1465 PROPERTIES OF THE NATURALLY COLORED COTTON AND ITS APPLICATION IN THE ECOLOGICAL TEXTILES

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Naturally colored cottons are unique in that they grow in colors and do not have to be dyed in fabric manufacturing. With naturally colored cotton, textile mills can reduce processing costs by using less water and energy and thus comply more easily with EPA regulations. In

spite of the aforementioned economical and ecological benefits, natural colored cotton is used by specific producers for niche market goods. Broad use of colored cottons is not effective yet due to their lower fiber qualities in comparison to conventional white cottons as well as the limited range of natural colors.

The aim of this work was to investigate the application of the naturally colored cotton of Greek origin in yarns and fabrics as well as to analyze the properties of yarns and fabrics made of this cotton.

Brown cotton of Greek origin was processed under industrial conditions using the rotor and ring spinning technology. The rotor and ring yarns were then woven to produce fabrics.

The brown Greek cotton can be processed in rotor mill into OE yarns of linear densities similar to that of yarns made of middle staple white cotton. Application of the brown cotton in warp preparation and weaving did not disturb the industrial processes and the fabric manufacturing

Keywords: naturally colored cotton, ecological textiles, woven fabrics

1. Introduction

According to archeological evidence naturally colored cottons were cultivated and used at least 2700BC [1] in the tropical and subtropical zones. It was then common, cotton in a variety of natural colors as mocha, tan, grey, blue and red-brown to be domestically grown and processed. Further the low yielding, short-fibered colored cottons were not suitable for machine spinning , therefore they failed to face the rapid industrial turnover.

In 1982 in the United States, Sally Fox, a plant breeder, set-up a breeding and selection program to improve the fiber quality of naturally colored cottons and finally succeded in developing colored hybrids able to withstand machine processing.

Since then the interest for naturally colored material was revised in other countries too and relevant breeding projects are in progress in Israel, Brazil, Peru, Greece, Turkey and the former Soviet Union.

Naturally colored cottons are unique in that they grow in colors and do not have to be dyed in fabric manufacturing. Dyeing can be one of the most costly steps in fabric finishing due to water and energy use, and waste production [2]. With naturally colored cotton, textile mills can reduce processing costs by using less water and energy and thus comply more easily with EPA regulations [3]. According to Dr. Frank Werber, National Program Leader for Fabric and Materials, Agriculture Research Service, USDA, naturally colored cotton is ecologically valid as well as economical [4].

In spite of the aforementioned economical and ecological benefits, natural colored cotton is used by specific producers for niche market goods. Broad use of colored cottons is not effective yet due to their lower fiber qualities in comparison to conventional white cottons as well as the limited range of natural colors.

It is well known that the properties of cotton fibers are highly influencing the spinning process as well as the quality parameters of the final products ie. yarns and fabrics. Spinning machines and process parameters are adapted to the particular properties of white cotton, established after many years of research.

Brown cotton with reasonable fiber quality was the result of intensive breeding work in Greece. A protocol of mutual collaboration between Poland and Greece enable the production of sufficient quantities of brown cotton to be processed in blends for yarn and fabric manufacturing.

Aim of this work was to investigate the application of the naturally colored cotton of Greek origin in yarns and fabrics as well as to analyze the properties of yarns and fabrics made of this cotton.

In the present paper the properties of brown cotton and cotton blends with white cotton were evaluated and the results were applied for machine setting. The properties of yarns and fabrics made of these blends were further evaluated to access the merit of brown cotton on these properties and on production process.

2. Materials and methods

In the present work brown cotton of Greek origin, totally 4 bales, was processed under industrial conditions using the rotor and ring spinning technology. The rotor and ring yarns were then woven to produce fabrics.

The same procedure was also applied to white cotton for comparison.

Evaluation of material properties was carried our after each step of production. More precisely the following measurements were applied:

- laboratory measurement of the naturally colored cotton properties by the AFIS instrument
- application of colored cotton quality parameters in yarn manufacturing
- laboratory measurement of the properties of the produced yarns
- designing of the woven fabric structures and patterns with the application of the naturally colored yarns,
- production the woven fabrics,

- measurement of the structural, mechanical and biophysical properties of woven fabrics made of the naturally colored cotton.

3. Results and discussion

3.1. Raw material

Naturally colored cotton of Greek was used for experimental production of yarns. Lay down was composed of 4 bales of brown cotton. Raw material was measured by means of the AFIS (Advanced Fiber Information System. According to the expectations the quality of naturally colored cotton used in experiment was not too high, but the properties of fibers taken from particular bales were at the similar level. The results of cotton measurement by means of the AFIS were compared with the statistical data in Uster® Statistics. It was stated that the brown Greek cotton applied for experiment represents the following quality level according to Uster® Statistics:

- Short Fiber Content by weight – 88%,
- Fineness – 80 %,
- Immature Fiber Content – 67 %,
- Maturity Ratio – 95 %,
- Nep Cnt/g – 86 %,
- Dust Cnt/g 77 %,
- Trash Cnt/g - > 95%,
- Visible Foreign Matter - > 95 %.

3.2. Yarn manufacturing

The industrial trials were performed in one of the Polish spinning mill. The rotor yarns of the linear density: 30 tex, 40 tex and 50 tex were manufactured. For each assortment two variant of different twist were produced:

- H – high twist,
- L – low twist.

During the cotton processing the monitoring of the technological process was carried out in order to assess the behavior of fibers during processing as well as the correctness of the technological process. It was stated that in spinning of the naturally colored cotton any disturbances of the technological process did not occur. Moreover it was stated that the yield of the spinning process of the color cotton was at the similar level to the yield of the spinning of middle staples white cotton.

Manufactured rotor yarns made of naturally colored cotton were measured in the range of the basic technological and mechanical properties according to standardized measurement methods.

On the basis of the obtained results it was state that the OE yarns made of naturally collared cotton of Greek origin are characterized by the good quality in the range of all basic parameters. Moreover, there are differences between properties of OE yarns produces at different twist. Yarns of lower twist are characterized by the lower breaking tenacity (fig. 1) and breaking elongation.

Simultaneously the yarns of lower twist show higher irregularity of breaking elongation and twist.
The results from the Uster® tester also confirmed the higher quality of OE yarns with higher twist in comparison to OE yarns with lower twist. In table 5 there is presented the quality level of OE yarns according to Uster® Statistics

3.3. Fabric manufacturing

For the experiment the plain woven fabrics were produced. They were made of white and brown cotton. For fabric production the OE yarns were used: warp yarn of linear density 30 tex, and the weft yarn of linear density 40 tex. The fabric samples were produced at the nominal warp density – 230/dm and at the nominal weft density – 180/dm. Raw fabrics were washed and ironed.

Raw and finished (washed) fabrics were measured in the range of the basic structural parameters and mechanical properties, like: strength, elongation, stiffness and shrinkage. The measurement was done according to standardized procedures. Moreover the measurement of the biophysical properties: air permeability, thermal resistance, thermal conductivity, thermal absorption and water vapor resistance was carried out. For the evaluation of the biophysical properties of fabrics modern measurement techniques were used: 'skin model' andThermo Labo II,

On the basis of the presented results it was sated that the prepared fabrics are characterized by the same structure: weave, width, warp and weft density as well as mass per square meter. The mechanical properties of the investigated fabrics are similar. The significant differences occurred in the fabric tenacity (fig. 2).

The washed fabric made of brown cotton in the warp and weft yarns has lower tenacity in the warp direction than the fabrics made of white cotton in the warp yarn. In the weft direction the lowest tenacity was stated for the fabric made of the white warp yarn and brown weft yarn.

The clear influence of an application of the colored cotton on the fabric shrinkage did not occur for both: raw and finished fabrics (fig. 3). We should emphasize here that for fabric finishing the pretreatment was only applied. The fabric samples were washed and ironed in the laboratory conditions. These processes do not assure the good dimension stability of fabrics.

The results of the heat keeping property according to Thermo Labo II measured by the wet contact show that the heat keeping property of the raw fabrics is at the same level for fabrics made of white and brown cotton. In the case of washed fabrics the highest heat keeping is assured by the fabrics made of the white cotton in the warp yarn and brown cotton in weft yarn.

Water absorbability (fig. 4) as well as air permeability of fabrics do not depend on the kind of cotton used for production: white or naturally colored fibers.

4. Conclusions

On the basis of the carried out research it can be concluded that:

- although the brown cotton of Greek origin is characterized by low maturity, great amount of total neps, SCN neps, trash and dust particles, its application in OE yarn manufacturing did not cause any disruptions,
- the quality parameters of OE yarns made of naturally colored cotton depend on the yarn twist,
- the quality of OE yarns made under industrial conditions is on the satisfactory level according to the Uster® Statistics except for yarn neppiness,
- the brown Greek cotton can be processed in rotor mill into OE yarns of linear densities similar to that of yarns made of middle staple white cotton: from 30 tex to 50 tex,

- application of the brown cotton in warp preparation and weaving did not disturb the industrial processes and the fabric manufacturing,
- the low strength of brown cotton fibers, in the warp yarn, caused a significant decrease in the tenacity of washed fabrics in the warp direction,
- brown cotton has not influence on fabric shrinkage,
- the thermal properties of fabrics made of colored cotton and colored cotton blends were similar to that made of white cotton while fabrics made of the brown cotton were warmer to the touch than that of white cotton.

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Table 1. Properties of naturally colored cotton of Greek origin

Bale	L(w)	L(w)CV	UQL(w)	SFC(w)	Fine	IFC	Mat	Nep	Dust	Trash	VFM
-	mm	%	mm	%	mtex	%	-	g^{-1}	g^{-1}	g^{-1}	%
I	22.7	34.2	27.6	10.8	166	7.0	0.87	366	850	149	2.87
II	21.4	35.7	25.9	12.3	160	7.7	0.83	504	1286	278	5.13
III	21.8	37.3	27.1	13.9	160	7.7	0.83	476	664	141	2.65
IV	21.7	34.6	26.2	11.0	160	7.4	0.84	437	976	248	3.86
Av.	**21.9**	**35.4**	**26.7**	**12.0**	**162**	**7.4**	**0.84**	**448**	**944**	**204**	**3.63**

Table 2. Parameters of rotor yarns produced in the industrial conditions

No	Parameter	Unit	Value of the parameter					
			30 tex		40 tex		50 tex	
			H	L	H	L	L	H
1.	Linear density	Ttex	29.7	30.4	39.1	40.0	48.7	50.6
2.	Mass variation coefficient	%	3.78	2.17	0.66	2.21	1.56	1.42
3.	Tenacity	cN/tex	10.60	9.75	10.20	9.24	9.68	8.44
4.	Breaking force variation coeff.	%	12.0	12.0	10.7	11.6	12.3	11.3
5.	Breaking elongation	%	9.72	8.40	8.90	8.40	8.42	7.54
6.	Elongation variation coefficient	%	6.62	8.05	7.83	7.22	7.61	9.16
7.	Twist	obr. m^{-1}	939.0	821.4	763.2	658	653.0	550.4
8.	Twist coefficient	-	161.8	143.2	150.9	131.6	144.2	123.7
9.	Twist variation coefficient	%	2.31	3.24	1.61	2.72	1.91	2.12
10.	CV	%	14.2	15.3	14.4	16.78	15.8	15.4
11.	Thin places/1000 m	-	8.0	4.8	0.0	15.2	10.4	8.0
12.	Thick places/1000 m	-	54.4	72	56.0	56.0	48.0	40.0
13.	Neps/1000 m	-	72.0	69.6	59.2	27.2	36.8	12.0

Table 3. Quality of OE yarns according to Uster® Statistics'2001

No	Linear density	Variant	CV %	Thin places	Trick places	Neps
1.	30 tex	H	29	19	36	81
2.		L	62	5	52	80
3.	40 tex	H	54	< 5	56	83
4.		L	> 95	79	56	70
5.	50 tex	H	95	82	60	79
6.		L	90	76	53	55

Legend:

Quality level acc. to Uster® Statistics	*Description*
< 5 %	*Very good*
5 % ÷ 25 %	*Good*
25 % ÷ 50 %	*Average*
50 % ÷ 75 %	*Satisfactory*
75 % ÷ 95 %	*Unsatisfactory*
> 95 %	*Bad*

Table 4. The set of fabric variants

Symbol of variant	Color of yarn	
	warp	weft
WW	white	white
WB	white	brawn
BB	brawn	brawn

Table 5. The structural and mechanical parameters of fabrics

Parameter	Unit	Raw fabrics			Finished fabrics		
		WW	WB	BB	WW	WB	BB
Width	m	1.74	1.74	1.73	1.63	1.63	1.62
Mass per meter	g	159.8	152.8	157.5	179.1	177.5	176.0
Mass per square meter		277.7	265.2	273.2	291.4	289.8	285.6
Warp density	dm^{-1}	230	231	232	244	245	248
Weft density	dm^{-1}	179	176	180	196	197	204
Tenacity in warp direction	cN	411	425	417	403	399	372
Tenacity in weft direction	cN	406	331	408	432	372	415
Elongation in warp direction	%	17.3	17.0	12.5	32.1	31.7	26.9
Elongation in warp direction	%	12.5	12.0	11.7	21.0	19.8	18.3
Shrinkage in warp direction	%	16.8	17.1	18.4	5.9	6.3	5.2
Shrinkage in weft direction	%	13.0	11.6	11.6	4.2	5.0	4.7

Table 6. The thermo physiological properties of fabrics

Parameter	Unit	Raw fabrics			Finished fabrics		
		WW	WB	BB	WW	WB	BB
Air permeability	mms^{-1}	810.3	828	-	598.4	574.8	-
Water absorbability	%	123.0	123.2	121,4	167.3	159.9	161.1
Warm/cool feeling	Wm^{-2}	0.102	0.100	0.129	0.110	0.118	0.104
Thermal conductivity	$Wm^{-1}K^{-1}$	0.040	0.037	0.041	0.045	0.044	0.047
Heat keeping property	%	33.6	34.05	33.7	37.3	40.2	35.9
Heat keeping property	%	60.5	61.0	60.5	61.9	64.0	62.3
Water vapour resistance	m^2PaW^{-1}	12.30	13.39	10.27	10.12	14.22	11.73
Air permeability	mms^{-1}	810.3	828.0	-	598.4	574.8	-
Water absorbability	%	123.0	123.2	121.4	167.3	159.9	161.1

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Fig. 1. Tenacity of rotor yarns made of brown Greek cotton

Fig. 2. Fabric tenacity in warp direction

Fig. 3. Fabric shrinkage: in warp direction

Fig. 4. Water absorbability of fabrics

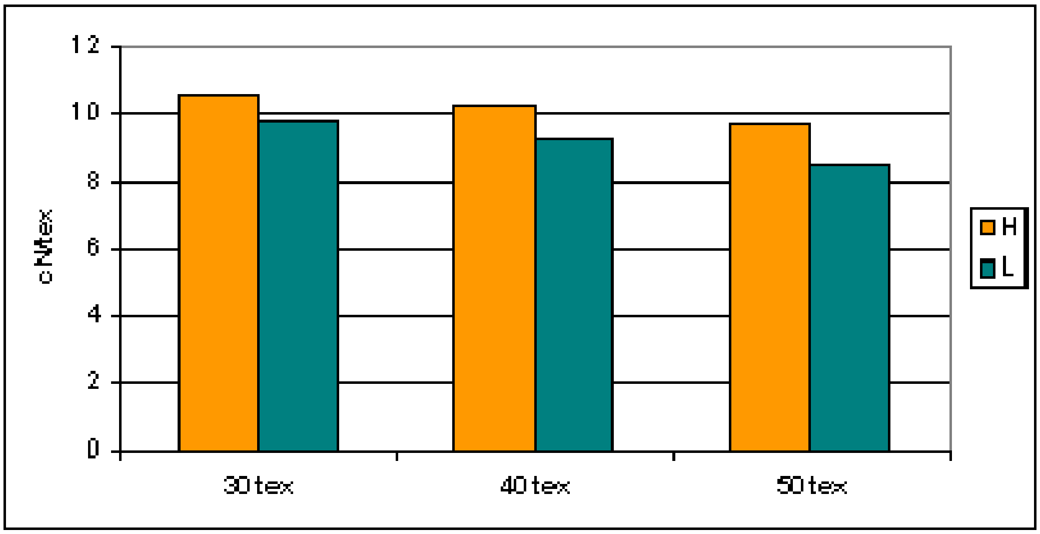

Figure 1.

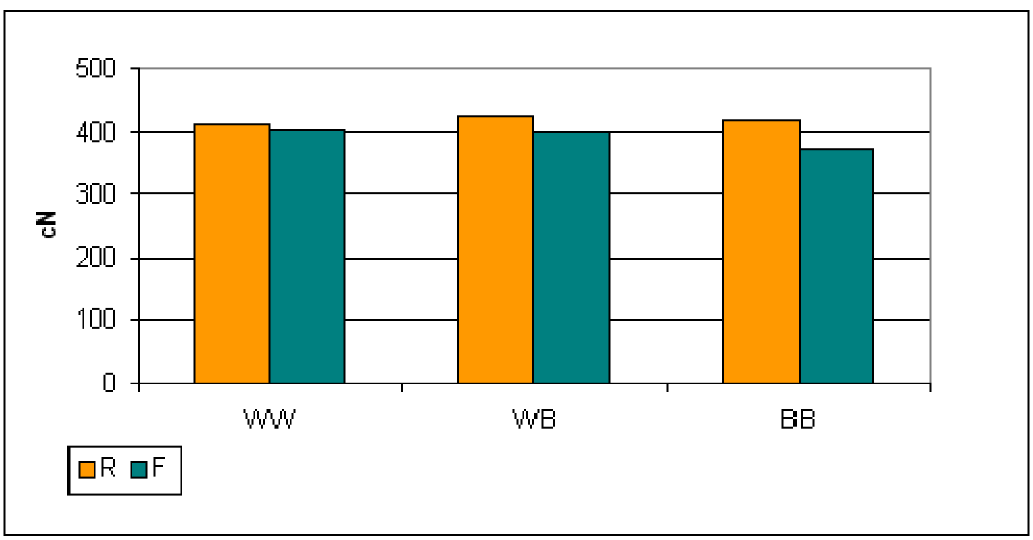

Figure 2.

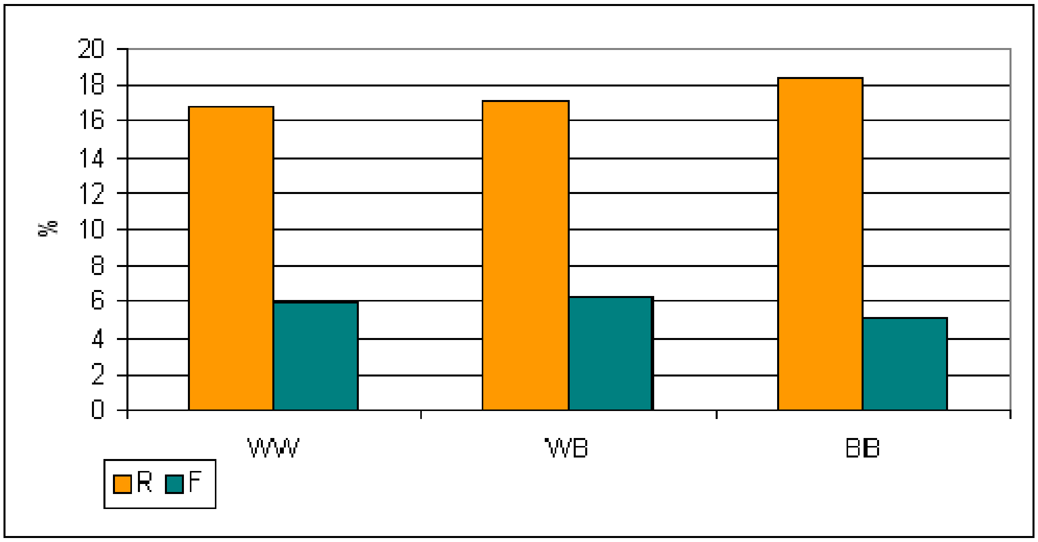

Figure 3.

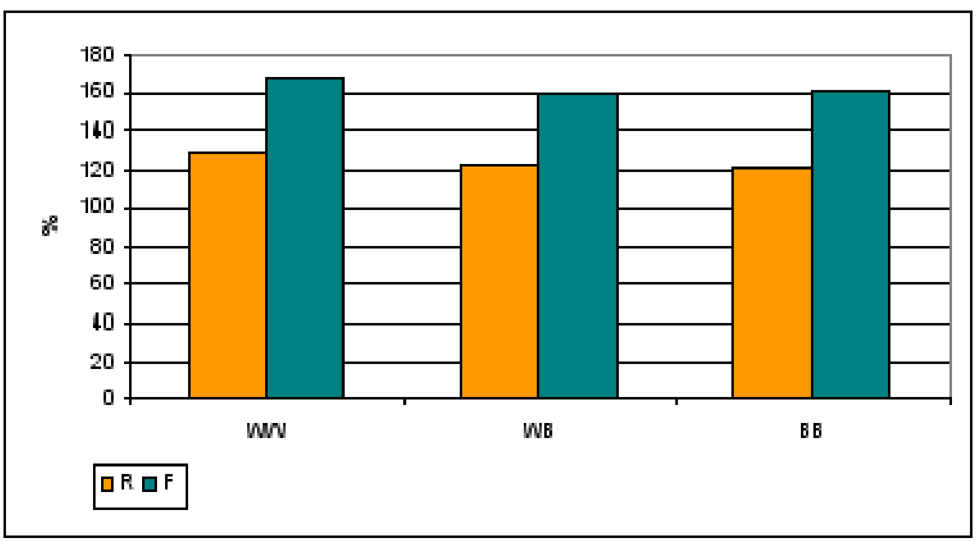

Figure 4