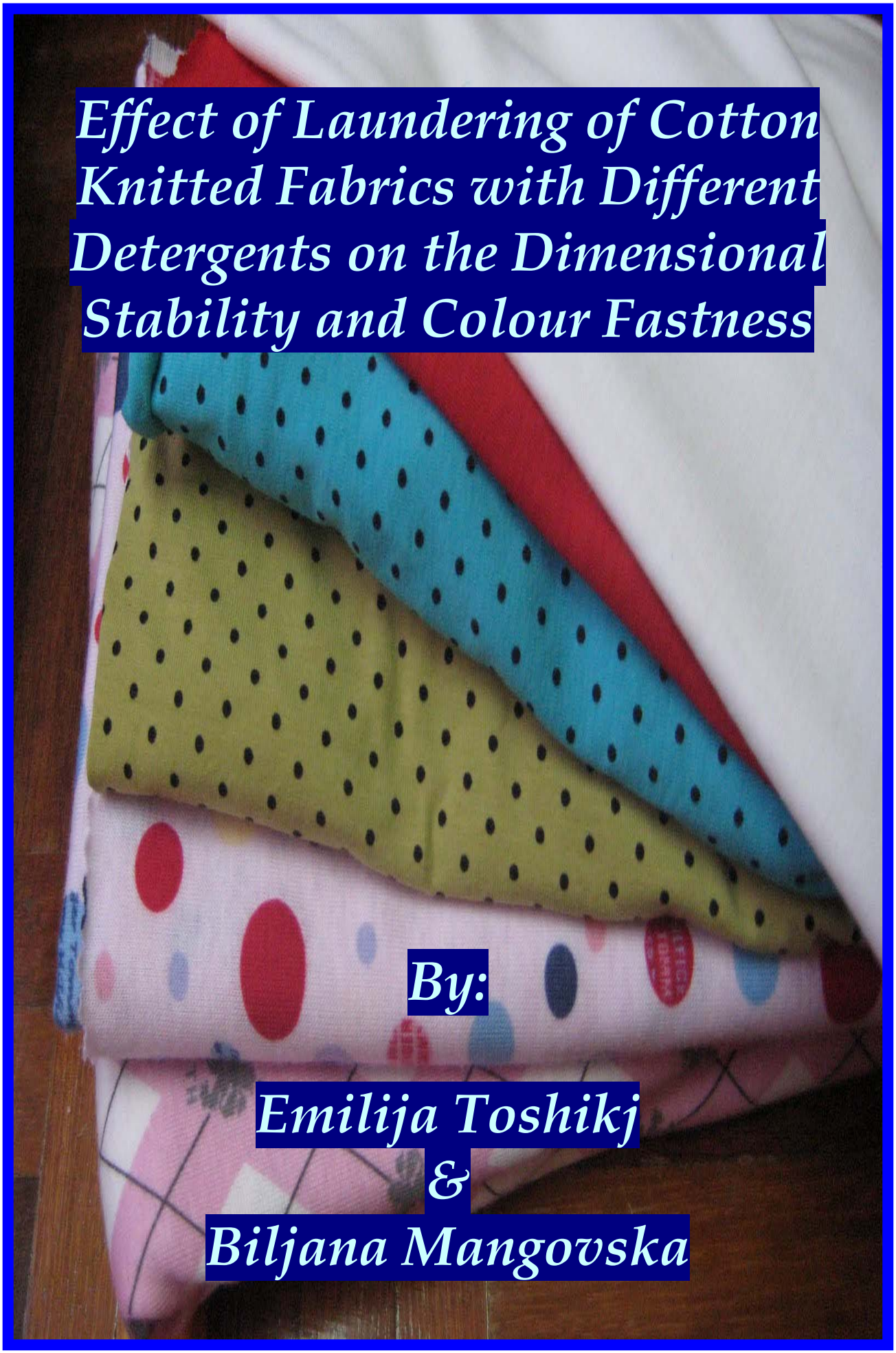
Effect of Laundering of Cotton Knitted Fabrics with Different Detergents on the Dimensional Stability and Colour Fastness



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EFFECT OF LAUNDERING OF COTTON KNITTED FABRICS WITH DIFFERENT DETERGENTS ON THE DIMENSIONAL STABILITY AND COLOUR FASTNESS

Original Scientific Paper
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Abstract: *The effect of repeated laundering processes with two commercial detergents with different formulation on structural characteristics such as weight per unit area, fabrics thickness, course and wale density, stitch density and dimensional stability as well colour fastness of the single jersey knitted fabrics made from 100 % cotton of two different grades after same finishing process, first and fifth washing cycles were investigated. The colour changes and staining was evaluated by the Grey Scale, CIE Lab coordinates and colour difference ΔE. Structural characteristics and shrinkage increased linearly with repeated laundering regardless of the type of the detergent and grade of cotton but with small differences between different grades of cotton. Liquid detergent, Lira showed more homogeneous structural characteristics giving knitted fabrics with better dimensional stability than powder detergent, Ariel. Dyed knitted fabrics have excellent colour fastness to washing.*

Key words: *reactive dye, laundering, detergents, dimensional stability, colour fastness.*

UTICAJ RAZLIČITIH DETERDŽENATA NA STABILNOST DIMENZIJA I POSTOJANOST OBOJENJA PAMUČNE TRIKOTAŽE PRILIKOM PRANJA

1. INTRODUCTION

Today's consumer conscious is not only aware of the style and comfort of the knitted fabrics, but also of there care and durability. With the rising demands of the cotton knitted fabrics, demands in term of dimensional instability, shrinkage and colour fading, in contrast to its excellent attributes, are the most critical quality problems after repeated laundering. Consequently, the "quality" term is placing a higher priority of the manufacturers' objectives [1,2]. Fabric performance is influenced by a number of variables that occur both in pre-consumer and post-consumer period. Fiber quality, yarn formation, fabric construction, textile wet processes and consumer washing processes can all have an influence on the fabric performances [3]. Consumer washing processes such as detergent selection and laundering regimes also play a major role in ability to retain fabrics performance. Nowadays, two household detergents, markedly different in formulations and physical and chemical properties, are widely used in the daily life and are suitable for laundry purposes. Laundry detergents have traditionally been powdered but the use of liquid laundry detergents has gradually increased over the years [4]. Market studies show that costumers frequently use one type of detergent for all shades (light, medium or dark shade) [5].

The aim of this research work was to evaluate the effect of different detergents in the laundering of single jersey fabrics from different grades of cotton through changes in structural characteristics, dimensional stability, colour fastness to washing after finishing processes, first and fifth washing cycles.

2. EXPERIMENTAL

Materials an d Methods

Between 18 and 25 kg single jersey weft-knitted fabrics, from two different grades of cotton, were produced on Orizio JOHN/C circular-bed knitting machine with 20/1 tex yarns (28 gauge, 30" diameter, 28 needles per 1", 2580 total needle number). Greige fabrics were kept on a flat surface for two weeks under standard atmospheric condition and after dry relaxing were finished, dried and thermo stabilized by compacting and than were laundered. Finishing processes, including enzymatic scouring and dyeing with bi-functional reactive monochlorotriazine-vinylsulphone (MCT/VS) dye in black shade were done under the industrial conditions in a winch dyeing machine by a regime given on *Figure 1*. The

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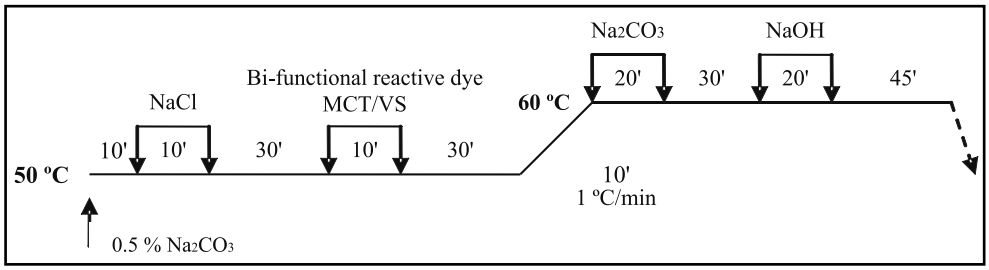

Figure 1 *Dyeing diagram for black bi-functional MCT/VS reactive dye*

carboxymethylcellulose and perfume. Both detergents are used in domestic laundering.

Structural Characteristics and Dimensional Stability

Fabric thickness was measured by Mesdan LAM between two plane parallel plates under same pressure with an accuracy of 0.01 mm. The resulting value is an average of ten measurements on three samples.

Table 1 *Structural characteristics of greige and dyed knitted fabrics made of two different grades of cotton*

		Fabric State									
		Greige					Dyed and Thermo stabilized				
Grade of Cotton	Sample Names	Weight (g/m^2)	Thickness (mm)	Wale (cm^{-1})	Course (cm^{-1})	Stitch Density (cm^{-2})	Weight (g/m^2)	Thickness (mm)	Wale (cm^{-1})	Course (cm^{-1})	Stitch Density (cm^{-2})
1	1	143.19	0.57	12. 83	22.00	282.33	157.87	0.55	14.66	20.66	303.00
	2	138.72	0.62	13.00	21.50	279.42	158.01	0.55	14.16	20.33	288.08
	3	143.19	0.57	12.83	22.00	282.33	159.09	0.55	14.50	19.83	288.00
	4	131.51	0.54	12.67	20.17	255.42	162.61	0.54	14.33	20.50	294.00
	5	-	-	-	-	-	163.34	0.55	14.83	21.33	316.41
	6	-	-	-	-	-	163.90	0.58	14.66	21.16	311.00
	7	-	-	-	-	-	162.59	0.55	15.00	21.16	318.00
	8	-	-	-	-	-	156.00	0.54	14.66	20.83	305.00
2	1	147.53	0.60	12.67	22.50	285.08	158.00	0.50	15.33	20.50	315.00
	2	144.55	0.58	13.00	22.00	285.92	160.93	0.54	15.00	21.83	318.00
	3	137.45	0.51	13.00	22.33	290.33	154.14	0.55	14.83	22.33	331.08
	4	118.21	0.50	12.00	18.83	226.00	175.94	0.55	15.66	20.66	324.00
	5	155.01	0. 60	13.17	23.50	309.42	158.01	0.56	15.50	20.00	310.00
	6	140.58	0.58	12.67	20.67	261.67	159.81	0.54	15.16	20.66	314.00
	7	134.49	0. 60	11.17	22.17	247.17	160.89	0.55	15.16	20.16	306.00

finishing process was repeated eight times for knitted fabrics made of cotton 1 and seven times for knitted fabrics made of cotton 2. So at the end of the finishing processes we had 15 samples for further testing. Structural characteristics of greige and finished fabrics are shown in *Table 1*.

Laundering Process

Cotton knitted fabrics were washed in a domestic washing machine at 60 °C for 1 hour in 1 and 5 washing cycles with different detergents and flat dried. Before laundering, squares of 350 x 350 mm were drawn. Two specimens of each sample, washed all together, were tested. Liquid Lira (Ohis) and powder Ariel (Procter & Gamble) laundry detergents were used for laundering the knitted fabrics respectively. Detergents formulation were: liquid Lira base on anionic, non-ionic surfactants, enzymes and optical brightener, and powder Ariel based on anionic, non-ionic and cationic surfactants, zeolites, perborate, phosphate, phosphonate, soap, enzyme, optical brighteners,

Wale and course density were measured using a magnifying glass, three measurements for each density were made at different places on the knitted fabrics. From the mean values of the course and wale densities the stitch density was calculated.

Shrinkage was determined by measuring the samples before and after first and fifth washing cycles and was calculated as:

$$S = 100\ (Lo - L) / Lo\ (\%)$$

where: *Lo* is the distance between the data lines before washing out and *L* is after washing.

Colour Fastness

Colour fastness to washing of the dyed fabrics were tested by ISO 105-CO1. Staining and colour changes that occurred during washing tests were assessed by

means of the appropriate grey scales.

CIE Lab coordinates and Colour differences

Colour was measured on X-RITE CA 22 (D65/10°) spectrophotometer and evaluated according to the CIE Lab colour coordinates. The colour difference, ΔE^* is calculated by the following equation:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

where: ΔE^* is the CIE Lab colour difference calculated from CIE Lab coordinates before and after first laundering. Here ΔL^*, Δa^*, Δb^* and hence ΔE^*, are in commensurate units. ΔL^* denotes the difference between lightness (where $L^* = 100$) and darkness (where $L^* = 0$), Δa^* the difference between green $(-a^*)$ and red $(+a^*)$, and Δb^* the difference between yellow $(-b^*)$ and blue $(+b^*)$.

3. RESULTS AND DISCUSSION

Changes in structural characteristics after dry relaxation, wet finishing processes and thermo stabilization are given in *Table 1*. There are significant changes in structural characteristics of knitted fabrics after dyeing and thermo stabilization compared to greige dry relaxed knitted fabrics. Structural changes of the fabrics through the knitting, dry and wet relaxation processes are caused by the complex thermal, mechanical and physical action followed by swelling. During the wet relaxation processes of cotton knitted fabrics, the shape and orientation of the loops changed, fabrics swelled, structural spaces were reduced, internal stresses released followed with the higher or lower degree of shrinkage. Wet processing creates the ideal conditions for fabrics structure relaxations, followed by increase in weight per unit area, wale and stitch density and slightly reduced thickness and course density (*Table 1*). Relaxation of the knitted fabrics continued during the laundering processes regardless of the type of the detergent and grade of cotton but with small differences between grades of cotton. Different grades of cotton affect fabric characteristics even after several washing cycles (*Table 2*). Laundering has a considerable effect on structural (weight/m^2, thickness, course, wale and stitch density) and shrinkage properties. The effects of different detergents (in the laundering) on the structural characteristics and shrinkage of reactive dyed knitted fabrics from different grades of cotton after first and fifth washing cycles and statistical analysis of the measured properties are given in *Tables 2* and *3*. Fabric thickness, weight and stitch density increased 9.09%, 8.14% and 4.64 % for cotton 1 and 9.26%, 8.09% and 4.37 % for cotton 2, after first washing cycle with Lira and 9.09%, 8.21% and 8.19 % for cotton 1 and 11.11%, 8.98% and 3.29 % for cotton 2 after fifth washing with Ariel, respectively.

Major changes in cotton knitted fabrics occurred after the first washing cycle while smaller changes continue to occur during the additional laundering. Full relaxation and shrinkage is not always attained during the first washing cycle. Residual stresses of the knitted fabrics are eliminated after several washing cycles [6]. The higher the number of repeated laundering, the higher is the degree of shrinkage. This resulted in higher knitted density and consequently higher weight of the fabric. Increase of the fabric thickness, weight and stitch density of 10.91%, 13.20% and 7.28 % was noticed on cotton 1 and 11.11%, 13.06% and 9.92 % on cotton 2, washed with Lira and 10.91%, 14.30% and 11.33 % on cotton 1 and 12.96%, 14.48% and 7.21 % on cotton 2 washed with Ariel after fifth washing cycle, respectively.

The average values of dimensional properties and shrinkage of knitted fabrics from different grade of cotton after first and fifth washing cycles are presented in *Table 3*. Shrinkage values of the single jersey knitted fabrics made of cotton 1 and 2 in wale direction after first washing cycle with Lira and Ariel are -0.99 % and -1.37 % and -1.00 % and -1.34 %, respectively and after fifth washing cycle -1.56 % and -2.51 % and -2.71 % and -3.03 %, respectively the average value never exceeding 3.03 %. Shrinkage values of cotton 1 and 2 in course direction after first washing cycle with Lira and Ariel are -6.75 % and -5.56 % and -7.05 and -5.79 %, respectively and after fifth washing -7.18 % and -6.43 % and 7.93 % and -7.46, respectively. Shrinkage in course direction, regardless of the type of the detergent and grades of cotton, is almost twice higher than shrinkage in wale direction. In knitted cotton fabrics the shape and orientation of the loops changes as the fibers swell and relax towards their minimum energy conformation. The loops become rounder in shape, causing shrinkage in the wale direction, especially when the fabric has been previously dried under tension. In order to release the stresses imposed by bending twisted yarns into loops, the loops themselves tend to twist out of the plane of the fabric. This causes shrinkage in the course direction, and often produces significant differences in twist level in the two legs of the knitted loops. The value of finished cotton knitted fabric shrinkage must not exceed ± 3 % [7] (a sign "-" symbolized that sample shrunk, and "+" sample lengthened).

Table 2 *The effects of different detergents, on structural characteristics and shrinkage of reactive dyed knitted fabrics, from different grades of cotton after first and fifth washing cycles; Q = Weight per unit area, d = Fabric thickness, W = Wale density, C = Course density, D = Stitch Density, DS (%) Wale = Shrinkage in wale direction, DS (%) Course = Shrinkage in course direction*

			Fabrics State													
			After 1st washing cycle							After 5th wasing cycle						
Detergent	Grade of Cotton	Sample Names	Q (g/m^2)	d (mm)	W (cm^{-1})	C (cm^{-1})	D (cm^{-2})	DS % Wale	DS % Course	Q (g/m^2)	d (mm)	W (cm^{-1})	C (cm^{-1})	D (cm^{-2})	DS % Wale	DS % Course
Lira Liquid	1	1	174.00	0.60	15.66	20.50	321.00	-1.40	-5.00	181.00	0.61	16.00	20.50	328.00	-1.50	-5.10
		2	172.00	0.60	14.68	20.50	301.00	-0.00	-8.30	182.00	0.63	16.00	19.50	312.00	-1.30	-9.20
		3	174.00	0.60	15.15	20.00	303.00	-1.70	-7.00	182.00	0.61	16.37	19.00	311.00	-1.70	-7.00
		4	173.00	0.60	15.69	20.33	319.00	-1.70	-5.90	183.00	0.61	17.11	19,00	325.00	-1,.0	-6.00
		5	176.00	0.60	15.05	21.33	321.00	-1.20	-5.60	184.00	0.61	16.48	20.33	335.00	-2.00	-6.70
		6	173.00	0.60	14.81	21.33	316.00	-1.00	-5.00	181.00	0.61	16.15	20.00	323.00	-1.00	-6.00
		7	172.00	0.60	15.67	21.50	337.00	-0.90	-7.80	178.00	0.61	17.43	19.50	340.00	-3.00	-7.90
		8	173.00	0.60	14.68	21.66	318.00	-0.00	-9.40	181.00	0.61	15.52	21.00	326.00	-0.30	-9.50
	2	1	175.00	0.58	15.02	21.50	323.00	-2.50	-5.80	182.00	0.60	17.58	19.00	334.00	-3.30	-6.70
		2	168.00	0.59	14.69	22.33	328.00	-0.70	-4.70	182.00	0.60	15.82	22.00	348.00	-3.00	-5.00
		3	175.00	0.60	15.84	22.16	351.00	-1.70	-5.30	183.00	0.61	16.16	22.16	358.00	-1.70	-7.30
		4	176.00	0.58	15.33	21.33	327.00	-0.30	-5.00	181.00	0.60	16.16	21.66	350.00	-0.30	-6.30
		5	176.00	0.58	15.28	21.33	326.00	-0.30	-7.80	182.00	0.61	18.60	18.66	347.00	-5.00	-7.80
		6	174.00	0.59	16.00	21.50	344.00	-2.70	-4.20	181.00	0.60	16.00	22.00	352.00	-2.80	-5.60
		7	175.00	0.60	14.93	21.17	316.00	-1.40	-6.10	184.00	0.61	18.86	18.50	349.00	-1.50	-6.30
Ariel Powder	1	1	172.00	0.58	16.00	20.50	328.00	-1.00	-5.00	184.00	0.60	17.00	20.00	340.00	-2.30	-6.00
		2	174.00	0.59	15.99	20.33	325.00	-0.00	-9.10	183.00	0.61	16.32	21.33	348.00	-3.30	-10.00
		3	174.00	0.60	15.84	20.83	330.00	-1.40	-7.30	185.00	0.62	17.10	19.66	336.00	-3.60	-9.30
		4	173.00	0.60	15.80	20.50	324.00	-2.00	-6.70	184.00	0.61	15.90	20.50	326.00	-5.60	-6.80
		5	174.00	0.60	15.58	21.50	335.00	-1.20	-6.10	183.00	0.61	19.00	18.00	342.00	-1.30	-6.60
		6	174,00	0.61	15.25	21.50	328.00	-1.30	-5.60	182.00	0.61	17.28	19.50	337.00	-3.00	-5.70
		7	172.00	0.62	15.28	21.60	330.00	-0.90	-7.20	182.00	0.62	17.23	19.33	333.00	-2.30	-8.00
		8	175.00	0.61	15.22	21.16	322.00	-0.20	-9.40	183.00	0.61	18.01	18.66	336.00	-0.30	-11.00
	2	1	174.00	0.60	15.49	21.50	333.00	-4.20	-7.50	182.00	0.60	17.05	20.00	341.00	-6.00	-7.80
		2	175.00	0.60	15.10	21.66	327.00	-0.60	-5.00	183.00	0.61	18.06	18.66	337.00	-3.00	-7.00
		3	175.00	0.59	15.34	21.83	335.00	-1.70	-5.70	185.00	0.61	16.68	20.50	342.00	-2.30	-6.60
		4	174.00	0.59	15.05	21.66	326.00	-1.10	-6.10	185.00	0.61	16.63	20.33	338.00	-1.60	-9.00
		5	179.00	0.59	15.40	21.50	331.00	-0.60	-6.70	184.00	0.60	16.77	20.33	341.00	-2.70	-1.00
		6	174.00	0.60	14.58	21.66	316.00	-0.30	-2.80	185.00	0.60	16.55	20.66	342.00	-3.30	-5.00
		7	178.00	0.60	15.63	20.66	323.00	-0.90	-6.70	187.00	0.61	16.99	19.83	337.00	-2.30	-6.80

Table 3 *Average values of structural properties and shrinkage of knitted fabrics from different grades of cotton after first and fifth washing cycles; DS (%) Wale = Shrinkage in wale direction, DS (%) Course = Shrinkage in course direction*

Stages	Grade of cotton	No.	Weight (g/m^2)	Thickness (mm)	Wale (cm^{-1})	Course (cm^{-1})	Stitch Density (cm^{-2})	DS % Wale	DS % Course
Finishing	1	8	160.33	0.55	14.60	20.73	302.94	-	-
	2	7	161.10	0.54	15.23	20.88	316.87	-	-
1st washing cycle with liquid detergent, Lira	1	8	173.38	0.60	15.17	20.89	317.00	-0.99	-6.75
	2	7	174.14	0.59	15.30	21.62	330.71	-1.37	-5.56
1st washing cycle with powder detergent, Ariel	1	8	173.50	0.60	15.62	20.99	327.75	-1.00	-7.05
	2	7	175.57	0.59	15.23	21.49	327.29	-1.34	-5.79
5th washing cycle with liquid detergent, Lira	1	8	181.50	0.61	16.38	19.85	325.00	-1.56	-7.18
	2	7	182.14	0.60	17.03	17.03	348.29	-2.51	-6.43
5th washing cycle with powder detergent, Ariel	1	8	183.25	0.61	17.23	19.62	337.25	-2.71	-7.93
	2	7	184.43	0.61	16.96	20.04	339.71	-3.03	-7.46

Thus, changes depend on of the yarns and fabric properties, and the chemical composition of the aqueous solution which is going to wet them. The pH has an influence on the fiber's absorbency and swelling capacity. Swelling of cellulose in an alkaline solution is greater than in neutral medium [8]. Lira acting in neutral medium, showed more homogeneous structural characteristics giving knitted fabrics with

Table 4 *The effect of different detergents, on the washing fastness of reactive dyed knitted fabrics, from different grades of cotton*

Detergents	Gray scale rating														
	Grade of cotton														
	1								2						
Liquid, Lira	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5
Powder, Ariel	5	5	5	5	5	4	5	5	4	5	4	5	5	5	5

Table 5 *Colour changes and staining on dyed knit fabrics tested by ISO 105-CO1; CS = Change of shade, ST = Staining*

Change of shade and staining	Gray scale rating														
	Grade of cotton														
	1								2						
CS	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Cotton ST	4/5	4/5	4/5	4/5	4/5	4	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5	4/5
Wool ST	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

Table 6 *The effect of different detergents on the CIE Lab coordinates of reactive dyed knitted fabrics from different grades of cotton*

Grade of cotton	Sample Names	Stages														
		Dyed and thermo stabilized					After 1st washing cycle with liquid detergent, Lira					After 1st washing cycle with powder detergent, Ariel				
		CIE Lab coordinates														
		L^*	a^*	b^*	C^*	H^*	L^*	a^*	b^*	C^*	H^*	L^*	a^*	b^*	C^*	H^*
1	1	2.79	-1.07	0.44	1.16	157.42	1.60	-0.90	0.40	0.98	155.71	2.09	-0.91	0.56	1.07	148.65
	2	3.12	-0.66	0.73	0.99	132.18	2.17	-0.78	0.35	0.85	156.16	2.11	-0.81	0.28	0.87	161.00
	3	3.03	-0.79	0.66	1.04	140.23	1.91	-0.84	0.34	0.91	158.06	2.14	-0.85	0.07	0.86	175.40
	4	3.11	-1.00	0.73	1.24	143.94	2.12	-1.01	0.29	1.07	164.21	2.39	-1.03	0.32	1.08	162.91
	5	2.75	-0.87	0.93	1.28	133.17	2.32	-1.13	-0.14	1.14	182.05	2.42	-1.06	0.24	1.09	167.20
	6	2.28	-0.85	0.92	1.25	132.66	1.71	-0.95	0.44	1.06	155.09	2.19	-0.93	0.52	1.07	150.99
	7	2.73	-0.93	0.78	1.25	140.09	2.32	-0.91	0.42	1.02	155.97	2.26	-0.92	0.43	1.03	155.25
	8	2.10	-0.80	0.89	1.20	131.73	1.62	-0.97	0.15	1.00	171.55	1.52	-0.95	0.17	0.97	169.91
2	1	3.85	-0.80	0.56	0.98	145.18	1.99	-0.93	-0.19	0.95	191.87	2.73	-0.94	-0.16	0.95	189.28
	2	2.58	-0.85	0.41	0.95	154.25	1.94	-0.93	-0.35	1.01	194.16	2.14	-0.87	0.11	0.88	183.70
	3	3.36	-0.62	0.74	0.96	129.98	2.05	-0.58	0.41	0.72	145.65	2.58	-0.67	0.43	0.79	147.28
	4	1.46	-0.48	0.93	1.05	117.65	1.66	-0.59	0.61	0.86	134.38	1.43	-0.61	0.52	0.80	140.11
	5	2.61	-0.73	0.56	0.92	142.5	2.21	-0.79	-0.09	0.8	183.95	2.09	-0.78	0.18	0.80	167.30
	6	2.54	-0.73	0.49	0.89	146.00	1.58	-0.77	0.25	0.82	161.97	1.88	-0.84	0.04	0.84	177.12
	7	3.12	-0.60	0.77	0.97	127.98	2.05	-0.56	0.72	0.92	128.93	2.19	-0.59	0.73	0.94	128.87

Table 7 *Statistical analysis of CIE Lab coordinates of reactive dyed knitted fabrics from different grades of cotton; A = average value, M.D = mean deviation, V.C = variance coefficient*

Phases		Grades of cotton											
		1						2					
		CIE Lab coordinates											
		No.	L^*	a^*	b^*	C^*	H^*	No.	L^*	a^*	b^*	C^*	H^*
Dyed-Thermo stabilized	**A**		2.74	-0.87	0.76	1.18	138.93		2.79	-0.69	0.64	0.96	137.65
	M.D	8	0.38	0.13	0.16	0.11	8.78	7	0.76	0.13	0.18	0.05	12.77
	V.C		13.86	14.94	21.05	9.32	6.32		27.24	18.84	28.12	5.20	9.27
After 1st washing cycle with liquid detergent, Lira	**A**		1.97	-0.94	0.28	1.00	162.35		1.93	-0.74	0.19	0.87	162.99
	M.D	8	0.30	0.11	0.19	0.09	9.79	7	0.23	0.16	0.41	0.10	27.46
	V.C		15.22	11.70	67.85	9.00	6.03		11.91	21.62	215.78	11.49	16.84
After 1st washing cycle with powder detergent, Ariel	**A**		2.14	-0.93	0.32	1.00	161.41		2.15	-0.76	0.23	0.86	161.95
	M.D	8	0.28	0.08	0.17	0.09	9.36	7	0.43	0.14	0.33	0.07	23.33
	V.C		13.08	8.60	53.12	9.00	5.79		20.00	18.42	143.47	8.13	14.40

better dimensional stability than Ariel acting in alkali medium (pH 10.7 [9]). More intensive swelling, uneven shrinkage with higher differences in fabric thickness was caused by Ariel (*Tables 2* and *3*).

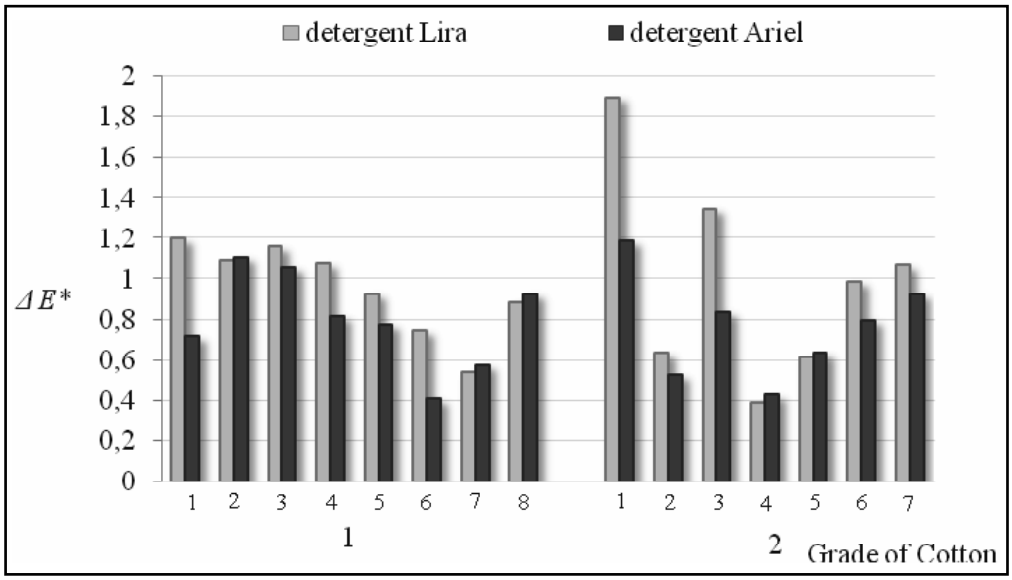

Figure 2 *Effect of different detergents in the laundering on the colour difference, ΔE^* of reactive dyed knitted fabrics from different grades of cotton*

More than 70 % of domestic washing is carried out at 60 ºC or lower temperatures [10]. This trend has developed from the need of frequent laundering, saving and minimize colour fading.

The results in *Tables 4* and *5* showed that knitted fabrics dyed with bi-functional MCT/VS reactive dye in black shade showed similar fastness behavior between and among different grades of cotton.

Different detergents in laundering of reactive dyed knitted fabrics made of different grades of cotton gave different CIE Lab coordinates, the results given in *Tables 6* and *7*.

Perborate hydrolysis in water and produces hydrogen peroxide only above 90 ºC. It is not effective as whitening agent at lower temperatures (60 ºC). The result of the CIE Lab coordinates of laundered cotton fabrics with Lira showed the decrease of the L^* and b^* values. L^* and b^* values decreased from 2.74 to 1.97 and from 2.79 to 1.93 and from 0.76 to 0.28 and 0.64 to 0.19 for cotton 1 and 2 after first washing cycle with Lira and Ariel, respectively. Ariel did not have a significant effect on the colour of the washed fabrics. Optical brightener in Lira contributed to the reduction of b^* values, compensating the yellowness and increasing the H^* values. Knitted fabrics became darker with a lower degree of saturation, lower C^* values. The colour differences, ΔE^* given in *Figure 2*, between 0.41 and 1.2 for cotton 1 and between 0.39 and 1.19, except 1.9 and 1.35 for cotton 2 showed insignificant difference within and between the fabrics from different grades of cotton. The results of ΔE^*, given in *Table 8*, showed 0.96 for cotton 1 and 0.99 for cotton 2 in laundering with Lira and 0.80 for cotton 1 and 0.77 for cotton 2 in laundering with Ariel, are less than 1. Between different grades of cotton were noticed high variance coefficients, 23.92 % for cotton 1 and 51.51 % for cotton 2 (*Table 8*).

4. CONCLUSION

Laundering dyed fabrics in dark shade at 60 ºC with liquid detergent, Lira showed more homogeneous structural characteristics with small differences between different cotton grades and decreased L^* and b^* values giving fabric with better dimensional stability, dipper shade than powder detergent Ariel. Colour shade of fabrics was not impaired by detergent Ariel.

Table 8 *Colour differences and their statistical analysis; A = average value, M.D = mean deviation, V.C = variance coefficient*

Detergents	Colour difference, ΔE^*							
	Grade of cotton							
	1				2			
	No.	A	M.D	V.C	No.	A	M.D	V.C
After 1st washing cycle with liquid detergent, Lira	8	0.96	0.23	23.95	7	0.99	0.51	51.51
After 1st washing cycle with powder detergent, Ariel	8	0.80	0.24	30.00	7	0.77	0.26	33.76

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