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Cotton canvas trousers washing: an inception of a new horizon in apparel industry

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Abstract

Nowadays, fashionable trouser (denim) with washing effect is very popular, especially among the youth. The global fashion trend has led to the development of diverse washing processes that are predominantly applied to denim fabric. However, no known research has studied the application of the washing effect on canvas fabric. Therefore, this paper aims to make fashionable canvas fabric trousers by applying various washing effects. To do so, ready-to-dye canvas fabric trouser was constructed, then dyed with dischargeable reactive dye (Lava). Chemical washing processes such as whisker, enzyme, and PP spray were then applied on dyed canvas trousers. Finally, developed samples were being characterized by mechanical tests such as tensile strength, tear strength, stiffness, abrasion, pilling, colorfastness to wash, and colorfastness to rubbing. Besides, to evaluate fabric surface, various tests such as Scanning Electronic Microscope (SEM), Reflectance% values have also been characterized. Tensile strength, tear strength, stiffness, reflectance% value, and wear index% changed significantly for every subsequent process. The tensile strength of finished trousers was 489.87 N at warp and 350.57 N at weft direction and the tear strength was 48.01 N and 35.56 N at warp and weft direction, respectively. The reflectance% value of 18.74 was observed at the PP sprayed area. Overall, the research revealed the possibility of using cotton canvas as a pair of fashionable trousers contributing to the development of the apparel industry.

Keywords: Canvas, Enzyme wash, PP spray, Tensile strength, Tear strength, Fashionable trousers

Introduction

Denim, one of the world's most used fabrics, is mostly popular with the youngsters, and plays a very important role in shaping the style business. Among numerous clothes, this freshly-assembled clothes is open to innovations (Ertas et al., 2016; Montazer & Sadeghian, 2007). Denim comes now-a-days all told forms, appearance and washes to match with each dress for a vintage look (Cheriaa & Baffoun, 2015). Freshly-assembled denim garment's chemical washing may be a basic finishing method in apparel's industries, and various properties such as visual, mechanical of treated denim garments are largely influenced by it (Khan & Mondal, 2013). The unwashed denim garment is not comfortable to wear, thanks to its weaving and coloring impact, it may be modified through washing to introduce trendy style and fashion (Khan et al., 2012). To get the desired vintage look on the indigo-dyed denim garments, cellulose enzyme may be used in the denim washing (Yu et al., 2017). Washing of consumer goods materials also improve the comfort properties (Khedher et al., 2009).

Like denim, canvas cloth is also deemed as a heavy carrying cloth due to its significant strength and weight. It is used for devising sails, tents, marquees, backpacks, associate degreed as a support for an oil painting due to its bumper strength. It is also utilized in fashionable objects such as purses, device cases, and shoes. (Crawford et al., 2016; Hoshiba et al., 2015; Yildiz et al., 2014).

The origin of the word canvas is truly derived from the Latin and Greek words for hemp. The thirteenth century French words “canevas” and “canevaz” area unit derivatives of the Latin word “cannapaceus” (Canwil Textiles, 2015, The best uses of cotton canvas fabric: History). Canvas fabric is sometimes product of cotton or linen. However, other fibers, such as, jute, nylon, polyester, hemp and their blends are also sometimes used to make a canvas (Contrado, n.d., canvas: advantages of canvas fabric). The best advantages of cotton canvas as a clothing material may found due to its suitableness, weavability, cheaper and abundant handiness and higher wet swelling properties (Basu, 2008).

Canvas materials have a variety of useful qualities that make them a good cloth alternative alongside several finish uses. Canvas fabric promptly accepts numerous chemical processes to enhance its natural qualities which is one of the foremost attributes of canvas. Because of its bumper strength; makers use canvas to form something that withstands a troublesome and sturdy end while retaining its natural and virtually ancient looks. Bags, backpacks, shoes, totes, trampolines and ever coats moreover as outwear all have the benefit of canvas cloth (Contrado n.d., canvas: advantages of canvas fabric; Labgold & Kolo, 2007; Young & Jardine, 2012).

The most commonly and used dyes for the cotton materials are the reactive dyes. Not all reactive dyes area unit dischargeable utterly and there should be a range of dyes used to match shades that is to be marketed as dischargeable (Zubair, 2011).

Dischargeable reactive dyes (Lava) buttress a sustainable dyeing method due to lower energy and water consumption. They offers nice potentialities in creating wash effects thanks to their wonderful decolorization with potassium permanganate and accelerator. Wash fastness may be achieved while not pre-cationization or binders (Dystar n.d., lava dyes; Package n.d.).

The most crucial aspects of garments are quality and appearance (Niinimäki, 2010). Washing is a finishing process that leads to the improvement of comfort/luxury properties of the garment. It also influences the different mechanical properties of garments (Sarkar & Khalil, 2014). As it causes a more worn appearance and aged look, it reduces the mechanical properties of garments (Khedher et al., 2009).

Cotton canvas fabric has been successfully using as a protective clothing material such as fire resistant, water resistant, oil paintings, ultraviolet resistant fabric, modular garments, gloves since many years ago. However, no such initiative has been taken to push canvas cloth as a fashionable clothes like denim and no studies on the analysis of physico-mechanical and luxury properties of reactive dyed-washed canvas trousers have been reported (Ackroyd, 2002; Ceremonial Fabrics, 1934; Collins, 1939; Edlich et al., 2004; El-Dessouki, 2015; Falterman & Griffith 1969; Fritsche, 1957; Graham & Ruppenicker, 1983; Irzmańska & Stefko, 2012; JI et al., 2006; Nets et al.; Onar et al., 2009; Turner, 1979; Young & Jardine, 2012; Zhang et al., 2012). Therefore, the aim of this study is to make the canvas fabric as a fashionable trousers which has comparable characteristics as commercial denim pants.

Methods

Materials

100% cotton canvas fabric was used with matt $\frac{1}{1}(2)$ weave construction, weft and warp count of 10 Ne, weft density 54/inch, warp density 80/inch, and fabric weight per unit area 320 g/m^2 or 9.44 oz/yd^2. Fabric was produced from Akij Textile Ltd., Manikganj, Dhaka, Bangladesh. The produced fabric was then treated by singeing, desizing, mercerizing, stentering and rolling processes to make ready for dyeing canvas (RFDC) fabric. 100% spun polyester 40/2 tex navy blue sewing thread was used for sewing the trousers. Industrial lock stitch sewing machine and five thread overlock stitch machine were used for sewing purposes of trousers parts. The brand, model and origin of industrial lock stitch machine was HIGHLEAD, GC-128 and China respectively. The brand, model and origin of overlock sewing machine was PEGASUS, M732-70-5X5, and Japan respectively. Dischargeable reactive dye (Lava dye GLF) from Dystar (Turkey), desizing agent (Supralase 1200L) and antiback staining agent (Dispersol Max 1080) from Kann (Turkey), neutralizing agent (Sodium meta bisulphate) from BASF (China) were collected. Lavacell NHC was used as a cellulase enzyme with Dispersol Max 1080. Potassium permanganate (PP) with phosphoric acid was used in PP spray (Figs. 1, 2).

Trousers making

In the research, 12 trousers (long pant) had been produced by using a lock stitch and over lock sewing machine. Measurement of trouser was as follows: waist 33", inseam 29", side seam 35", front rise 9" and back rise 11".

Dyeing procedure

The dyeing process was carried out with dischargeable reactive dye (Lava dye) at 50 °C for 40 min on canvas trousers (Fig. 3).

Whiskering process

After dyeing whisker effect was being developed on canvas trousers by means of pattern and emery paper. 600 number of emery paper was used to create whisker effect. This effect was done on upper thigh area of trousers.

Enzyme wash

Surface cellulose fibers of the denim fabric is break down by enzyme, and it hydrolyzes them during washing (Arjun et al., 2013). For getting proper fading on garments, enzyme wash is the most essential wash in the garments industry. Enzyme washing was carried out in a front loading washing machine (Tonelo 120 LW, model- PP 320, Italy) and procedure of enzyme washing with recipe is shown in Fig. 4.

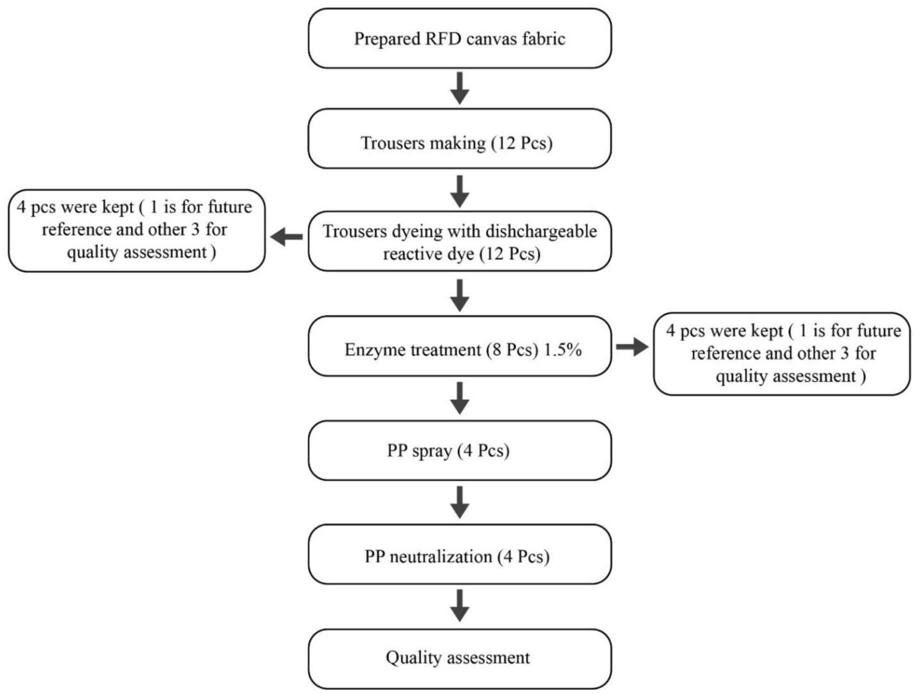

Fig. 1 Process sequence of research methodology

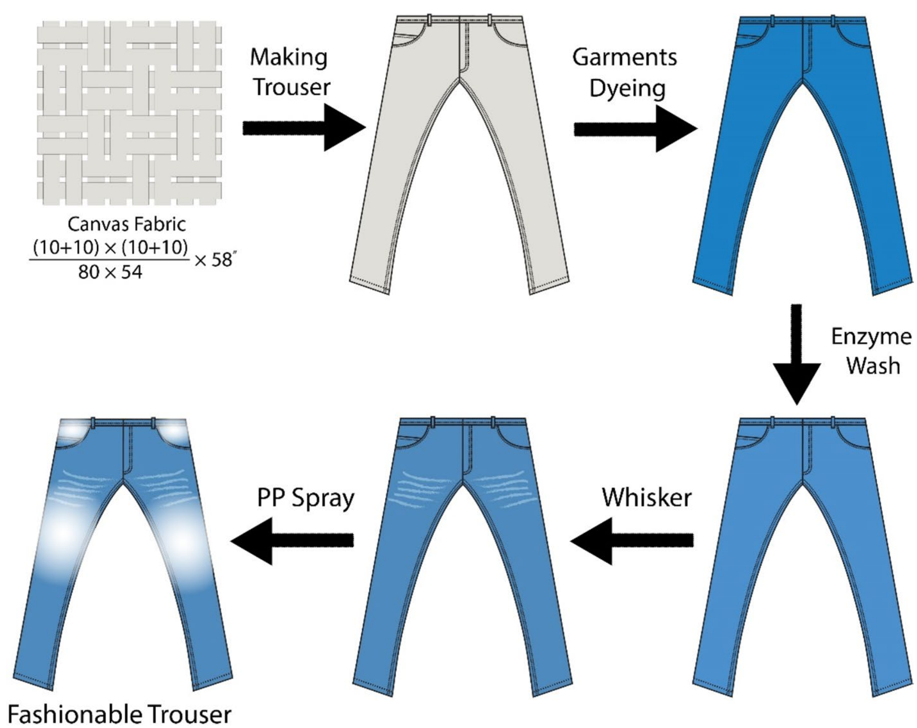

Fig. 2 Graphical abstract of this study

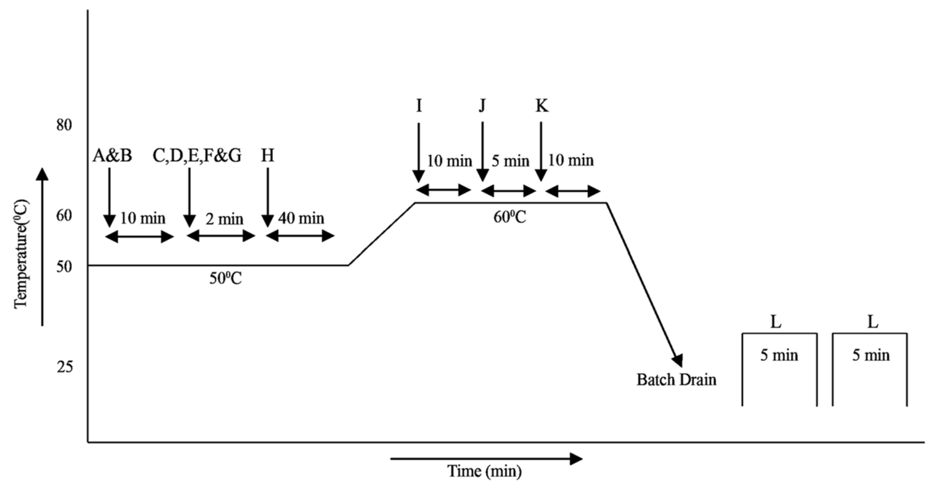

Fig. 3 Schematic diagram of canvas trousers dyeing. See Table 1 for A-L descriptions

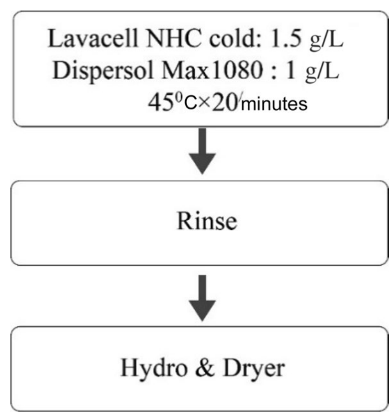

Fig. 4 Enzyme washing process

Potassium permanganate spray (PP spray) followed by PP neutralization

Potassium permanganate spray was done on canvas to take a bright effect on sandblast area. Potassium permanganate solution was sprayed on blasted portion of canvas trousers with the help of spray gun. 10 g/L potassium permanganate and 1 g/L phosphoric acid was taken into the chamber of PP spray gun. Then, about 80 g solution was sprayed on the pre-defined area of trousers. PP sprayed trousers were neutralize by adding 2 g/L sodium meta-bi sulphite into the solution containing material liquor ratio 1:8 at 40^{0}C temperature at 5 min in the front loading washing machine.

Testing and analysis

All developed canvas trousers at various stages was conditioned with standard testing atmosphere for 24 h according to according to BS EN ISO 139:2005 and ASTM D1776.

To characterize developed canvas trousers at various stages, three test specimen for each of the tests and stages, were cut from three developed samples of the same stage. The obtained average results from three were depicted in various figures.

Test specimen were prepared according to EN ISO 13934–2 (Grab method) to determine tensile strength by Universal Strength Tester (Testometric, model- M250-3CT, England).

Test specimen were prepared according to EN ISO 13937–2 (Grab method) to determine tear strength by Universal Strength Tester (Testometric, model- M250-3CT, England).

Change of color or staining was measured according to ISO 105-C06 standard.

Rubbing fastness was evaluated according to ISO 105X 12 method by Crock Meter (JAMES Heal, model-670, England)

To measure the bending length in cm by Fabric Stiffness Tester (MESDAN-LAB) was used according to the standard BS 3356–1990.

Pilling and abrasion resistance were determined by Martindale Abrasion Tester according to SN 198,525 standard.

Data Color 650 was used to determine reflectance value of the developed samples.

Scanning Electronic Microscope (Hitachi, model-SU1510, Japan) was used to examine the fabric surface of the treated samples.

To look the enlarging view of the developed samples Digital Microscope (Jiusion, model 40-1000X, China) was used.

Results and discussion

To indicate samples briefly by codes throughout the results and discussion part of this article, the following used sample codes are shown in Tables 1 and 2

Visual appearance

The visual appearance of canvas trousers was modified significantly after applying dyeing and various washing processes which have been shown in Fig. 5. After employing such processes, canvas trousers seems to develop wash look appearance as good as denim pants (jeans) capable of imparting trend-setting fashion touch. All these photos was captured from 10 inches above from the samples by A10 Samsung android phone using 1.5 zooming.

Color fastness to washing

Enzyme treated fabric samples could exhibit identical rating in fading and staining. Throughout the enzyme treatment, the surface fiber at the side of the unfixed dye within the fiber surface can be removed as a result; no unfixed dye would be dismissed from the denim material throughout the color fastness to washing test (Kan et al., 2011). The results found from color fastness test are illustrated in Fig. 6. In case of fading in Fig. 6(a), colorfastness test showed very good results for all processes because of a very negligible amount of dye was removed from the samples. However, in case of staining in Fig. 6(b), a comparatively lower grade was found in cotton due to the higher attraction of cotton fiber towards reactive dye. In Fig. 6 also exhibited that, there were no observable effects found by applying enzyme and PP spray both in fading and staining. Due to the well fixation of dyes to the samples, the developed samples showed optimistic results in color fading test.

Table 1 Recipe for dischargeable reactive dye

Symbol	Ingredients	Amount
A	Detergent	1 g/L
B	H_2O_2	1 g/L
C	Invatex CS	1 g/L
D	Softanal ACX	1 g/L
E	Albatex DBC	1 g/L
F	Gluber salt	40 g/L
G	Soda ash	12 g/L
H	Lava dye GLF	19 g
I	Hot wash	–
J	Sefrafast CRD	1 g/L
K	Hot wash	–
L	Normal wash	–

Table 2 Sample codes and meaning

Sample code	Meaning
RFDC	Ready For Dyeing Canvas
AD	After Dyeing
AE	After Enzyme
APN	After PP Followed by PP Neutralization

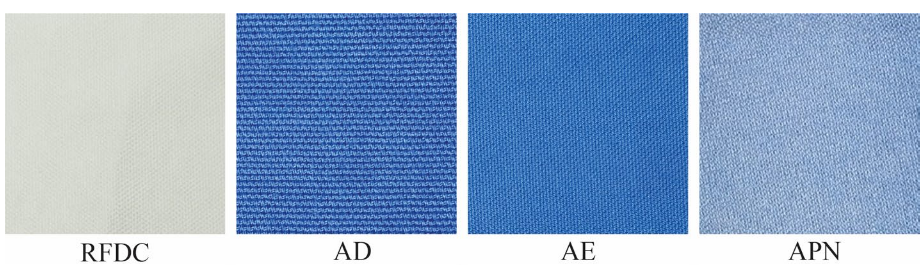

Fig. 5 Visual appearance in various processes. *RFDC* Ready For Dyeing Canvas, *AD* After Dyeing, *AE* After Enzyme, *APN* After PP Followed by PP Neutralization

Color fastness to rubbing

Surface fiber and unfix dye may be crocked out from the fabric surface during the rubbing fastness test resulting in improved fastness test results (Kan et al., 2011). Color fastness to rubbing test results are depicted in Fig. 7(c). This results revealed that the rubbing fastness test result in dry condition always gives a higher value than in wet condition for all samples. This may be due to the fact that, in wet condition the dye molecules get scope to soluble, so color worn out easily from the sample. The dry and wet rubbing test results were exhibited the same value for all the developed samples.

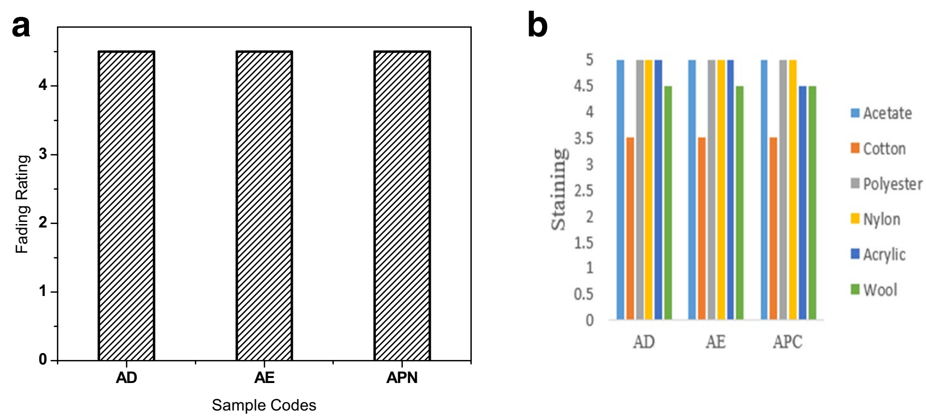

Fig. 6 Color fastness to washing **a** Fading rating. **b** Staining rating. *AD* After Dyeing, *AE* After Enzyme, *APN* After PP Followed by PP Neutralization

Tensile strength

The results obtained from tensile strength at both warp and weft direction are presented in Fig. 7(a). The results revealed that tensile strength at warp direction exhibited higher strength than weft direction due to the compactness of warp yarn in the constructed canvas fabrics. But in both directions tensile strength reduces gradually due to lowering the yarn interlacement strength between warp and weft yarns by means of mechanical friction into the machine and chemical reaction for every subsequent processes.

Tear strength

The warp directional tearing strength is slightly beyond that of the pick, the rationale being that fabric have higher warp densities than pick densities (Bilisik & Yolacan, 2011). Tear strength test results both at warp and weft direction are illustrated in Fig. 7(b). The results exhibited higher tear strength at warp direction than at weft direction due to more ends per inch in the constructed sample. After dyeing tear strength showed more strength due to the more compactness of warp and weft yarn. Due to the subsequent processes tear strength decreases significantly due to mechanical friction into the machine and chemical reaction.

Abrasion resistance and pilling test results

The results displayed that the wear index (WI %) increases gradually by applying dyeing and various washing processes on canvas trousers which are depicted in Fig. 7(d). Higher wear index percentage indicates less abrasion resistance. This is due to, every subsequent processes weaken the bond between the fiber and dye molecules. The more wear index value the less durability of the fabric. There was no significant changes occurred due to various processes in pilling test which are also shown in Fig. 7(d). This results gave very good rating.

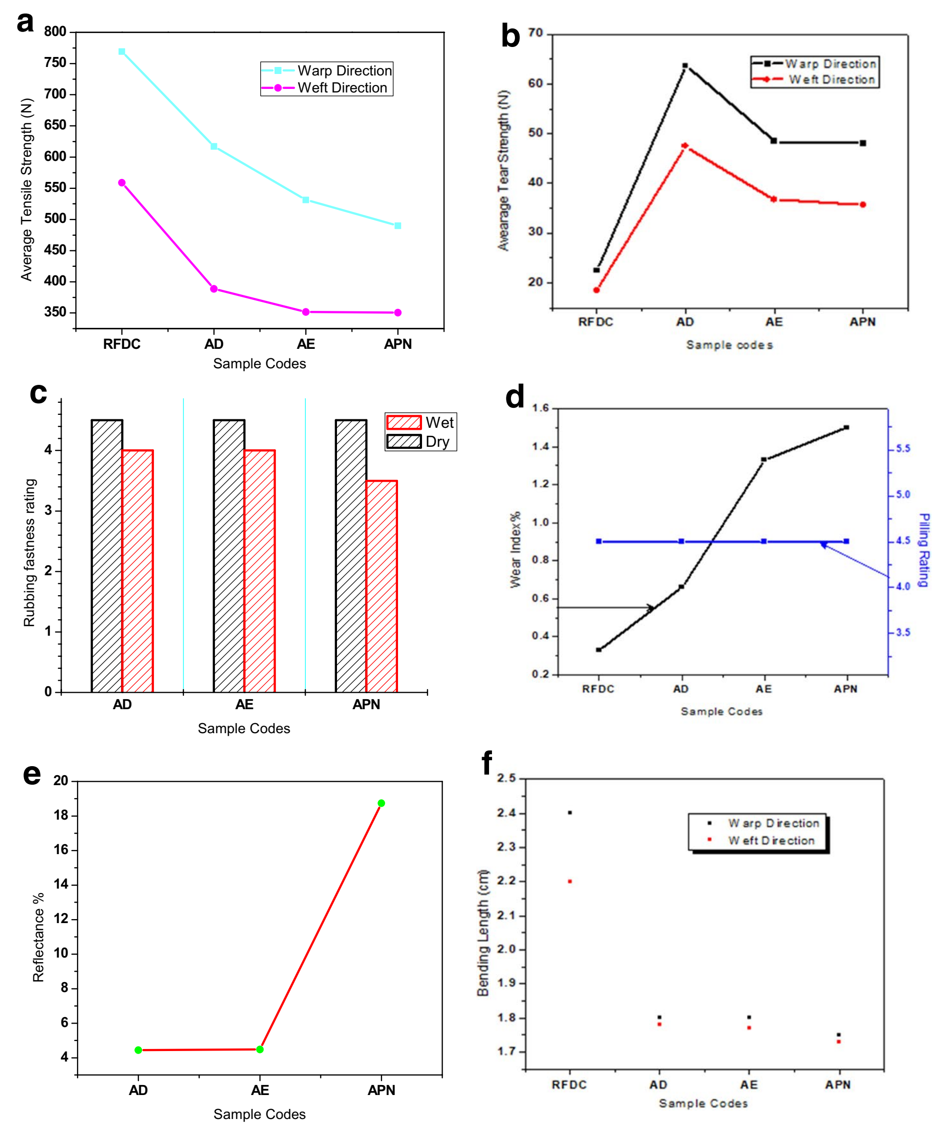

Fig. 7 **a** Tensile strength at warp and weft direction. **b** Tear strength at warp and weft direction. **c** Rubbing fastness test restults at wet and dry condition. **d** Wear index% and pilling rating in various stages. **e** Reflectance% test results and **f** Stiffness test results based on bending length (cm). *RFDC* Ready For Dyeing Canvas, *AD* After Dyeing, *AE* After Enzyme, *APN* After PP Followed by PP Neutralization

Reflectance % measurement

Reflectance% measurements test results are presented in Fig. 7(e). It showed that there was no significant changes occurred to reflectance % after enzyme process. But after PP spray the reflectance % value increased significantly compared to after enzyme wash due to more fading was developed by PP spray.

Stiffness test

Fabric stiffness increased with the increase of weft density (Bedez Ute, 2019). The results obtained from stiffness test are depicted in Fig. 7(f). It is known that the higher the bending length, the higher is the stiffness. Stiffness test results showed that warp direction exhibited little bit more stiffness than weft direction because of more compactness of warp yarn. After dyeing and washing processes stiffness reduced significantly.

SEM images

Microscopic images of various sample surfaces are illustrated in Fig. 8. This results indicated the surface status of canvas fabric for enzyme wash and PP spray. In comparison to grey fabric with dyed sample, dyed sample had more degradation of surface fiber than grey fabric. Because the reaction of different chemicals during dyeing. Due to the enzyme wash, it caused more washing effects and degraded more surface fiber. When PP is sprayed more degradation happened which are seen in Fig. 8.

Digital microscopic view

Significant color fading of canvas trousers was found under digital microscopic view at 225X which are shown in Fig. 9. Fashionable trousers made from cotton canvas fabric were also modified significantly at various stages of dyeing and washing technique which are illustrated in Fig. 9.

CF means colorfastness. From the Table 3, it was observed that CF to dry rubbing, CF to water, tear strength, tensile strength, stiffness and pilling test results of developed canvas trousers met the reference value requirement. In most cases, test results showed beyond the reference value of denim trousers. It can concluded that, 100% cotton canvas trousers met the requirement of denim trousers, and it can be used as an alternative of denim trousers.

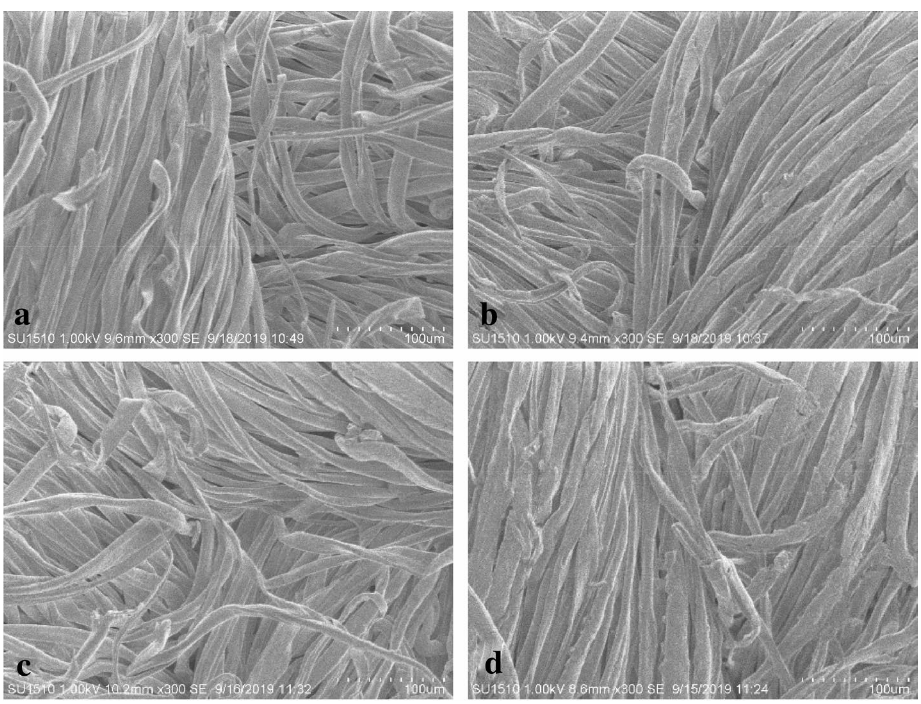

Fig. 8 Microscopic pictures of fibers from different washed samples at 300 SE **a** RFDC (Ready For Dyeing Canvas), **b** AD (After Dyeing), **c** AE (After Enzyme), **d** APN (After PP Followed by PP Neutralization)

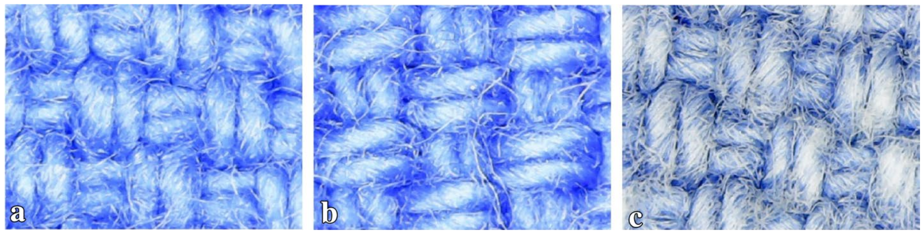

Fig. 9 Digital microscopic view of different treated canvas surface garments at 225X **a** AD (After Dyeing), **b** AE (After Enzyme), **c** APN (After PP Followed by PP Neutralization)

Table 3 Comparison of test results with the reference value of commercial denim trousers (Minimum Quality Requirement QA 6.0, 2018)

SL	Test name	Test result	Reference value	Comments
1	CF to dry rubbing	3/4	3/4	Pass
2	CF to wet rubbing	-	-	-
3	CF to water	Staining: 3/4	Staining: 3/4	Pass
4	Tear strength	Warp: 48.01 N Weft: 35.56 N	> 16 N	Pass
5	Tensile strength	Warp: 489.87 N Weft: 350.7 N	> 300 N	Pass
6	Stiffness	Warp: 1.75 Weft:1.73	1.5–4.5	Pass
7	Pilling	4/5	3/4	Pass

Generally, the denim trousers are found commercially between 3.5 and 13 oz per square yards. Two to four wash cycles have been done on commercial denim trousers to get the desired vintage look. Commercial denim trousers test results are mentioned in Table 3.

Conclusions

In this research, fashionable trousers was introduced successfully through industrial washing technique from 100% cotton canvas fabric. Canvas trousers exhibited modified appearance which seem to look trendy style and fashion. Visual and mechanical properties of canvas trousers also has been revealed by this research. To do so, samples were developed maintaining a definite methods and then investigated on various aspects. Tensile strength, tear strength, stiffness, wear index%, and reflectance % changed significantly for every subsequent processes; however the variation in pilling, abrasion, rubbing and colorfastness to washing was negligible. Tensile strength of finished trousers were found at warp and weft direction 489.87 N and 350.57 N respectively. The reflectance% value was observed 18.74 at the PP sprayed area. Tear strength of finished trousers were also found at warp and weft direction 48.01 and 35.56 N respectively. From the above results, it can be concluded that convenient washing effects can be achieved on canvas trousers and it can be used as a trousers in apparel's industry. Hope, this research will create a new door for canvas fabric in the apparel's industry. However, in future more important characterization could be done such as shrinkage%, dimensional stability, and moisture management tests in this study. Furthermore, effects of various concentration of enzymes, ozone wash, laser treatment, bleach wash can be investigated on dyed-washed canvas trousers.

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Author contributions
MSM conceived the ideas, experimental design, interpretation of the results, and drafted the manuscript of the analysis. MSM and MMRK collected the data and performed the experiments. MMRK supervised and give continuous support to perform the experiment successfully. MNUH participated in its design and assisted to draft the manuscript. MMRK, and MNUH contributed to the interpretation of the results and revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
The raw data required to reproduce these findings cannot be shared at this time as the data also forms part on an ongoing stduy.

Competing interests
No potential conflicts of interest regarding this research, authorship, and/or publication of this article.

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