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The Use of Aloe Vera as a Natural Thickening Agent for the Printing of Cotton Fabric with Natural Dyes

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Abstract: ***In this present work the effect of the addition of aloe Vera into printing paste as part of the thickener, when printing with natural dyes, on the spectral values of the printed fabric, is examined. Furthermore, the effect of aloe Vera on the colour fastness properties and the fabric sewability is also investigated.***

Keywords: Aloe Vera, saffron, curcumin, sewability, thickener

1. Introduction

In the last years, in the field of fibres and textiles, natural products have started to gain the interest of consumers and textile producers. Because of the increased and constant use of some harmful chemicals with a bad effect on people's health, chemists and textile producers started to look for alternative substances to surpass these problems. Herbals and natural dyes have gained attention in textile sciences.

Aloe Vera leaves contain polysaccharides which are found in abundance in nature. Aloe Vera gel possesses some biological activities that include the promotion of wound healing, antifungal activity, hypoglycemic or anti-diabetic effects, and anti-inflammatory, anticancer and gastro-protective properties. Thus the Aloe Vera gel is viscous and colourless and can be used as a thickener agent accompanied by natural dyes and avoid the harmful effect of synthetic thickeners and dyes [1-3].

Saffron is the aqueous extract of the dried stigmas of a flower scientifically identified as *Crocus sativus L*. Saffron was known by ancient nations and has remained among the world's costliest substances throughout history. It is native to Iran and Greece. It is now cultivated largely in Southern Europe, Tibet and other countries. In India, it is mainly cultivated in Kashmir and Uttaranchal. It is widely used as a spice and as a colouring and flavouring agent in the preparation of various foods and cosmetics. The stigmas of the plant are mainly used for therapeutic purposes. Topically it is applied in the form of a paste to treat skin diseases like acne [4-8].

Annatto constitutes a colourant of the plant kingdom. It is derived from the outer layer of seeds of the tropical tree fruit *Bixaorellana*, which was named after Francisco de Orellana, a scientist and explorer of the upper Amazon. Due to its non-carcinogenic nature, annatto doesn't harm the human body or environment. Hence it has been traditionally used in medicines for the healing of wounds, skin eruptions, and burns. Nowadays annatto colorant finds wide applications in the food industry, where due to the restrictions in the use of synthetic colourants are the most used natural food colourant next to the by far most expensive saffron [9-12].

Curcumin is being recognized and used worldwide in many different forms for multiple potential health benefits. For example, in India, turmeric—containing curcumin—has been used in curries; in Japan, it is served in tea; in Thailand, it is used in cosmetics; in China, it is used as a colourant; in Korea, it is served in drinks; in Malaysia, it is used as an antiseptic; in Pakistan, it is used as an anti-inflammatory agent; and in the United States, it is used in mustard sauce, cheese, butter, and chips, as a preservative and a colouring agent, in addition to capsules and powder forms. The antioxidant and anti-inflammatory properties of curcumin are well known and this is why it is used in various fields of human health [13, 14]

Due to their less toxic properties these three natural dyes Saffron, Annatto and Curcumin, apart from their applications in the food industry, find wide applications as colourants in the textile industry. All these dyes impart many fine shades to cotton fabrics.

Aloe Vera is a known humectant agent commonly used in skincare, that tends to soften surfaces acting as an intermediate lubricating medium as well the humidity formed can act as a surface plasticizer [15]. The incorporation of aloe Vera in the textile wet process could enhance the handle fabric properties and its ease of process in the sewing stage. Additionally, the refractive index of the aloe Vera itself in conjunction with the elevated humidity within the fabric substrate should also affect the reflectance curves of the fabric.

2. Scope

The scope of the current study was to examine the effect of the addition of aloe Vera into printing paste as part of the thickener, when printing with natural dyes, on the spectral values of the printed fabric. Furthermore, the effect of aloe Vera on fabric sewability is also investigated.

3. Materials and Methods

3.1. Materials

The current study used two substrates of 100% cotton composition in two different fabric constructions, namely a knitted single jersey fabric with a mass density of $170g*m^{-2}$ and woven poplin of a 1/1 plain weave fabric of 192 $g*m^{-2}$. Both fabrics before their use were desized and bleached with the absence of optical brightening agents, to enhance their absorbability, and herewith named as a control substrate. The constituents for the preparation of the printing pastes: the acrylic binder Novabind 1001H, ProchimicaNovarese, Italy, soft 100%, the acrylic thickener Kahaptrint RCF, KYKE HELLAS SA and the fixing agent Novabind ICP: ProchimicaNovarese, Italy, isocyanate based free of formaldehyde. Annatto and Curcumin powders supplied by Alps Industries Ltd (India) were used without further purification for all dyeing and printing processes. A commercial sample of saffron stigmas (Cooperative de Safron, Crocos, Kozani, Greece) was used.

3.2. Apparatus

The overhand mixer used was obtained from IKA-WERCK (RW 14H). The ultrasonic processor that was used was UP 100H from Hielscher. Colour measurements were performed using a Macbeth CE 3000 spectrophotometer underD65 illumination, 100 standard observers with UV included and specular components included. A Q-Sun (Xe-1-B) Xenon test chamber (Q-LAB, USA) was used for the light fastness tests. An ASDL International Ltd (Shirley Developments Ltd, UK) apparatus was used for the rub fastness tests (wet and dry). A VeriVide D65 (Leslie Hubble Ltd, UK) colour assessment cabinet was used for the evaluation of colour change and evaluation of the fastness tests. ASDL International model M 231 Perspirometer was used for the perspiration fastness tests.

Measurements of the sewability were conducted using the L.M. Sewability. The apparatus measures the force exerted by a needle penetrating through the fabric perpendicularly. The force developed is known to be correlated with the ease of the stitching process, named sewability [16,17]. Fabrics with needle-high penetration tend to cause needle heating, breakage and problematic processing [16].

3.3. Methods

The printing pastes were prepared using the following recipes:

Table 1: Printing paste containing AV gel

Constituents	gr/100gr paste
Natural dye	2
AV gel	80
Sodium Alginate	2
Binder	15
Fixer	1

Table 2: Printing paste containing a commercial thickener

Constituents	gr/100gr paste
Natural dye	2
Commercial Thickener	1
Binder	15
Fixer	1
Water	81

Visual examination was performed in the colour cabinet under the light D-65 simulating daylight in the absence of UV light to avoid biased decisions. The samples were observed at a 45° angle, free from wrinkles and in sufficient plies to avoid background reflection. All samples were examined under the same conditions to avoid the influence of any other factor, as temperature and humidity as aloe Vera is known for its strong retention of humidity properties which can alter or shift the reflection curve of the substrate applied.

The needle penetration force was measured in (g) and is a measure of the sewability force. Measurements were conducted using the L&M sewability tester apparatus. Consecutive readings of force built during the penetration of fabric by the selected needle (90s title) were taken at a rate of 100 penetrations/min [16]. The arithmetic mean of 200 perforations is measured over a specimen length of about 350 mm wide.

The high count values procedure of the sewability tester was not considered as the mass density g/m^2 of the treated samples after printing would be different and hence the sewability threshold would be affected, making the results meaningless [16].

4. Results and Discussion

4.1. Colour measurement

The colourimetric coordinates L*, a*, b*, C, h°, and K/S values of the printed fabrics are given in Table 3 for knitted and in Table 4 for woven cotton fabrics, where AV-Saffron or any other dye means the paste with Aloe Vera gel as a thickener and CT-Saffron the paste containing the commercial thickener.

Table 3: Colorimetric data (L*, a*, b*, C*, h*, $K/S_{\lambda max}$ values) of knitted cotton samples

Sample	K/S	L*	a*	b*	C*	h°
AV-Saffron	17.2	76.4	4	43.8	44	84.8
CT-Saffron	4.9	68.8	15.1	69.3	70.9	77.7
AV-Curcumin	15.1	81.6	-2.8	51.5	51.6	93.1
CT-Curcumin	14.1	80.9	-3.1	49.8	49.9	93.6
AV-Annatto	17.4	72.8	6.8	30.8	31.6	77.5
CT-Annatto	24.3	77.4	8.9	29.9	31.2	73.6

Table 4: Colorimetric data (L*, a*, b*, C*, h*, $K/S_{\lambda max}$ values) of woven cotton samples

Sample	K/S	L*	a*	b*	C*	h°
AV-Saffron	16	76.6	4.6	43.8	44	84
CT-Saffron	4.8	69.2	14.5	70.3	71.8	78.3
AV-Curcumin	10.5	77.5	-1	53.6	53.6	91.1
CT-Curcumin	10.2	78.9	-4.7	54.1	54.3	94.9
AV-Annatto	24.2	79.1	5.7	27.6	28.2	78.3
CT-Annatto	19.6	76.6	8.3	33.4	34.4	76.1

The h° values and the other colour coordinates of the printed samples in Tables 3 and 4 are in satisfactory agreement with the visual assessment. Colour strength values K/S are higher for woven cotton samples treated with AV, except for CT-Annatto. In addition, higher K/S values are observed when the AV thickener is applied to both fabrics. The effect of colour change is mostly prominent in the saffron natural pigmentation, while it is barely visible in the case of the curcumin. The visual assessment confirms the previously stated trends seen be K/S values.

4.2. Fastness Properties and Determination

The prints were subjected to: wash, light, rub (wet, dry) and perspiration(acid, alkaline), according to the following standards, BS 1006: 1990 CO6, BO2, XO5, X12, EO4 respectively (The Society of Dyers and Colourists 1999). The results are given in the following tables.

Table 5: Colour Fastness Tests of knitted cotton samples

Sample	Washing fastness							Lightfastness	Rubbing fastness	
	CC	CS							Dry	Wet
		W	A	P	PA	C	Ac			
AV-Saffron	3	5	5	5	4/5	4/5	5	3/4	5	4
CT-Saffron	3	5	5	5	5	3/4	5	3/4	5	3
AV-Curcumin	3	5	5	5	3/4	4/5	4/5	2	4/5	3
CT-Curcumin	4/5	5	5	5	4/5	4/5	5	2	5	4
AV-Annatto	2/3	5	5	5	5	4/5	5	3	5	4/5
CT-Annatto	2/3	5	5	5	5	5	5	3/4	5	5

CC:Colour change, CS:Colour Staining, W=wool, A=acrylic, P=polyester, PA=polyamide, C=cotton, Ac=acetate

Table 6: Perspiration Fastness Tests of knitted cotton samples

Sample	Perspiration fastness													
	Acidic							Alkaline						
	CC	CS						CC	CS					
		W	A	P	PA	C	Ac		W	A	P	PA	C	Ac
AV-Saffron	4/5	5	4/5	5	5	4	4	4/5	3	5	5	4/5	3/4	5
CT-Saffron	4/5	5	4	5	4	2/3	3/4	4/5	3/4	3/4	3/4	3/4	2/3	3/4
AV-Curcumin	5	5	5	5	5	5	5	5	5	5	5	4/5	4/5	4/5
CT-Curcumin	5	5	5	5	5	5	5	4	5	5	5	5	5	4/5
AV-Annatto	4/5	5	5	5	5	5	5	4	5	5	5	5	5	5
CT-Annatto	5	5	5	5	5	5	5	4/5	5	5	5	5	5	5

CC:Colour change, CS:Colour Staining, W=wool, A=acrylic, P=polyester, PA=polyamide, C=cotton, Ac=acetate

Table 7: Colour Fastness Tests of woven cotton samples

Sample	Washing fastness							Lightfastness	Rubbing fastness	
	CC	CS							Dry	Wet
		W	A	P	PA	C	Ac			
AV-Saffron	3	5	5	5	5	5	5	3/4	5	4/5
CT-Saffron	3	5	5	5	5	4/5	5	3/4	5	3
AV-Curcumin	3/4	5	5	5	3/4	4/5	4/5	2	5	4
CT-Curcumin	3/4	5	5	5	4	4/5	4/5	2	5	4/5
AV-Annatto	2/3	5	5	5	5	5	5	3/4	5	4/5
CT-Annatto	2/3	5	5	5	3	4/5	4	3/4	5	5

CC:Colour change, CS:Colour Staining, W=wool, A=acrylic, P=polyester, PA=polyamide, C=cotton, Ac=acetate

Table 8: Perspiration Fastness Tests of woven cotton samples

Sample	Perspiration fastness													
	Acidic							Alkaline						
	CC	CS						CC	CS					
		W	A	P	PA	C	Ac		W	A	P	PA	C	Ac
AV-Saffron	5	5	4/5	5	5	4	4	5	5	4/5	4/5	4/5	3/4	5
CT-Saffron	4/5	5	4	5	4	2/3	3/4	4/5	3/4	3/4	3/4	3/4	2/3	3/4
AV-Curcumin	5	5	5	5	5	5	5	5	5	5	5	4/5	4/5	4/5
CT-Curcumin	5	5	5	5	5	5	5	4	5	5	5	4/5	4/5	4/5
AV-Annatto	4/5	5	5	5	5	5	5	4	5	5	5	5	4/5	5
CT-Annatto	5	5	5	5	5	5	5	4/5	5	5	5	5	5	5

CC:Colour change, CS:Colour Staining, W=wool, A=acrylic, P=polyester, PA=polyamide, C=cotton, Ac=acetate

All printed fabrics were subjected to several standard fastness tests commonly performed for printed textile fabrics: Wash, light, rub, and perspiration. In Tables 5, 6, 7 and 8 the above fastness values are presented. All samples, knitted and woven, show very good too excellent fastness to the above test in most cases except for the light fastness of knitted and woven cotton samples printed with Curcumin.

Table 9 demonstrates the resistance developed by the fabric when the needle passes through it. The incorporation of the printing past over the fabric causes the developing needle penetration force to be significantly higher. Unfortunately, in the case of the woven fabric, the initial force in the control sample was 299.50g and the addition of the printing film increases the needle penetration force much higher than 550g which is the maximum capacity of the apparatus hence measurements were not comparable.

In the case of the knitted fabric, there is a notable difference in the penetrating force developed by the three printing pastes, namely that of the annatto and saffron being significantly lower than that of turmeric. The addition of aloe vera in the printing past in comparison to the commercial thickener shows a significant drop in the penetration force of turmeric and marginally in saffron, and it is further discussed.

Table 9: Average needle penetration force through the printed fabric

Fabric Type	Treatment		Arithmetic Mean (g)
Knitted fabric	Control[1]	-	181,00
	Curcumin	CT[2]	476,00
		AV[3]	324,00
	Annatto	CT[2]	315,00
		AV[3]	388,50
	Saffron	CT[2]	356,00
		AV[3]	344,50
Woven fabric	Control[1]	-	299,50
	Curcumin	CT[2]	505,00
		AV[3]	505,50
	Annatto	CT[2]	463,50
		AV[3]	510,00
	Saffron	CT[2]	505,00
		AV[3]	506,50

[1]Control=Non treated substrate, [2]CT= Commercial thickener, [3]AV=Aloe Vera

Table 10 illustrates that knitted samples printed with turmeric paste exerted a lower spread of the results in the needle penetration force measured in comparison to the rest of the test performed, as observed by the CV% values. CV% is used for the inter-comparison of the standard deviation of different samples as it has been normalized by their mean value. The LM Sewability tester operation instruction manual indicates a variation in the results of 10% is acceptable. Therefore, a student T-test was performed to analyze the statistical significance of the average values between the two treatments of curcumin and presented in Table 2. A Sig. value of 0 verifies the rejection of the null hypothesis that the two means are equal at the 95%confidence level. This implies that the aloe Vera treatment in the case of turmeric lowers the needle penetration force and therefore helps in the sewability of the fabric.

Although a positive trend in sewability was also noticed incorporating aloe Vera in the saffron printing pastes, with similarly low statistical Sig. a value close to zero (0) (appendix), the difference between the two means was only minor representing the small effectiveness of aloe Vera in this case. Moreover, the CV% of the test performed was a marginal over the accepted 10% value. In the case of Annatto, the CV% reached up to 20% and therefore the opposite trend cannot verify and considered.

Table 10: Coefficient of variation and standard deviation of the needle penetration force through the knitted fabric

Treatment		sd	cv%
Curcumin	CT	44,46	9,34
	AV	28,99	8,95
Annatto	CT	57,00	18,09
	AV	79,58	20,48
Saffron	CT	43,86	12,32
	AV	38,86	11,28

Table 11: T-test value of curcumin printed knitted samples with commercial and aloe Vera thickener

Sample	TestValue = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
CT-Curcumin	151,413	199	,000	476,000	469,80	482,20
AV-Curcumin	157,655	199	,000	324,000	319,95	328,05

5. Conclusion

The incorporation of aloe Vera affected the colourimetric values of the printing pastes, except for the curcumin. When considering the fastness of the paste annatto and curcumin showed excellent resistance. Printing pastes as expected lower the fabric's sewability, hence causing difficulties in the makeup process, due to the additional printed film over the fabric surface, that the needle must penetrate through. Pastes such as the curcumin impact significantly the sewability, as they formed a more coherent film, than others. However, the addition of aloe Vera in the paste, improved sewability in this case more than in the rest of the pastes and a significant drop of the needle penetration force observed. In conclusion, it can be claimed that the printing paste of curcumin paste aloe Vera showed the best results in all properties measured, namely colourimetric, wet fastness and sewability.

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