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# Pilling Performance and Abrasion Characteristics of Selected Basic Weft Knitted Fabrics

**Abstract**
*The aim of this study was the determination of the effects of dyeing, knit construction and the thread yarn production type on the abrasion resistance and pilling performance of selected basic weft knitted fabrics. For this aim jersey and interlock fabrics were produced from 100% cotton ring and compact yarns. Some of the fabrics produced were dyed. The abrasion resistance and pilling performance of raw and dyed fabrics were measured. The results obtained were classified according to the knit construction, whether the fabric was raw or dyed, and the properties of the yarn from which the fabric was produced. According to the results obtained, the abrasion resistance and pilling performance of interlock fabrics were found to be higher than those of jersey fabrics, those of dyed fabrics higher than those of raw fabrics, and those of fabrics produced from compact yarns were higher than those fabrics produced from ring yarns.*

**Key words:** *abrasion resistance, compact yarn, pilling, weft knitted fabric.*

## Introduction

Knit fabrics will find wider use in time since they can be produced more easily for a lower cost, and they are more flexible. However, knit fabrics are less stable than weave fabrics since they are produced with low twist yarn and have a slack construction, as a result of which they have a low abrasion resistance and pilling performance. Especially in garments produced from knit fabric and garments approaching a state of disuse does the pilling problem play an important role.

Abrasion resistance and pilling performance are two of the most important mechanical characteristics of fabrics. The resistance of a fabric against the force of friction is known as the abrasion resistance. In general, pilling is a fabric defect observed as small fiber balls or a group consisting of intervened fibers that are attached to the fabric surface by one or more fibers [1].

There are many factors, such as the yarn spinning system, fabric construction and finishing operation, which affect the abrasion resistance and pilling performance. With certain precautions taken in fabric production, the abrasion resistance and pilling performance of knit fabrics can be developed positively.

Many textile scientists have studied factors that have an effect on pilling and abrasion resistance [2 - 5].

Baird et al. stated that washing increases pilling tendency and speed [6].

Candan et al. studied the abrasion resistance of knitted fabrics from OE and ring spun yarns and found that knitted fabric from ring spun yarns is slightly better than knitted fabric from OE spun yarns [7].

Özdil et al. compared knitted fabrics from compact spun yarns with classic ring spun yarns and reported that knitted fabric from compact yarns demonstrated better pilling performance [8].

Candan & Önal evaluated the pilling performance of weft knitted fabric made of open-end and ring spun yarns. They reported that 100 % cotton samples knitted from ring spun yarns tend to have lower pilling rates than those constructed from 100 % cotton open-end spun yarns [9].

Akaydin studied basic knitted fabrics from ring combed and compact yarns and determined that the abrasion resistance and pilling performance of supreme fabric were lower than interlock fabrics. He ascribed this situation to interlock fabric being more stabile, thicker and voluminous than supreme fabric and to the characteristic of knit construction [10].

Mavruz & Ogulata produced jersey, rib knit and interlock fabrics from ring and compact yarns in Ne 30 and Ne 40 numbers and examined the grams, bursting strength and pilling properties of these fabrics. However, they did not determine the important difference between the pilling properties of fabrics produced from ring and compact yarns [11].

Betran et al. stated that the pilling tendencies of woollen jersey and rib knit fabrics can be predicted by looking at fibre, thread and fabric properties using artificial neural networks [12].

The study by Nergis & Candan included the pilling performance and abrasion resistance of plain knitted fabric from chenille yarns. The results showed that yarn properties (component yarn count, pile length) and laundering or dry-cleaning do not influence the pilling performance and abrasion resistance of dry relaxed fabrics, whose component yarns tend to decrease [13].

***Table 1.*** *Properties of yarns used in the production of the knitted fabrics.*

| Yarn Characteristics | Ring | Compact |
|---|---|---|
| Linear density (count), tex | 14.78 | 14.78 |
| Tenacity, cN/tex | 17.31 | 20.54 |
| Breaking elongation, % | 4.68 | 4.82 |
| Hairiness, H | 5.79 | 5.04 |
| Evenness, % CV | 11.43 | 11.13 |
| Thin places,- 50% km | 0 | 0 |
| Thick places, + 50% km | 7 | 4 |
| Neps, + 200% km | 14 | 11.4 |

Omeroğlu & Ulku stated that fabrics woven from compact yarns had more pilling resistance compared to those woven from ring yarns. They ascribed this situation to ring yarns showing more hairiness characteristics on the surface. In addition, according to abrasion resistance test results, they determined that fabrics woven from compact yarns led to a 19.3% - 43.0% less weight loss compared to those woven from ring yarns [14].

Can, in his experimental studies, investigated the abrasion resistance and pilling of plain weave fabrics made from 100% cotton ring carded, ring combed and OE rotor spun yarns. He found that the abrasion resistance and pilling performance of fabrics made from OE rotor spun yarns had a maximum value. However, he determined that the abrasion resistance and pilling performance of fabrics made from ring carded spun yarns had a minimum value [15].

Pamuk & Çeken researched the abrasion resistances of 7 different types of automobile seat covers commonly used in automobiles, after 10000 rubs of abrasion. These fabrics were flat woven, woven velour, circular knitted flat, circular knitted pile, warp knit flat, warp knit pol and warp knit double bar raschel (DNBR). As a result of the experimental studies, they determined that warp knit double bar raschel showed the highest abrasion resistance, whereas flat woven, circular knitted flat and warp knit flat fabrics showed the lowest [16].

Jasińska, instead of the standard method currently used to evaluate pilling tendency, developed a new method in which a more objective and uniform evaluation could be made. According to the method developed, the most subjective factors in the standard method are visual perception and the experience of observers. The new method allows to increase assessment precision and the repeatability of pilling assessment. The main advantage of the new method is the replacing of the organoleptic technique of pilled surface assessment with a new technique using computer image analysis and the raster graphics method to detect and calculate pilled changes on a fabric surface [17].

## Material and method

In this study, ring combed yarns and compact yarns in two different numbers were manufactured from combed rovings produced from the same cotton blend. The counts, tenacity, evenness and hairiness of the yarns were measured. ASTM D 861-99, ASTM D 1422–99, ASTM D 1578–93, ASTM D 1425–96 and ASTM D 5647 were used respectively. Data of the yarns are given in ***Table 1***. The yarn twist coefficient was selected as $\alpha_e = 3.50$.

RL-Jersey and RR-Interlock fabrics were produced from yarns, the properties of which are given in ***Table 1***. Jersey fabrics were produced on circular knitting machines of 32 inch diameter, and a gauge of E28 machine and interlock fabrics on circular knitting machines of 30 inch diameter and E24. Some properties and fabric codes are given in ***Tables 2*** and ***3***. The fabric sett, fabric weight, abrasion resistance and pilling of the fabrics were measured according to the relevant standards: ASTM D 3775–3a, ASTM D 3776–96, ASTM D 4966, ASTM D 4970–02 and ASTM 3786, respectively.

We processed all the grey fabrics of compact and conventional ring-spun yarns in the same baths to eliminate any variations during these processes. The grey fabrics were first scoured with hydrogen peroxide, the bath ratio being 1/12. The following scouring, hot washing, acetic acid processing and rinsing processes were carried out in succession. Then all the fabrics were dyed blue with reactive dyes in a jet dying machine. During the dyeing, we processed the fabrics at 25 °C at the beginning and increased it to 60 °C for 45 minutes. Following cold rinsing, 0.5 g/l of acetic acid and 3% of softener were applied, respectively. Afterwards, the tube slitting, drying and sanforing processes were carried out.

The abrasion resistance was measured as a cycle quantity which showed the breaking off of any yarns in that time. Pilling was measured as the pill number in a certain area at 2000 cycles. There is a possibility of pouring pills according to the fiber and yarn structure at 5000 and 7000 cycles. In addition, pill formations may not be observed clearly at 125, 500 and 1000 cycles. For this reason, 2000 cycles were chosen for the pilling test. A higher number means a higher abrasion resistance, whereas a lower number means a higher pilling performance.

***Table 2.*** *Physical properties of jersey fabrics produced from 14.78 tex (Ne 40/1) yarn.*

| Construction | Code | Weight, g/m$^2$ | Wale density, wpc | Course density, cpc | Abrasion resistance, cycle | Pilling, pills/area |
|---|---|---|---|---|---|---|
| Ring raw | RJ1 | 101 | 13 | 21 | 16600 | 212 |
| Ring dyed | RJ2 | 101 | 13 | 21 | 22700 | 161 |
| Compact raw | CJ1 | 102 | 13 | 21 | 20200 | 193 |
| Compact dyed | CJ2 | 102 | 13 | 21 | 24300 | 149 |

***Table 3.*** *Physical properties of interlock fabrics produced from 14.78 tex (Ne 40/1) yarn.*

| Construction | Code | Weight, g/m$^2$ | Wale density, wpc | Course density, cpc | Abrasion resistance, cycle | Pilling, pills/area |
|---|---|---|---|---|---|---|
| Ring raw | RI1 | 167 | 12 | 18 | 26500 | 158 |
| Ring dyed | RI2 | 172 | 12 | 18 | 51300 | 128 |
| Compact raw | CI1 | 170 | 12 | 18 | 31300 | 146 |
| Compact dyed | CI2 | 177 | 12 | 18 | 54700 | 122 |

## Results and discussion

In this study, the abrasion resistance and pilling performance of jersey and interlock fabrics produced from ring and compact yarns in a raw and dyed state were evaluated. The abrasion resistance of fabrics produced from ring and compact yarns is shown in ***Figure 1***. and the pilling performance in ***Figure 2***. The abrasion resistance of raw and dyed fabrics is in ***Figure 3***. and the pilling performance in ***Figure 4***. The abrasion resistance of jersey and interlock fabrics is shown in ***Figure 5***. and the pilling performance in ***Figure 6***.

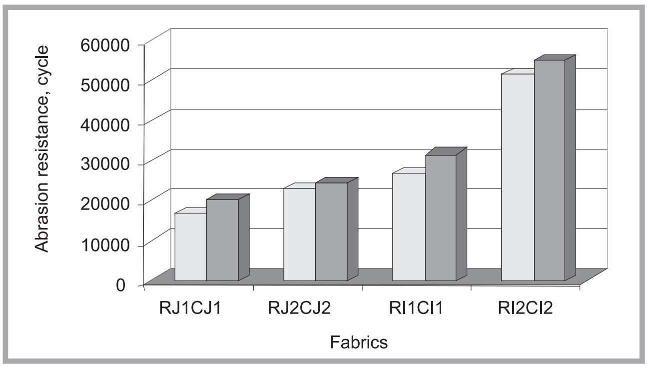


***Figure 1.*** *Abrasion resistance values of fabrics produced from ring and compact yarns; ☐ - ring fabrics, ■ - compact fabrics.*

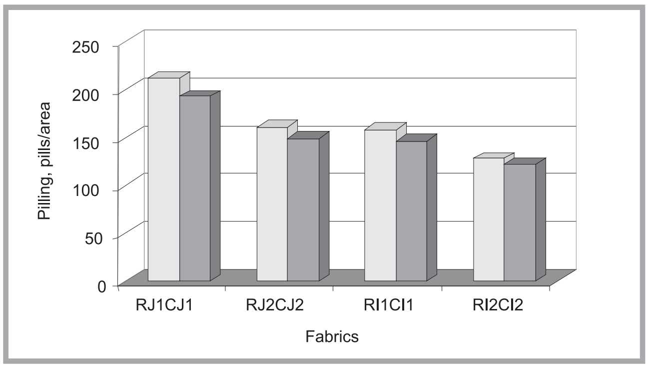


***Figure 2.*** *Pilling values of fabrics produced from ring and compact yarns; ☐ - ring fabrics, ■ - compact fabrics.*

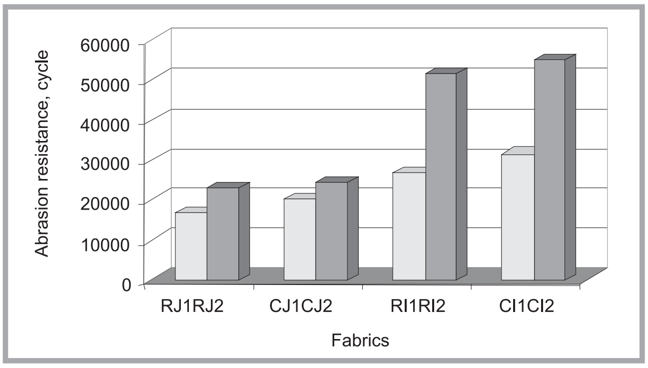


***Figure 3.*** *Abrasion resistance values of the raw and dyed fabrics; ☐ - grey fabrics, ■ - dyed fabrics.*

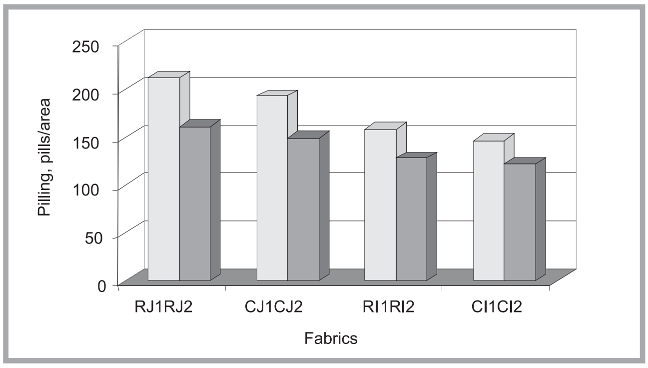


***Figure 4.*** *Pilling values of the raw and dyed fabrics; ☐ - grey fabrics, ■ - dyed fabrics.*

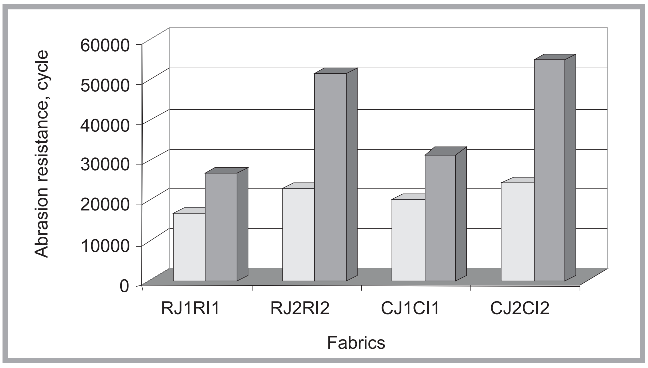


***Figure 5.*** *Abrasion resistance values of jersey and interlock fabrics; ☐ - jersey fabrics, ■ - interlock fabrics.*

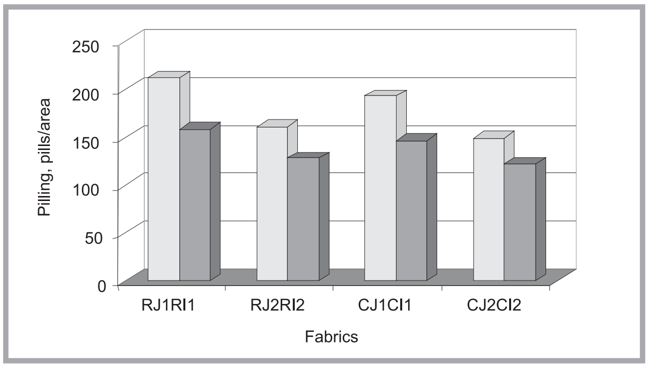


***Figure 6.*** *Pilling values of jersey and interlock fabrics; ☐ - jersey fabrics, ■ - interlock fabrics.*

The abrasion resistance and pilling performance of fabrics produced from ring yarns in a grey or dyed state were found to be lower than those produced from compact yarns. During compact yarn production, since the spinning triangle is made smaller and fibres outside the yarn are stretched less and behave like interior fibres in the yarn structure, the threads obtained do have better hairiness values, as well as a higher tenacity and breaking elongation [18]. When ***Table 1*** is examined, it can be seen that compact yarns have less hairiness than ring yarns. It can be said that yarn hairiness is effective in the fabric abrasion resistance and pilling performances.

Of both fabric types it can be said that the abrasion resistance and pilling performance of dyed fabrics produced from both ring and compact yarns are higher than those of raw fabrics. Furthermore, the fabrics become relaxed during pre-finishing and dyeing operations, and their dimensions become stable; hence this can be considered as effective.

Of the raw and dyed fabrics produced from both ring and compact yarns, it can be said that the abrasion resistance and pilling performance of jersey fabrics are lower than those of interlock fabrics. Furthermore, interlock fabric is more stable, thicker and more voluminous than jersey fabric, and the characteristic of stick construction can be considered as effective .

Test results for the pilling tendency are explained visually in the photographs below.

When the values of the images in ***Figures 7.a-d*** (see page 54) are evaluated, it is found that the pilling tendencies of fabrics knitted from compact yarns are lower than those of fabrics knitted from

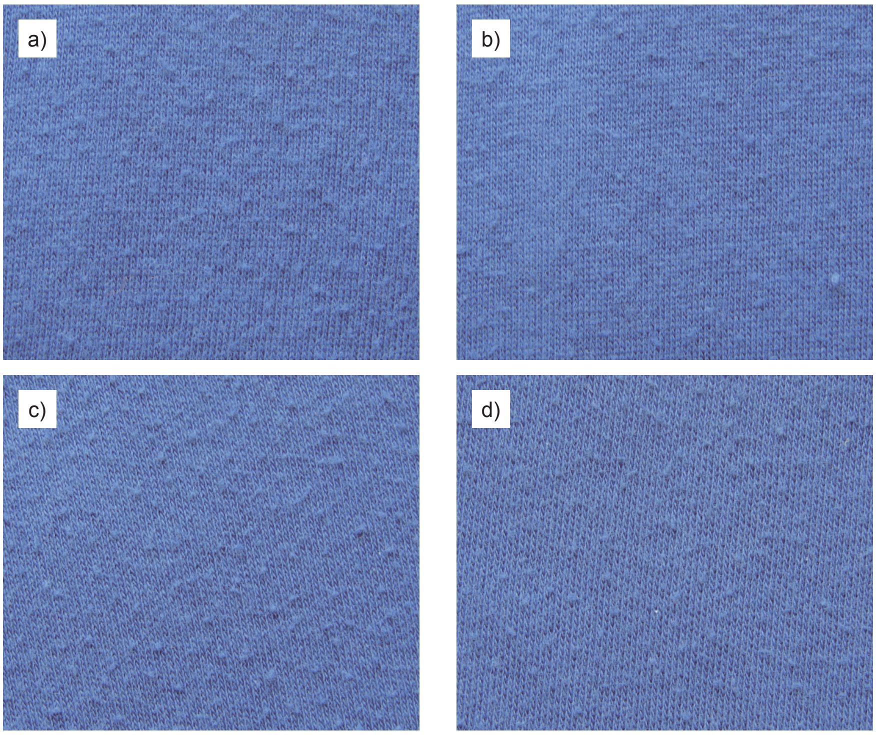


***Figure 7.** Photos of fabrics after pilling; a) ring jersey, b) compact jersey, c) ring interlock, d) compact interlock.*

ring combed yarns. When the hairiness values of both yarns, given in ***Table 1***, are analysed, it is found that compact yarns have lower hairiness. This situation may be the resultof a lower pilling tendency in fabrics of compact yarns.

## Conclusions

In this study, the effect of knit construction, the yarn production system and dyeing operation on abrasion resistance and pilling performance was researched. Jersey and interlock fabrics were produced from 20 tex ring and compact yarn. These fabrics were then dyed in the same dyeing machine in the same conditions. A total of eight fabrics were classified according to the knit construction, yarn production system and whether they were raw or dyed. The results stated below were obtained by measuring the abrasion resistance and pilling performances in each class.

The abrasion resistance and pilling performance of raw or dyed jersey or interlock fabrics produced from compact yarns were found to be higher than those of fabrics produced from ring yarns. Since the fibres of compact yarns hold more tightly within the yarn structure, they have a denser and closer structure than ring yarns. As a result of this, fibre movements causing abrasion and pilling will be limited. The tensile strength and extension of compact yarns are higher than those of ring yarns of the same number. This situation will allow to decrease the twist during compact yarn production. Therefore, thanks to the soft holding of knitted fabrics produced from low twisted yarns, clothing comfort will increase. During knitted fabric production with high strength compact yarns, the efficiency of production will increase due to the decrease in tensile strength, hence the quality of the fabric will rise. In addition, since the hairiness of compact yarns is low, paraffin use during fabric production can be kept at a minimum . Moreover, due to low hairiness, the surface of the fabric produced will be brighter and smoother.

Of the jersey and interlock fabrics produced from compact and ring yarns, the abrasion resistance and pilling performance of dyed fabrics were found to be higher than those of raw fabrics. During the dyeing operation, fibres on the fabric surface will cling to it, hence the fabric will achieve a closer state, and the movement of fibres within the yarn will be limited.

Of the raw or dyed knit fabrics produced from compact and ring yarns, the abrasion resistance and pilling performance of interlock fabrics were found to be higher than those of jersey fabrics.

As a result of this investigation, it can be said that the knit construction, yarn production system and dyeing operation have an effect on the abrasion resistance and pilling performance of knit fabrics. To be able to produce knit fabrics whose abrasion resistance and pilling performance are high, compact yarns should be used and more stable interlock fabrics preferred instead of jersey fabric. The results stated are valid for jersey and interlock fabrics produced from 100% cotton fibre but not valid for yarn produced from different fibres and for different knit types.

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