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PHYSICAL PROPERTIES OF SINGLE JERSEY BAMBOO COTTON FABRIC PRODUCED ON HOME KNITTING MACHINE

(Sifat-sifat Fizikal Fabrik Kaitan *Single Jersey* Buluh Kapas Diperbuat oleh Mesin Kaitan Rumah)[#]

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ABSTRACT

The Silver Reed Model LK150 knitting machine is a home knitting machine which is extremely lightweight and compact, making it preferable by most home knitters. There are various knitwears with interesting patterns can be made using this model. In the field of garments manufacturing by using flatbed knitting machines, it is important to understand the physical properties of fabric so that their impact on dimensional changes can be predicted to produce the most suitable end use. The samples were produced by using a blended bamboo/cotton yarn, with a composition of 30% cotton and 70% bamboo. The main objectives of this study are to to evaluate the physical properties of single jersey fabric knitted on home knitting machine by using different stitch dials and to relate the physical properties with different stitch lengths. Then, all tests were conducted to compare the physical properties of samples between three different stitch dials and the effects of before and after washing. The physical properties measured in this research were stitch length, stitch density, weight, thickness, absorbency and shrinkage. The result indicated that the longer the stitch length, the higher the percentage of the water impact penetration. Meanwhile, there was a slight reduction on the density, thickness and fabric weight. In addition, the result after three times washing showed that the samples only had slight changes in density, thickness, weight and stitch length, but has significant changes on the water impact penetration.

Keywords: knitting machine; bamboo; cotton; stitch length; physical properties

ABSTRAK[2]

Mesin Silver Reed Model LK150 adalah mesin kait rumah yang sangat ringan dan padat, menjadikannya lebih baik oleh kebanyakan pengait di rumah. Terdapat pelbagai pakaian yang dikait dengan corak yang menarik boleh dibuat menggunakan model ini. Di bidang pembuatan pakaian yang dihasilkan dari mesin kait rata, penting untuk memahami sifat fizikal kain supaya kesan terhadap perubahan dimensi dapat diramalkan untuk menghasilkan penggunaan akhir yang paling sesuai. Sampel dihasilkan menggunakan benang buluh/kapas campuran, dengan komposisi kapas 30% dan buluh 70%. Objektif utama kajian ini adalah untuk menilai sifat fizikal kain *single jersey* yang dibuat oleh mesin kaitan rumah, dengan menggunakan dail *stitch* yang berbeza dan mengaitkan sifat-sifat fizikal dengan panjang *stitch* yang berbeza. Kemudian, semua ujian telah dilakukan untuk membandingkan ciri-ciri fizikal sampel antara tiga dail *stitch* yang berbeza dan kesan sebelum dan selepas dicuci. Ciri-ciri fizikal yang diukur dalam kajian ini ialah panjang *stitch*, kepadatan *stitch*, berat, ketebalan, penyerapan dan pengecutan. Keputusan yang diperoleh menunjukkan bahawa semakin panjang benang *stitch*, semakin tinggi peratusan penembusan kesan air. Sementara itu, terdapat sedikit pengurangan kepadatan, ketebalan dan berat kain. Keputusan selepas tiga kali cucian menunjukkan bahawa sampel hanya mempunyai sedikit perubahan kepadatan, ketebalan, berat dan panjang *stitch*, tetapi mempunyai perubahan ketara terhadap penembusan kesan air.

Kata kunci: mesin mengait; buluh; kapas; panjang *stitch*; sifat fizikal

1. Introduction

Knitting is a method to turn thread or yarn into a piece of cloth. There are two types of knitting; weft knitting and warp knitting. Weft knitting is a method of producing a fabric in which the loops are made in horizontal way from a single yarn and intermeshing of loops take place in a circular or flat form across wise basis. Meanwhile, warp knitting is a method of forming a fabric in which the loops are made in vertical way along the length of the fabric from each warp yarns and intermeshing of loops take place in a flat form of length wise basis (Textile Study Centre, 2016). The type of machines used for knitting are flatbed knitting machine and circular knitting machine. Flatbed knitting machine consists of a main needle bed with multiple parallel slots extending longitudinally and each receives a reciprocating double-hooked knitting needles (Matsui et al, 1969). Silver Reed Model LK150 is one of home knitting machines with simplicity in design and ease of use which assures fun and pleasure in knitting (Angelika's Yarn Store, 2018). This home knitting machine was designed and produced primarily for home use. It has different functions that can be used to knit garments in different ways. Nonetheless, home knitting machines are not so popular among home knitters and those unrelated with textile industry. Thus, this study aims to expose more about home knitting machine to users with little background of textile studies. This is due to the fact that people usually knit their products without really know the basic physical properties that the machine can offer.

When this home knitting machine is used for mass-production of knitted garments, special cares should be taken into consideration to knit at proper setting, in order to meet the required end use properties. One of the setting is the stitch dial, as it affects the stitch length of the fabric. This is because the stitch length is the main factor that influences the dimensions of a knitted structure. Apart from this, shrinkage is one of the most serious problems of the knitted fabrics, particularly found in single jersey knitted fabrics due to the differences between the face and back side of the single jersey fabrics that tend to curl. The fabric possesses some high stretchy features, light weighted and most often used for T-shirts, dresses, woman's tops and ladies suiting (Akter, Abdullah & Mazedul 2017).

Moreover, this study will observe the physical properties of single jersey fabric between before and after washing. From the past studies, it was found that the longer the stitch length, the greater the dimension of the fabric, and the larger the shrinkage occurred on both cotton/acrylic and polyethylene (Nasir, 2008). Dimensional stability of weft knitted fabrics is a serious problem in view of fabric quality control (Keshkari, 2002). It was found that the stitch density of plain knitted fabrics in dry and relaxed state is dependent only on the stitch length, and independent of other yarn and knitting variables (Doyle & Hurd, 1953).

Additionally, people usually use common yarns like cotton, wool and acrylic in knitting. Hence, in the current work, a different kind of yarn is used which is bamboo cotton yarn, that can be the substitute for the existing yarn. This is because, bamboo cotton yarn has many good properties, such as good absorbency, very soft-feel (chemically-manufactured) or ramie-like feel (mechanically-manufactured), antimicrobial, moisture wicking capabilities and its anti-static nature (Waite, 2009). An increasing presence of bamboo fibre in the fabric will also cause reduction in fabric thickness and gram square per metre for all linear densities of yarn. When the constituent yarn gets finer, the fabric air and water-vapour permeability are also improved (Prakash et al, 2012)

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Generally, stitch length will influence the fabric dimensions and other properties like weight, density and shrinkage. Variations in course length between one garment and another can produce horizontal bareness and impair the appearance of the fabric (Khalil, & Solaiman, 2014). Hence, the objective of this study is to evaluate the physical properties of single jersey fabric knitted from bamboo/cotton yarn on home knitting machine by using different stitch dials and to relate the physical properties with the different stitch length.

2. Materials and Method

30% cotton / 70% bamboo yarn in Figure 1 was bought online from cottonhousestore.com. The yarns were knitted into single jersey structure on a flatbed knitting machine, Silver Reed Model LK150 at textile laboratory, UiTM Kampus Kuala Pilah.

Figure 1: Bamboo Cotton Yarn

2.1. *Preparation of samples*

The yarns were knitted on flat bed knitting machine for 3 different stitch dials; 1.5, 2.5, and 3.5. The samples were named as Sample A for 1.5 stitch dial, Sample B for 2.5, and Sample C for 3.5 stitch dial respectively. The sample preparation descriptions were displayed in Table 1a – 1C. All samples were relaxed for 24 hours before conducting the testing.

Table 1a: Sample Preparation for Thickness, Weight, Stitch Length and Stitch Density

Machine setting	A	B	C
Stitch dial	1.5	2.5	3.5
Number of needles	50	50	50
Number of courses	70	70	70

By implementing the standard method of ISO 6330-2012, the samples were knitted for about 36cmx36cm so that a 20cmx20cm box can be marked on the sample. From Table 1b, different samples will have different machine setting because this setting will affect the width and compactness of the sample. When the number of stitch dial is lower, the number of courses and needles need to be higher in order to achieve the required size of sample.

Table 1b: Sample Preparation for Dimensional Changes Test

Machine setting	A	B	C
Stitch dial	1.5	2.5	3.5
Number of needles	70	67	57
Number of courses	100	95	85

Based on Table 1c, water impact penetration samples vary in size for testing by following the AATCC 42 – 2007 standard method. The sample size must be wider than the blotting paper that was put beneath the sample. After all preparations of the samples was done, the samples need to be placed in the conditioning room for 24 hours in order to relax the samples before doing the testing.

Table 1c. Sample Preparation for Water Impact Penetration

Machine setting	A	B	C
Stitch dial	1.5	2.5	3.5
Number of needles	60	50	47
Number of courses	130	117	110

2.2. *Physical properties*

Among properties evaluated in this study were stitch density, thickness, stitch length, weight, water impact penetration and dimensional change.

2.1.1. *Stitch density*

Counting glass/pick glass was used to count courses/inch and wales/inch as shown in Figure 2. Five random places were marked on the sample. This test was conducted to observe the compactness of samples based on ASTM D 3775 – 2008 standard method.

Figure 2: Stitch Counting on the Sample

2.1.2. *Thickness*

The thickness reading was taken from 10 random places on a fabric sample. The equipment used was thickness gauge, following the standard MS ISO 5084-2003.

2.1.3. *Stitch length*

This test is to measure the length of a stitch in each sample. It was measured by cutting out five courses and measuring the average by dividing it with five numbers of wales. Each of the course must be measured properly by straightening the yarn on the ruler.

2.1.4. *Weight*

These test methods cover the measurement of fabric mass per unit area (weight) and are applicable to most fabrics. The sample was cut and the weight was recorded to calculate the average weight of the knitted fabric sample based on MS ISO 3801 – 2003 standard method.

2.1.5. *Water impact penetration test*

Absorbency is the ability of a fabric to take in moisture. This is a very important property, which will affect many other characteristics such as skin comfort, static build–up, shrinkage, water repellency and wrinkle recovery. The test method utilized the impact penetration test by using impact penetration tester, following the standard of AATCC 42 – 2007.

2.1.6. *Dimensional change*

This test was done to measure the changes in length and width of fabric sample after several washing cycles using top load vertical washer with standard method of ISO 6330-2012. It was marked as illustrated in Figure 3 and sewn on cotton fabric to secure them from being unraveled. The washing was repeated for three times.

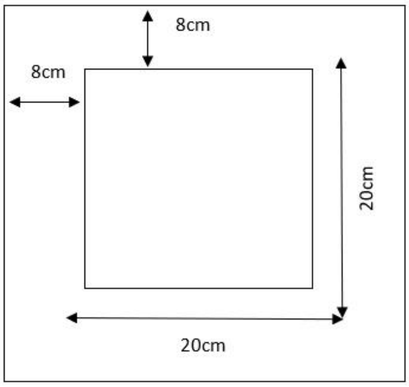

Figure 3: Dimensional Stability Marking

3. Results and Discussion

3.1. *Physical properties*

In this research, bamboo cotton yarns were knitted in three different stitch dials to get knitted fabrics of different density. Some physical properties of the fabrics could be examined using various tests, including weight, density, stitch length, thickness, dimensional stability and water impact penetration test. The results were presented in Table 2 and discussed in this section.

Table 2. Physical Properties of Single Jersey Fabric with Three Different Stitch Dials

Physical properties test	**Stitch dial**		
	A	**B**	**C**
Stitch length (cm)	1.45	1.61	1.85
Stitch density (stitches/inch)	70	57	35
Thickness (mm)	1.04	0.93	0.82
Weight (g/m2)	359.8	330.9	274.1
Absorbency (%)	13.68	21.35	48.27

All physical testings on the effects of stitch dial towards the physical properties of single jersey fabric were tabulated. The result showed that all physical properties were affected by the stitch dial setting. First, the stitch dial setting will affect the stitch length, where the higher dial setting will produce a longer stitch length and the lower dial setting will produce a shorter stitch length (refer Figure 4). Next, the relationship between the stitch length and the stitch density, thickness, weight and absorbency are further discussed based on Figure 5-8.

Figure 4: The Relationship between the Stitch Length and Stitch Dial

Based on Figure 5, the relationship between the stitch length and stitch density was observed. The result showed that the lower stitch length produced a higher stitch density of fabric sample. This is due to the higher number of course and wales per inch in the fabric. Hence, the stitch density increases because shorter stitch length will make the fabric more compact and thus, higher stitch density.

Figure 5: The Relationship between the Stitch Density and Stitch Length

By referring to Figure 6, the thickness was also affected by the stitch length. A shorter stitch length makes the fabric thicker, and a longer stitch length causes the fabric to be thin. This is also related to the fabric compactness, where the shorter stitch length will make the fabric become more compact and thick.

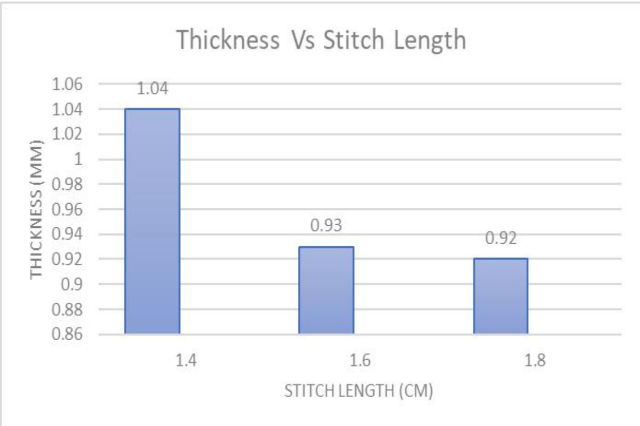

Figure 6: The Relationship between the Thickness and Stitch Length

Based on Figure 7 and 8, it was observed that the weight of fabric and absorbency were also affected by the stitch length. The longer the stitch length, the lower the weight of fabric. This is because the shorter stitch length produces a tight structure of fabric, meanwhile a longer stitch length has loose structure and more lightweight. Next, for the water impact penetration test, the result showed that the percentage of water impact penetration is higher for sample with longer stitch length. The loose characteristic causes the fabric to have more open structure enabling the water to penetrate easily onto the bloating paper. This was opposite to a lower stitch length sample, where they were tighter in structure, making it harder for water to penetrate through them.

Figure 7: The Relationship between the Weight and Stitch Length

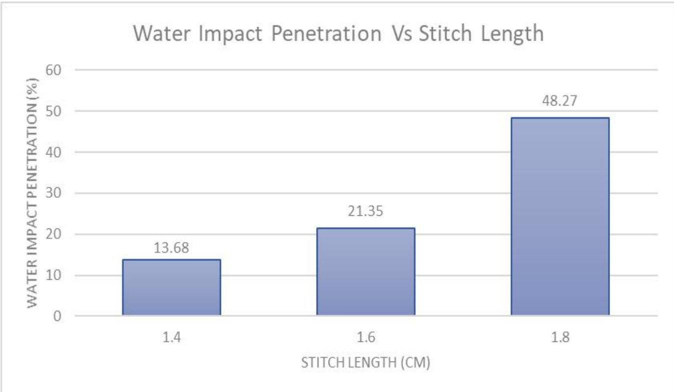

Figure 8: The Relationship between the Water Impact Penetration and Stitch Length

3.2. *Dimensional changes*

Based on Table 3, the percentage of dimensional changes in course and wale direction of the sample for three washing cycles was investigated. It was observed that after the first washing, the samples had no changes in course or wale direction. This indicates that the selected samples did not shrink or expand in any direction. Next, after the second washing, the width decreased slightly by 3% to 4%. Meanwhile, in wale direction, the length increased for Sample C, but no changes in length for Sample A and B. As for the width, after the second washing, all samples decreased by 3% to 4% respectively which demonstrated that they shrunk in the course direction. After the third washing, the width of the material shrunk by 4% to 5% for all samples, meaning that all of them shrunk in the course direction after the third washing. For wale direction, Sample B and C expanded by 4.15% and 10% respectively. On the contrary, Sample A had no dimensional changes in wale direction after the third washing. Hence, Sample C showed the most significant dimensional changes in course and wale direction. Meanwhile, Sample B was affected by the dimensional changes and Sample A showed the least changes. This could be due to the compactness of sample A and B which causes them to be more stable during the washing process in comparison to Sample C that was looser and more lightweight. A loose structure would have more spaces for the yarn to mobile during washing and displacing, making the fabric to expand or shrink.

Table 3: Dimensional Change in Wale and Course Direction

No. of washing	Length of sample (%)			Width of sample (%)		
	A	B	C	A	B	C
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	4.15	-4.15	-3.5	-3.35
3	0	4.15	10	-5	-4	-5

3.3. *Overall quality after washing*

After the third washing cycle, all physical properties tests were repeated to see the after-washing effects. The physical changes were plotted on the spider web chart as shown in Figure 9a-9c. Based on Figure 9a, 9b and 9c, the result showed slight changes on the physical properties after the third washing cycle. First, the weight had slightly reduced for all samples. This could be due to the loss of some microfibers during the washing process. Next, the thickness of the fabric increased because of the increased compactness as they shrink. This is due to the fact that the stitches become closer and leave a little space, making the yarn raised. Thus, the fabric was thicker. For absorbency, all samples showed higher percentage of the water impact penetration after the third washing. This means that the sample has became more absorbent after the third washing. It is because of the increase in surface area after washing due to micro pilling that occurs, making the fabric more absorbent (Clean Cloth Nappies, 2019). The physical changes were not significant because the washing cycle was done for three times only. Hence, more washing cycles are needed to see more significant changes on the after-washing effect.

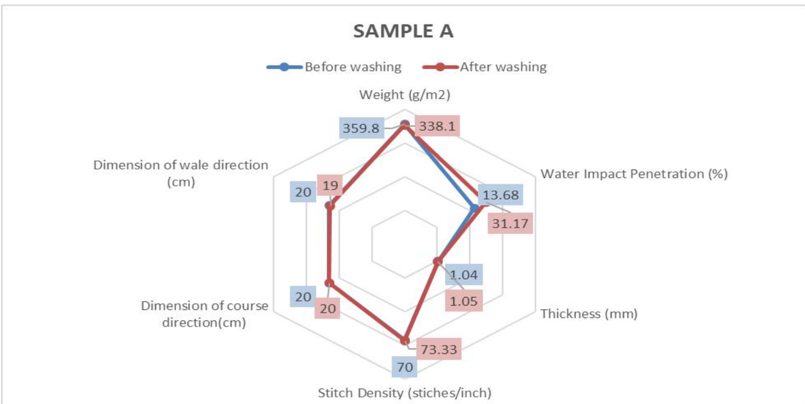

Figure 9a: Physical Changes for Sample A after Third Washing

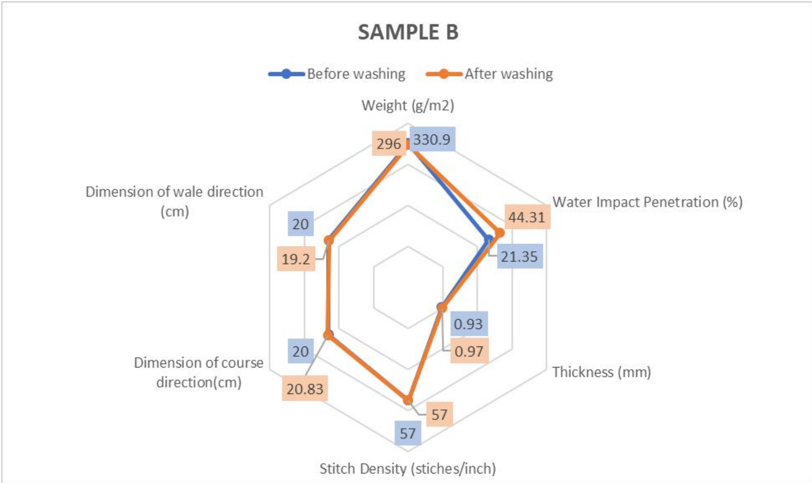

Figure 9b: Physical Changes for Sample B after Third Washing

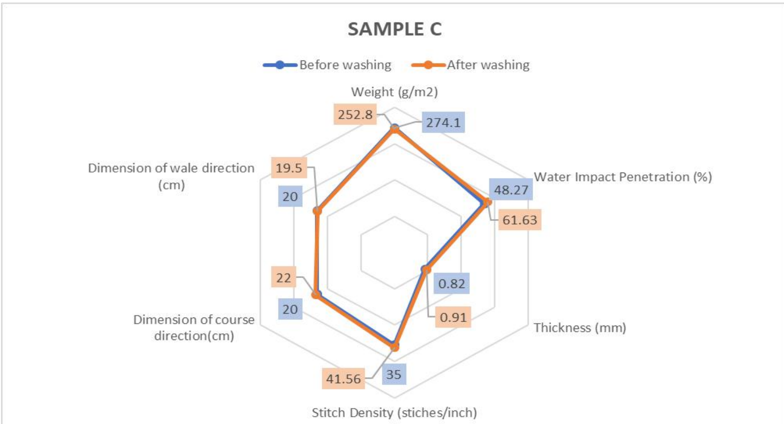

Figure 9c: Physical Changes for Sample C after Third Washing

4. Conclusion

In this study, the stitch length is the most important factor affecting the stitch density, thickness factor, fabric weight, absorbency and dimensional changes on bamboo cotton knitted fabric. The result showed that when the stitch dial increased, the stitch length of the knitted fabric was also affected. The longer the stitch length, the higher the percentage of the water impact penetration. Meanwhile, there was a slight reduction in density, thickness factor and fabric weight.

Drawing from this analysis, it is learned that the three times of washing only have slight changes on the density, thickness, weight and stitch length but has highly significant changes on the water impact penetration. The weight of the samples was slightly reduced for the three samples as the microfibre of knitted fabric was lost during washing. The washing test imitates the daily washing by consumers, but it was done for three times only in this research. Thus, it requires more washing cycles to clearly observe the effects of washing for long term use.

Home knitters must properly decide the right machine setting to obtain the desired properties for their products as the stitch dial setting will affect the physical properties.

It is possible to knit using bamboo cotton yarn using home knitting machines. However, the experimental result also showed that it was practically difficult to obtain the perfectly stable state for plain knitted fabric. This is not only because the knitted structure could not fully relax due to high internal restrictive forces but also due to the fact that different drying processes and conditions would result in different fabric dimensions.

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