EFFECTS OF VARIOUS HOME DRYING PRACTICES ON SMOOTHNESS APPEARANCE, SHRINKAGE, HANDLE AND OTHER PROPERTIES OF WOVEN FABRICS

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Abstract: *The main goal of this study is to examine drying practices in order to make an objective evaluation of fabric properties after one and five cycles of washing-drying. Light and medium weight wool, cotton and polyester weave fabrics are tested to compare fabric behavior in terms of weight and also in terms of fiber nature under different drying practices. Smoothness, shrinkage, mechanical properties related to fabric handle and other physical properties were measured after machine, drip line, flat and line drying. As results, special drying effects reveals more important in the case of cotton and wool fabrics, and tumble drying method affects more the measured properties especially after successive cycles of washing-drying.*

Keywords: *Drying methods, repeated laundering cycles, smoothness appearance, fabric handle.*

1 INTRODUCTION

Although the topic of laundering cannot be considered innovative, researchers need to continue to re-examine and report current trends and practices to teach consumers textile maintenance. Especially on the light of increasing costs of apparel, laundering equipment, energy, consumer time, but also fabric compositions, structures, and finishing treatments. To be truly satisfactory the garments should be able to be washed and dried in a household dryer or hanged in the open air without crease retention or loss of desired hand and physical properties.

According to previous studies, fabrics appear smoother after machine drying than after line drying. In fact, the heated air of the clothes dryer allows the fibers to relax and recover from deformation. Machine-dried fabrics tend to have a softer hand than those that are lines dried. This also could affect consumer acceptance [1]. The shrinkage potential of knitted fabrics depends on the conditions of drying during the finishing process. In a tumble-dryer, the knitted fabrics shrink the most [2]. Other authors have shown that reproducible and complete relaxation will only occur after cotton knitted fabrics have been washed and tumble dried five times [3, 4].

Previous works have also confirmed the need to use tumble drying as opposed to line or flat drying to facilitate total relaxation and hence maximum shrinkage [5]. It was also demonstrated that tumble drying plain single Jersey, Interlock and Lacoste cotton weft knitted structures under a normal cotton cycle causes significant length and width shrinkage. The amount of shrinkage increases sharply in plain single Jersey and Lacoste [6]. Tumble drying causes greater levels of shrinkage compared to line drying of plain woven cotton fabrics. Tumble drying reduces the level of wrinkling. Over drying increases the level of shrinkage in woven cotton fabrics and also improves the appearance of the fabrics [7]. In another work, the effect of sunlight and drying methods on the strength of real wax printed cotton fabrics produced in Ghana was studied. Sunlight caused the specimens to lose more strength in the sun than in the shade. The effect is more severe on the specimens dried on a flat surface than those on the clothesline [8]. The reference [9] has shown that tumbling in the dryer is effective in removing wrinkles from garments of the hydrophobic fibers. The reference [10] has shown that line-dried cotton and polyester fabrics were significantly stiffer than machine dried fabrics

In our previous works, we reported the effect of laundering conditions (machine load, spinning speed and repeated cycles) on fabric properties of three woven cotton fabrics. Spinning speed and machine load have significant effects on dimensional, on mechanical tactile and on clothing properties of woven cotton fabrics [11]. The use of overlaid contour plots via experimental design allowed the determination of optimum spinning conditions for selected fabrics.

On the other hand, we studied the behavior of the same cotton fabrics under industrial ironing conditions. We focused on using Taguchi method coupled with desirability function analysis for solving multicriteria optimization problem. Experimental results have shown that different optimal ironing conditions may be applied on different woven cotton fabrics [12].

The main goal of this study is to examine the effect of drip line drying, flat drying, line drying and tumble drying on fabrics' properties. Light and medium weight wool, cotton and polyester woven fabrics are tested for good comparison and conclusion. Smoothness appearance, shrinkage, physical and mechanical properties were evaluated.

2 EXPERIMENTAL

2.1 Description of test fabrics

The investigation has been carried out with nine types of weaved fabrics going from light to medium weight. Basic characteristics of the selected fabrics are shown in Table 1. Samples 60x60 cm were cut from each fabric for laboratory laundering procedures according to ISO 6330: 2003: Domestic washing and drying procedures for textile testing.

2.2 Fabric characterization

Washed and dried samples were tested according to the following test methods.

- Smoothness appearance following AATCC 124: 2009.
- Recovery angle following ISO 2313: 1972.
- Dimensional change in warp and weft directions according to ISO 3759: 2007 and ISO 6330: 2001.
- Air permeability following ISO 9237: 1995.
- Siro FAST system was used in all measurements of the following mechanical properties:
  - Thickness T_2 [mm], measured at 196.12 Pa pressure using FAST 1: compression meter,
  - Surface thickness ST [mm],

$$ST = T_2 - T_{100} \quad (1)$$

where T_{100} is the thickness measured at 9.8 kPa.

  - Bending rigidity B_i [μNm],

$$B_i = W \times C_i^3 \times 9.807 \times 10^{-6} \quad (2)$$

where W is fabric mass area [g/m²], C_i is the bending length measured on FAST 2: bending meter, i: 1/2 respectively warp and weft direction.

  - Extensibility, *E100-1* [%] and *E100-2* [%] is extension in warp and weft direction respectively at a fixed force of 98 N/m, measured using FAST 3: extension meter.
  - Shear rigidity G [N/m],

$$G = 123 / E5\_B \quad (3)$$

where *E5-B* [%] is the extension in the bias direction (45°) to warp or weft at 4.9 N/m.

Measurement methods are clearly described in previous studies [13, 14].

All experimental tests were carried out under standard atmosphere for conditioning and testing textiles following ISO 139: 2011.

2.3 Methods

Washing method was adapted to simulate five repeated home laundering practices in washer-extractor machine “Electrolux Wascator FOM 71 MP-Lab”, following ISO 6330: 2003.

In order to study the effect of drying method on fabric properties, 4 drying methods described in Table 2 are tested. Fabric dried until fully dry out; 5% of residual humidity for cotton and wool fabrics and 2% for polyester fabrics.

All experimental tests were carried out under standard atmosphere for conditioning and testing textiles, according to ISO 139: 2011.

Table 1 Basic structural parameters of unwashed fabrics

Fiber content	Cotton (100%)			Polyester (100%)			Wool (100%)		
Fabric code	**CO1**	**CO2**	**CO3**	**PES1**	**PES2**	**PES3**	**WO1**	**WO2**	**WO3**
Weave design	Plain	Twill 3/1	Twill 3/1	Plain	Plain	Twill 3/1	Plain	Plain	Twill 3/1
Mass per unit area [g/m^2]	138.4	228.1	344	75.1	124.2	241.5	146.6	204	262
Thickness [mm]	0.322	0.562	0.796	0.274	0.3	0.589	0.326	0.598	0.721

Table 2 Description of drying modes

Mode	Description	Conditions
Mode 1	Drip line dry: The wet fabric is carefully depressed and hanged on a line in wale direction thus fully dry out.	20 ± 2°C
Mode 3	Flat dry after spinning: The thoroughly wet fabric is carefully depressed, spread on a flat, smooth surface and drains thus fully dry out.	
Mode 2	Line dry after spinning: The thoroughly wet fabric is carefully depressed and hanged on a line in wale direction thus fully dry out.	
Mode 4	Tumble dry after spinning: The thoroughly wet fabric is carefully depressed and drains in a tumbler dryer (Electrolux T4130)	20 minutes at 60°C

3 RESULTS & DISCUSSION

3.1 Smoothness appearance

AATCC 124: 2009 is based on a numerical scale of 5 for negligible or no wrinkles to 1 for severe wrinkles. Results relative to cotton, polyester and wool fabrics are respectively shown in Figures 1a, 1b and 1c.

Tumble drying (mode 4) produced higher wrinkle evaluation grades than static drying (mode 1, 2, 3) after one washing drying cycle. For cotton and polyester fabrics, tumble drying caused the least wrinkling and the highest wrinkle evaluation grades at the end of the 5th cycle.

Cotton and wool fabrics dried in machine received ratings between 2 and 3. Polyester fabrics used generally for blouses, skirts and shirts had rating between 3 and 4 which is the range typically found as the minimum required in apparel performance specifications [15]. In fact, polyester fabrics have the smallest absorption ability because of the higher degree of crystalline zones in the polymer fibers. In addition, the glass transition temperature is about 85°C and it is not reached by the laundering. So, the fabric can resist to wrinkles.

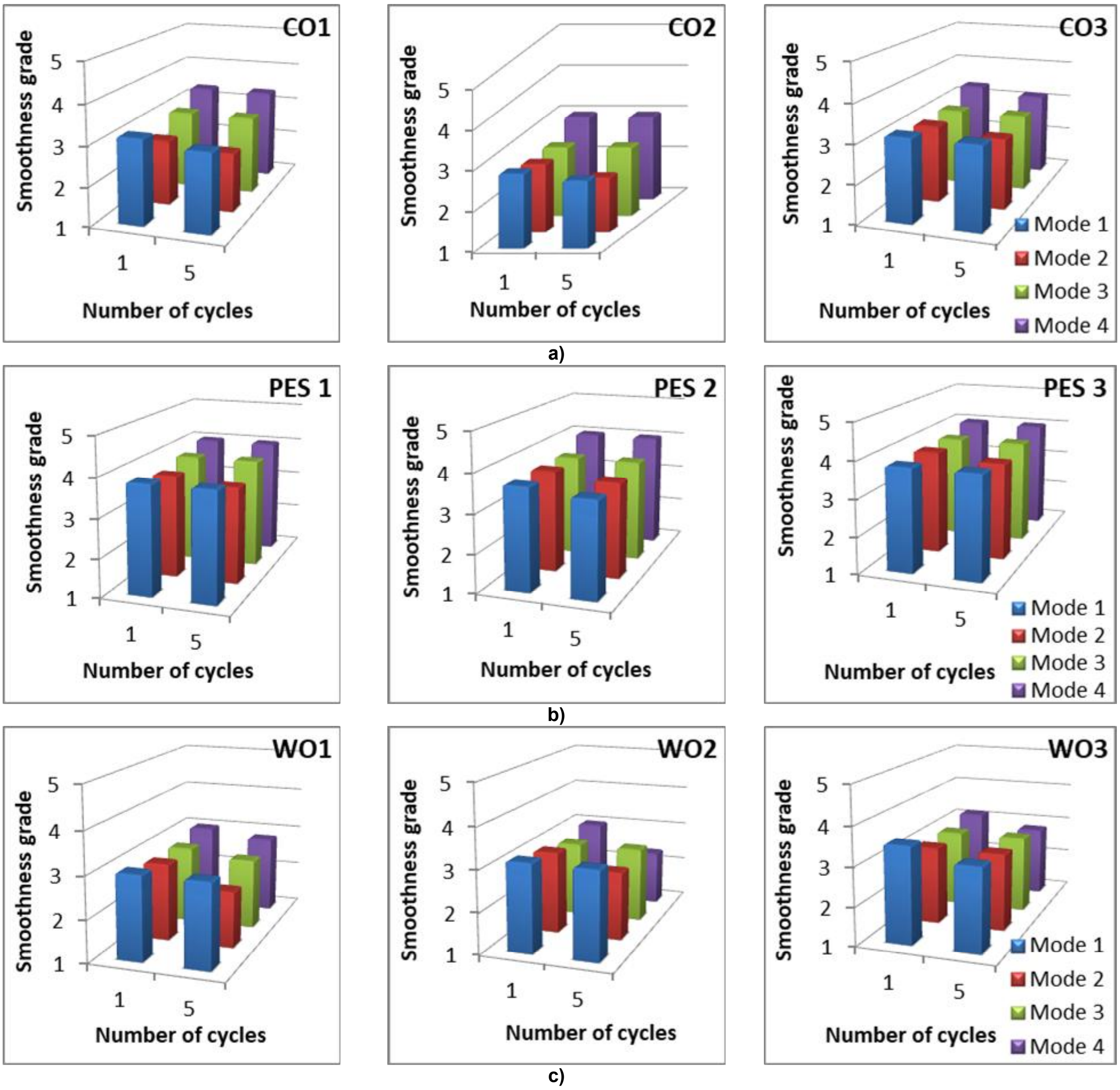


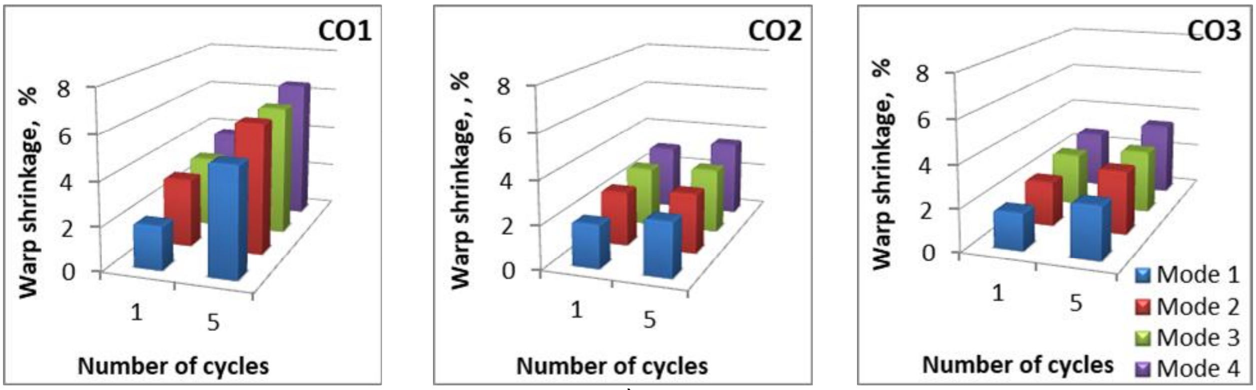
Figure 1 Mean fabric smoothness rating for drying treatments: a) cotton fabrics, b) polyester fabrics and c) wool fabrics

Under static drying conditions, drainage and evaporation of water from the cotton and wool fabrics cause increasing capillary attraction between fibers and yarns. This tends to hold the fabric in the wet conformation, and as the fibers de-swell and the moisture content falls, strong inter and intra fiber adhesion develop as hydrogen bonds reform in the cellulosic matrix. Any wrinkles folds or creases then become hydrogen-bonded into the dry fabric structure. These cannot easily be removed unless T_g is exceeded by an appropriate combination of moisture and heat [16].

In tumble drying, the constant agitation of the fabric structure prevents capillary attraction between yarns and fibers from forming inter-fibers adhesions in the structure. Consequently as the fibers de-swell, there is sufficient mobility in the structure for further relaxation to occur. At tumble drying temperatures, intra fibers hydrogen bonds will not reform until the fabric is almost bone dry. Consequently, as long as cotton and wool fabrics are removed from the drier before they are completely dry, and before the drier cools down, much of the undesirable wrinkling and creasing can be avoided.

3.2 Shrinkage

Mean fabric shrinkage, in warp and in weft direction, for each fabric following machine or static drying are shown respectively in Figures 2 and 3.



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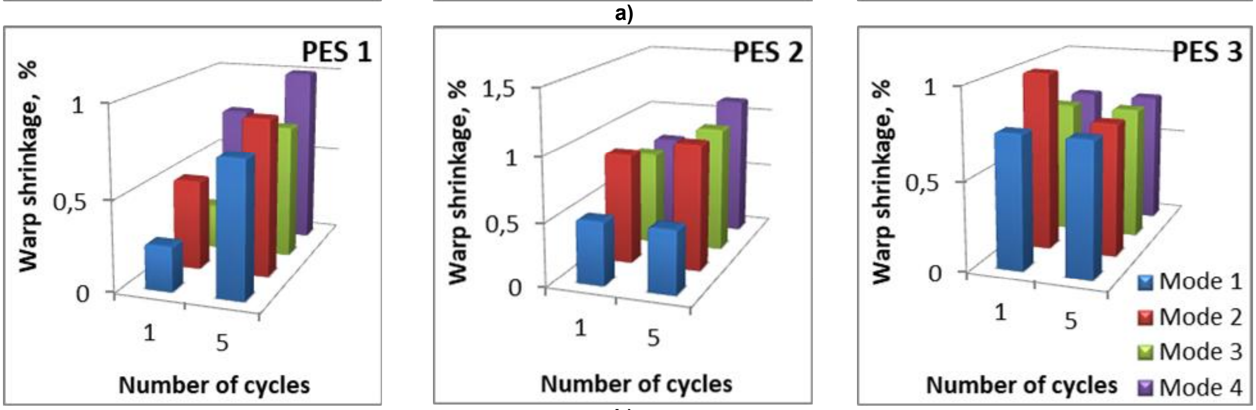

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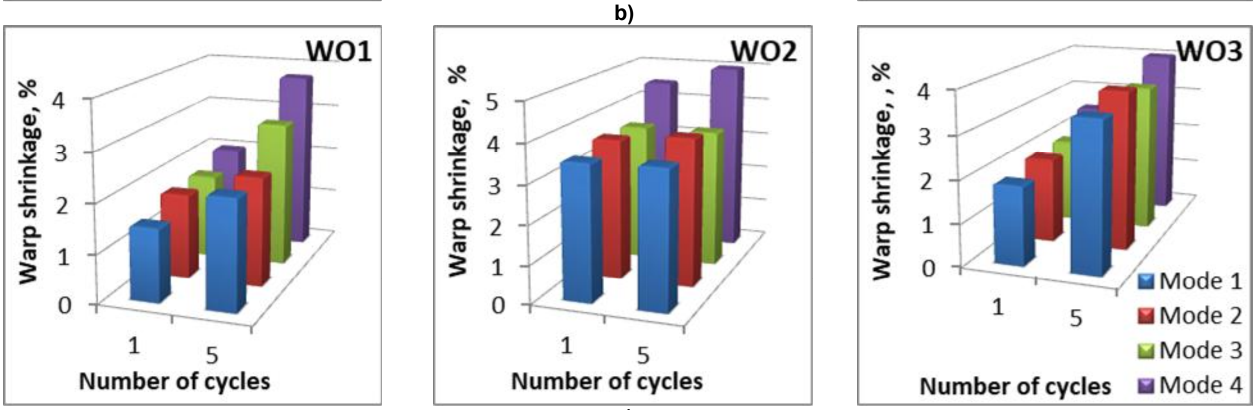
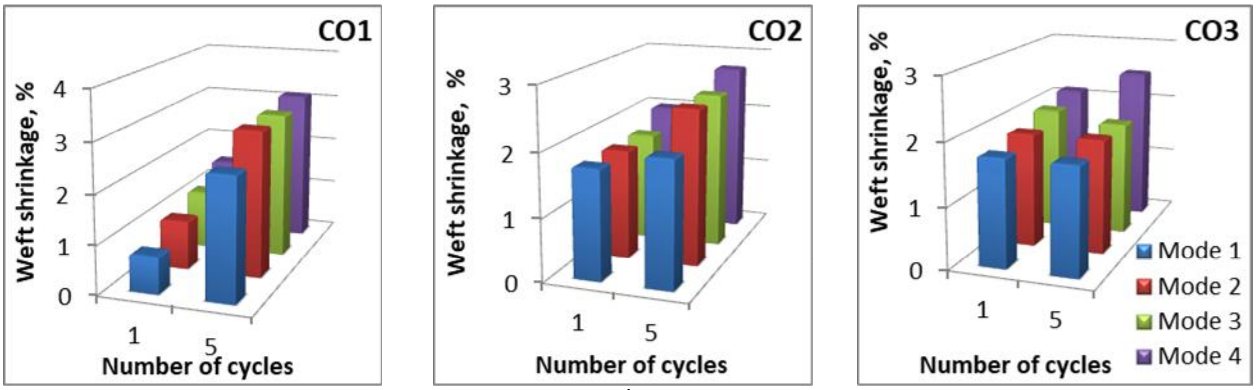


c)

Figure 2 Mean fabric shrinkage in warp direction for drying treatments: a) cotton fabrics, b) polyester fabrics and c) wool fabrics



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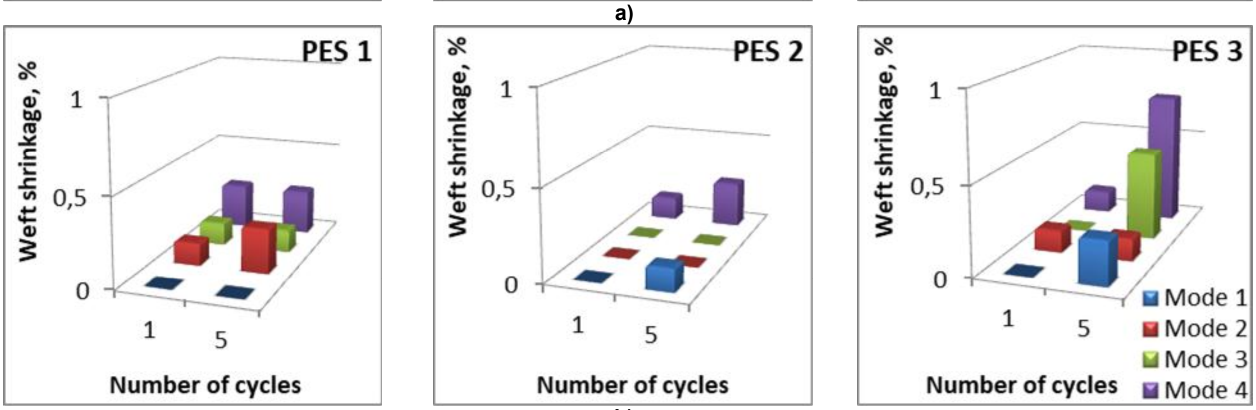

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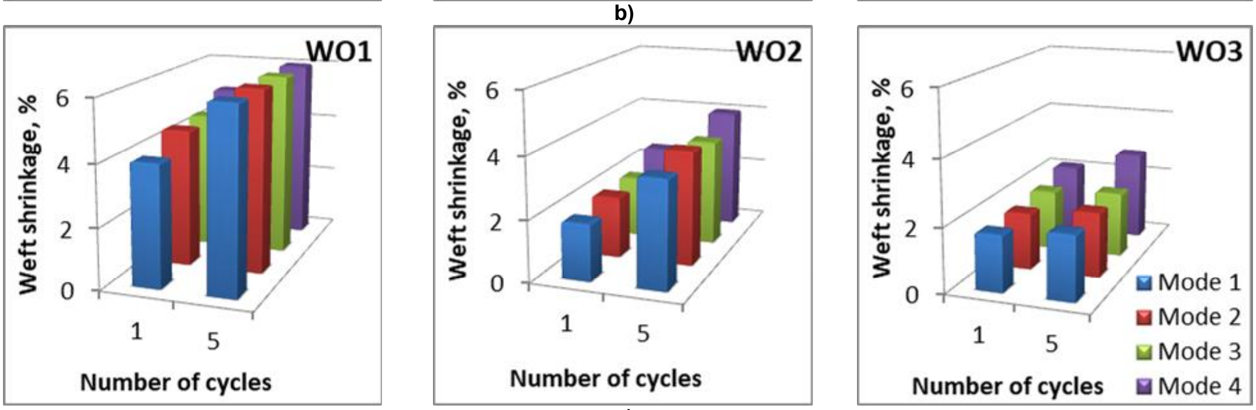

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Figure 3 Mean fabric shrinkage in weft direction for drying treatments: a) cotton fabrics, b) polyester fabrics and c) wool fabrics

Tumble drying caused higher mean levels of shrinkage compared to static drying, both in warp and in weft direction. The value of shrinkage is due to fabric structure and fiber composition.

Cotton and wool fabrics continue to shrink after the 5th cycle of washing. Agitation and temperature is the cause of shrinkage in tumble drying. Polyester fabrics shrink lower than cotton and wool fabrics after tumble drying. The cause may be the contraction of the structure by temperature during time.

Wool fabrics shrank more under tumble drying and with less level in the case of line drying and after drip line drying. This may be due to the fact that the yarn diameter increased after line drying, since studies on the role of yarn swelling on the mechanism of shrinkage in wool fabrics have suggested that voids are created within the yarn as it dries. Tumble drying breaks the hydrogen bonds that had been formed between fibers and yarns when in the swollen state and allows the yarn to collapse inward, reducing yam diameter and facilitating further shrinkage.

3.3 Fabric handle

Fabric handle is related to basic mechanical properties; compression, bending, tensile especially initial low stress regions of these properties [17]. The results of the measurements of different fabric properties before and after various drying regimes are given below in Tables 3 and 4. We analyzed the data set for any possible trends or cause-effect relationships.

Table 3 Mean fabric properties measured by Siro Fast system for drying treatments, 1st cycle

Fabric	Mode	T_2 [mm]	ST [mm]	B-1 [μNm]	B-2 [μNm]	E100-1 [%]	E100-2 [%]	G/10 [N/m]
CO1	1	0.957	0.658	9.29	12.31	5.20	2.96	10.88
	2	0.969	0.67	9.35	12.31	5.20	2.90	11.08
	3	0.956	0.657	8.95	12.18	5.33	2.90	9.84
	4	0.954	0.655	9.04	12.49	5.25	2.95	10.25
CO2	1	0.807	0.263	34.26	5.80	5.30	2.93	11.18
	2	0.806	0.262	48.62	8.75	5.33	3.00	12.30
	3	0.806	0.262	33.92	6.33	5.25	2.87	10.98
	4	0.809	0.265	34.57	5.99	5.25	2.95	10.25
CO3	1	0.941	0.275	38.03	39.81	4.83	3.27	13.67
	2	0.955	0.288	38.02	40.06	4.90	3.33	12.95
	3	0.955	0.256	39.81	39.81	5.00	3.33	13.67
	4	0.952	0.285	37.74	40.38	4.85	3.30	13.18
PES1	1	0.411	0.111	8.41	5.33	0.70	3.20	1.54
	2	0.402	0.101	7.89	5.08	0.85	3.20	1.54
	3	0.408	0.108	8.23	5.07	0.75	3.20	1.51
	4	0.405	0.105	7.92	5.10	0.90	3.25	1.45
PES2	1	0.286	0.032	5.50	13.03	2.13	0.70	4.27
	2	0.288	0.033	5.35	13.68	2.66	0.70	4.32
	3	0.287	0.032	5.03	13.66	2.25	0.75	4.32
	4	0.286	0.032	5.51	13.07	2.80	0.75	4.10
PES3	1	0.62	0.165	0.72	8.89	2.65	2.80	2.98
	2	0.618	0.162	0.76	8.08	2.70	2.80	3.08
	3	0.619	0.163	1.03	8.60	0.65	2.75	3.08
	4	0.621	0.166	0.46	8.10	0.65	2.80	2.89
WO1	1	0.641	0.275	4.37	4.26	2.85	6.00	2.05
	2	0.683	0.317	4.28	4.28	3.15	6.00	2.34
	3	0.645	0.279	4.24	4.36	2.88	6.00	2.14
	4	0.638	0.272	3.88	4.02	3.15	6.33	2.24
WO2	1	0.982	0.32	6.99	6.99	4.00	3.00	2.93
	2	0.99	0.328	7.74	7.01	4.22	3.10	3.09
	3	0.991	0.329	7.49	7.01	4.25	3.00	2.99
	4	0.988	0.326	6.86	6.38	4.50	3.25	3.04
WO3	1	0.904	0.291	10.80	9.89	3.50	4.55	3.08
	2	0.957	0.342	10.90	9.92	3.80	4.50	3.24
	3	0.955	0.339	10.90	8.96	3.50	4.50	3.20
	4	0.915	0.302	9.99	9.05	4.13	4.75	3.24

Table 4 Mean fabric properties measured by Siro Fast system for drying treatments, 5th cycle

Fabric	Mode	T_2 [mm]	ST [mm]	B-1 [μNm]	B-2 [μNm]	E100-1 [%]	E100-2 [%]	G/10 [N/m]
CO1	1	0.938	0.646	7.30	9.66	5.66	3.16	14.30
	2	0.938	0.646	8.00	9.60	5.60	3.20	13.67
	3	0.938	0.646	7.96	9.40	5.70	3.00	15.00
	4	0.938	0.647	8.06	9.77	5.65	3.20	13.67
CO2	1	0.811	0.268	29.39	4.80	5.00	2.81	12.30
	2	0.807	0.262	31.02	4.67	5.20	2.85	11.83
	3	0.81	0.265	30.70	4.80	5.11	2.79	11.18
	4	0.815	0.27	29.89	4.70	5.20	2.90	11.71
CO3	1	0.972	0.305	32.17	29.78	6.50	4.12	15.77
	2	0.962	0.295	32.95	30.65	6.49	4.22	15.38
	3	0.972	0.305	32.87	30.57	6.55	4.25	15.38
	4	0.972	0.305	30.73	30.51	6.56	4.35	14.47
PES1	1	0.406	0.116	5.94	4.82	1.20	3.00	1.51
	2	0.41	0.119	6.26	4.34	1.35	3.00	1.51
	3	0.408	0.116	6.40	5.10	1.30	3.33	1.50
	4	0.407	0.116	6.43	4.72	1.40	3.12	1.45
PES2	1	0.28	0.028	4.97	10.45	2.90	0.65	3.46
	2	0.282	0.031	4.78	10.13	3.10	0.65	3.51
	3	0.281	0.031	4.94	10.13	3.33	0.65	3.28
	4	0.281	0.03	5.07	10.40	3.40	0.70	3.08
PES3	1	0.615	0.132	7.38	6.64	2.85	2.80	2.59
	2	0.613	0.131	7.16	7.16	3.00	2.85	2.54
	3	0.612	0.129	7.40	7.40	3.00	2.85	2.52
	4	0.614	0.132	6.40	7.94	3.13	2.90	2.46
WO1	1	0.645	0.273	3.23	3.30	3.12	6.65	1.54
	2	0.699	0.327	3.13	3.25	3.55	6.66	1.70
	3	0.684	0.306	3.50	3.24	3.11	6.50	1.51
	4	0.725	0.345	2.80	2.80	3.33	6.85	1.51
WO2	1	0.991	0.326	6.46	5.81	4.00	3.33	2.46
	2	1.002	0.324	6.61	5.83	4.20	3.30	2.59
	3	1.003	0.325	6.46	5.97	4.00	3.35	2.31
	4	1.115	0.423	5.84	5.69	4.25	3.50	2.34
WO3	1	0.97	0.26	8.97	8.67	4.00	4.88	2.40
	2	0.978	0.268	9.03	8.73	4.33	4.90	2.84
	3	0.977	0.267	9.22	8.41	4.00	4.85	2.34
	4	1.004	0.292	7.40	7.59	4.50	5.00	2.40

Compression may be defined as a decrease in intrinsic thickness with an appropriate increase in pressure. Surface thickness *ST* (equation 1) shows the roughness of fabric surface and structural stability of a surface layer. The fabric is considered to consist of an incompressible core and a compressible surface. It is reported that an increase in the surface thickness (less than 0.1 mm) can be perceived subjectively in fabric handle. For very thin and light-weight fabrics, a smaller increase in *ST* could produce a perceptible change in handle [18]. The thickness T_2 measured in cotton fabrics in the case of tumble drying is lower compared to the same fabrics dried with static methods and a maximum is reached after flat drying. These results coincide with the results of reference [7] which explains this with an increase of the weft and the warp yarn diameter of cotton in plain structures dried on the line compared to the same samples dried on machine. In another reference, the some author explained that drying in tumble broken hydrogen bonds of cotton in yarns and in fibers in a swollen state which allow to yarns to penetrate in the spaces formed in the dry state [6].

Under different drying methods, the thickness of polyester and wool fabrics is not affected in the first cycle of laundering. The felting phenomena of wool fabrics appear after successive cycles of tumble drying and may explain the fact that fabrics becomes thicker after tumble drying.

Bending length (equation 2) is related to the ability of a fabric to drape and bending rigidity is related more to the quality of stiffness felt when the fabric is touched and handled.

Static drying (mode 1, 2, 3) resulted in higher stiffness compared to tumble drying. In ASTM D1388: 1981, it is stated that differences in bending rigidity of about 10 percent can just be detected subjectively [15]. Using this criterion, there should be no perceivable differences in stiffness between the line-dried, the flat dried, the drip line dried and the machine-dried samples in the first cycle. After five cycles of washing drying, all samples should exhibit pronounced decreases in stiffness. The drip line dried cotton, polyester and wool samples show slight noticeable stiffness after 5th cycles of laundering. The decrease is more severe in the case of tumble drying.

The ability of a fabric to stretch at low loads is critical to garment and other sewn product's making up procedures. Tumble drying gives higher extensibility in warp direction of wool and cotton fabrics. This is may be due to the increase in fiber and yarn crimp as a consequence of relaxation from weaving tension and more freedom for fibers and yarn movement. However, there are no differences in extensibility in weft direction. The method of drying appeared to have little or no effect on the results of polyester fabrics. These results are confirmed after five cycles of laundering.

Shear rigidity is a parameter providing a measure of the resistance to rotational movement of warp and weft threads within a fabric when subjected to low levels of shear deformation. A decrease in shear rigidity is noted after tumble drying. Shear rigidity is higher after static drying. Shear rigidity decreases by successive cycles of washing-tumble drying. In fact, there is a reduction of fiber-fiber contact in interlacement points of yarns and a decrease of inter yarns pressure in the structure which becomes completely relaxed under washing and especially after tumble dry.

4 WRINKLE RECOVERY

Wrinkle recovery is the property of a fabric which enables it to recover from folding deformations. The approach based on wrinkle recovery angles standardized in AATCC 66-20083 and ISO 2313:1972 specified the compression force and time to create a folded wrinkle and the suspension condition to observe the change in the folding angle.

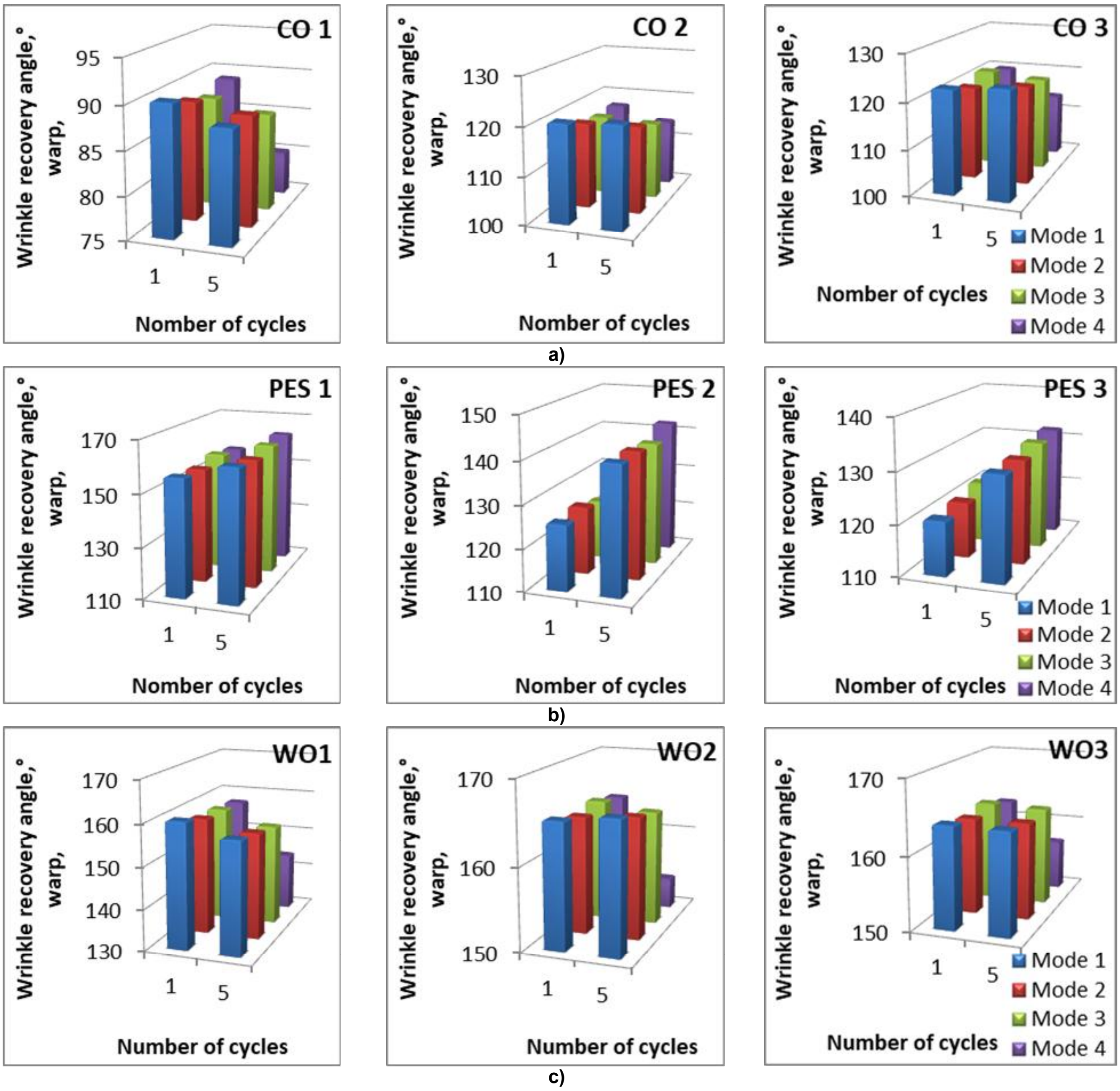
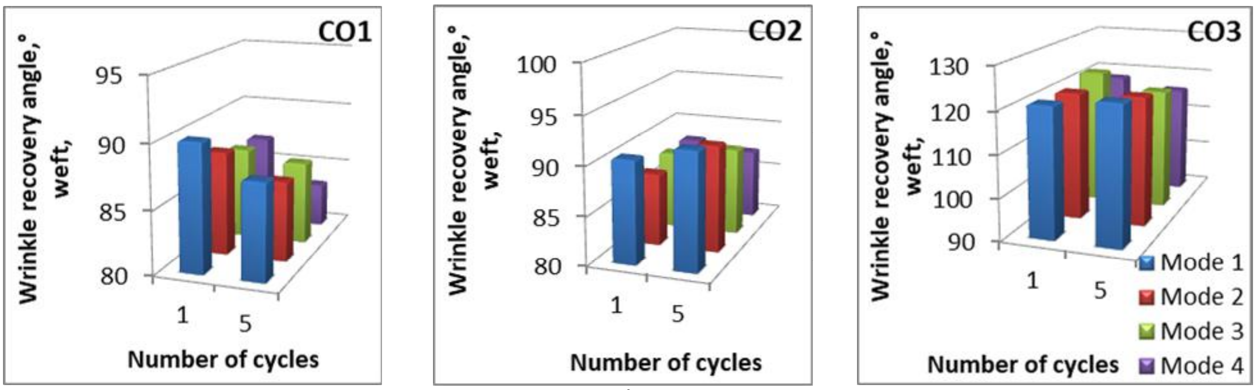


Figure 4 Mean fabric wrinkle recovery in warp direction for drying treatments: a) cotton fabrics, b) polyester fabrics and c) wool fabrics



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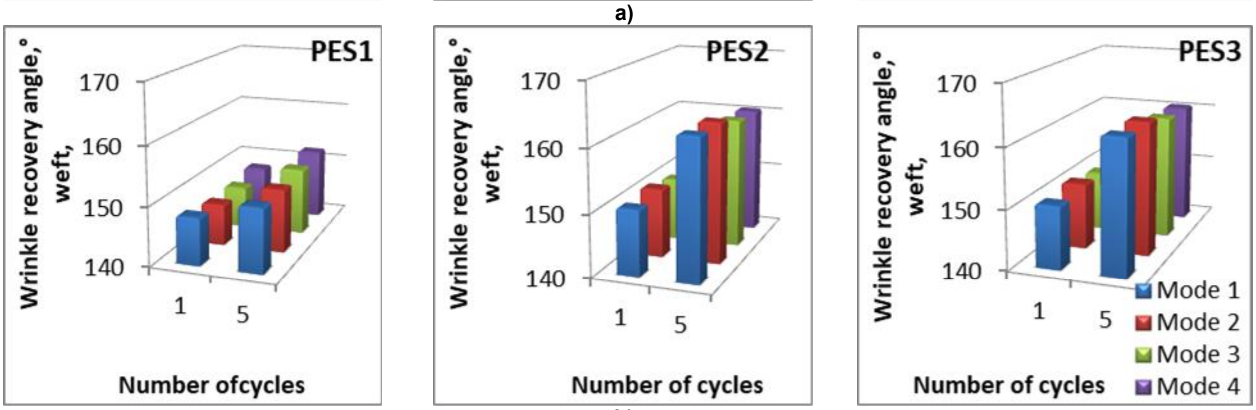

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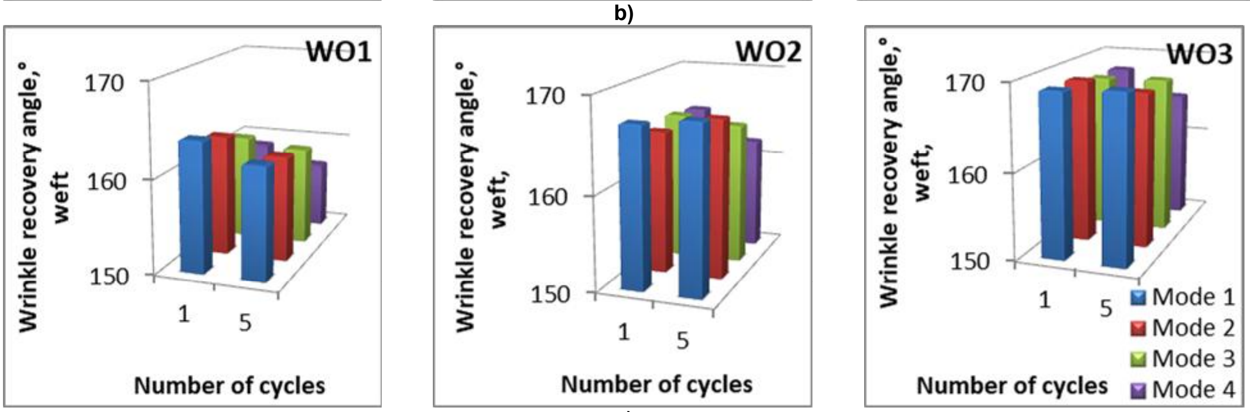


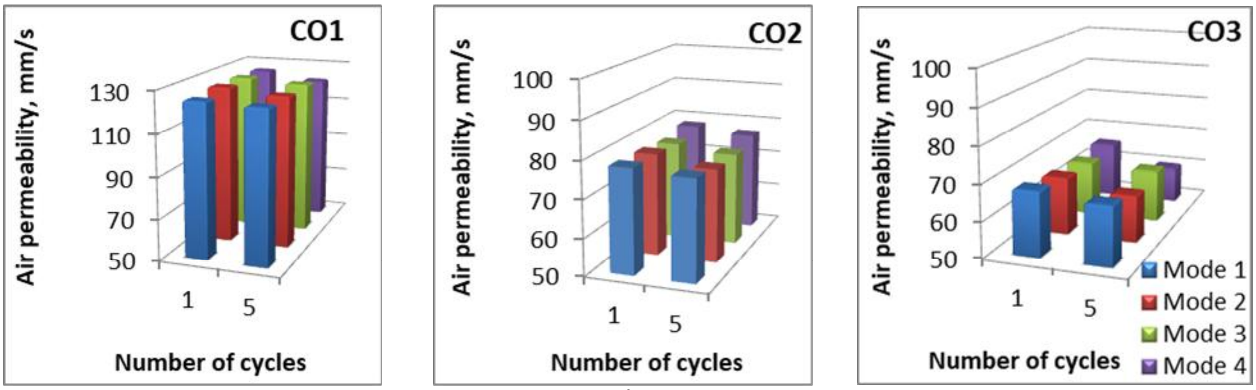
c)

Figure 5 Mean fabric wrinkle recovery in weft direction for drying treatments: a) cotton fabrics, b) polyester fabrics and c) wool fabrics

Figures 4 and 5 show that successive washing-drying cycles, whatever the drying method, decreases wrinkle recovery angle of cotton and wool fabrics, but increase in the case of polyester fabrics. Drying method had not a large effect on the wrinkle recovery angle in weft and in warp direction in the first cycle of laundering-drying. The variation is clearer after successive cycles during which tumble drying have a clear effect.

5 AIR PERMEABILITY

Air permeability facilitates human body ventilation and vapor removal. This property is crucial, especially for underwear and clothes worn in a hot environment [19]. Air permeability is defined according to ISO 9237: 1995 as the velocity of an air flow passing perpendicularly through a test specimen under specified conditions of test area, pressure drop and time.



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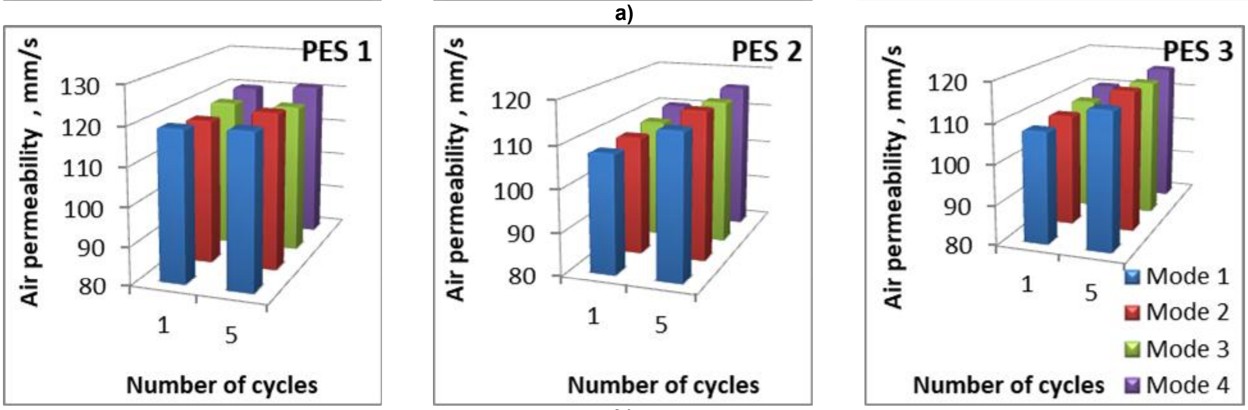

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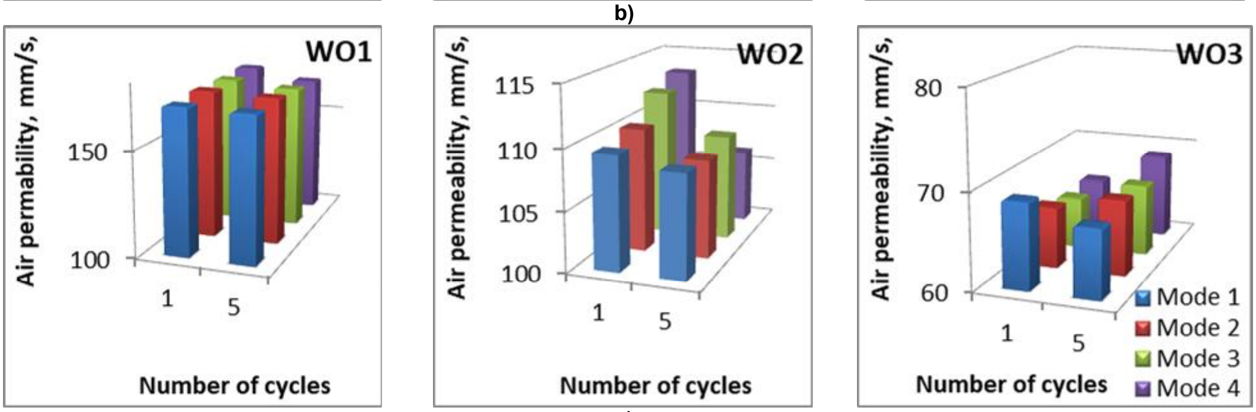

c)

Figure 6 Mean fabric air permeability for drying treatments: a) cotton fabrics, b) polyester fabrics and c) wool fabrics

The results presented in Figure 6 show that air permeability strongly depends on the fabric structure and fiber contents. The air permeability of all fabrics, after washing and drying cycles, decreased compared to air permeability of untreated fabrics. It occurred because of the influence of shrinkage during washing and drying under the impact of moisture, heat and mechanical action. Interestingly, that air permeability of fabrics from cotton and wool yarns decreased most of all than fabrics weaved from synthetic yarns. In fact, laundering processes cause an increase in the thread density of the fabrics, and as a result a decrease in the fabric's porosity, this in turn diminishes the air permeability. So, drying regimes which cause the most fabric shrink may also cause the most loss in air permeability.

6 CONCLUSION

The study summarized the effect of drying methods on the smoothness appearance, wrinkle recovery, shrinkage, hand properties and air properties on woven fabrics. Tests were carried on nine different fabrics and four different drying methods: drip line drying, flat drying after water extraction, line drying after water extraction and tumble drying were tested. The fabric changes that occur during repeated laundering, especially during drying such as, shrinkage, are highly dependent of fiber type and fabric construction. In terms of the overall objectives of this investigation, we have shown that tumble drying causes greater levels of shrinkage than static drying. We also have shown that consumer will be satisfied by fabric appearance after tumble drying through successive cycles. In spite of the weak variations of the mechanical properties, the effect of drying method reveals significant especially in the case of cotton and wool fabrics. Succeeded cycles of drying intensified the effects. In future works, we will interest on other types of fabrics and also on garment behavior.

7 REFERENCES

1. Wilkinson P.R., Hoffman R.M.: The effects of wear and laundering on the wrinkling of fabrics, Textile Research Journal 29(8), 1959, pp. 652-660, https://doi.org/10.1177/004051755902900806
2. Mikučionienė D., Laureckienė G.: The influence of drying conditions on dimensional stability of cotton weft knitted fabrics, Materials Science (Medžiagotyra) 15(1), 2009, pp.64-68
3. Burkett F.H.: The starfish project: An integrated approach to shrinkage control in cotton knits, Part 1 - Introduction and definition of the reference state, Knitting International 40, 1986, pp. 40-42
4. Heap S.A.: Computer predictions for cotton shrinkage, Knitting International 23, 1984, pp 40-44
5. Brown K.S.M.: The effect of laundering on the dimensional stability and distortion of knitted cotton fabrics, PhD thesis, Bolton Institute, 2000
6. Higgins L., Anand S.C., Hall M., Holmes D.: Factors during tumble drying that influence dimensional stability and distortion of cotton knitted fabrics, International Journal of Clothing Science and Technology 15(2), 2003, pp.126-139, https://doi.org/10.1108/09556220310470132
7. Higgins L., Anand S.C., Holmes D.A., Hall M.E., Underly K.: Effects of various home laundering practices on the dimensional stability wrinkling, and other properties of plain woven cotton fabrics. Part II: Effect of rinse cycle softener and drying method and of tumble sheet softener and tumble drying time, Textile Research Journal 73(5), 2003, pp.407-420, https://doi.org/10.1177/004051750307300507
8. Fianu D.A.G., Sallah A.R.; Ayertey A.: The effect of sunlight and drying methods on the strength of Ghanaian Real Wax printed fabrics, International Journal of Consumer Studies 29(1), 2005, pp. 34-40, DOI: 10.1111/j.1470-6431.2005.00371.x
9. Rawlings G.D., Stanley H.E., Wilkinson P.R.: The home laundering of wash and wear garments of hydrophobic fibers, Textile Research Journal 26(12), 1956, pp. 974-980, https://doi.org/10.1177/004051755602601213
10. Morris M.A., Prato H.H., White N.L.: Line-dried vs. machine-dried fabrics: Comparison of appearance, hand and consumer, Home Economics Researchs Journal 13(1), 1984, pp. 27-35, https://doi.org/10.1177/1077727X8401300105
11. Cheriaa R., Jedda H., Ben Marzoug I., Sakli F.: Optimization of spinning cycle conditions via overlaid contour plot of weave cotton fabrics, International Conference of Applied Research on Textile CIRAT-7, November 10-12, 2016, Hammamet, Tunisia
12. Cheriaa R., Ben Marzoug I., Sakli F., Study of woven cotton fabrics during industrial ironing, International Conference of Applied Research on Textile CIRAT-8, November 9-10, 2018, Monastir, Tunisia
13. Cheriaa R., Ben Marzoug I., Sakli F: Effects of repeated ironing-laundering cycles on cotton, cotton/ polyester and polyester plain fabrics, International Journal of Applied Research on Textile 4(2), 2016, pp.31-44, http://atctex.org/ijartex/current-issue.html
14. Cheriaa R., Ben Marzoug I., Sakli F.: Effects of industrial ironing on mechanical and dimensional properties of cotton, wool and polyester fabrics, Indian Journal of Fibre & Textile Research 41, 2016, pp.167-172
15. American Society for Testing and Materials: 1981, Annual Book of ASTM Standards, Part 32, 249
16. Bishop D.P.: Physical and chemical effects of domestic laundering processes, Chemistry of the Textiles Industry, Carr C.M. (eds), Springer, Dordrecht, 1995; pp 125-172, https://doi.org/10.1007/978-94-011-0595-8_4
17. Matsudaira M.: Fabric handle and its basic mechanical properties, Journal of Textile Engineering 52(1), 2006, pp.1-8, https://doi.org/10.4188/jte.52.1
18. Ly N.G., Tester D.H., Buckenham P., Roczniok A.F., Adriaansen A.L., Scaysbrook F., De Jong S.: Simple instruments for quality control by finishers and tailors, Textile Research Journal 61(7), 1991, pp. 402- 406, https://doi.org/10.1177/004051759106100707
19. Frydrych I., Dziworska G., Matusiak M.: Influence of the kind of fabric finishing on selected aesthetic and utility properties, Fibres & Textiles in Eastern Europe 11(3), 2003, pp.31-37