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Aloe Vera Leaf Gel Extract for Antibacterial and Softness Properties of Cotton

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Abstract

Natural plants extract for antimicrobial of textile finishing is a vital and potential area of current and future aspects therefore has greater market value. Cotton has long been recognized as media to support the growth of microorganisms such as bacteria and fungi. Among all the natural antimicrobial agents the plant products comprise the major segment. The objective of this work was to investigate the antibacterial properties of Aloe Vera leaf gel extract on cotton, also its effects on the performance parameters of fabric. Softness properties were also imparted on the fabric as it is the inherit property of Aloe Vera leaf gel. Best antimicrobial properties were achieved by pad dry method with high concentrations as compared to coating method. The softness of pad-dry samples was prominent against coated fabric. Whiteness Index decreased less in pad-dry as compared to coated samples.

Keywords: Microorganisms; Antimicrobial; Aloe vera; Inhibition zone; Whiteness index

Introduction

Textile finishing involves treating a textile material in such a way that the product has the desired functional properties required for its intended use and therefore has greater market value. The desired properties may include the fabric's dimensions and their stability, its weight, drape, appearance, softness and handle, as well as any required functional properties such as resistance to creasing, flames, water, oil, dirt or bacteria. For the treatment of diseases inhibitory chemicals employed to kill micro-organisms or prevent their growth. Today, however, with increased knowledge of the causative agents of various infectious diseases, antibiotic has come to denote a broader range of antimicrobial compounds, including anti-fungal and other compounds [1].

The microorganisms are found almost everywhere in the environment and can multiply quickly when basic requirements, such as moisture, nutrients and temperature are met. Most synthetic fibers, due to their high hydrophobicity, are more resistant to attacks by microorganisms than natural fibers. Proteins in keratinous fibers and carbohydrates in cotton can act as nutrients and energy sources under certain conditions. Soil, dust, solutes from sweat and some textile finishes can also be nutrient sources for microorganisms [2].

For these reasons, it is highly desirable that the growth of microbes on textiles be minimized during their use and storage. Consumers' demand for hygienic clothing and active wear has created a substantial market for antimicrobial textile products. Estimations have shown that the production of antimicrobial textiles was in the magnitude of 30,000 tones in Western Europe and 100,000 tones worldwide in 2000. Furthermore, it was estimated that the production increased by more than 15% of year in Western Europe between 2001 and 2005, making it one of the fastest growing sectors of the textile market. Sportswear, socks, shoe linings and lingerie accounted for 85% of the total production [2].

Obtaining the greatest benefit, an ideal antimicrobial treatment of textiles should satisfy several requirements. Firstly, it should be effective against a broad spectrum of bacterial and fungal species, but at the same time exhibit low toxicity to consumers. Secondly, the finishing should be durable to laundering, dry cleaning and hot pressing, a greatest challenge as textile products are subjected to repeated washing during their life. Thirdly, the finishing should not have negative effect on the quality (e.g., physical strength and handle) or appearance of the textile. Finally, the finishing should preferably be compatible with chemical processes such as dyeing, be cost effective and not produce harmful substances to the environment. One further consideration is that the antimicrobial finishing of textiles should not kill the resident flora of nonpathogenic bacteria on the skin of the wearer [3].

Healing power of most of plants has been used since ancient times ranging 250000-500000 species on earth. Aloe Vera is a succulent plant species that is found only in cultivation, having no naturally occurring populations [4]. In the last few decades with the increase in new antimicrobial fiber technology, a range of synthetic antimicrobial products such as triclosan, metals and their salts organometallics and their quaternary ammonium compounds have been developed. Although the synthetic antimicrobial agents are very effective against the growth of many microbes and give a durable effect on textiles but they are cause of the concern due to the associated side effects, action on non-targeted areas and cause water pollution. Hence there is a great demand of antimicrobial agents based on natural ecofriendly agents which not only helps to improve antimicrobial effect but fulfill statutory requirements by regulating agencies [5].

Regarding the current research Wiyong et al. [6] investigated an antibacterial activity of apatite-coated titanium dioxide (TiO_2) against bacteria. They suggested that the presence of apatite-coated TiO_2 shows antibacterial activity for textile applications [6]. Mahesh et al. focused on plant based natural dyes and other bioactive natural extract in textile coating as antimicrobial textile finish has gained significant momentum [7]. Ramsamy et al. worked on natural extract finish '*punica guranatum*' for dyeability and antimicrobial properties on

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cotton fabrics and reported natural extract dyed fabric has prominent antimicrobial activity with clear zero inhibition zone and wash durability sustain up to 10 washes [8]. Joshi et al. [1] reviewed bioactive agents based on natural products like chitosan, natural dyes, neem extracts and other herbal products for antimicrobial finished textiles [3].

Kedarnath et al. [9] tested the antimicrobial activity of Aloe Vera extract against pathogenic bacteria. Methanol extract has showed maximum inhibitory activity against *E. coli* and *Candida* [9]. A study was done to identify, quantify, and compare the phytochemical contents, antioxidant capacities, and antibacterial activities of Aloe vera lyophilized leaf gel (LGE) and 95% ethanol leaf gel extracts by Fatemeh [10].

The current research aspects of Aloe Vera leaf gel extracts and its application to textile material for both antibacterial cum softness properties has not been reported yet in the previous works so far. In present manuscript, natural plant Aloe Vera extract is applied on pure cotton fabric and its antimicrobial, mechanical and softness properties were analyzed.

Methods and Materials

Plain weave (1/1) 100% cotton fabric with 126.2 GSM, 40 Ne warp and weft count, 115 ends/inch and 90 picks/inch was used in this research work.

Chemicals

Aloe Vera (Aloe-emodin1,8-dihydroxy-3(hydroxyl-methyl)-9,10 anthracene dione) was taken from plants nursery at university. Methanol (CH_3OH) from Merk Millipore Chemicals was used for Aloe Vera extraction, lab scale wetting agent, Lutexal Hit Plus (acrylate based polymer, synthetic thickening agent) by BASF Chemicals for generating viscosity of gel paste and Printofix Binder 77 N (acrylate based binder) from Clariant Chemicals were used for 100% cotton fabric.

Equipment

a) Processing equipment: Lab scale Soxhlet Extractor by PCSIR, Stentor, padder and flat-bed printing machines by Tsujii Dyeing Machine Manufacturing Co. Japan were used for performing experiments.

b) Testing equipment: Spectrophotometer and bending testor (Gretag Macbeth Ltd., England), digital weight balance (Kyoto, Japan), lab scale coefficient of friction tester, magnifying glass and sample cutter testing equipment were utilized.

c) Testing equipment for antimicrobial finish: Lab scale petri dish, sterilized bottles, auto clave and incubator (Daihan Scientific, Korea), laminar flow (Biological Medical Services, USA) and pipettes (Socorex) equipment were specifically used for antimicrobial testing.

d) Design of experiment: Padding pressure was maintained at 1.5 bars and the padder moving at speed of 10 rpm. Table 1 shows design of experiment for padding and coating.

For maintaining acidic pH 5.5 drops of citric acid if necessary. Pick up was kept at 70-80%. Time used for drying of fabric was 60 sec. Time used for curing of fabric was 300 sec. Temperature used for Aloe Vera extract finish was 100°C for drying for coating of fabric.

e) Soxhlet Extraction Method: The solid cubes of Aloe Vera leaf (inside material) as shown in Figure 1 containing some of the desired compounds (mainly anthraquinones) were placed inside a thimble made from thick filter paper, which was loaded into the main chamber of the Soxhlet extractor. The extraction solvent i.e., Methanol was taken into a distillation flask and the Soxhlet extractor was placed onto this flask. The methanol in the distillation flask was heated to reflux and its vapors travel up a distillation arm, and floods into the chamber housing the thimble of solid Aloe Vera cubes. The condenser ensures that every methanol vapor cools, and drips back down into the chamber housing the solid Aloe Vera cubes (Figure 1). The chamber containing the Aloe Vera material got slowly filled with warm methanol. Some of the desired compounds get dissolved in the warm methanol. When the Soxhlet chamber was almost full, the chamber was automatically emptied by a siphon side arm, with the methanol running back down to the distillation flask. The thimble ensures that the rapid motion of the methanol does not transport any solid material to the still pot. This cycle was repeated for 4-5 times until the cubes gets small and the desired materials are extracted.

During each cycle, a portion of the non-volatile compound dissolves in the solvent. After many cycles the desired compound

	Concentration	Temperature	No. of Samples
Padding	150 (g/l)	100°C	9
		120°C	
		140°C	
	200 (g/l)	100°C	
		120°C	
		140°C	
	250 (g/l)	100°C	
		120°C	
		140°C	
Coating	150 (g/l)	120°C	9
		140°C	
		160°C	
	200 (g/l)	120°C	
		140°C	
		160°C	
	250 (g/l)	120°C	
		140°C	
		160°C	

Table 1: Design of experiment.

Figure 1: Aloe Vera gel cubes.

(anthraquinones and polysaccharides) was concentrated in the distillation flask. The advantage of this system was that instead of many portions of warm methanol being passed through the sample, just one batch of methanol is recycled.

After extraction, the methanol was removed, by exposing it to open air. As methanol is highly volatile liquid and evaporates fast at room temperature, leaving behind the desired materials. The non-soluble portion of the extracted solid was left in the thimble.

Application methods

Application of Aloe Vera extract finish was done by the following methods i.e., Pad → Dry and Coating → Dry → Curing. First, samples of 15 × 15 inches were cut according to the processing provisions of lab scale stenter available at wet processing lab, and dimensional requirements for tensile and tear test instruments (warp and weft wise). Second step was preparation of recipe according to design of experiment. Liquor amount taken for each sample was 400 mL. Then application of finish was done through padding followed by drying at 100°C, 120°C and 140°C for Aloe Vera extract finish for antimicrobial finish respectively. After application testing of samples was done and results were analyzed.

Testing

As Aloe Vera extract is applied on a cotton fabric for both antibacterial and softness properties, so some mechanical performance of textile testing methods involves.

a) Anti-microbial testing: The test method used was parallel streak method AATCC-147 was used to visualize the antimicrobial activity of Aloe Vera leaf gel extract applied on the cotton fabric by estimating the inhibition zone of developed culture.

b) Co-efficient of friction testing: Coefficient of friction testing measures the ease with which two surfaces in contact can slide past one another where there are two different values associated with the coefficient of friction static and dynamic ASTM D 1894.

c) Bending tester: The standard method used for bending test was ASTM D 1388. Testing was done using tensile strength tester.

d) Whiteness CIE testing: Whiteness of samples was determined as per AATCC 110-2005. Testing was done using Gretagmacbeth Color Eye 7000 A.

Results and Discussion

Antimicrobial results

Antimicrobial activity of pad-dry samples treated with different concentrations and dried at different temperatures is shown in Figure 2a-c. It can be seen from these Figures that Aloe Vera exhibits its activity against *Staphylococcus aureus* and *E. coli* to reasonable extent. The zone of inhibition can be clearly seen from these figures; the bacteria grows on agar solution but when it approaches the fabric samples; the Aloe Vera bleeds from the fabric and shows resistance against the bacteria and there is almost no growth surrounding the bacteria.

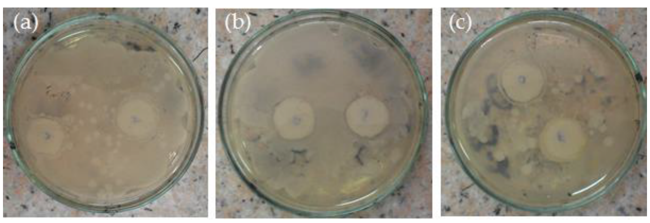

Figure 2: (a) Antibacterial activity of sample A and C (b) Antibacterial activity of sample D and F (c) Antibacterial activity of sample G and I.

The zone of inhibition for Aloe Vera is less, when compared to the zone of inhibition of other synthetic antibacterial agents. This can be understood from the point that Aloe Vera gel consists of almost 200 components or ingredients and its antibacterial agents may be present in less quantity as compared to other components.

It is also clear from this experiment that Aloe Vera, a natural product in its pure form works against bacteria and can be used for those purposes where extent of bacteria is not as strong as Malaria causing bacteria. In Figure 2c the Aloe Vera shows maximum resistance, its zone of inhibition is clearer as compared to Figure 2a and 2b. The reason is that in these samples the Aloe Vera concentration is higher as compared to the concentrations of Figure 2a and Figure 2b. Coating samples did not show any zone of inhibition, because the binder did not allow the Aloe Vera to leave the fabric so that it could work against the bacteria approaching them.

Coefficient of friction results

Coefficient of friction comprises two types of tests i.e., coefficient of static friction and coefficient of dynamic friction. Coefficient of static and dynamic friction for both pad-dry and coating samples padded with different concentrations and dried at different temperatures (Table 2).

Coefficient of static and dynamic friction (pad dry). It is shown by the Figure 3 that there is no effect of temperature on the standard/

	Standard Fabric	Drying Temp	150 g/l	200 g/l	250 g/l
Pad dry		100°C	0.565	0.566	0.576
	0.544	120°C	0.577	0.58	0.582
		140°C	0.574	0.588	0.599
		100°C	0.497	0.495	0.492
	0.514	120°C	0.487	0.48	0.491
		140°C	0.486	0.475	0.49
Coating	0.568	120°C	0.599	0.605	0.651
	0.601	140°C	0.601	0.602	0.61
	0.571	160°C	0.56	0.57	0.576
	0.509	120°C	0.516	0.513	0.599
	0.555	140°C	0.499	0.53	0.553
	0.519	160°C	0.494	0.541	0.576

Table 2: Coefficient of static and dynamic friction.

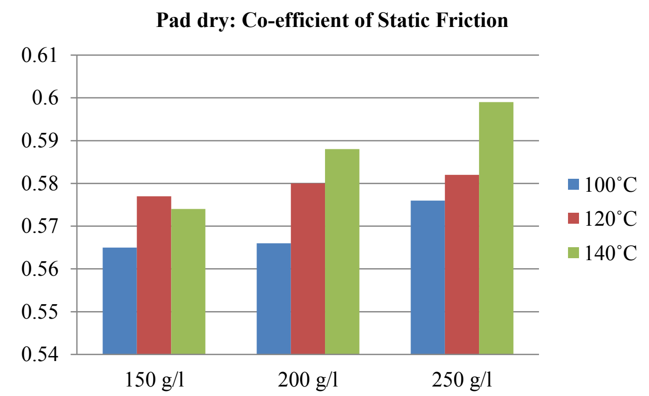

Figure 3: Coefficient of Static friction for the pad-dry samples.

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unfinished fabric as they all have same co-efficient of static friction. There is an increase in trend as the concentration is increased also the trend increases with the raise in temperature.

It is shown by the Figure 4 that the coefficient of dynamic friction of standard/unfinished fabric is very high as compared to any of the finished fabric, treated with Aloe Vera. This shows that Aloe Vera exhibits softness and gives soft feel on cotton fabric results in lowering of co-efficient of dynamic friction. Also, increase in centration gives more softness and increase in temperature has reverse effect on it as Aloe Vera gets graded and cotton gets stiff at high temperature.

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Co-efficient of static and dynamic friction (coating). It can be seen from the Figure 5 that standard fabric has low coefficient of static friction at 120°C but high at 140°C and again low at 160°C. The treated samples showed an increase in trend at 120°C due to increase in concentration of Aloe Vera. The results of co-efficient of static friction at 140°C and 160°C are almost same for all concentrations (Figure 5).

It is shown by the Figure 6 that the standard/unfinished samples at all temperatures have greater coefficient of dynamic frictions as compared to 150 g/kg samples because the Aloe Vera is in low concentration and its softness property is diminished due to presence of binder and thickeners. At high concentrations, the Aloe Vera shows its softness properties as it over comes some of the hardness effects of the binder and thickeners present at the same concentrations in the recipe.

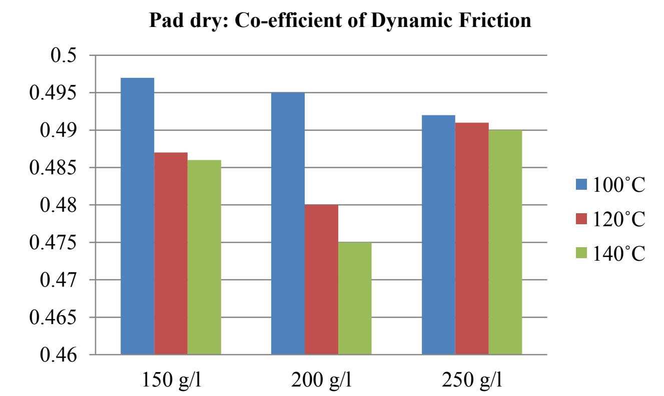

Figure 4: Coefficient of dynamic friction for the pad-dry samples.

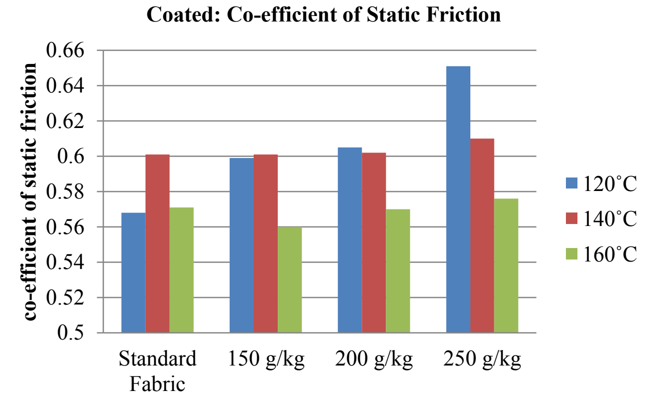

Figure 5: Coefficient of Static friction for the coated samples.

Whiteness index

Whiteness index for pad-dry samples padded with different concentrations and dried at different temperatures (Table 3).

Pad dry samples

It can be seen from the Figure 7 that an increase in concentration of Aloe Vera dims the whiteness of the finished samples as Aloe Vera is not transparent and has some light green color in gel form. Also within the same concentration the whiteness decreases with the increase in temperature because at high temperatures Aloe Vera gets yellow type color due to dehydration.

Coated samples

It is shown by the Figure 8 that standard fabric having binder and thickener and no Aloe Vera gives decrease in whiteness as temperature is increased. Curing is done for 5 minutes; cellulose turns yellow at high temperature if it is exposed for long time, also thickener and

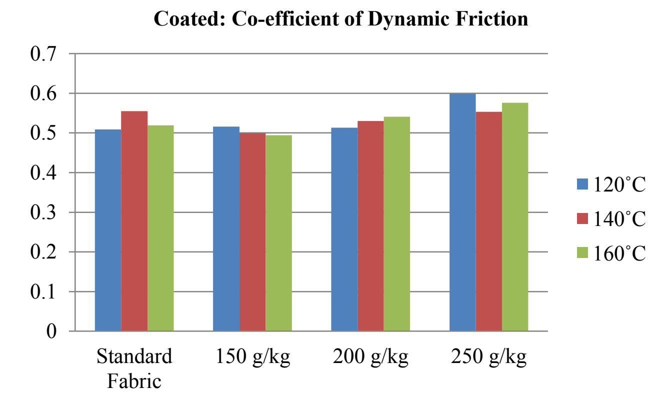

Figure 6: Coefficient of dynamic friction for the coated samples.

	Standard Fabric	Drying Temp	150 g/l	200 g/l	250 g/l
Pad-dry	0	100°C	67.59	67.49	67.08
	68.72	120°C	67.24	66.65	66.15
	0	140°C	66.82	66.01	65.49
Coating	68.34	120°C	66.13	65.99	63.34
	61.85	140°C	58.92	56.88	61.85
	60.86	160°C	48.9	47.23	60.86

Table 3: Whiteness index for samples.

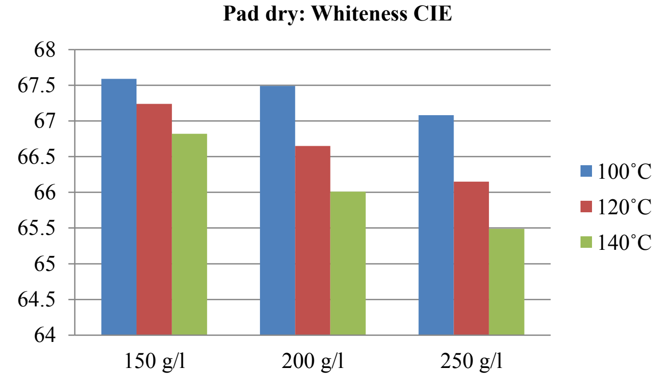

Figure 7: Whiteness index for pad- dry samples.

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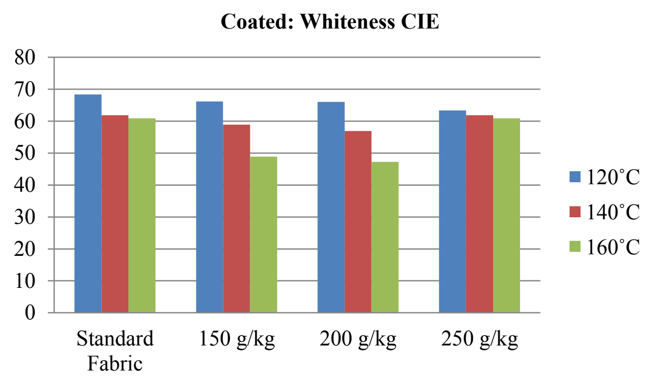

Figure 8: Whiteness index for coated samples.

		Standard Fabric	Drying Temp	150 g/l	200 g/l	250 g/l
Pad dry	Warp direction	0	100°C	4.32	4.49	4.36
		4.46	120°C	5.13	5.33	4.38
		0	140°C	4.11	4.47	4.08
	Weft direction	0	100°C	4.31	4.16	3.8
		4.33	120°C	4.71	4.53	4.7
		0	140°C	4.12	5.13	4.5
Coating	Warp direction	5.46	120°C	4.91	5.31	5.06
		5.47	140°C	5.28	5.32	5.48
		5.63	160°C	5.15	5.33	5.08
	Weft direction	5.05	120°C	4.8	4.8	4.45
		4.87	140°C	4.86	4.71	4.55
		5.13	160°C	4.55	4.61	4.65

Table 4: Bending length of samples.

binder assists in this result. And for other samples with different concentrations of Aloe Vera, whiteness is decreased with increase of temperature and concentration.

Bending length tests - stiffness test

Bending length of pad-dry and coating with respect to warp and weft wise samples, with different concentrations and dried at different temperatures (Table 4).

Pad dry

a) Warp wise bending length. It is clear from Figure 9 that bending length decreases as the concentration of Aloe Vera increases. Aloe Vera has softening effect and so its decreases the bending length of the finished fabric.

b) Weft wise bending length. From Figure 10 the temperature difference did not give any clear trend in the stiffness of the fabric. But the concentration increase gives a decrease in bending length of the fabric.

Coating

a) Warp wise bending length: The bending length of coated samples is greater as compared to the pad-dry samples as in Figure 11. This is due to the presence of binder and thickener in the recipe that stiffens the fabric. Also, the bending length of different concentrations is less compared to the standard fabric (containing only binder and thickener, no Aloe Vera) because the Aloe Vera present in the different concentrations lowers the stiffness of the fabric. Temperature has no obvious effect on the bending length of finished samples.

b) Weft wise bending length: In Figure 12 the bending length in the weft direction is less as compared to the warp direction because the weft yarns are more relaxed as compared to the warp yarns. Increase in concentration of Aloe Vera decreases the bending length also. The temperature tends no trends for bending length.

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Conclusion

Antibacterial and softness effect from Aloe Vera leaf gel extract on cotton fabric has been evaluated. From this work, we concluded that the best antibacterial properties could be achieved by pad dry method with high concentrations of Aloe Vera extract while coated samples with extract could not give such zone of inhibition. The softness of

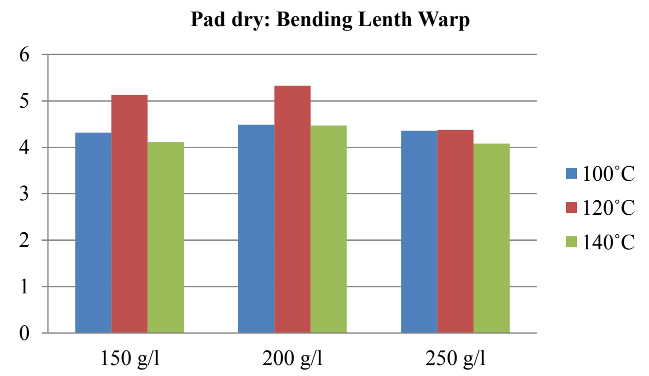

Figure 9: Bending length of pad-dry samples in the wrap direction.

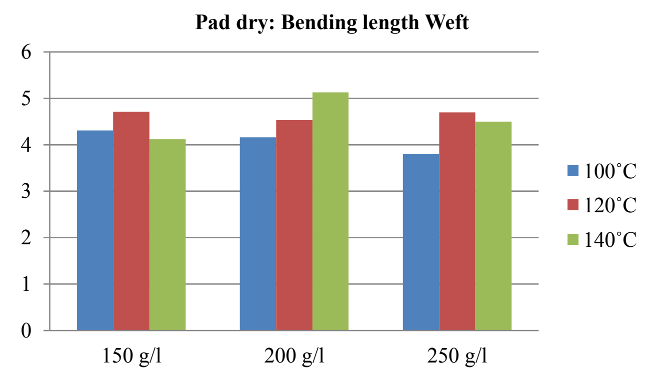

Figure 10: Bending length of pad-dry samples in the weft direction.

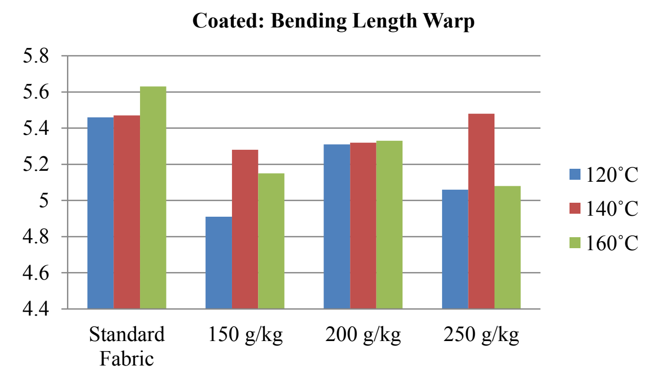

Figure 11: Bending length of pad-dry samples in the wrap direction.

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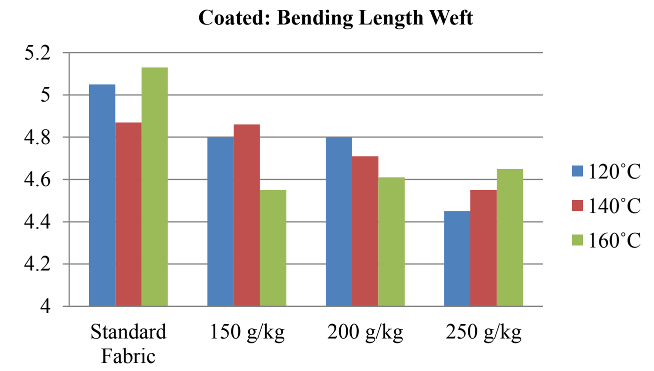

Figure 12: Bending length of pad-dry samples in the weft direction.

pad-dry samples is prominent against coated fabric as thickeners and binder adds in stiffness. Whiteness Index decreases less in pad-dry as compared to coated samples. Aloe Vera itself is not transparent and bares light green color, imparting some change in color of fabric, even when not cured at high temperature. The stiffness of coated fabric is greater as compared to padded samples, the main reason for that is binder and thickener.

Future Work

Aloe Vera can be mixed in the printing paste, but its compatibility with the auxiliaries must be checked before its application for textile printing. A careful selection should be made while choosing auxiliaries for coating so it could not affect the mechanical properties or whiteness of the fabric. Aloe Vera can be applied to the dyed fabric, for this shade change must be considered in different compatible natural plant extracts that are antimicrobial could be used for multi effects.

Conflict of Interest

We, the all authors verify and declared that there is no conflict of interest among any other organizations.

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