

# Investigation of Comfort Properties of Knitted Denim

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**Abstract:** Knitted denim was designed by using cross terry structure on circular knitting machine. Knitted denim looks like a denim fabric which has visual appearance like woven denim. Two type of cross terry structure 2/1 and 3/1 were used which gives twill effect with 2 and 3 floats respectively. Four types of materials, cotton, polyester, flax and polypropylene were used. With four materials and two structural combinations 8 samples were produced. Comfort properties of knitted denim including moisture management, air permeability, thermal, and bursting strength were tested. For checking the inherent anti-microbial property of materials anti-microbial test was also applied. Samples containing flax and polyester were found with best results and not even a single sample was found anti-microbial.

## 1. Introduction

Knitting is fabric construction technique in which a continuous yarn is changed into the vertical or horizontal intermeshed loops of yarn either with machine or by hand. According to the movement of yarn during knitting process, it is categorized into two main classes i.e. weft knitting and warp knitting [1]. Weft knitting is mostly used for wearing purposes. Basic weft knit structures is single jersey, rib, interlock and purl. A fabric known as terry is a derivative of single jersey. The knitted denim has a basic structure of terry [2, 3].

Denim is the kind of a fabric, and a traditional blue denim is warp faced woven cotton fabric in 3/1 or a 2/1 twill constructions. Warp is dyed with Indigo dye while weft yarn is remaining undyed. In twill weave the weft yarn interlaces with more than one yarn [4]. Denim is a complete lifestyle statement. On the other hand, for knit denim, cross terry structure is used. While in knitting the knit yarn is dyed and tuck is remained as undyed. In knitting one feeder knits and other feeder loops in this way diagonal lines are formed [5]. Usually knit denim is used for multi purposes as trouser, shoes, hats, socks, shirts, collars and cuffs, curtains as well as fabric's elements [6]. The statistics tells as that denim accounts about 3% of the total world fabric production. An American has eight pairs of jeans, while the Europeans having almost five to six pairs of jeans [7, 8].

The fibre we are going to use to make these knitted denim are flax, cotton, polypropylene and polyester. Knitted denim can be combined with some functional fibres like Tencel, bamboo fibre, spandex, soybean fibre and other fibres to create innovative products with enhanced properties and appearance [9]. The process of manufacturing knitted denim involving ball warping, re-beaming, indigo dyeing, re-winding to cheese/cone form and finally knitted in single jersey circular knitting machine



[10]. Knitted denim can also be dyed and converted to soft cones by re-winding and knitted in a circular knitting machine [11].

Knitted denim fabric provides good wrinkle resistance, improved stretch, extensibility to body fit ease, long lasting neat appearance and provide high level of comfort in the garments, as it is highly pliable, breathable, difficult to tear, highly crease resistant, highly air permeable and limb fabric [12]. Also the knitted denim are piece dyed as previously the woven denim fabric are generally made from dyed yarns. Denim knit fabric can be produce by float plated technology, thread fleece and interlocked plated jacquard. In float plated technology 70% of indigo yarn and 30% cotton yarn is used and the output is almost 220 GSM fabric weight. In thread fleece technique, 50% indigo yarn and 50% cotton yarn is used, resulting in almost 130 GSM. Moreover, In interlocked plated jacquard technique 70% indigo yarn and 30% cotton yarn is used to get Greige GSM of 180 [13]. There are two types of knitted denim with respect to structural constructions, which are knit denim and tuck denim. Tuck denim was produced by two ways tuck denim on 4 tracks and Tuck denim on 3 tracks [14].

The human body produces heat during excessive workout, to eliminate this excessive heat a natural cooling system of body triggers and the sweat is produced from the glands on skin [15, 16]. Management of liquid water is mostly referred as the fabric's "moisture management" and the management of water vapours is termed as the fabric's "breathability" [17]. The management of fabrics moisture management is seen by adsorption, absorption/diffusion, wicking, desorption and evaporation which were tested in this research [18].

This project emphasises on making of knitted denim by using different types of yarn combinations. The main objective is to make knitted denim more cost effective have properties like good moisture management, good comfort level and anti-microbial properties.

## 2. Experimental

### 2.1. Materials

Materials used for the production of knitted denim were combination of natural and synthetic yarn. Natural fibre yarns were 30 Denier cotton and 27 Denier flax; synthetic yarns were 275 Denier polyester and 275 Denier polypropylene. To get the denim effect, the dyed yarn was used. Indigo dyes on natural yarns (cotton and flax) were used. While the synthetics yarns remain undyed because synthetics yarn is used on technical front side (commercially back side).

### 2.2. Knitting

As far as the machine is concerned circular weft knitting single jersey machine, Fukuhara Japan 1992, 90 feeders was used for the production of knitted denim. Stitch length of 0.32 cm for knit and stitch length of 0.15 to 0.16cm for loop. Method used for the production of knitted denim is precisely described below. For getting knitting denim effect cross-terry structure with 3 and 4 tracks repeat were used, and the experiment design is shown in table 1.

**Table 1.** Design of experiment.

Sr.	Structure	Technical Face	Technical Back	Sr.	Structure	Technical Face	Technical Back
1	2/1 Terry	Cotton	Polyester	5	3/1 Terry	Flax	Polyester
2	2/1 Terry	Cotton	Polypropylene	6	3/1 Terry	Cotton	Polypropylene
3	2/1 Terry	Flax	Polyester	7	3/1 Terry	Cotton	Polyester
4	2/1 Terry	Flax	Polypropylene	8	3/1 Terry	Flax	Polypropylene

### 2.3. Finishing

Finishing processes are applied to the samples because when samples are removed from the machine they possess a lot of shrinkage. When samples are washed and relaxed they come to their normal relaxed state. Also removal of shrinkage is very necessary because when fabric is converted into the garment if it contains shrinkage then dimensions of final garment will not stay in the required position. Its required shape will not achieve. Samples were washed in room temperature water to remove the dust and other stains got by the fabric during knitting process. All the samples were tumble dried for one cycle.

### 2.4. Test

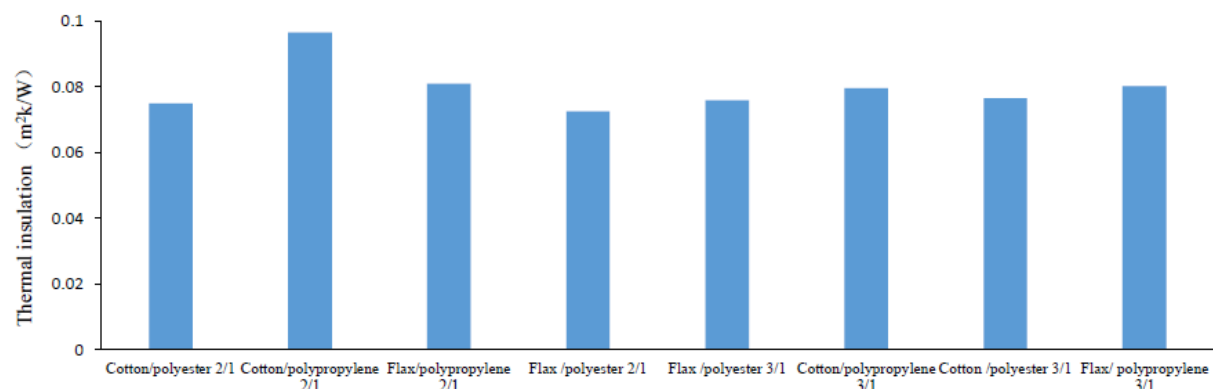
ASTM D 3786 (textile fabrics diaphragm bursting strength tester) was used to check the bursting strength of knitted or woven fabric. Moisture management test (AATTC 195) method was used for the inspection of fabric for liquid moisture management. There are five grades scale (1-5) in assessing the moisture management according to the OMMC value. The grades of the indexes are: 1(0-0.2) = very poor, 2(0.2-0.4) = poor, 3(0.4-0.6) = good, 4(0.6-0.8) = very good, 5(>0.8) = excellent. ISO 11092 test method was used for checking the thermal properties of woven or knitted fabrics. ASTM D 737 test method measured the rate of air flow perpendicular to the surface of textile material at prescribed pressure. AATCC TM100-2004 was used for checking the anti-microbial activity of fabrics.

Culture of *Staphylococcus aureus* and *Escherichia coli* were cultivated in two flasks separately and the flask was incubated separately at 37°C for 18 hrs. After incubation growth of bacteria on the petri plates were counted and percentage reduction in bacteria for each sample against *Staphylococcus aureus* and *Escherichia coli* was calculated.

## 3. Results and Discussion

### 3.1. Thermal Property

The thermal properties of samples are showed in figure 1. It is obvious that the sample made from cotton and polypropylene (2/1) shows the highest thermal insulation among the samples with the value of 0.0964 m<sup>2</sup>k/W, because the thermal properties of polypropylene is very good, thus it added with flax gives the highest thermal insulation amongst other samples. While the sample made from flax/polyester has the least heat insulation with the value of 0.0725 m<sup>2</sup>k/W. As polyester is poor resistant of heat, the samples which have polyester show comparatively low thermal insulation.

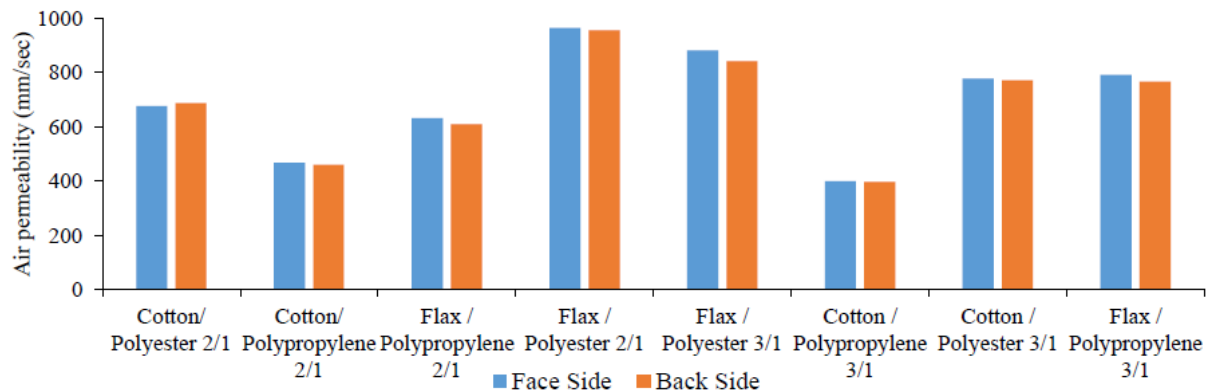


**Figure 1.** Thermal properties of the samples.

### 3.2. Air Permeability

In figure 2, the knitting sample made from flax/polyester shows the highest air permeability value of 964 mm/sec for the face side of the fabric and 556.33 mm/sec for the back side of the fabric, indicating

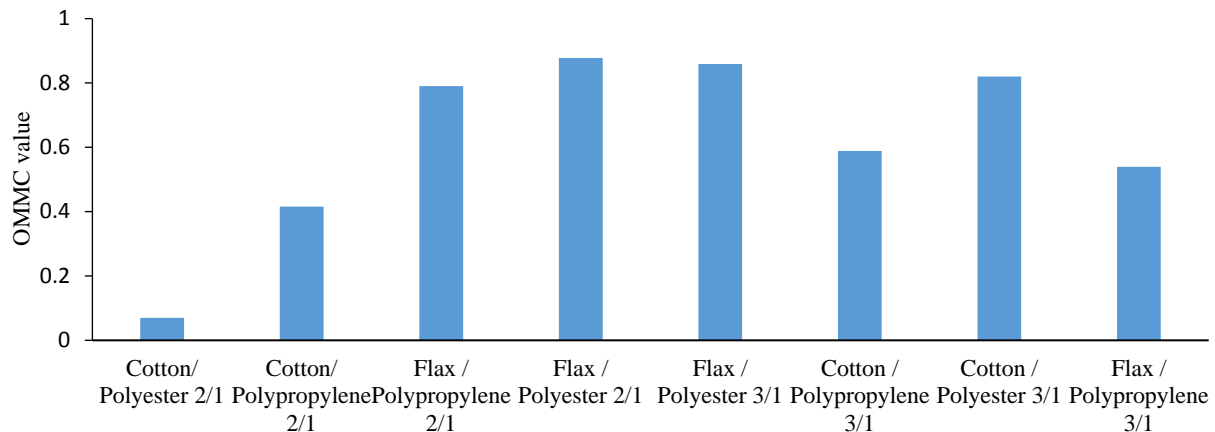
the fabric has passed more air through it as compared to other. It can be said that the fabric was more permeable and had higher pore amounts than other fabrics. On the other hand the lowest value of air permeability was shown by cotton/polypropylene 3/1 with the value of 399 mm/sec for the front of the fabric and 396.33 mm/sec for the back of the fabric. There are many aspects, which effect the air permeability of the fabric, e.g. construction, fabric type, thickness, bulk density, and air porosity in the yarn. Seen like the combination of cotton and polypropylene has more bulk density and smaller air porosity in the interlooped yarns of the knitted structure.



**Figure 2.** Air permeability of front and back of the fabric samples.

### 3.3. Moisture Management

This test was done on the moisture management tester machine. A solution of sodium chloride was dropped on the fabric surface and the time given to the solution to drop on the fabric was 20 sec. After that the spreading radius and speed or time taken by the sample to spreading was recorded and overall moisture management content was calculated. Three test samples were taken from each fabric and the average values for overall moisture management capacity (OMMC) were calculated, and the results are presented in figure 3. Moisture management results show that the flax/polyester 2/1 has the highest value of overall moisture management capacity of 0.878, which indicates that this sample had manage the moisture transmission in fabric in better way than others. It hints that this property was assistance to rapidly remove the sweat from the body by transmitting outside of the fabric. The flax/polyester 3/1 also shows comparatively higher value of moisture management than other samples. Whereas the cotton/polyester 2/1 shows the least value of 0.0698, which was possibly attributed to the flax and polyester. It can be seen from the graph where there is flax in the samples the values of moisture management are relatively higher. Flax fibre has naturally higher wicking ability, it can gain upto 20% water before feel damp, which contributes a better moisture management with flax contents.



**Figure 3.** Moisture management test of the fabric samples.

### 3.4. Anti-Microbial Property

Anti-microbial test were applied to the samples to check the natural property of materials to resistant attack of microorganisms. The following results (figure 4) were achieved by the test. It is concluded that from these pictures taken after the activity of bacteria on these samples, the material used in these samples were not naturally anti-microbial because bacteria had grown on them. None of the fabric sample showed any resistance to bacterial growth showing their inability to resist microorganism.



**Figure 4.** Anti-microbial test of the fabric sample.

## 4. Conclusion

The flax/polyester demin fabric produced by the 2/1 twill effect showed the best results in moisture management and air permeability but showed average value in thermal test results. Antibacterial/anti-microbial activity was not observed at any fabric. Flax/polyester 3/1 and Polyester/Cotton 3/1 also showed better results. They also exhibited better properties than other sample. Samples with flax and polyester showed comparatively better results. Polypropylene with cotton gives medium results of thermal, moisture management and air permeability.

## 5. Acknowledgement

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