SAWTRI TECHNICAL REPORT

NO 337

Cotton in Fine Gauge Single Jersey

Part II: Fabrics from Unmercerised and Mercerised Singles Yarns — All Cotton and 60/40 per cent Cotton/Polyester Blends

by

G.A. Robinson, M.P. Cawood and D.A. Dobson

SOUTH AFRICAN
WOOL AND TEXTILE RESEARCH
INSTITUTE OF THE CSIR

P.O. BOX 1124
PORT ELIZABETH
REPUBLIC OF SOUTH AFRICA

ISBN 0 7988 0977 9

COTTON IN FINE GAUGE SINGLE JERSEY
PART II: FABRICS FROM UNMERCERISED AND MERCERISED SINGLES YARNS – ALL COTTON AND 60/40 PER CENT COTTON/POLYESTER BLENDS

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

ABSTRACT

Knitting of all-cotton and 60/40 per cent cotton/polyester blends from singles yarns on a 28 gauge machine is described. Plain single jersey was knitted from unmercerised and mercerised yarns and the fabrics were DP treated. In the case of the cotton/polyester blend fabrics, these were heat set and DP treated. The caustic soda mercerised yarns produced fabrics which were lighter in mass, more air permeable and had lower durable press properties, less pilling, lower area shrinkage, increased bagging and improved wrinkling behaviour. The DP treatment was more effective on the all-cotton fabrics than on the blends.

INTRODUCTION

In a previous report[1] the knitting of all-cotton plied yarns on a 28 gg Single Jersey machine was investigated, the yarn and fabric details were given, and the fabric properties discussed.

In a review of cotton knitted goods, Shah and Varghese[2] stated that yarn mercerising is limited to plied yarns and even with the improved strength obtained the garments made from these yarns have poor flat abrasion properties especially after crosslinking with N-methylol compounds in durable press treatments.

Murphy *et al*[3] also compared the effect of yarn mercerising on knitted fabrics and showed that when treated with DMEU the yarn-mercerised fabrics had a higher abrasion resistance than unmercerised fabric.

Mackin[4] reported that mercerisation generally caused an increase in yarn strength from 10 to 40 *per cent* depending on the yarn construction. In our earlier report[1] on all-cotton yarns the average increase in breaking strength after hank mercerisation and bleaching was 18 *per cent.* In an I.C.I.[5] report on the use of Terylene/cellulosic-fibre yarns in knitwear it was stated that lighter mass fabrics can be made from this blend than from equivalent all-cotton yarns while still retaining adequate stability and durability. It was also implied that underwear knitted from Terylene/cellulosic yarns has a longer wear life.

Frick and Gautreaux[6] found that the knitted structure had little effect on the stability imparted to the fabric by finishing. They found that to reduce shrinkage to below 5 *per cent,* preshrinkage was necessary as part of the treatment so as to complement resin finishing.

In this report unmercerised and mercerised singles yarns of 100 *per cent* cotton and 60/40 *per cent* cotton/polyester have been knitted to show the effect of mercerisation and resin treatment on plain jersey knitwear.

EXPERIMENTAL

Fibre:

Cotton: A three component fibre blend of cotton of between 28,6 mm and 34,9 mm (1 1/8″ to 1 3/8″) staple length was processed up to the combing stage.

Polyester: ®Trevira type 120, 38 mm, 1,7 dtex was used.

Yarns:

Two lots of slivers were prepared, all-cotton and a 60/40 blend of cotton/polyester blended at the draw frame. Both these lots were spun into 15 tex Z925 singles yarn.

The yarns were cleared on an Uster Classimat prior to hank winding. Each yarn lot was divided into two parts and processed as follows:

(a) bleached and dyed (unmercerised)

(b) mercerised, bleached and dyed (mercerised).

Preparation:

The yarns were hank mercerised with caustic soda and bleached with hydrogen peroxide under standard mill conditions. Dyeing was also carried out in hank form prior to winding and waxing with paraffin wax (m.p. 60 to 63°C).

Testing:

All the yarns were tested for irregularity, linear density, breaking strength, extension, neps, thick and thin places and friction at each stage of finishing to determine the effect of the various processes on these yarn physical properties.

Knitting:

The machine details were as follows:

Machine	:	Bentley JSJ
Gauge	:	28
Diameter	:	76 cm (30 inches)
Yarn input tension (cN)	:	3
No. of feeders in use	:	16
Machine speed (r/min)	:	14
Designs	:	Plain
Type of positive feed	:	Trip tape
Take down tension	:	medium

One basic fabric i.e.: a plain single jersey was knitted from each of the four yarn lots. These fabrics were coded in a similar manner as used in Part 1[1] for the 15 tex yarns.

TABLE I

LEGEND FOR YARN AND FABRICS (15 tex singles)

Yarn Treatment	Fabric Treatment					
	All-Cotton		60/40 cotton/polyester			
	Untreated	DP Treated	Untreated	DP Treated	Heat Set only	Heat set prior to DP treatment
Unmercerised	O_1	C_1	O_2	C_2	O_2H	C_2H
Mercerised	$U_1(m)$	$I_1(m)$	$U_2(m)$	$I_2(m)$	$U_2H(m)$	$I_2H(m)$

All the fabrics were divided into two parts, one being retained untreated and the remainder finished as follows:

Finishing:

All-cotton – permanent press treated

60/40 blend – 1. permanent press treated
2. heat set only
3. permanent press treated after heat-setting, giving six sets of fabrics in all. The legend for the fabrics is shown in Table I.

Prior to finishing all the fabrics were dry-cleaned in a Permac Böwe dry-cleaning machine to remove the paraffin wax which had been applied to assist in knitting.

Edge curling was prevented by applying a cotton fusible interlining tape 3,5 cm wide at each side of the cutting line using dry heat and pressure. The fabrics were then slit open to a width of 170 cm and sewn together end-to-end.

Permanent Press Treatment of Fabrics:

The fabrics were padded to 80 *per cent* pick-up with a solution comprising:
5 *per cent* ®Aerotex M3 (Cyanamid-aminoplast resin)
5 *per cent* ®Fixapret CP conc (BASF-aminoplast resin)
1 *per cent* ®Mystolube S (Catomance-polyethylene emulsion)
1 *per cent* Zinc nitrate hexahydrate (catalyst)
0,2 *per cent* ®Tergitol Speedwet (Union Carbide – wetting agent) made up to 20ℓ with water at room temperature. After padding, the fabrics were stentered at 160°C for 4 to 5 minutes and then washed in a rotating drum type washing machine (normal cycle) in a washing solution containing 0,5 g/ℓ ®Lissapol N (I.C.I.). After rinsing, the fabrics were tumble-dried and finally decatised.

Heat Setting:

Heat setting was carried out on a stenter at 180°C for 30 seconds.

Test procedures:

All the fabrics were tested as described in an earlier report[1].

RESULTS AND DISCUSSION

Preparation:

Certain characteristics of the combed sliver are shown in Table II(a) and the polyester sliver in Table II(b).

TABLE II(a)

COMBED COTTON CHARACTERISTICS

Micronaire value	4,1
2,5% Span length after combing	32,5 mm
Length uniformity ratio	56%
Zero gauge bundle strength	43 cN/tex

TABLE II(b)

POLYESTER (TREVIRA TYPE 120) CHARACTERISTICS

Fibre linear density	1,7 dtex
2,5% Span length	35,3 mm

Yarns:

Table III lists the physical properties of the all-cotton yarns and Table IV lists the physical properties of the 60/40 cotton/polyester yarns at the various stages of finishing. It can be seen from Tables III and IV that the two types of yarns are of similar linear density, in each case the actual yarn linear density after mercerising, bleaching, dyeing and waxing was marginally higher than that of the control. The breaking strength of the yarns also increased after mercerising but in the case of the 60/40 *per cent* cotton/polyester blends the increase in breaking strength of the yarn was not as great as was the case for the 100 *per cent* all-cotton yarns. The CV breaking strength of the all-cotton yarns was generally higher than that of the blend yarns, whereas the extension at break was generally higher for the blends than for the all-cotton. The all-cotton yarns had significantly more thick and thin places and neps than the blend yarns.

TABLE III

RESULTS OF PHYSICAL TESTS ON YARNS AT VARIOUS STAGES OF FINISHING (ALL-COTTON – 15 TEX)

Yarn State	Yarn Linear Density	Friction (cN)	Breaking Strength (cN)	CV (%)	Extension (%)	Irregularity (%)	Thin Places per 1000 m	Thick Places per 1000 m	Neps per 1000 m
n	14,5	29	253	10,2	7,6	19,8	150	532	512
							weighted averages		
bdw	14,0	11	288	7,0	6,8	15,8	10	85	220
mbdw	15,2	13	333	8,5	5,9	15,8			

n = natural
b = bleached
m = mercerised
d = dyed
w = waxed

TABLE IV

RESULTS OF PHYSICAL TESTS ON YARNS AT VARIOUS STAGES OF FINISHING (60/40 COTTON/POLYESTER BLENDS – 15 TEX)

Yarn State	Yarn Linear Density	Friction (cN)	Breaking Strength (cN)	CV (%)	Extension (%)	Irregularity (%)	Thin places per 1000 m	Thick places per 1000 m	Neps per 1000 m
n	14,7	32	274,0	6,7	6,3	15,6	18	44	100
							weighted averages		
bdw	15,2	12-13	299,3	6,9	9,7	15,3	11	69	112
mbdw	15,0	13	298,2	7,9	7,0	14,8			

n = natural
b = bleached
m = mercerised
d = dyed
w = waxed

TABLE V

DETAILS OF A PLAIN FABRIC AT VARIOUS STAGES OF RELAXATION (15 TEX) 100% COTTON

	Lot	Relaxed state	Stitch Length (ℓ)	Courses/ cm	Wales/ cm	k_1	k_2	k_3
unmercerised	O_1	After dry relaxing	0,271	16,7	.13,6	16,68	4,53	3,69
		After washing	0,272	21,1	15,9	24,82	5,74	4,32
unmercerised	C_1 (treated)	After dry relaxing	0,270	19,3	12,6	17,73	5,21	3,40
		After washing	0,270	19,3	13,2	18,57	5,21	3,56
mercerised	U_1(m)	After dry relaxing	0,270	17,1	13,2	16,45	4,62	3,56
		After washing	0,272	20,5	15,1	22,90	5,58	4,11
mercerised	I_1(m) (treated)	After dry relaxing	0,271	18,7	13,2	18,13	5,07	3,58
		After washing	0,271	19,5	13,2	18,90	5,28	3,58
	60/40 PER CENT COTTON/POLYESTER							
unmercerised	O_2	After dry relaxing	0,273	17,3	13,8	17,79	4,72	3,77
		After washing	0,266	21,2	15,6	23,40	5,64	4,15
unmercerised	C_2 (treated)	After dry relaxing	0,262	19,7	13,0	17,58	5,16	3,41
		After washing	0,261	20,2	14,0	19,26	5,27	3,65
mercerised	U_2(m)	After dry relaxing	0,272	16,1	14,2	16,91	4,38	3,86
		After washing	0,272	20,0	14,3	21,16	5,44	3,89
mercerised	I_2(m) (treated)	After dry relaxing	0,272	17,9	13,0	17,22	4,87	3,54
		After washing	0,267	18,5	14,2	19,03	4,94	3,79
	60/40 PER CENT COTTON/POLYESTER (AFTER HEAT SETTING)							
unmercerised	O_2H (Heat set only)	After dry relaxing	0,265	20,1	14,2	20,04	5,33	3,76
		After washing	0,264	20,5	15,0	21,43	5,41	3,96
unmercerised	C_2H (Heat set and treated)	After dry relaxing	0,261	18,9	13,8	17,77	4,93	3,60
		After washing	0,260	19,7	14,2	18,91	5,12	3,69
mercerised	U_2H(m) (Heat set only)	After dry relaxing	0,267	18,1	14,2	18,32	4,83	3,79
		After washing	0,270	18,9	14,6	20,11	5,10	3,94
mercerised	I_2H(m) (Heat set and treated)	After dry relaxing	0,270	16,9	13,8	17,0	4,56	3,72
		After washing	0,266	17,7	13,8	17,29	4,71	3,67

TABLE VI

A COMPARISON OF THE PHYSICAL PROPERTIES OF PLAIN SINGLE JERSEY FABRICS KNITTED FROM MERCERISED AND UNMERCERISED YARNS, DP TREATED AND UNTREATED SINGLES 100 PER CENT COTTON (15 TEX)

Lot	Fabric Mass (g/m^2)	Fabric Thickness (mm) (at 0,5 kPa)	Bursting Strength (kN/cm^2)	Air Permeability* ($m\ell/s/cm^2$) 3 layers of fabrics	Martindale Abrasion		Area Shrinkage (%)	DP Rating	Bagging (IR %)	AKU wrinkling (De-aged)*** [SD of AKU wrinkling curve (mm)]					
					% Mass loss after 1 000 cycles	Pilling** after 2 000 cycles				1 hour recovery			24 hour recovery		
										Wales creased	Courses Creased	Mean	Wales creased	Courses Creased	Mean
Untreated															
O_1	89	0,42	6,6	100	0,8	3,0	29,5	3,5	48	0,10	0,13	0,12	0,06	0,09	0,08
U_1(m)	82	0,39	5,9	128	0,6	2,0	26,0	1,0	44	0,09	0,06	0,08	0,06	0,04	0,05
DP treated															
C_1	101	0,45	3,2	89	8,6	5,0	3,6	4,3	58,5	0,13	0,33	0,23	0,10	0,31	0,21
I_1(m)	98	0,43	4,0	101	16,9	4,8	3,1	3,5	47	0,06	0,08	0,07	0,04	0,07	0,06
SINGLES 60/40 PER CENT COTTON/POLYESTER															
Untreated															
O_2	98	0,43	6,6	99	0,3	3,2	23,2	3,1	45	0,06	0,04	0,05	0,05	0,04	0,05
U_2(m)	92	0,42	5,0	110	1,7	1,3	18,5	3,0	47	0,07	0,05	0,06	0,06	0,04	0,05
Heat Set															
O_2H	101	0,48	7,2	78	nil	4,0	13,1	3,3	–	0,05	0,05	0,05	0,03	0,06	0,05
U_2H(m)	94	0,45	5,4	107	0,8	1,7	17,8	2,6	38	0,06	0,06	0,06	0,05	0,06	0,06
DP treated															
C_2	102	0,45	4,2	88	3,1	3,3	6,3	3,3	54	0,07	0,06	0,07	0,05	0,06	0,06
I_2(m)	93	0,44	4,4	113	3,6	2,7	5,5	2,5	47	0,07	0,10	0,09	0,05	0,04	0,05
Heat set and DP treated															
C_2H	109	0,47	4,0	86	4,8	5,0	6,4	4,1	43	0,28	0,23	0,26	0,16	0,14	0,15
I_2H(m)	101	0,45	3,9	126	8,8	4,5	6,2	4,3	40	0,12	0,14	0,13	0,07	0,09	0,08

* measured at 98 Pa water pressure

** IWS rating
1 = poor
5 = good

*** To eliminate any ageing effects the fabrics were soaked in water at 20°C for 30 min, centrifuged, steam pressed while still damp before being conditioned at 27°C and 75% RH for 24 hours before being creased.

All-Cotton, singles yarn:

The effect of mercerisation:

It can be seen from the k_1 values Table V [0_1 vs $U_1(m)$] that the use of mercerised yarns in plain single jersey reduced relaxation shrinkage. The differences were very slight in the case of the resin treated fabrics [C_1 vs $I_1(m)$] but more significant in the case of the untreated fabrics.

Table VI gives the results of the physical tests carried out on the fabrics. It can be seen that the mercerised fabrics were of lower mass due to being less relaxed, thinner, had higher air permeability, pilled more, had a lower DP rating but had poorer resistance to bagging but better wrinkle resistance.

The effect of DP treatment:

The application of resin to the all-cotton plain jersey fabric increased its mass and thickness, but reduced the bursting strength of the fabric and had an adverse effect on the abrasion resistance. Air permeability decreased slightly, pilling improved, area shrinkage was reduced to within acceptable limits and there was an improvement in the durable press properties, bagging improved slightly but in general the fabrics wrinkled more.

60/40 per cent cotton/polyester, singles yarns:

The effect of mercerisation:

It can be seen from Tables V and VI [O_2 vs $U_2(m)$ and C_2 vs $I_2(m)$] that when mercerised yarns were used in preference to natural yarns for single jersey knitting there was a reduction in the relaxation shrinkage of the fabrics observed after washing.

The effect of after-treatments:

1. **DP treatment only:**

Again both the unmercerised and mercerised fabrics followed parallel trends. This time the fabrics were heavier but only marginally thicker, they were less air permeable but had lower bursting strength, with a higher percentage mass loss after 1 000 cycles on the Martindale Abrasion Tester. The DP treatment reduced area shrinkage during washing but not really to an acceptable degree.

2. **Heat setting only:**

Both the unmercerised and mercerised fabrics followed similar trends. The fabrics were slightly heavier and thicker and less air permeable. They had higher bursting strength, better abrasion resistance, better pilling, lower area shrinkage during washing, increased bagging but no improvement in wrinkling.

3. **Heat setting plus a DP treatment:**

Again similar trends were observed. The fabrics were heavier and thicker and DP treatment again had an adverse effect on bursting strength, abrasion resistance

and wrinkling. However, the resistance to pilling, area shrinkage during washing and the DP properties were good.

It would appear that heat setting of 60/40 *per cent* cotton/polyester blends was beneficial but alone was not sufficient. When combined with a DP treatment considered necessary to control washing shrinkage there are certain adverse effects but generally the easy care properties such as pilling, shrinkage and durable press outweigh the disadvantages such as loss of bursting strength, abrasion resistance and poorer wrinkle resistance.

Comparison of All-Cotton with 60/40 blend:

Effect of Blend [C_1 vs C_2H and $I_1(m)$ vs $I_2H(m)$]

It would appear that when comparing the above fabrics the only significant differences are that the 60/40 blend fabrics had the better abrasion resistance and reduced resistance to bagging but double the amount of area shrinkage during washing. It would appear that neither the heat setting nor the DP treatment of the blend fabrics was as effective as the DP treatment was on the all-cotton.

Comparing Singles and Plied Yarn in Plain Single Jersey:

If the differences between the use of singles yarns and plied yarns[1] in all-cotton fabrics are compared, it can be seen that the same trends applied to both the singles and the plied yarns with the exception that mercerisation of the plied yarns increased the bursting strength of the fabrics indicating that mercerisation was more effective on plied yarns than on singles yarns. Plied yarns also produced fabrics with very much higher air permeabilities probably because of a reduction in the hairiness of yarns after singeing (gassing) prior to mercerising. The all-cotton singles fabric had a lower area shrinkage after DP treatment than the fabrics knitted from plied yarns, in other words the DP treatment appeared to be more effective on singles than plied yarns. Generally speaking, the wrinkling results were better for the fabrics knitted from singles than from plied yarns.

SUMMARY AND CONCLUSIONS

In this report the effect of the mercerisation of singles all-cotton yarns and 60/40 *per cent* cotton/polyester yarns has been studied. All the fabrics were knitted at the same stitch length and were DP treated. Tests have been carried out to evaluate the relaxation and physical properties of the fabrics and comparisons made between the various fabrics: unmercerised vs mercerised; all-cotton vs 60/40 blends; untreated vs resin-treated.

It has been shown that as far as *plain* single jersey knitted fabrics are concerned, either from 100 *per cent* cotton or 60/40 blend, the area shrinkage after washing was higher in the wale direction than in the course direction, but the unmercerised yarns produced fabrics with a slightly higher area relaxation shrinkage than those made from mercerised yarns. Durable press treatment was most effective

in reducing the washing shrinkage of the fabrics but less effective on the blend fabrics. In all cases the mercerised fabrics were lighter in mass, thinner and more air permeable and, in general, mercerisation reduced the resistance to bagging but slightly improved the wrinkling performance. The blend fabrics had better abrasion resistance than the all-cotton fabrics but pilled more. This could probably have been improved by using a low pilling polyester. DP treatment reduced abrasion resistance far more in the all-cotton than in the blends; it also resulted in less pilling. Mercerisation tended to have a slightly adverse effect on abrasion resistance and there was a definite trend to higher pilling for the mercerised fabrics. Durable press treatment reduced the bursting strength but tended to improve the air permeability, vastly reduced the washing shrinkage (to acceptable limits) and improved the durable press properties. However, the DP treatment had an adverse effect by slightly reducing the resistance to bagging, and slightly increasing the wrinkling; this was particularly true in the case of the unmercerised yarns. Heat setting of the blend fabrics in conjunction with a DP treatment in general gave the best results.

The effect of mercerisation on the cotton/polyester blend yarns was of little significance and apart from the appearance of the fabrics, brightness and darker dyeing shades there appears to be no advantages in the mercerisation of singles blend yarns.

ACKNOWLEDGEMENTS

The authors wish to thank members of the Department of Cotton Spinning, Dyeing and Finishing, and Physical Testing for spinning, bleaching and dyeing the yarns, finishing the fabrics and carrying out the physical tests on the fabrics respectively. Appreciation is also expressed to Messrs Wellington Industries (Pty) Limited, Cape, for mercerising the yarns. Permission of the Rhodesian Cotton Promotion Council to publish these results is appreciated.

THE USE OF PROPRIETARY NAMES

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

REFERENCES

1. Robinson, G. A., Cawood, M. P. and Dobson, D. A., Cotton in Fine Gauge Single Jersey, Part I: Plied Yarns. *SAWTRI Tech. Rep.* No. 269 (September 1975).
2. Shah, K. J. and Varghese, J., Processing of Cotton Knitted Goods – A Review *Colourage* 22 (9) 21 (May 1975).

3. Murphy, A. L. *et al,* DP Cotton Knits made from Mercerised Yarn Retain Strength, Shape, Abrasion Resistance. *10th Cotton Utilization Res. Conf.* New Orleans, La. (April 1970).
4. Mackin, I. F., Wet Processing Cotton Yarns, *Colourage* 23 (2) 21 (January 1976).
5. I.C.I. Fibres – Technical Information. Terylene/cellulosic Fibre Weft-Knitted Underwear. F. 8 (Edition 2) (April 1970).
6. Frick, J. G. (Jr) and Gautreaux, Gloria A., Effect of Fabric Structure in Crosslink Finishing of Knitted Cotton. *America's Text. The Knitter* A-T4 (8) 28 (August 1975).

Published by
The South African Wool and Textile Research Institute,
P.O. Box 1124, Port Elizabeth, South Africa,
and printed in the Republic of South Africa
by Nasionale Koerante Beperk, P O. Box 525, Port Elizabeth.

ISBN 0 7988 0977 9