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# Knittability of Short Staple Wool Blend Yarns Spun on Two Different Systems and Knitted on a 28 Gauge Single Jersey Machine

by

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# KNITTABILITY OF SHORT STAPLE WOOL BLEND YARNS SPUN ON TWO DIFFERENT SYSTEMS AND KNITTED ON A 28 GAUGE SINGLE JERSEY MACHINE

*by G. A. ROBINSON, M. P. CAWOOD and D. A. DOBSON*

## ABSTRACT

*The knitting of short staple wool blend yarns on a 28 gauge single jersey knitting machine was investigated. Wool was blended with either cotton, polyester or acrylic fibres and the wool-rich blends i.e. blends containing 50 per cent wool or more were processed on the worsted system whilst blends containing less than 50 per cent wool were processed on the cotton system.*

*The knitting performance of each yarn was measured and knittability factors evaluated. Wool/acrylic yarns performed relatively poorly, in some cases worse than the 100 per cent wool yarns. The wool/cotton and wool/polyester blend yarns performed the best and small additions (25 per cent) of either cotton or polyester fibre increased the knitting performance substantially. Additions of 50 to 75 per cent gave relatively high knittability factors with the 100 per cent cotton and polyester yarns knitting best of all, especially in the case of the plain single jersey structure.*

## INTRODUCTION

In previous SAWTRI investigations on the knitting performance of yarns knitted on a single jersey machine, most work done has been centred around 100 *per cent* wool yarns[1,2]. Recently, however, Hunter *et al*[3,4] related physical properties of wool blends and cotton yarns to the number of yarn breakages when knitting single and double jersey structures. In these reports it was suggested that by blending certain synthetic fibres with natural fibres, the knitting performance of the yarns could be improved. It was also noted that the relative importance of the various yarn properties depended somewhat on the fabric structure being knitted[3].

Shepherd[5] investigated the effect of the blend composition of yarns from wool and low pilling polyester on their knitting performance on an 18 and a 22 gauge machine when knitting a Punto-di-Roma structure. He found an improvement in the knitting performance (less fabric holes) as the low pilling polyester component increased and this trend was much more significant when more than 40 *per cent* polyester was used in the blend.

In this report the influence of blend composition on the knitting performance of short staple intimate blend yarns comprising wool blended with cotton, acrylic or polyester (® Trevira types 120 and 330) knitted on a fine gauge (28 gauge) single jersey knitting machine has been investigated.

## EXPERIMENTAL

### Fibres

Details of the fibres used for the various blends are shown in Table I.

### Preparation of wool in open top form

Combed wool tops containing 0,5 *per cent* dichloromethane extractable matter were converted into *open top* simply by re-combing at as close a gauge as possible (so as to remove practically no noil) and by collecting the combed fibres without coiling. These open tops were then regarded as the raw material for this project. This short wool was blended with the cotton, acrylic and polyester fibres in the following proportions:

| | | |
|---|---|---|
| 100 *per cent* wool | | |
| 75 *per cent* wool | : | 25 *per cent* synthetic or cotton |
| 50 *per cent* wool | : | 50 *per cent* synthetic or cotton |
| 25 *per cent* wool | : | 75 *per cent* synthetic or cotton |
| | | 100 *per cent* synthetic or cotton |

giving a total of 17 blends as shown in Table III.

The lots containing 50 *per cent* or more of wool were processed on the worsted system while the 25/75 blends and the 100 *per cent* synthetic or cotton were processed on the cotton system. Unfortunately at the time of this investigation insufficient knowledge about integration of the two systems restricted the use of cotton or synthetic-rich blends to the cotton processing system and those of wool-rich blends to that of the worsted processing system. This aspect has been covered in a very recent paper[6].

### Processing on the Worsted System

The wool in open top form was blended with the acrylic, polyester and carded cotton in loose fibre form (see properties in Table I) in 50/50 and 75/25 blends. These blends, together with the 100 *per cent* wool control were then intimately blended by passing them through a worsted card followed by three gilling operations, a further operation of combing and then a final finisher gilling. The card was set with very close settings as previously used for wool/cotton blends[7]. Very close settings were likewise used on the gill boxes and comb. Drafts on the gill boxes were 4, 4 and 6 during preparing with the ratch set at 27 mm. The tops were recombed on a Schlumberger PB 26 comb followed by two finisher gillings on an autoleveller gill box and a final drawing operation.

The rovings were then spun on a Rieter H6 worsted spinning ring frame to give 24 tex Z742 yarns.

### Processing on the Cotton System

All the 25/75 blends were formed by layer blending and processed along normal blowroom procedure with the exception that due to the bulkiness caused

## TABLE I

## PHYSICAL PROPERTIES OF FIBRES USED IN THE BLENDS

| Fibre | 2,5% Span Length (mm) | Actual mean fibre length (mm) | CV (%) | Fine-ness (dtex) | Fibre bundle test (3,2 mm gauge length) | |
|---|---|---|---|---|---|---|
| | | | | | Tenacity (cN/tex) | Extension (%) |
| Wool (20 µm) | 49,62 | 51,50 | 40,5 | 4,33 | 13,2 | 15,3 |
| Cotton | 31,37 | 25,99 | 37,7 | 1,67 | 26,2 | 6,2 |
| Acrylic | 46,61 | 53,11 | 12,1 | 3,3 | 21,7 | 19,7 |
| Trevira 120 | 33,14 | 32,95 | 20,0 | 1,7 | 41,7 | 10,5 |
| Trevira 330 (Special) | 31,61 | 32,43 | 21,1 | 3,6 | 43,4 | 14,7 |

by the presence of the wool, smaller laps were made than normally used in the case of 100 *per cent* cotton or synthetic. All the laps were processed without trouble with the exception of the 25/75 wool/acrylic blend where excessive static electricity was generated in the region of the doffer comb and coiler trumpet, but this was eliminated by the liberal use of French chalk.

No trouble was experienced during the drawing process and the roller settings used for the various blends are shown in Table II.

The various fibre lots were processed into rovings of about 400 tex with 36 turns/m with the exception of the 100 *per cent* cotton lot which was processed with 50 turns/m because of the shorter fibre length.

All the rovings were then spun into 24 tex Z 742 yarns giving a tex twist factor of 36,40.

In the case of the 25 *per cent* wool/75 *per cent* Trevira 330 and the 100 *per cent* Trevira 330, drafting difficulty was experienced. The weighting was insufficient to control the roving in the break draft zone which resulted in excessive end breakages and the formation of slubs. This difficulty was overcome by slip-drafting. The same applied in the case of the 25 *per cent* wool/75 *per cent* acrylic blends as well as the 100 *per cent* acrylic lots (lots 12 and 13).

It was also noticed that in the case of the 25 *per cent* wool/75 *per cent* Trevira 330 and the 100 *per cent* Trevira 330, an excessive amount of fibre shedding occurred.

# TABLE IV

## THE NUMBER OF YARN BREAKAGES (PER 100 000 m OF YARN KNITTED) AT DIFFERENT TIGHTNESS FACTORS FOR THE DIFFERENT BLENDS KNITTED INTO PLAIN SINGLE JERSEY

| Type of Fibre | 100%wool or other fibre | | 25% Wool/75% other fibre | | 50% Wool/50% other fibre | | 75% Wool/25% other fibre | |
|---|---|---|---|---|---|---|---|---|
| | MTF* | Number of breakages | MTF* | Number of breakages | MTF* | Number of breakages | MTF* | Number of breakages |
| Wool | 17,6 | 40 | | | | | | |
| | 18,1 | 98 | | | | | | |
| | 18,8 | 93 | | | | | | |
| | 19,4 | 404 | | | | | | |
| | 20,2 | 847 | | | | | | |
| | 20,9 | 1 239 | | | | | | |
| Acrylic | 18,1 | 16 | 18,1 | 33 | 17,0 | 77 | 17,6 | 40 |
| | 18,8 | 93 | 18,8 | 51 | 17,6 | 293 | 18,1 | 139 |
| | 19,4 | 703 | 19,4 | 308 | 18,1 | 254 | 18,8 | 475 |
| | 20,2 | 2 696 | 20,2 | 3 152 | 18,8 | 1 831 | 19,4 | 1 898 |
| | 20,9 | 4 002 | 20,9 | 3 850 | 19,4 | 3 700 | 20,2 | 2 096 |
| Cotton | 19,4 | 0 | 19,4 | 18 | 18,8 | 68 | 18,8 | 25 |
| | 20,2 | 18 | 20,2 | 36 | 19,4 | 193 | 19,4 | 105 |
| | 20,9 | 19 | 20,9 | 161 | 20,2 | 583 | 20,2 | 392 |
| | 21,8 | 865 | 21,8 | 1 496 | 20,9 | 1 901 | 20,9 | 1 769 |
| | 22,7 | 2 224 | 22,7 | 2 112 | 21,8 | 3 532 | 21,8 | 3 060 |
| Trevira 120 | 19,4 | 0 | 19,4 | 18 | 18,8 | 76 | 18,8 | 68 |
| | 20,2 | 9 | 20,2 | 118 | 19,4 | 396 | 19,4 | 123 |
| | 20,9 | 28 | 20,9 | 66 | 20,2 | 674 | 20,2 | 337 |
| | 21,8 | 423 | 21,8 | 836 | 20,9 | 1 807 | 20,9 | 1 504 |
| | 22,7 | 1 834 | 22,7 | 1 968 | 21,8 | 2 440 | 21,8 | 2 725 |
| Trevira 330 | 19,4 | 0 | 19,4 | 0 | 18,8 | 17 | 18,8 | 34 |
| | 20,2 | 0 | 20,2 | 0 | 19,4 | 105 | 19,4 | 105 |
| | 20,9 | 0 | 20,9 | 28 | 20,2 | 446 | 20,2 | 273 |
| | 21,8 | 216 | 21,8 | 147 | 20,9 | 1 400 | 20,9 | 1 580 |
| | 22,7 | 1 753 | 22,7 | 1 907 | 21,8 | 2 912 | 21,8 | 3 149 |

*Calculated at a constant yarn linear density of 24 tex.

# TABLE V

## THE NUMBER OF YARN BREAKAGES (PER 100 000 m OF YARN KNITTED) AT DIFFERENT TIGHTNESS FACTORS FOR THE DIFFERENT BLENDS KNITTED INTO SATIN STITCH

| Type of Fibre | 100% wool or other fibre | | 25% Wool/75% other fibre | | 50% Wool/50% other fibre | | 75% Wool/25% other fibre | |
|---|---|---|---|---|---|---|---|---|
| | MTF* | Number of breakages | MTF* | Number of breakages | MTF* | Number of breakages | MTF* | Number of breakages |
| Wool | 13,17 | 47 | | | | | | |
| | 13,61 | 43 | | | | | | |
| | 14,04 | 254 | | | | | | |
| | 14,49 | 1 660 | | | | | | |
| | 14,98 | 8 865 | | | | | | |
| Acrylic | 13,61 | 6 | 13,61 | 19 | 13,17 | 54 | 13,61 | 74 |
| | 13,76 | 25 | 13,76 | 37 | 13,31 | 338 | 13,76 | 150 |
| | 14,04 | 76 | 14,04 | 32 | 13,61 | 560 | 14,04 | 533 |
| | 14,20 | 566 | 14,20 | 328 | 13,76 | 1 570 | 14,20 | 1 776 |
| | 14,49 | 7 743 | 14,49 | 3 012 | 14,04 | 3 137 | 14,49 | 11 660 |
| Cotton | 15,55 | 0 | 15,55 | 0 | 14,49 | 66 | 14,20 | 32 |
| | 15,75 | 91 | 15,75 | 192 | 14,71 | 53 | 14,49 | 144 |
| | 16,12 | 780 | 16,12 | 3 208 | 14,98 | 631 | 14,71 | 1 183 |
| | 16,38 | 5 772 | 16,38 | 51 025 | 15,21 | 5 685 | 14,98 | 4 005 |
| | | | | | 15,55 | 11 380 | 15,21 | 10 565 |
| Trevira 120 | 15,21 | 0 | 14,98 | 0 | 14,20 | 64 | 14,98 | 0 |
| | 15,55 | 21 | 15,21 | 14 | 14,49 | 164 | 15,21 | 14 |
| | 15,75 | 372 | 15,55 | 91 | 14,71 | 106 | 15,55 | 91 |
| | 16,12 | 14 720 | 15,75 | 1 462 | 14,98 | 1 663 | 15,75 | 1 462 |
| | | | 16,12 | 22 135 | 15,21 | 12 239 | 16,12 | 22 130 |
| Trevira 330 | 15,55 | 0 | 15,21 | 0 | 14,49 | 33 | 14,20 | 32 |
| | 15,75 | 29 | 15,55 | 7 | 14,71 | 53 | 14,49 | 98 |
| | 16,16 | 233 | 15,75 | 86 | 14,98 | 468 | 14,71 | 539 |
| | 16,38 | 1 280 | 16,12 | 554 | 15,21 | 723 | 14,98 | 2 817 |
| | | | 16,38 | 1 983 | 15,55 | 4 858 | 15,21 | 6 442 |

*Calculated at a constant yarn linear density of 24 tex.

in fibre length. Trevira 120 is a fibre commonly blended with cotton and therefore Trevira 330 (normally 75 mm) was cut specially to the same length for blending with the short wools. The cotton and Trevira 120 were of comparable fineness, whereas the acrylic and Trevira 330 were of a fineness normally used for blends with wool. Bundle tenacity results showed that wool was the weakest fibre, the acrylic next, then cotton, with the polyesters the strongest. Trevira 330 had the highest bundle tenacity.

**Yarns**

Table III shows the results for some of the physical properties of the yarns. Only small differences in yarn linear density and yarn to metal friction (as determined on a SAWTRI yarn friction tester) were observed. The yarns had similar frictional properties after waxing and the effect of blend level was small with the exception of the Trevira 330 blends.

The breaking strength of all the yarns increased with a decrease in the wool content. Trevira 120 effected the greatest increase, followed by the cotton and Trevira 330, while the acrylic showed the smallest increase in yarn strength which confirms previous findings of Aldrich and Grobler[8].

Fig. 1 shows the relationship between the yarn tenacity and blend composition for the yarns[6]. It can be seen that at all the blend levels the wool/Trevira 120 blend had the highest yarn tenacity and the wool/acrylic blend the lowest irrespective of whether it was spun on the cotton system or the worsted system as described earlier.

In the case of the wool/Trevira 330 blend these yarns had a slightly higher tenacity than the wool/cotton blends when spun on the worsted system but the reverse was true for the blends spun on the cotton system. This may be due to the relatively longer mean fibre length of the wool/Trevira 330 blend.

The percentage extension at break of the Trevira blend yarns increased slightly as the polyester content increased. With an increase in the acrylic component above 50 *per cent*, an increase in the yarn extension occurred. The wool/cotton blends, however, showed a sudden decrease in extension with the addition of 25 *per cent* cotton and then remained reasonably constant with a further increase in the cotton content, (see Table III).

Aldrich and Grobler[8] encountered similar results on polyester/wool blends but found that an addition of 25 *per cent* acrylic fibre to wool decreased the elongation at break dramatically after which it increased only slightly with further increases in acrylic content.

The irregularity of the yarns tended to increase with a decrease in the wool content until it reached a maximum somewhere around 50 to 25 *per cent* of wool whereafter it decreased. The 100 *per cent* Trevira 120 and the cotton yarns were found to be the most regular. The wool/acrylic blends were the most irregu-

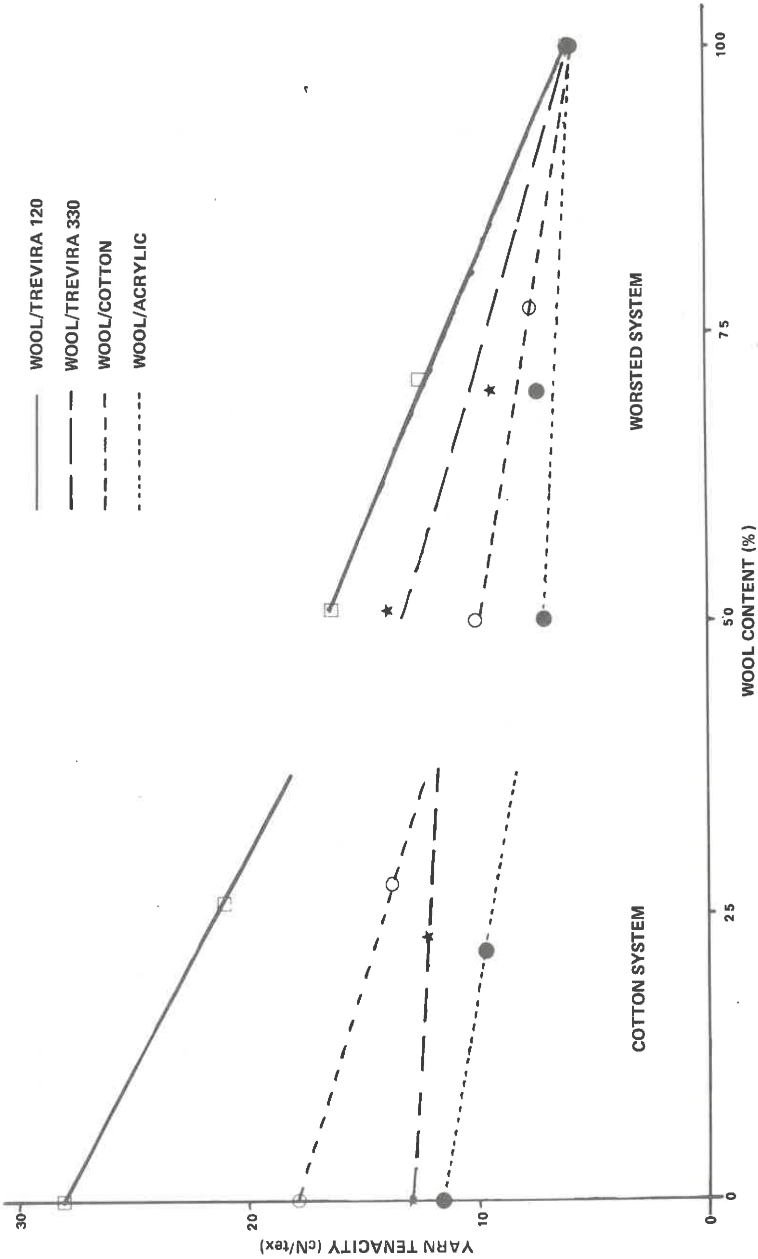


**FIGURE 1**
**Relationship between yarn tenacity and blend composition for a 24 tex yarn, spun on both cotton and worsted systems.**

lar yarns except for the 75/25 and 100 *per cent* acrylic which appeared to be slightly more regular than the equivalent blends of Trevira 330.

### Knitting Performance

The number of yarn breakages per 100 000 metres of yarn knitted at different tightness factors for the various yarns and structures are given in Tables IV and V.

**TABLE VI**

**THE KNITTABILITY FACTORS OF THE BLEND YARNS CALCULATED FROM THE BEST FIT STRAIGHT LINE (log number of breakages = aMTF + b) AT 100 YARN BREAKAGES PER 100 000 m OF YARN KNITTED**

| Blend Composition | PLAIN | | SATIN STITCH | |
|---|---|---|---|---|
| | *Correlation coefficient of the best fit | Knittability factor | *Correlation coefficient of the best fit | Knittability factor |
| 100% W | 0,976 | 18,3 | 0,970 | 13,6 |
| 70% W/30% A | 0,976 | 17,9 | 0,995 | 13,7 |
| 50% W/50% A | 0,961 | 17,2 | 0,955 | 13,6 |
| 22% W/78% A | 0,968 | 18,8 | 0,922 | 14,0 |
| 100% A | 0,977 | 18,8 | 0,987 | 14,0 |
| 77% W/23% C | 0,991 | 19,4 | 0,996 | 15,7 |
| 50% W/50% C | 0,996 | 19,0 | 0,953 | 15,7 |
| 27,5% W/72,5% C | 0,978 | 20,6 | 0,926 | 15,9 |
| 100% C | 0,954 | 21,3 | 0,918 | 16,0 |
| 71% W/29% P120 | 0,989 | 19,1 | 0,984 | 15,8 |
| 51% W/49% P120 | 0,968 | 19,4 | 0,883 | 15,4 |
| 26% W/74% P120 | 0,940 | 20,5 | 0,984 | 15,8 |
| 100% P120 | 0,976 | 21,4 | 0,993 | 15,7 |
| 70% W/30% P330 | 0,993 | 19,3 | 0,998 | 15,8 |
| 51% W/49% P330 | 0,987 | 19,5 | 0,980 | 15,8 |
| 23% W/77% P330 | 0,965 | 21,7 | 0,964 | 16,2 |
| 100% P330 | 0,950** | 22,0 | 0,927 | 16,1 |

W = Wool
A = Acrylic
C = Cotton
P120 = Trevira 120
P330 = Trevira 330

*All correlation coefficients are significant at the 95% level and better
**Not significant

The knittability factors[9,10] for each yarn lot were then obtained from the knittability curves. It was found by statistical analysis that the knittability curves could also be represented by the linear function:

$$\log y = ax + b$$

where $y$ = number of yarn breakages per 100 000 m of yarn knitted,
and $x$ = machine tightness factor.

Since the knittability factor[9] was defined as the tightness factor at which 100 yarn breakages occurred per 100 000 metres of yarn knitted, therefore:

$$\log 100 = a.\text{MTF} + b$$

or $$\text{MTF (or knittability factor)} = \frac{2 - b}{a}$$

The results for the plain and satin stitch structures appear in Table VI.

**Plain Single Jersey Structure**

The knittability factors were plotted against the blend compositions for the four type of blends (see Fig. 2). It appears that the acrylic blends had the lowest knittability, especially the 75/25 and 50/50 wool/acrylic blend yarns (which had the highest irregularity), even lower than the 100 *per cent* wool. The 25/75 and 100 *per cent* acrylic blends performed better than the 100 *per cent* wool.

The wool/cotton, wool/Trevira 120 and wool/Trevira 330 followed similar trends. There was a sharp increase in the knittability factor when 25 *per cent* cotton or synthetic was added and then only a slight increase in the relative knittability up to 50 *per cent* in the case of synthetic. These results are peculiar to the worsted spun yarns only because as the cotton or synthetic component approached 75 *per cent* and finally 100 *per cent* (yarns spun on the cotton processing system) the relative knittability of the yarns increased sharply.

It appears, therefore, that there is a two-fold effect reflected in these results, viz., an effect obtained by the difference in the two processing routes and the effect of the increased cotton or synthetic component. Furthermore, it can be seen that the Trevira 330 yarns knitted better than the Trevira 120 yarns especially at the 75 *per cent* and 100 *per cent* levels spun on the cotton system although the Trevira 120 blend yarns had the overall better physical properties. A possible reason for this result is the substantially lower mean yarn linear density of the Trevira 330 blend yarns as shown in Table VII. This supports Hunter *et al's*[3] work, where it was found that for plain single jersey only yarn linear density and yarn friction significantly affected the number of breakages.

A second consideration is the differences in fibre bundle tenacity and extension observed in Table I. The Trevira 330 had both higher bundle tenacity and extension than any of the other blend fibres. This suggests that during knitting the yarn is restrained in such a way that the fibres break rather than slip which is similar to the

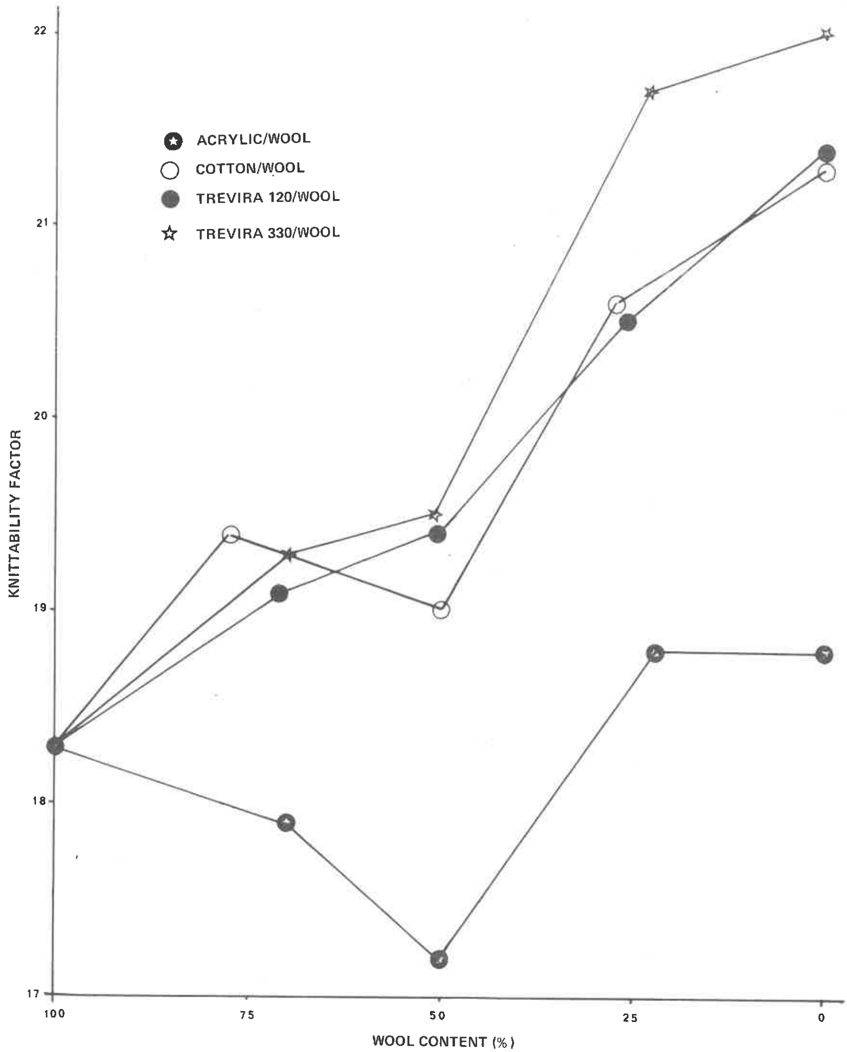


**FIGURE 2**
**Knittability factors vs percentage composition of blend yarns for the plain structure**

fibre bundle test. This fibre breakage weakens the yarn and results in yarn breakages. The highest number of yarn breakages during knitting occurred in the blends with the lowest bundle tenacity and *vice versa.*

## TABLE VII.

## AVERAGE YARN LINEAR DENSITY FOR THE 50/50, 75/25 AND 100 PER CENT BLENDS OF COTTON, POLYESTER 120 AND POLYESTER 330 BLENDS WITH WOOL

| | Wool/Trevira 120 | Wool/Trevira 330 | Wool/ Cotton |
|---|---|---|---|
| Average yarn linear density | 24,8 | 22,8 | 24,9 |

**Satin Stitch Structure**

Fig. 3 shows the knittability factors plotted against the blend compositions for the various blend yarns. The wool and wool/acrylic blend yarns once again showed the lowest knittability and the trend was for the knittability factor to remain reasonably constant as the acrylic content increased. The wool/cotton and two wool/polyester blend yarns showed very similar curves with the knittability factors increasing sharply with either 25 *per cent* cotton, Trevira 120 or Trevira 330 in the blend. The knittability of these yarns then appeared to remain fairly constant with a further increase in the cotton and/or polyester content. The Trevira 330 blend yarns processed on the cotton system as well as the 50/50 blend (worsted system) once again performed better than the other equivalent yarns although not to the same extent as for the single jersey structure.

**General**

It would appear that structure plays an important role in the knitting performance of yarns, as was previously observed[3]. It was also noticed that the satin stitch structure was much more sensitive to small increases in tightness than the plain single jersey structure.

Although Figs. 2 and 3 present a somewhat similar trend, the differences between the types of blends is accentuated in the case of the plain structure.

When the yarn tenacity curves are compared with knittability it is clear that yarn tenacity, although very important, is not the only criterion for good knittability. Other factors such as yarn linear density, irregularity, extension and friction and even fibre bundle tenacity all play a role in determining the knitting performance.

## SUMMARY AND CONCLUSIONS

The influence of blend composition and spinning system on the knitting performance of wool blend yarns for short staple fibres has been studied. Wool was blended with cotton, Trevira 120, Trevira 330 and acrylic fibre in 75/25, 50/50 and 25/75 proportions with 100 *per cent* wool, cotton, Trevira and acrylic yarns used as

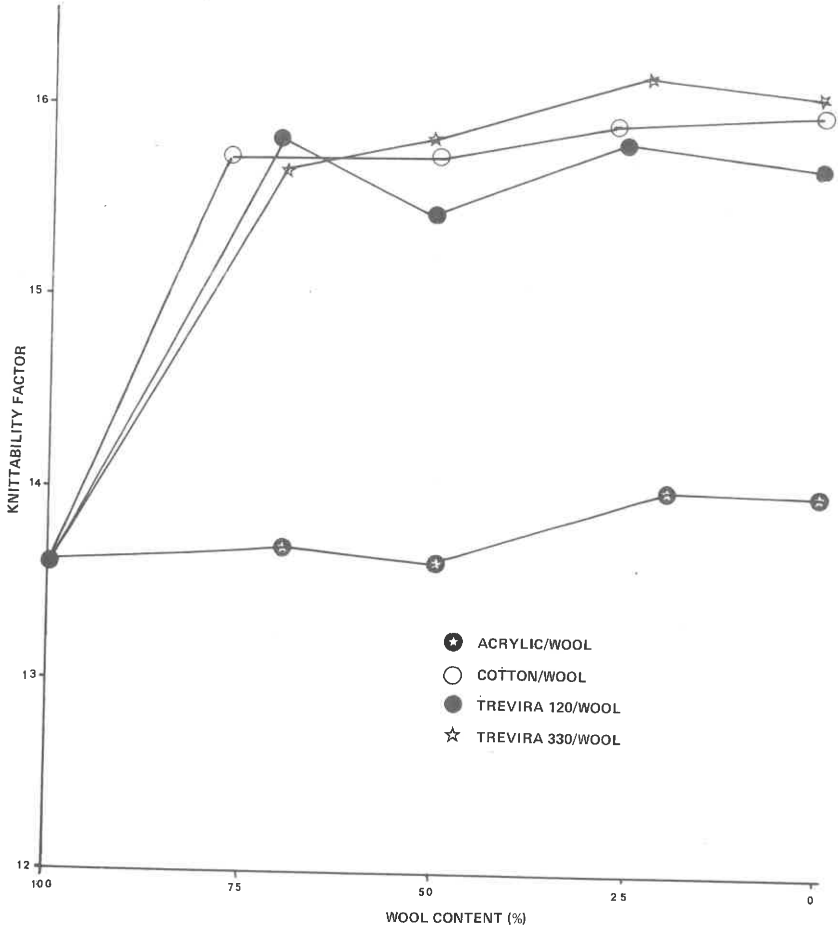


**FIGURE 3**
**Knittability factors vs percentage composition of yarns for the satin stitch structure**

controls. The 50/50 blends as well as the wool-rich blends were processed on the worsted system whilst the cotton or synthetic-rich blends were processed on the cotton system. The yarn properties and the corresponding knittability factors were studied.

The breaking strength increased with an increase in the cotton or synthetic fibre content with the Trevira 120 effecting the greatest increase, cotton and Trevira 330 slightly less and acrylic the smallest. The wool/cotton blends had the lowest extension at break. Generally, the irregularity of the blend yarns were worse than that of the 100 *per cent* control yarns with the 50/50 blends being worst of all.

The relatively high yarn tenacities of the wool/Trevira 120 blends was not always reflected in the knittability results. The wool/Trevira 330 blends, despite their lower yarn tenacities, gave higher knittability factors indicating that fibre bundle tenacity is an important factor in yarn knittability. In general it appeared that yarns spun on the cotton system had higher yarn tenacities than yarns spun on the worsted system and this was not entirely due to the higher cotton or synthetic component.

The effect of structure also appeared to affect knittability of the yarns. Although similar trends were observed for both plain and satin stitch structures the differences between the different blends was greater for the plain structure than for the satin stitch structure.

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## THE USE OF PROPRIETARY NAMES

®Trevira is the product of Messrs Hoechst (Pty) Limited.

The fact that fibres with proprietary names have been mentioned in this report does not in any way imply that SAWTRI recommends them or that there are not substitutes which may be of equal or better value.

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