of cotton screen printed fabric using 50:50 and 75:25 each arecanut: myrobolan and 0.5 per cent natural gum source. Good (3) and good (3) scores were obtained in absence and presence of mordant on dry rubbing respectively. Nevertheless, irrespective of dye concentration good (3) wet rubbing fastness was noticed in absence of mordant. Good (3) wet rubbing fastness was observed in presence of ferrous sulphate mordant. Ferrous sulphate mordant acts as a electron acceptor to form co-ordination bonds with dye molecules making them insoluble in water (Srivatsav and Udawat, 2014) [12] that helps in better dye absorption and responsible for good colourfastness properties.

Further both the samples without mordant exhibited good (3) rubbing fastness grades compared to the samples printed with ferrous sulphate mordant. This indicates that the dye bond with fabric and fibre without mordant is strong enough. The low colour fastness in mordant treated fabric is due to the mordant metal bonding and the dye in the fabric is less strong and unstable (Uddin, 2014) [13].

Table 4: Colour fastness properties of cotton samples screen printed with arecanut: myrobolan pigment using sodium alginate gum (0.50%), after treated with 5 gpl salt solution

Concentration (arecanut: myrobolan)	Colour fastness grades											
	Light	Washing			Perspiration						Rubbing	
					Acid			Alkali			Dry	Wet
		CC	SC	SW	CC	SC	SW	CC	SC	SW		
Without mordant(control)												
50:50	4	3/4	3	3	3/4	3/4	3	3	3/4	3/4	3/4	3
75:25	4	3/4	3	3	3	3/4	3/4	2/3	2/3	3	3/4	3
With ferrous sulphate ($FeSO_4$)												
50:50	4	3	3	3	3	3/4	3	3/4	3	3/4	3	3/4
75:25	5	3	3	3/4	3	3/4	3	3/4	3	3/4	3	3/4
CC –Change in colour SC - Stain on cotton SW – stain on wool												

Ratings: 1-5, where 1 - poor, 2 - fair, 3 - good, 4 - very good and 5 - excellent
Ratings: 1-8, where 1 - poor 2 – low, 3 - average, 4 - rather average, 5 - good, 6 – very good, 7 – extremely good and 8 - excellent

Conclusion: Eco-printed cotton samples with $FeSO_4$ mordant using 0.5 per cent *kokilaksha* gum concentration exhibited higher depth of colour evenness of print, sharpness of print and overall appearance compared to other concentrations (0.1 – 0.4%). Samples with respect to wash fastness properties were good (3) to very good (3/4) compared to perspiration and rubbing grades. There was slight colour change in the entire printed sample. All the samples printed with 50:50 and 75:25 arecanut: myrobolon (with $FeSO_4$ exhibited good (3) to very good (3/4) colour fastness properties compared to without mordant printed samples. Samples after treated with dry cleaning showed good (3) to very good (3/4) colourfastness properties compared to salt treated fabrics. With respect to light, washing & perspiration grades of samples printed with $FeSO_4$ scored good colour fastness grades compared to rubbing fastness grades.

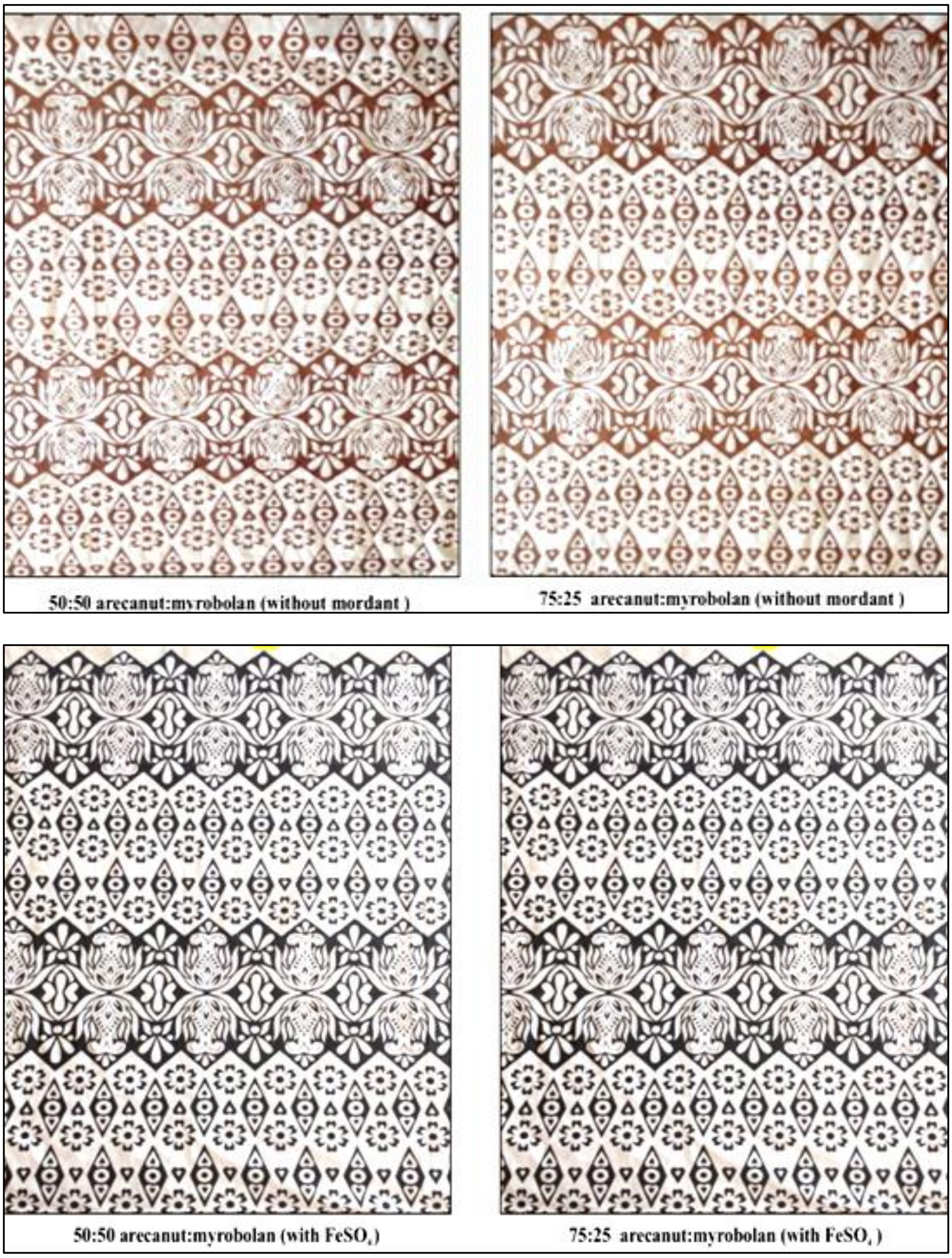

Plate 2: Samples printed with Arecanut: myrobolan pigment using sodium alginate gum (0.5%) with and without mordant

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