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WASH FASTNESS PROPERTIES OF PRE-MORDANTED TIE-DYED COTTON FABRICS DYED WITH MUUKU BARK AND MAROGOLD FLOWERS NATURAL DYES.

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Abstract: *There is a global quest for consumer eco-friendly and sustainable products fashioned with natural dyes through either printing or dyeing. However, research on imparting white patterns on textile substrates with natural dye has concentrated on dyeing and printing techniques rather than on tie-dyeing technique. Tie-dying an ancient craft used for traditional/local identification has been executed at room temperatures with synthetic dyes. This paper thus investigates the effect of mordants on wash fastness of pre-mordanted tie-dyed cotton fabrics using natural dyes. Colourants from two plants acquired from Kenya namely marigold flower and muuku bark plant were extracted using aqueous extraction method. Before dyeing, the fabrics were scoured and bleached. Saltless dyeing preceded by first pre-mordanting tie-dyed cotton fabrics with copper sulphate and anhydrous Iron sulphate mordant for 30 minutes at 100^{0}C. After pre-mordanting, fabrics were dyed with extracted colourants at 100^{0}C for 45minutes. Colour change and staining to wash on the tie-dyed fabric was analyzed. Tie-dyed cotton fabrics tied using binding and tying technique dyed with muuku natural dye gave intricate brighter lines and shades respectively than those dyed with marigold flowers. Fastness properties of the tie-dyed fabrics were acceptable ranging from 3/4 (fairly good) to 4/5 (very good). Anhydrous Iron sulphate as an inducer gave the best fastness grades. The results suggest tie-dyeing as a possible technique for pattern creation of environmental friendly fabrics.*

Key words: *Natural dyes, Tie-dyed, sustainable, fastness, eco-friendly.*

1. INTRODUCTION

Sustainable eco-friendly goods produced from natural dyes is the current global need of textile consumers. This is attributed to the affirmed environmental pollution, carcinogenic and unhealthy usage of synthetic dyes and salts from the textile industry [1]. Therefore, emphasis on clean & sustainable environment and healthy living can be achieved through responsible production, application and consumption of eco-friendly dyes. Application techniques of dyes such as dyeing and printing with little accent on tie-dyeing have been employed to accomplish eco-friendly patterned products. It's argued that tie-dyeing is similar to dyeing and printing [2]. However, unlike printing where creation of white patterns in cloths requires modelling patterns using software, skilled personnel [3], lengthy periods & large capital investments for screen development; tie-dyeing fabric preparation on the other hand, requires human wisdom (intellectual development of patterns) and binding (tight tying) of fabric with strings or rubber bands. This art of dyeing dating back to pre-historical times [4], is plausive for creation of unique attractive patterns and colours. The fundamental procedures embedded into five major techniques [5], principally are: folding, tying and sowing/stitching of fabrics done to inhibit absorption of colourant in individualized cloth fragments.

Natural dyes have been employed for dyeing, printing [6], and tie-dye with reactive dyes [4]; but meagerly been applied in tie-dyeing with natural dyes [7]; either through cold dyeing or at elevated temperatures advocated for [8], because higher temperatures enhance exhaustion and penetration of dye into textile substrates. Therefore, the objective of this study is to evaluate the wash fastness of pre-mordanted and dye tie-dyed cotton fabrics via saltless dyeing at elevated temperatures using marigold flowers and muuku bark natural dye. Marigold flowers botanically termed as *Tagetes erectal* is a weed (with yellow flowers) found in plantation and has been used as a dye [9], but not exploited for tie-dyeing. Muuku tree on the other hand an indigenous tree found in semi-arid areas of Kenya, likewise has various applications such as ornamental, medicinal (leaves and barks) and dye. Regardless of the plant part used for dyeing, it's imperative to determine the wash fastness properties of dyed fabrics since the elegance of natural tie-dyed fabrics lies in the beautiful shades associated with age. Furthermore, traditional aesthetics instigate the existence of universal and timeless criteria of artistic value.

2. MATERIALS AND METHODS

2.1 Material

These included: 4 meters of grey cotton fabric, sodium hydroxide, Hydrogen peroxide, copper sulphate (Cu_2So_4), Anhydrous Iron sulphate (Fe_2SO_4), marigold flowers and muuku bark natural dye, Narcolab/Multase detergent, grey scales, and wetting agent.

2.2 Method of extraction of natural dye

Marigold flowers and Muuku bark were collected, washed, dried and grinded into powder using a grinding machine. With a ratio of 1:10; 600g of respective powder dissolved in water was extracted for 30 minutes at 95-97^{0}C. After extraction, colourants were left to cool, sieved and stored for dyeing.

2.3 Dyeing Process

Before dyeing, cotton fabric was divided into four sections (each measuring 1 meter) and prepared. The preparation process entailed combined scouring (5g/l) and bleaching (8ml/litre) with 2m/l of wetting agent. After preparation, the fabrics were washed and dried. Subsequent process was tie-dyeing of each meter of substrate using different procedures namely sandwiching, binding & tying, sew-twisting (shown in **Fig. 1** and **Fig. 2**) and pre-mordanting of two meters of substrate with 50g of copper sulphate and anhydrous Iron sulphate respectively for 30 minutes at 100^{0}C.

Wet on wet dyeing process was conducted through dyeing with muuku dye (fabric pre-mordanted with Cu_2So_4) and marigold flower (fabrics pre-mordanted with Fe_2SO_4) at 100^{0}C for 45 minutes using 2 liters of extracted colourant. After dyeing, fabrics were washed with detergent, rinsed, shade dried and analyzed for wash fastness using ISO105-C-06:2010(E). Fastness to wash was repeated twice, and the average grade recorded.

***Fig. 1**: Tied for Copper Sulphate mordanting*

***Fig. 2**: Tied for hydrous Iron sulphate mordanting*

3. RESULTS AND DISCUSSION

3.1. Techniques of tying

Dyeing with copper sulphate and anhydrous Iron Sulphate created beautiful shades of orange-brown and lighter black shades as shown in **Fig. 3**, **Fig. 4, Fig. 5** and **Fig. 6** respectively.

***Fig. 3:** Dyed with Muuku bark Dye*

***Fig. 4:** Tie-dyed with Muuku dyes*

The dyeing process was executed under the same conditions of temperature, time, same dye (muuku dye), colour inducer and fabric but with different tying techniques. Sample A (**Fig. 3)** that embraced binding & tying technique while sample B (**Fig. 4) which** exploited sew-twisting method, resulted into the production of spiral and rectangular patterns respectively. Both techniques produced bright shades. However, sample A showed distinct spirals than sample B.

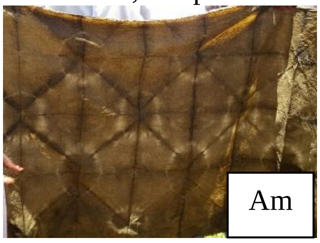

Fig. 5*: Tie-dyed with marigold flower*

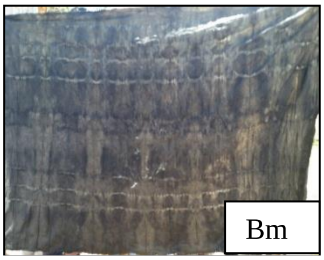

Fig. 6*: Dyed with marigold flowers*

Sample Bm was tie-dyed using sew-twisting techniques while sample Am entailed sandwiching technique; where parts tied are characterized by umbrella like shapes. As can be seen, sample Am gave intricate brighter lines than sample Bm. owing to the tightness during tying. However, for all samples dyed, the shades were dull as affirmed in natural dyeing of cotton substrates. Nonetheless cotton fabrics dyed with mukku natural dye gave brighter shades than fabrics dyed with marigold dye.

3.2. Wash fastness

Colour fastness is considered acceptably if the dye has ablity to retain or withstand colour change when washed. Fastness properties of dyed fabrics in reference to **Fig. 3 - Fig. 6**; colour change (CC) and colour staining (CS) are displayed in Table 1. For assessment, gray scale with nine gauges ranging from 1, 1/2, 2, 2/3, 3, 3/4, 4, 4/5 to 5 where 1 signifies very poor, fairly very poor, poor, fairly poor, fair, fairly good, good, very good and excellent respectively was used.

Table 1: Fastness Properties of tie-dyed Cotton Fabrics

Fastness to wash						
Particular dye and mordant	CC_1	CC_2	**Average**	CS_1	CS_2	**Average**
Dyed with muuku & copper sulphate						
1. Sample A	4	3/4	**4**	4	3/4	**4**
2. Sample B	3	4	**3/4**	4	3/4	**4**
Dyed with marigold flowers & anhydrous Iron Suilphate						
1. Sample A_m	4/5	4/5	**4/5**	4/5	4/5	**4/5**
2. Sample B_m	4/5	4	**4**	4/5	4	**4**

The fastness grade of the control fabric (fabric unmordanted) dyed with marigold dyed was 1 (very poor) for both colour staining and colour change; and 2 (poor) for control fabric dyed with muuku bark natural dye

3.2.1. Colour Staining

As can be seen from Table 1, colour staining grades ranged from good (4) signifying the lowest grade to very good (4/5) denoting the highest grade. This is ascribed to the elevated temperature of 100^0C used during the dyeing process [4]; which enhanced sorption of dye into the fabric hence through bonding with mordant formed complex coordination [10]. Sample Am tied via sandwiching technique and mordanted with Iron sulphate using marigold dye had the highest grade of 4/5. Generally all the fabrics exhibited acceptable similar fastness properties.

3.2.2. Colour Change

Wash fastness grades in Table 1 indicate that fabrics dyed with marigold flowers and muuku dye similarly exhibited acceptable fastness properties levels ranging from 3/4 (fairly good) to 4/5 (very good). This implies that, when fabrics were washed, there was a negligible change in colour. This can be ascribed to the crosslinking of hydroxyl groups of the dye molecules with cotton fabric and hydrogen bonding between dye, fabric & mordant that formed metal dye complexes. Fabrics tied via sandwiching technique and pre-mordanted with anhydrous Iron sulphate exhibited better fastness levels than those mordanted with copper sulphate.

In summary, a comparative analysis of the two mordants recomends sandwiching technique and pre-mordanting with anhydrous ferrous sulphate as the suitable mordant for dyeing cotton fabrics using marigold flower natural dye.

5. CONCLUSIONS

The purpose of this paper was to evaluate the wash fastness properties of pre-mordanted tie-dyed cotton fabrics tied using different techniques. The findings demonstrate that it's possible to tie-dye cotton fabrics with marigold flower and muuku bark natural dyes. Fabrics dyed with muuku bark natural dye gave brighter shades and distinct lines than fabrics dyed with marigold tie. The wash fastness levels of dyed cotton fabrics were acceptable ranging from fairly good (3/4) to very good (4/5). Fabrics that were first pre-mordanted with anhydrous Iron sulphate then dyed with marigold dye gave the best fastness properties ranging from 4 (good) to 4/5 (very good). Samples dyed with copper sulphate had the lowest grade of 3/4 (fairly good). The best mordant was therefore hydrous Iron sulphate. For this dyeing, binding and tying techniques of pattern designing achieved intricate line/spirals than sew-twisting and sandwiching technique. However, sandwiching technique enabled better sorption of dyes as observed by the best fastness grades. Despite this exploratory nature of the study, the results offers awareness on the opportunities of using unexploited natural dyes in tie-dyeing and hence accords us the information on attaining sustainable eco-friendly tie-dyed cotton fabrics created with low environmental impact. The study thus provide the following insights for future research: use of natural mordants, dyeing under various conditions and optimization of extractions conditions of natural dye.

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ANALYSIS OF DIFFERENT BLEND FABRIC DYEING WITH REACTIVE AND DISPERSE DYES AND EVALUATE COLOR PARAMETERS AND FASTNESS PROPERTIES

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Abstract: *The main object of this researh work is to analyze different blend fabric dyeing with reactive and disperse dyes and evaluate color parameters. In this research work Remazol reactive dye, Tricon diperse dye and four types of blended fabrics were used like as 50/50 polyester viscose blended fabric (Blend A), 65/35 Polyester Cotton s/j blended fabric (Blend B), 60/40 CVC s/j blended fabric (Blend C), and 80/20 chief value cotton (CVC) s/j blended fabric (Blend D) for dyeing with light, medium & dark shade. The different blend fabrics were dyed by batch process with the help of lab dyeing machine keeping material to liquor ratio 1:10. Spectrophotometer was used to find out the color strength and amount of dye in the fabrics before and after soap wash. Beside this washing and rubbing fastness levels of the dyed blended fabrics were investigate. It was found that, considering all the blends the k/s value and fastness properties of blend D is better for light, medium and dark shade. But if it is considered only dark shade, then k/s value of blend B is higher than all the blends.*

Key words: *blended fabrics, color strength, washing and rubbing fastness, Spectrophotometer, cotton and polyester dyeing.*

1. INTRODUCTION

The dyeing of the polyester and cotton, polyester and viscose blend fabric has becomes a challenge to the modern textile industries due to its variation in color value, shade depth, tensile strength and surface residual weight loss. These blends are famous due to their aesthetic value and user friendly performance [1]. Blended is the sequence of processes required to convert two or more kind of staple fibers into a single yarn or two or more kind of yarn into a fabric composed of an intimate mixture of the component fiber or fabric [2, 3]. Cotton fabrics are known to have been in use at least for 7000 years. This dominance of cotton fiber is mainly due to its natural comfort, performance, and appearance [4]. In recent years, the cotton/polyester blends are considered as the most widely used fabrics [5]. Polyester fibers have a hydrophobic character, and swell to a very small extent in the water bath. Hence the penetration of the dyestuff molecules inside the fibers would be very difficult [6]. Owing to this phenomenon, the dyestuff molecules first absorbed on the fiber surface may diffuse into the fiber interior. Subsequently, the bonding interactions between the dyestuff & cellulose may be formed [7].

Four fabric structures were dyed with three different shade % by Remazol reactive dye and Tricon disperse dye. Finally, spectrophotometer was used to find out the color strength and amount of dye present in the dyed samples. Color fastness to wash [8], color fastness to rubbing [9] for all dyed fabrics were determined. Samples dyeing with the Remazol & Tricon showed superior rubbing fastness & wash fastness with a standard color yield. Here Blend D fabric shows better depth of shade in reactive dyeing for all shades and all blended fabric structures.

2. EXPERIMENTAL METHODOLOGY

2.1 Materials and Reagents.

To complete this research work four types of blended fabrics were used like as 50/50 polyester viscose blended fabric (Blend A), 65/35 PC s/j blended fabric (Blend B), 60/40 CVC s/j blended fabric (Blend C), and 80/20 CVC s/j blended fabric (Blend D). Dyes used for polyester part dyeing included Tricon yellow Br.SP-3RT, Tricon red-SP-2RT and Tricon blue-EACT. Also dyes used for cotton part dyeing included Ana: yellow-3RS, Ana: Red-3BS and Remazol blue RR. Other chemicals Salt, Soda, Wetting agent and Sequestering agent were used. Some instrument i.e Electric balance, Scissor, Sample dyeing machine, hot wash machine, Pipette, Dryer and Spectrophotometer with color match software were used to complete this research work.

2.2. Collection of materilas.

All the fabrics (5gm of each fabric), dyes, chemicals and auxiliaries were collected from the Trust knitwear LTD, Gazipur, Bangladesh.

2.3. Preparation of Sample and stock solution:

In this research work blended fabrics were prepared according to standard from Trust Knitwear Industries Ltd. Also 0.5% stock solution of Remazol red, yellow, and blue was prepared.

2.4. Analytical Procedures:

2.4.1. Procedure for dyeing

The different blend fabric were dyed by batch process with the help of lab dyeing machine keeping material to liquor ratio 1:10 for the mentioned shade percentage in the table -1 and table 2. During dyeing standard method were followed as per prescribes by the manufacturers. At first, marked 12(4X3) dyeing pot for the 4 samples and 3 shade. As this research is on the blend fabric i.e fabric composition is polyester and cotton or viscose. At first polyester part is dyed according to the recipe mentioned in the table 1 and then cotton or viscose part is dyed according to the recipe mentioned in the table 2. After dyeing the samples were treated as washing, neutralized and drying sequencially.

Table 1: *Recipe using for blended fabric dyeing (polyester part)*

Dyes and chemicals	**Light shade**	**Medium Shade**	**Dark Shade**
Tricon yellow SP.RST	0.1%	0.4%	1.0%
Tricon Red SP.2RT	0.2%	0.66%	1.74%
Tricon blue EACT	0.001%	0.0024%	0.0046%
Dispersing agent	2g/L	2 g/L	2 g/L
Acetic acid, Wetting agent, Sequestering agent, Anti-creasing agent and Leveling agent were used 1g/L. material to liquor ratio = 1 :10; temperature: 120^{0}C, Time 40 minutes and fabric weight 5 gm (these parameters were used for three shades).			

Table 2: *Recipe using for blended fabric dyeing (cotton part)*

Dyes and chemicals	**Light shade**	**Medium Shade**	**Dark Shade**
Ana: yellow 3RS	0.1%	0.3%	0.9%
Ana: Red 3BS	0.2%	0.88%	1.8%
Remzol blue RR	0.001%	0.002%	0.0024%
Glauber salt	20g/L	30 g/L	50 g/L
Soda ash	5g/L	8 g/L	12 g/L
Wetting agent, Sequestering agent, Anti-creasing agent and Leveling agent were used 1g/L. material to liquor ratio = 1 :10; temperature: 80^{0}C, Time 60 minutes and fabric weight 5 gm (these parameters were used for three shades).			

2.4.2. Measurement of color strength (K/S)

To determine the color strength spectrophotometer (Data-color International SF 600 plus, D65) was used. The color strength (K/S) and CIELAB values of dyed cotton and polyester samples were measured at the respective wavelength.

2.4.3. Determination of amount of hue at dyed sample:

Spectrophotometer was also used to determine the amount of hue present in the dyed sample as well as also evaluate the dye loss% for different blend fabric for different shade%.

2.4.4. Measurement of Color Fastness to wash:

According to the ISO standards ISO105-C10:2006 method [10] was followed for wash fastness test. A specimen of 10 × 4cm was attached with a multifiber fabric strip. The change in color and degree of staining was evaluated visually using geometric grey scale.

2.4.5. Measurement of Color Fastness to rubbing:

Color Fastness to Rubbing ISO standards ISO105-X12:2001[9] method was followed for rubbing fastness test. Finally removed the rubbing cloth and color transfer was evaluated by using grey scale for staining

3. RESULTS AND DISCUSSION

Spectrophotometer was used to determine the color strength and amount of hue of different blend fabrics individually. The effects of color strength, amount of hue and fastness properties on different blend fabrics for diferent shade% are discussed below sequentially.

3.1. Effect of different blend and shade% on k/s value

Effects of different blend and shade% on k/s value are shown in the Table 3 and Fig.1. Here k/s values of four types of blend fabrics are compared for Light, Medium and Dark shade. In case of blend A and blend B, the k/s value of blend B is better. Considering all the blends the k/s value of blend D is better for light, medium and dark shade. But if it is considered only dark shade, then k/s value of blend B is higher than all the blends.

Table 3: *Effect of k/s value on different blend and shade%*

Fabric structure	**K/S Value**		
	Light	**Medium**	**Dark**
Blend A	3.19	5.16	15.65
Blend B	3.92	5.99	21.75
Blend C	2.59	5.75	19.07
Blend D	4.16	6.43	19.93

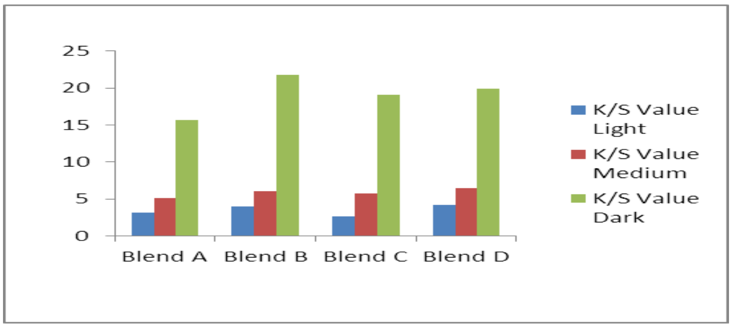

Fig. 1: *Effect of k/s value on different blend and shade%*

3.2. Effect of different blend and shade% on amount of hue at dyed sample

Table 4 described the Effect of different blend and shade% on amount of hue at dyed sample. Amount of hue at dyed fabric was taken before wash and after wash. Amount of hue absorbed by the fabrics and hue loss are described for individual blends and shade% in the table 4.

Table 4: *Effect of different blend and shade% on amount of hue at dyed sample*

Shade %	Fabric structure	Hue	Amount	Hue at fabric		Hue loss	
				Before wash	After wash	Before wash	After wash
Light	Blend A	Y	0.1	0.09	0.07	0.01	0.03
		R	0.2	0.080	0.078	0.12	0.122
		B	0.001	0.0005	0.0002	0.0005	0.0008
	Blend B	Y	0.1	0.075	0.023	0.025	0.077
		R	0.2	0.194	0.188	0.006	0.012
		B	0.001	0.0008	0.0006	0.0002	0.0004
	Blend C	Y	0.1	0.073	0.017	0.027	0.083
		R	0.2	0.17	0.17	0.03	0.03
		B	0.001	0.0004	0.0003	0.0006	0.0007
	Blend D	Y	0.1	0.0549	0.0545	0.0451	0.0455
		R	0.2	0.1677	0.1665	0.0323	0.0335
		B	0.001	0.0007	0.0005	0.0003	0.0005
Medium	Blend A	Y	0.3	0.087	0.054	0.213	0.246
		R	0.88	0.130	0.284	0.75	0.596
		B	0.002	0.0009	0.0004	0.0011	0.0016
	Blend B	Y	0.3	0.125	0.099	0.175	0.201
		R	0.88	0.713	0.158	0.167	0.722
		B	0.002			0.002	0.002
	Blend C	Y	0.3	0.0553	0.052	0.2447	0.248
		R	0.88	0.832	0.79	0.048	0.09
		B	0.002	0.0018	0.0015	0.0002	0.0005
	Blend D	Y	0.3	0.213	0.190	0.087	0.11
		R	0.88	0.705	0.639	0.175	0.241
		B	0.002	0.0009	0.0005	0.0011	0.0015
	Blend A	Y	0.9	0.834	0.402	0.066	0.498
		R	1.8	1.36	1.221	0.44	0.579
		B	0.0024	0.0016	0.0014	0.0008	0.001
	Blend B	Y	0.9	0.45	0.24	0.45	0.66
		R	1.8	1.37	1.27	0.43	0.53

Dark		B	0.0024	0.0007	0.0015	0.0017	0.0009
	Blend C	Y	0.9	0.624	0.59	0.276	0.31
		R	1.8	1.607	1.26	0.193	0.54
		B	0.0024	0.0020	0.0017	0.0004	0.0007
	Blend D	Y	0.9	0.785	0.6899	0.115	0.2101
		R	1.8	1.5627	1.5199	0.2373	0.2801
		B	0.0024			0.0024	0.0024
Y= **Ana: yellow 3RS, R= Ana: Red 3BS, B= Remzol blue RR**							

3.3. Effect of different blend and shade% on wash fastness

Effect of different blend and shade% on wash fastness are shown in the table 5. In case of light shade it was observed that, Blend A, Blend B, Blend C and Blend D all fabrics are good to excellent washing fastness range 4 to 5. Considering the dark shade it was observed that, Blend C and Blend D has good to excellent washing fastness range 4 to 5, Only Blend A and Blend B fabric gives wash fastness range 3 to 4 and 2 to 3.

Table 5. *Colour fastness to wash for different type of blended fabrics*

Fabric structure	Shade%	Color staining						Color change
		acetate	cotton	polyamide	polyester	acrylic	wool	
Blended A	Light	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Medium	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Dark	3/4	4/5	4/5	4/5	4/5	4/5	3/4
Blended B	Light	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Medium	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Dark	4/5	2/3	4/5	4/5	4/5	4/5	2/3
Blended C	Light	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Medium	4/5	4	4/5	4/5	4/5	4/5	4
	Dark	4/5	4	4/5	4/5	4/5	4/5	4
Blended D	Light	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Medium	4/5	4/5	4/5	4/5	4/5	4/5	4/5
	Dark	4/5	3/4	4/5	4/5	4/5	4/5	3/4

3.4. Effect of blends and shade% on rubbing fastness

Table 6 and Fig. 2 described the effect of blends and shade% on rubbing fastness. It was found common for the entire shade% and blends wet rubbing fastness rating is lower than dry rubbing rating. Among the entire shade%, dark shade is very good to excellent for dry rubbing. Besides this considering different blends, Blend D showed better rubbing fatsness for both dry and wet condition in compare to other blends.

Table 6. *Effect of blends and shade% on rubbing fastness*

Shade %	**Blend A**		**Blend B**		**Blend C**		**Blend D**	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Light	4/5	3	4/5	3/4	4/5	3	4/5	3/4
Medium	4	2/3	4	3	4	3	4/5	3
Dark	4	2	4/5	2	4/5	2/3	4	3/4

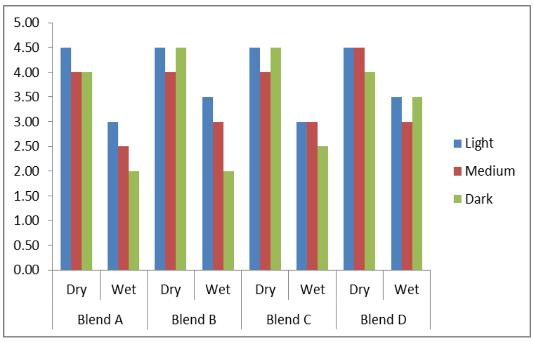

Fig. 2: *Effect of blends and shade% on rubbing fastnes*

4.CONCLUSION

This study was planned to compare the color strength between four types of blend fabrics as well as to check the fastness properties among blend fabrics with different composition. In this research work it was found that, with the increment of shade%, color fastness properties are affected for different blend fabric structures. Again it was also observed with the increment of shade % of cotton-viscose blend fabric a considerable change on color strength was found for different fabric structures. It is also concluded that, Blend D (80/20 chief value cotton (CVC) s/j blended fabric) is better than other three blend fabrics. Here Blend D fabric shows better depth of shade in reactive dyeing for all shades and all blended fabric structures.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ERASMUS+ PROJECT TEXMODA – AN ADVANCED TEXTILE COURSE AT YOUR FINGERTIPS

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Abstract: *The aim of the project TEXMODA is to develop a massive open on-line course (MOOC) on Novel Technologies for the textile, apparel and fashion industries. The target audiences are students and recent graduates of higher education and post-secondary VET institutes that attend or have attended related study fields (clothing and textile industry, fashion) and employees of SME's working in textile and fashion industry. At the level of learning content, the TEXMODA aims to develop a European competence profile on Novel Technologies for textile and fashion industry and a training course based on this competence profile. The project brings together five Universities, two business associations and a consulting company from five EU countries, all of them with experience in different aspects of textile / clothing / fashion industry. The synthesis of the partnership combines academic expertise and institutional capacity to mainstream results, incorporating the new course into the Universities' curricula and the flexibility and effectiveness of the private non-for profit and profit sectors.*
In this paper, a special attention will be focused in the module digital fashion design which provides a holistic approach for those who wish to learn moore about all the steps involved in the development of a collection.

Key words: *Erasmus+; Texmoda; MOOC; CAD, Digital Fashion Design;*

1. INTRODUCTION

TEXMODA is a European funded initiative that develops a European competence profile on Advanced Technologies for Textile and Fashion Industry, a training course (Curriculum and Learning material) based on this competence profile and a train the trainer course.

The training is addressed to students and recent graduates of higher education and post-secondary VET institutes that attend or have attended related study fields (clothing and textile industry, fashion) and employees of SMEs working in textile and fashion industry.

Eight partners are cooperating in this project, each of them specialist in a different field: four universities, one training and consulting center, one higher education school specialized in Fibre Science and Technology, one Apparel and Textile association, and one Clothing Industry association.

This project involves the participation of 8 partners, as follows:

- KTU - Kaunas University of Technology, from Lithuania;
- UNIWA - University of Western Attica, from Greece
- IDEC - a consulting company, from Greece
- UBI - University of Beira Interior, from Portugal
- UPV - University Polytechnic of Valencia, from Spain
- ENSAIT - Ecole Nationale Superieure Arts Industries Textiles, from France –

- LATIA - Lithuanian Apparel and Textile Industry Association, from Lithuania
- HCIA - Hellenic Clothing Industry Association, from Greece

The MOOC is constituted by video-lessons that cover all cutting-edge textile themes as seen in figure 1.

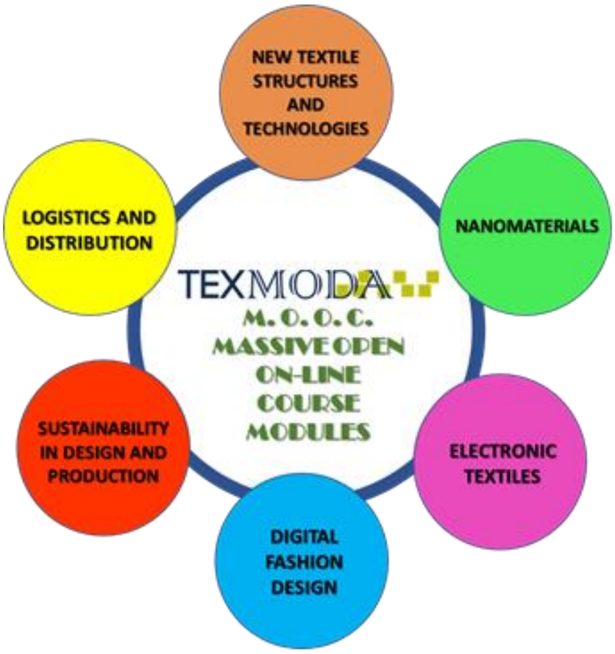

Fig. 1: MOOC modules

A brief description of each module is presented in table 1.

Table 1 - Constitutive modules of the MOOC

MODULE	DESCRIPTION
New textile structures and technologies	This module comprises a one-week course lecturing innovative and high performance fibres and yarns for the textile and fashion industry. Woven and knitted structures are also tackled.
Nanotechnology	The nanomaterials module is constituted by a one-week course addressing the importance of nowadays textile nanotechnology and their applications in all of their possible dimensions. Some case studies are also presented.
Electronic textiles	This two-weeks course starts with the basic definition within this field and includes a comprehensive review on all the major components of an electrotextile system. Some reliability and washability standards are also tackled.
Digital fashion design	This two-weeks course encompasses a detailed review on research and trend analysis for the development of a collection. A mini-collection

	development is to be simulated through the aid of CADs.
Sustainability in design and production	This module comprehends a one-week course involving a thorough explanation of the major concepts in sustainability, environmental management systems and their legal framework. Some financial and social aspects are also addressed.
Logistics and distribution	This one-week course deals with the major concepts revolving around the logistics, supply chain, inventories and all the legal and regulatory aspects related to them. An in-depth analysis of the global nature of the logistic and innovative approaches in logistics and distribution is also provided.

2. DIGITAL FASHION DESIGN MODULE

This module provides a holistic approach of all the steps involved in the development of a collection. It is particularly focused on the support provided by the utmost advanced tools and technologies available for designer´s in their respective working fields.

For this purpose, a two weeks course was designed, and six video lessons prepared. Each one of them is comprised by three units oriented for a specific goal and, in the overall, covering all the main issues of the textile design process.

As a mere example, a more detailed decription of the module digital fashion design is given in table 2.

Table 2: Syllabus of the module digital fashion design

UNIT	LESSON	SYLLABUS
Research and trend analysis in fashion design	Fashion design	This section entails the explanation of concepts such as design, design process and design methodology. Role and responsibilities of a fashion designer[1]. Collections and their influences. Theme and directions for collections: primary and secondary sources. Definition and interpretation of a capsule collection. Examples of contemporary designers.
	Collection development	Creative development: Concepts and themes. Lifestyle and definition of the Ideal customer. Trends and trends forecasting. Materials, colours, shapes and textures research. Design development: fashion drawing and illustration. Presentation boards: mood board, concept board, colour board, flats board and illustration board. Manufacturing and Technical specifications. Details, trims and fashion accessories.

	Market analysis	This video revolves around the operation of the fashion industry: fashion business and fashion globalization. Development mass-marketed collections: fast fashion and ready-to-wear. Luxury brands. Atelier and haute couture. Consumer profiling and customer identification. Costs: benchmarking and competitor's analysis. Brief notions of fashion marketing. Label and private label
Development of a capsule collection	Creative process-ideas	The development of a fashion collection involves more than creativity. Designers also need to stay on top of trends focusing on improving and expending the communication of new product ideas' - that means building mood boards with images, fonts, colors, textures and all types of visual data to showcase the style of the project and the feeling that the designer is aiming for.
	Colors, Materials and Textures	Selection of colors, materials and textures is the most important step in developing cohesive collections[2]. The final objective is to translate ideas into colors, fabrics and textures within the researched trends. The consumer´s satisfaction and, ultimately, a desire to buy are also key-issues to be considered.
	Shapes and proportions	It´s time for ideas to shape up. Here the fashion designer represents in paper and with digital fashion illustration a more correct approximation of final product,
Development and simulation of a mini-collection of fabrics	Fashion Design education and training	This section provides an overview of digital tools for textile and apparel product development. Marketed CAD solutions. Use of CAD systems in teaching environments. Description of different approaches to teaching computer-aided design to fashion and textile students. Pros and cons of each methodology. Assessment of the efficacy of teaching and learning with CAD.
	Context for weaved fabric design	Generic description of weaved fabric systems. Key factors in the use of CAD for woven textile design. Influence of the defining parameters: raw-materials, yarns and colors. Basic textile weave designs. The design process for textiles: Aesthetic and engineering design. Product development with CAD.
	Practical design applications	Based upon the developed capsule collection a few practical design applications with Kaledo Weave will be demonstrated.

Development and simulation of a mini-collection of knits	Fashion Design education and training	This section goes on the key issues affecting the design and the designer when developing a knit collection. Computer technology from a designer perspective. Technological influences on the creative process of knitwear design. Sustainable knitwear.
	Context for knitted fabric design	A brief history of knitted textiles. Generic description of knitted fabric systems. Relevance of raw-materials, yarns and colors in the knitting design process. Knitting fundamentals and some basic stitches and structures. Comparative study between fabrics and knits. Potential of CAD systems in the knitwear design. The state of CAD systems technology for knitwear[4].
	Practical design applications	Based upon the developed capsule collection a few practical design applications with Kaledo knit will be demonstrated.
Development and simulation of a mini-collection of prints	Fashion Design education and training	Main computer technologies in textile design: the computer as a designing, editing and presentation tool. Role of computer technology in the printing design.
	Context for knitted fabric design	Generic description of printed fabric systems. Importance of raw-materials, yarns, colors and motifs in the printing design process. Fundamentals of analog and digital printing.
	Practical design applications	This section expands on patterning development for analog and/or digital printing[5]. Processes of color research and shapes based upon the theme and concept of the collection, as well as the colors suggested by trend-setting platforms. Creation of a first draft of printing concepts for the capsule collection. Selection of the final idea and development of practical examples resorting to Kaledo Print. Testing and digital printing of the selected examples.
Fashion communication	Portfolio	Definition of portfolio. Portfolio production techniques. The importance of a portfolio in the designer´s career. Presenting and diffusing the designer´s work[6].
	Fashion promotion	Fashion communication on the Internet. Fashion websites and fashion dissemination through social networks. Fashion videos production. Live fashion shows. Fashion communication in the media: editorials and advertising.
	Fashion show	Production of look books. Styling and styling shoot. Catwalk presentations. Fashion communication issues: models, music, hair, make-

		up, show producer, ticketing and promotion. Budget and scale in fashion promotion.

3.CONCLUSIONS

The development of this MOOC has started with a multicentric inquire within both academic and industrial world. This inquire was carried out by the participants institutions and permitted the identification and targeting of the main concerns regarding innovative teaching and learning methodologies and, particularly, crucial areas of knowledge to be addressed.

The overall analysis of the conducted survey has shown that lifelong learning is of paramount importance for all the survey respondents. The most cited fields of knowledge by the industry respondents were protective textiles, sport and active leisure clothing, and fashionable smart clothing whereas academician put the focus on transport textules, and aerospace textiles and in sport and active leisure clothing.

Therefore, the implementation and use of open courses, oriented for the specific needs of the targeted audience, are powerful tools that can enhance the qualification of the personnel and contribute to improve the productivity and quality within their jobs.

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ANNALS OF THE UNIVERSITY OF ORADEA
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THE ELECTRICAL AND PHYSICAL EFFECTS OF YARNS CONTAINING METAL WIRE ON KNITTED FABRIC

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Abstract: *The textile industry is developed with the proliferation of technological developments and the functionalization of products about conductive textile structures day by day. Many applications could be seen including metal yarns and knitted or woven fabrics containing metal wire. This paper reported analyze that fabrication method, physical, electrical and electromagnetic shielding (EMSE) properties for knitted fabrics with single and double folded yarn, which has stainless steel wire. Polyester /Stainless steel wire (80/20) yarns were used in single (Nm 50/1) and double (Nm 50/2) folded structure. These yarns were produced as single jersey knitted fabric in sock machine. The fabric structures were formed by using conductive yarns containing metal wires as upper yarn, 70/20 denier lycra white yarn as lower yarn. The physical properties including tensile, twist, and evenness of metal yarns were analyzed. The properties such as pilling, abrasion, conductivity, EMSE of single jersey knitted fabrics were measured. Knitted fabric with double folded yarns was better pilling, abrasion, EMSE, surface, and volume resistivity values compared to fabric containing single folded yarns. The density of metal yarn in knitted fabrics was directly effective on the pilling, abrasion, conductivity and EMSE results. Knitted fabric with double folded yarns was appropriate to structure for using in EMSE applications and electronic textiles.*

Key words: *Metal Yarn, Stainless Steel Wire, Conductivity, Electromagnetic Shielding Effectiveness*

1. INTRODUCTION

In recent years, conductive textile structures have been shown in a lot of applications such as industry, military, space, medicine, protection, communication, or automation. Some researchers, in previous studies, [1-6] manufactured and analyzed metal yarns and knitted or woven fabrics containing metal wire because of using in conductivity or electromagnetic shielding effectiveness (EMSE) areas. These studies show that yarns and knitted containing metal wire for using in conductive textiles have a great potential to develop in both scientific and industrial research areas.

The first primary objective of this research was produced knitted fabric composed of yarn containing stainless steel wire. The second objective of the research was analyzed some properties of metal yarns and physical, conductivity and EMSE properties for knitted fabrics with single and double folded yarn. A1 (Nm50/2), which is double folded yarn, and B1 (Nm 50/1), which is single folded yarn, were used as upper yarn and 70/20 denier lycra white yarn as lower yarn. The data obtained from the measurements are evaluated with the fabric structures and their relations with each other. The results were expected to guide for applying optimum metal fabric properties for using conductive textiles.

2. MATERIAL AND METHOD

2.1. Manufacturing of Knitted Fabrics

In the experimental part, polyester conductive yarns containing Nm50/2 (A) and Nm 50/1 (B) stainless steel wire were used in fabric production. The numbers and electrical conductivity values of the conductive composite yarns are given in Table 1. For the production of single jersey knitted fabrics, the fabric surface was formed by using conductive yarns containing metal wires as upper yarn, 70/20 denier lycra white yarn as lower yarn. The fabric surfaces were produced by 168 needle-punched, LT610 classic sock machine of Weihuan brand. Two types of fabric were produced by changing the frequency settings of the machine (Table 2).

Table 1. *Properties of Conductive Yarns*

Composition of Yarns	Yarn Count		Electrical Conductivity*
	Nm	Dtex	
Stainless Steel/Polyester	50/1	200	40Ω/cm (±20%)
Stainless Steel/Polyester	50/2	400	20Ω/cm (±20%)

*Measured distance between electrodes = 5 cm

Table 2. *Properties of Single Jersey Knitted Fabrics*

Fabric Code	Yarn Number (Nm)	Weft Density (threads/cm)	Knitted Gauge * (°)
A1	50/2	17	0
B1	50/1	17	0,5

* Angle between platinum and needle

2.2. Measurements of Metal Yarns

The Tensile Strength of metal yarns was measured with Instron 4411 Tensile Strength Tester, Table Model (Metric) TM-M. The distance between the jaws was 10cm/min. Tenacity at Maximum load (cN/tex) is tensile strength of the yarn during breaking with the yarn pulling of the lower jaw. Elongation (%) is ratio of the first length of the yarn amount of elongation until the yarn breaking. Measurement of these values gives information about yarn strength.

The physical movement that allows the fiber to be joined is called a twist. The twisting tightens the fibers and provides a more adhering surface, preventing them from slipping over each other and providing yarn production. The number of yarn twists was measured by JAMES H. Heal& Co Twist tester according to TS 245 standard.

For subjective eveness method, the yarns were wrapped in a smooth and parallel manner on a black sheet. Standard photos were taken under appropriate light to obtain information about the yarn. Errors on thread periodic fluctuations and deformations were evaluated to the grade scale (A is better & D is worst) by ASTM Spun Yarn Appearance Standards.

2.3. Measurements of Knitted Fabrics

Abrasion (ASTM 4966) and pilling resistance (ASTM D4970) measurements of fabrics were evaluated with a Nu- Martindale Pilling and Abrasion Tester. Pilling resistance grades were interpreted according to EMPA Standard, SN 198525, K1 (1 is being poor & 5 is being excellent).

Conductivity measurements were performed on the knitted fabrics by using Keithley 6517A Electrometer High Resistance Meter instrument according to standard ASTM D257. Surface resistivity (ρs, ohm), Volume resistivity (ρv, ohm.cm) and Conductivity (σ, 1/ohm.cm) can be expressed as the following equations: [7]

$$\rho_v = R(\Omega) \times RCF \times t(cm) \quad (1)$$
$$\rho_s = R(\Omega) \times RCF \quad (2)$$
$$\sigma = 1/\rho_v \quad (3)$$

RCF (resistivity correction factor of the fabrics) is 53, 4 V and t (cm) is expressed that fabric thickness.

EMSE values are evaluated by general using such as casual wear, uniforms, and consumer electronic products in Table 2 [8]. EMSE (decibel, dB) of fabrics was measured by Electro-Metrics, Inc., model EM-2107A with ASTM D 4935-10 coaxial transmission line standard method ZVL Network Analyzer instrument between 0 and 3000 MHz.

Table 2: *Shielding Effectiveness (SE) Values of General Use*

Grading	Excellent	Very Good	Good	Moderate	Fair
Range	SE＞30 dB	30 dB≧SE ＞20 dB	20 dB≧SE ＞10 dB	10 dB≧SE ＞7 dB	7 dB≧SE ＞5 dB

The surface a views of metal yarns and knitted fabrics were obtained by using stereo microscopy. Metal yarns were viewed with 40 x magnification and knitted fabrics were as viewed front and back surface.

3. RESULTS AND DISCUSION

3.1. Metal Yarn Results

Metal yarn structures were viewed by stereo microscopy (see in Figure 1).The stainless steel wire was wrapped and seen clearly into the yarns.

Fig. 1: *Image of A1 and B1 yarns*

Table 3. *Tensile Properties of Metal Yarns*

Yarn Codes	Maximum Load (cN)	Elongation (%)	Tenacity at Maximum Load (cN/tex)	Extension at Maximum Load (mm)
A1	1142,90	12,81	29,11	32,01
B1	503,30	12,28	25,57	30,69

Tensile test results show that (in Table 3), in both yarn types, increasing yarn count or thinning of yarn was affected by decreasing strength and elongation (tensile strain at maximum load). The number of fiber and the amount of metal wire in yarn cross-section decreased with yarn thinning. In this case, fiber/ fiber and fiber / metal wire frictions, which directly affect strength and elongation, were reduced.

Table 4. *Twist and Evenness Properties of Yarns*

Yarn Codes	Yarn Twist Amount (T/m)	Evenness (grade scale)
A1	Z754,36	B
B1	S293,8	B

Increasing of the twist coefficient had increased tensile strength and elongation values because fibers and metal wires were better wrapped on each other. Increasing the twist is expected the result to increase the strength and elongation values.

Periodic fluctuations and deformations on the black plate were not numerous and neps in several places. According to this result, it was concluded that there is irregularity at the B level. B is stated in small quantities evenness for grade scale.

4.2. Knitted Fabric Results

Surface morphology of knitted fabrics were viewed by stereo microscopy (see in Figure 2). The A1 fabric, which is thicker with double folded yarn, was seen more frequent structure in fabric surface.

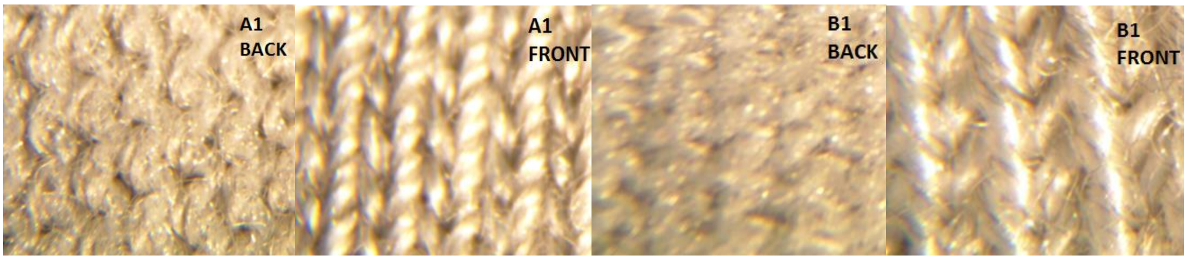

Fig 2: *Back and front of A1 and B1 Fabric Surfaces*

Table 5. *Pilling Grades of Knitted Fabrics*

Fabric Codes	Grades*
A1	1
B1	2

** According to EMPA Standard SN 198525, K1*

Pilling is due to the effect of friction forces on the fabric surface of the fiber ends and thus disrupts the fabric image. Almost every stage of textile production has an effect on pilling. The properties of the fiber used as raw materials, yarn properties, fabric properties and finally applied finishing processes are effective on pilling [9]. According to Table 5, A1 fabric, which is knitted with double folded yarn, has higher pilling resistance compared to B1 because of high cohesion force of fabric.

Table 6. *Abrasion Resistance Results of Knitted Fabrics*

Fabric Codes	Speed*
A1	175216
B1	195216

**Number of Revolutions at the time of Breaking*

The number of revolutions at the time of breaking of a loop in fabrics was measured. Yarns with high twist level is abraded less than yarns with low twist level [10]. Since the A1 yarn has a higher twist, it has been observed that the abrasion on the fabric surface is less than the B1 fabric (see in Table 6).

Table 7. *Conductivity Results of Fabrics*

Fabric Codes	**Thickness (cm)**	**Surface resistivity (ρs, ohm)**	**Volume resistivity (ρv, ohm.cm)**	**Conductivity (σ, 1/ohm.cm)**
A1	0,124	5,19582E+05	6,44281E+03	1,5521E-04
B1	0,119	2,2161E+04	2,63715E+03	0,3792E-03

Electric resistivity (ρ) is a measurement of the difficulty of wire against electric current. The low resistance indicates that the movement of the electric current is easily permissible [11]. Electric current flow is inversely correlated with the electrical volume resistivity and surface resistivity. Table 7 shows that B1 had higher conductivity results and lower surface and volume resistivity. Use of double folded yarn in the fabric increased surface and volume resistivity.

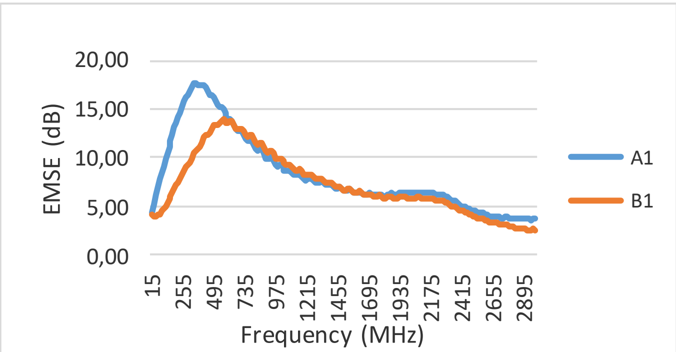

Fig.3: *EM Shielding Effectiveness of Fabrics*

The figure 3 showed that the best shielding and EMSE measurement results in fabrics the frequency ranges of 330-435MHz in A1 and 495-660MHz in B1. All of the fabrics had moderate grades for shielding effectiveness (dB) and the percentage of electromagnetic shielding (%).

EMSE values will increase by increasing the amount of stainless steel in the unit area per fabric [12]. The fabric, which was thinner with single folded yarn, displayed lower EMSE values as compared to double folded yarn. It was thought that this situation is due to the high density of wire in the double layer fabric.

5. CONCLUSION

In this study, polyester/stainless steel wire-based knitted fabrics with single and double folded yarns were successfully manufactured. It was seen to effects on pilling, abrasion, conductivity and EMSE of the fabric structure. Knitted fabric with double folded yarn (A1) has better pilling and abrasion resistance to B1 because of high cohesion force of fabric and high twist in A1 metal yarn. B1 fabric has a lower surface and volume resistivity because of low resistance electric current. A1 fabric displays better EMSE values because of the high density of wire structure. Amount of metal yarn in knitted fabrics was effective on the pilling, abrasion, conductivity and EMSE results.

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AN INVESTIGATION ABOUT BEHAVIOR ON THE WEAR PERFORMANCE OF MATTRESS FABRICS

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Abstract: *In this experimental study, it is investigated, comparatively, the effect on abrasion resistance of the presence of different type of yarns in the structure of knitted fabrics, used for mattress covers. The most significant problem is abrasion wear, which reduce the product 's life and quantify the fabric's durability under repetitive friction.*

Complex knits, with various fibrous compositions, and different masses, were subjected to rubbing wear, tested on the NU-Martindale device, then the samples were microscopically evaluated. The results demonstrated the influence of raw material and the number of friction cycles until the material fails. The polyester and viscose textile support showed the highest friction wear resistance. There were presented: the samples subjected to tests, the decrease of the abrasion resistance after the friction tests, the microscopic aspects and the mass loss of the degraded samples.

Future studies will also investigate other physico-mechanical characteristics of these types of products with the most demanding requirements that offer high durability and performance.

Key words: *knitwear, abrasion resistance, yarns, Martindale test, mass loss*

1. INTRODUCTION

Materials used as mattress coverings must either be compatible in structure and composition, but also provide performance features that maintain a long-lasting, pleasant, and easy-to-use look. The ability of the mattress packaging is just as important as its performance and essential in improving the quality of sleep. From previous author studies, these double knits can better meet the comfort and aesthetics of these relatively little studied flexible textiles. Abrasion wear is the modification of the surface and structure of a fabric abrasion by shifting the position of the yarns in the abrasion process. This property can be influenced/affect by many factors/parameters such as fiber composition, fiber fineness and fiber length, stitch length, yarn type, yarn count, knit structure etc., of a knittwear fabric [1].

From the literature, making a parallel to terry towels and mattress coverings made industrially by the same knitting technology, it was found that fibrous composition and fiber type significantly influences abrasion resistance. Thus, it was found that bamboo yarn was higher resistant than that of cotton yarn towels with many cycles of abrasion [2].

In the literature, the fiber composition, the type of fibers significantly influences the resistances. Thus, simple single jersey structures were investigated, and it results that fabrics made of 100% cotton yarn had better pilling performance than mixed yarns, but the abrasion resistance was the smallest. Polyester is generally considered to have the best abrasion resistance, but it is also demonstrated that polyester-cotton combinations appear to present the best abrasion resistance [3].

Other research has shown the effect of using carded and combed yarns on friction wear of circular knits, concluding that there are small minor differences in the abrasion test and more to the pilling [4].

Detailed studies were also carried out with compact yarns and conventional yarns in knitted fabrics [5], with different raw materials, especially bamboo and cotton in raschel fabrics and knits [6].

Resistance to abrasion and pilling is therefore a major concern for both, customers and manufacturers for whom the diversification of low-volume household textiles remains a topical issue. We appreciate the importance of industrial technologies in textile firms where the realization of the quality of these materials is an important factor [7].

Many studies have investigated the effect of pilling and abrasion on various types of knitwear, but for composite knitted fabrics used as double-sided coverings and filling structures there are almost nonexistent. As a result, the authors have proposed to analyze these types of successfully used knitwear for mattress coverings.

2. EXPERIMENTAL PART

In this experimental study, the abrasion resistance properties of knits, were investigated according to the type of raw material. Four types of knitted samples, with different compositions, shown in Table 1, were investigated.

Table1: *Characteristics of tested knitted fabrics*

Knitted fabric code	Type of yarn	Linear density (tex)	Content of the yarn in the knitted fabric (%)	Mass per unit area (g/m^2)
F1	Cotton PES PES-filler yarn	24 16,6 133,3	36,05 29,3 34,65	260
F2	70%viscose+30%wool PES PES-filler yarn	20 16,6 133,3	44 16,1 39,9	320
F3	50%PES+50%viscose PES PES-filler yarn	20 16,6 133,3	50,43 29,51 20,06	254
F4	70%bamboo+30%viscose PES PES-filler yarn	20 16,6 133,3	68,17 15,63 16,2	260

The knits were tested with the Nu-Martindale Model 864 equipment for friction wear resistance. The wear resistance of the samples was evaluated after 5 different friction cycles: 1.000, 3000,5000,12000,15000.

Abrasion resistance of mattress coverings by the Martindale method was achieved in accordance with: SR EN ISO 12947-1: 2008, Textiles-Determination of the abrasion resistance of fabrics by the Martindale method Part 1: Martindale abrasion testing.

The evaluation of abrasion resistance of knits is determined by controlling the deterioration of specimens, microscopic aspect, and mass loss. The mass loss through abrasion is checked at the digital analytical balance and is related to the initial weight of the samples.

3. RESULTS AND DISCUSSION

The partial results obtained from the test, gradual degradation of samples and the intervals at which the samples were evaluated, are shown in Table 2.

Table2: *Partial results, degradation of samples and evaluation interval*

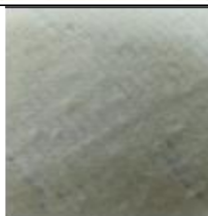
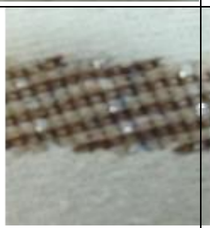
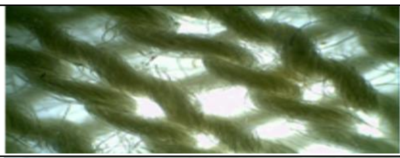
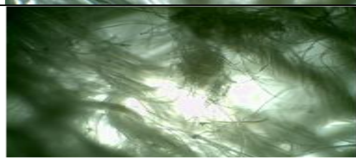
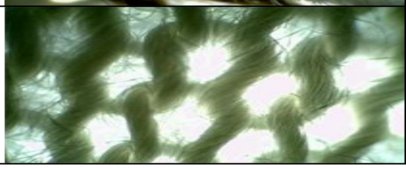
Knitted fabric / Number of cycles	1000	3000	5000	12000	15000
F1					
F2					
F3					
F4					

Table 3 shows the results after the final number of rubbing cycles, for each test sample. Samples appearance is highlighted by comparing samples before and after testing. For more pictures the Optika digital camera microscope was used, capturing pictures directly on the computer. In the captured images we can see the breaking of the yarns in the most used areas.

Table3: *The microscopic appearance of the knitwear samples following the influence of the number of abrasion cycles*

Knitted sample	The number of cycles after the specimen deteriorates	Sample before the test	Sample after the test
F1	14166		
F2	18483		
F3	22300		
F4	16233		

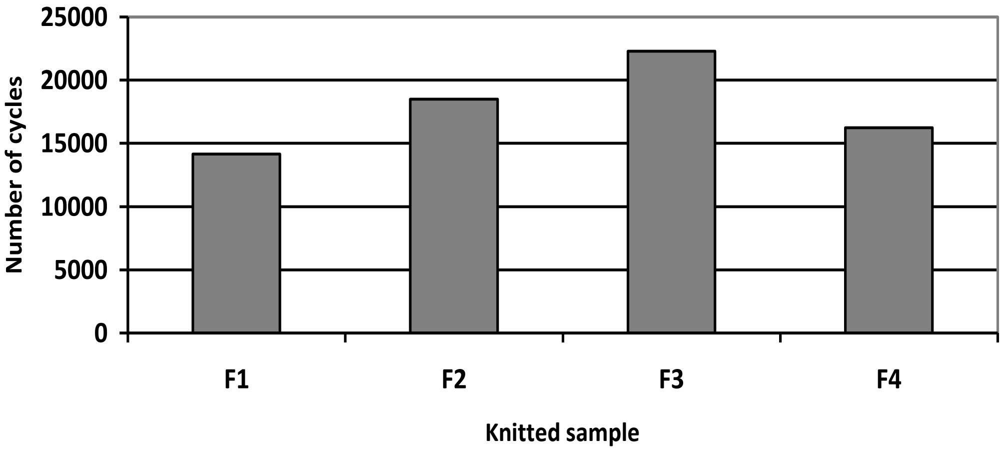


Fig.1: *Influence of the number of cycles on the deterioration of the knitted samples*

After analyzing the graphical representation in **Fig. 1**, we can observe:

- the highest resistance to abrasion stress is shown by the sample F3 and the lowest value for abrasion resistance is shown by the sample F1, the sample F3 shows a higher abrasion resistance of 57.41% compared to the least resistance sample, the sample F1;
- F2 sample has an abrasion resistance higher than sample F1 by 30.47%;
- F4 sample shows an improvement in resistance to sample F1, the value being 14.63% higher.

The mass loss of the material subjected to friction wear test demonstrates the high abrasion resistance of the polyester support and viscose due to the advanced mechanical resistance of the synthetic fibers, but also to the high-tenacity viscosity-resistant viscose fibers. On the other hand, according to the literature [2,3], cotton + polyester knit and wool + viscose, have lower strength and corresponding mass losses, being relatively higher than other samples subjected to testing. The bamboo + viscose composition is found approximately at the middle of the resistance drops and the table drop corresponds to that reported in literature for other types of knits [2], graphically represented in **Fig. 2**. The materials for mattress coverings tested (F1-F4 samples), abrasion quality was found to become poor with increasing number of cycles. Between the initial weight and the final weight after the damage to the maximum number of cycles, the percentage mass losses were graphically represented, resulting higher losses on the sample containing cotton and the wool content, which is consistent with other previous studies [2 ,3]. In Table 4 are presented the values for mass loss of the knitted samples.

Table4: *Mass loss of knitted samples*

Knitted sample	Mass loss (%)	Number of friction cycles
F1	2.03	14166
F2	1.76	18483
F3	1.23	22300
F4	1.89	16233

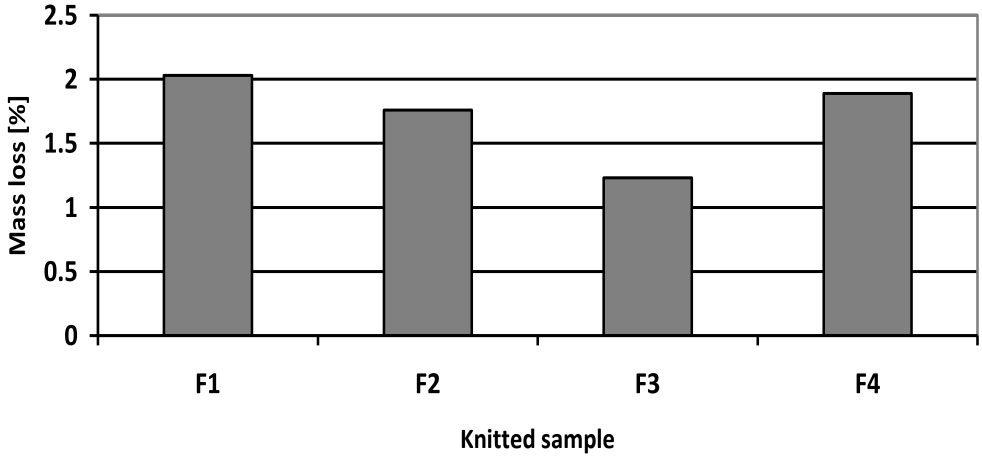


Fig.2: *Graphical representation of mass loss of abraded knitted supports*

4. CONCLUSIONS

The values obtained for the friction cycles up to the degradation of the complex knitted fabrics are different, being mainly influenced by the raw material used to obtain the mattress fabrics. We have carried out an investigation that can be useful to the house textile industry engineerins to correctly claim the right types of high-quality material.

The materials used for the investigations are promising for the duration of use, the best resistance being conferred by the blend of polyester with viscose, then the viscose with bamboo. Future studies will expand the incorporation of other fibrous supports into products for knitted mattresses and resonance investigations in the correct and suitable technological choice.

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THERMAL BEHAVIOUR OF COTTON FABRIC COATED WITH ELECTROSPINNING

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Abstract: *Electrospinning was patented by Formhals in 1934. Prior to the year 2000 electrospinning was the domain of only a few specialists; This situation has changed dramatically in recent years. Many research groups in research and industry work currently on electrospinning topic, the number of conferences or sessions at conferences devoted to electrospinning is continuously increasing. Electrospinning is a fabrication technique, which can be used to create nanofibrous nonwovens from a variety of starting materials. The structure, chemical and mechanical stability, functionality, and other properties of the mats can be modified to match end applications. On the other hand cellulosic polymers have gathered great interest in recent years in the field of nanoproducts useful for high-value applications. The electrospun cellulosic composite fibers with reliable thermal properties are suitable and promising in serving as thermo-regulating materials in many fields. Based on this information, in this study we applied cellulose acetate by electrospinning into a raw cotton fabric in order to examine electrospinning effect in thermal properties. In order to analize thermal behaviour samples were tested with a thermochromic camera. It was found that coating woven cotton fabric by electrospinning with cellulose acetate, reduced the rates of cooling and heating.*

Key words: *Electrospinning, Thermocamera, Cotton fabric, Woven fabric, Cellulose acetate.*

1. INTRODUCTION

Filter applications, functionalization of textiles, fiber reinforcement, catalysis, drug delivery, wound healing or tissue engineering are just a few examples of potential applications of nanotechnology on textile field. The route towards such nano-objects is based primarily on electrospinning [1]. Electrospinning is a process that creates nanofibers through an electrically charged jet of polymer solution or polymer melt [2]. Electrospinning was patented by Formhals in 1934, wherein an experimental setup was outlined for the production of polymeric filaments using electrostatic force [2]. Prior to the year 2000 electrospinning was the domain of a few specialists, the average number of papers published per year on this topic was well below 20. This situation has changed dramatically in recent years. In 2009 for instance, significantly more than 1500 papers were published on electrospinning, it is estimated that more than 200 research groups in academia and industry work currently on this topic, and the number of conferences or sessions at conferences devoted to electrospinning is continuously increasing [1, 3]. Electrospinning is applied predominantly to polymer-based materials including natural and synthetic polymers, but it has been extended towards the production also of metal, ceramic and glass nanofibers exploiting precursor routes [1]. In this study we appliers cellulose based electrofibers into a cotton woven fabric.

Cellulosic polymers have gathered great interest in recent years in the field of nanoproducts useful for high-value applications. The biodegradability, biocompatibility, and versatility of these natural polymers are the reasons for those approaches regarding the possibilities to transform them in nanostructured materials with large applications especially in biomedicine, for tissue engineering scaffolds, wound dressing, controlled release, and technology purposes such as filtration, catalysis, sensors, affinity membranes [4]. Cellulose derivatives like cellulose acetate, ethyl cellulose, carboxymethyl cellulose sodium salt, hydroxypropyl methylcellulose, and methylcellulose and also underivatized cellulose have been electrospun from their solutions in adequate solvents and their possible applications especially in biomedicine and technology are reported [5]. Cellulose acetate phthalate is a mixed ester of cellulose commonly used as a pharmaceutical excipient for enteric coating of tablets and capsules [6]. Ultrafine cellulosic (glycol/cellulose) composite fibers show high latent heat of fusion and crystallization; this shows a maximum in the efficiency of enthalpy and indicates that the fibers have good thermal stability and reliability.

Based on this information, we applied cellulose acetate into cotton fabric by electrospinning and investigated the effect on the thermal properties

2. EXPERIMENTAL

In order to coating with electrospinning we prepared a solution with %15 cellulose acetate into 85% acetone. We put cellulose acetate solution into a syringe which needles diameter is 1,5 micrometers. Through a micropump which feeds with 20 Kw power unit from 10 cm distance we coated electrofibers onto a raw twill cotton fabric with 210 g/m^2 at 1,5 mL/hr.

An experimental setup established to measure temperature changes in electrospinning coated fabric and uncoated one. To study the influence of the characteristics of each sample on the thermal conductivity, samples were tested with a thermochromic camera. The tests were performed taking meassuarements each 15 seconds for 120 seconds of heating cycle and 120 seconds of cooling cycle. The distance between the heater (by radiation) and the fabric is 30 cm. The test starts with the fabric at room temperature 21º C. After 120 seconds, the heater is taken away.

3. RESULTS

Table 1 shows temperatures which have been measured by thermocamera comparing the results of the coated by electrospinning and non coated cotton fabric. It is shown different temperatures analyzed each 15 seconds during 2 minutes of heating and cooling process.

***Table. 1**: Temperatures of coated and non-coated fabric*

	Heating (ºC)							
	15 s	30 s	45 s	60 s	75 s	90 s	105 s	120 s
Without electrospinning	36,5	36,8	37,7	37,9	37,9	37,0	37,6	38,1
Coated with electrosppining	30,1	32,1	33,1	35,0	35,4	36,0	36,7	37,4
	Cooling (ºC)							
	15 s	30 s	45 s	60 s	75 s	90 s	105 s	120 s

Without electrospinning	29,4	27,2	26,8	26,1	26,1	25,7	25,4	25,7
Coated with electrosppining	28,7	27,1	26,7	26,4	26,3	26,2	25,8	25,6

In order to see more clearly the different thermal behaviour of treated and untreated sample, results are shown in a different graphics, where it is appreciate the behaviour of the fabric during heating and cooling processes, Fig. 1 and 2 respectively.

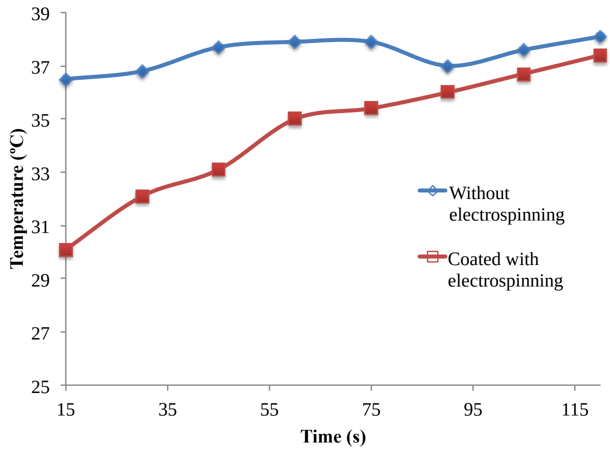

***Fig. 1**: Thermal behavior of each sample during heating*

At the beginning of heating the temperature in fabric without electrospinning starts heating at 36,5º·C and increase with a high acceleration till 38.1ºC after 2 minutes being heated. On the other hand the temperature in the fabric coated with electrospinning starts heating at 30,1ºC and increase till 37.4 ºC, comparing with the other fabric temperature increased with less acceleration.

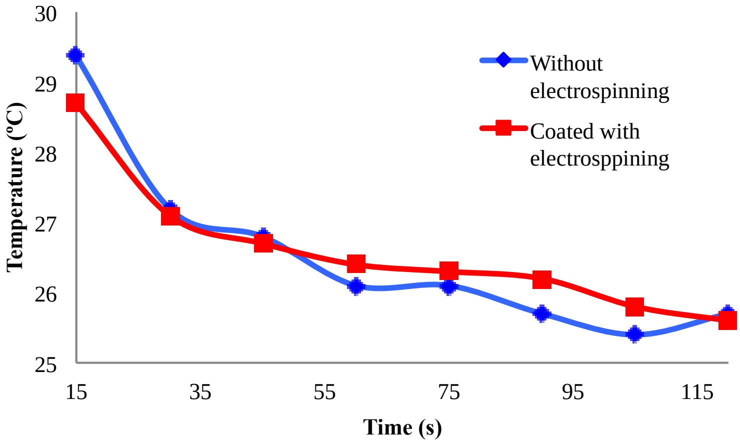

***Fig. 2**: Thermal behavior of each sample during cooling*

After we remove the heater, we saw that both fabrics started cooling at same temperature. The differences between temperatures measured in both fabrics are not very significative in cooling process.

4. CONCLUSIONS

Our experimental results shown that when we apply cellulosed acetate by electrospinning coating into 100% woven cotton fabric, during heating it the temperature on fabric increase in a slover acceleration. Moreover, in cooling process, the temperature on fabric decreases a bit slowly..

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

PHYSICO-CHEMICAL PARAMETERS OF RESIDUAL WATER FROM DIFFERENT SCOURING TREATMENTS OF HEMP/COTTON FABRIC

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Abstract: *Impact of economic development - ecological balance rises numerous and complex problems for the textile industry. It is known that all textile processes need important quantities of water and chemicals. This situation generates large amounts of wastewater which cannot be further use without additional treatments because of the environmental problems. The issue of environmental protection has become an essential part of the textile industry development strategy. Many studies in the field present alternatives for the conventional scouring to reduse water pollution. The applied ecological strategy is focused on process optimization and pollution prevention.*

The paper presents a comparison of the physico-chemical parameters of the wastewater resulted from the various scouring treatments applied on a cotton/hemp fabric. Three types of scouring treatments have been carried out: two with enzymes for which a commercial enzyme product, a washing agent and EDTA or sodium citrate as complexing agents were used, and one classical scouring treatment with sodium hydroxide. The main physico-chemical parameters of the residual water analyzed were: pH, salinity, turbidity, TDS (total dissolved solids), conductivity, chemical oxygen demand (CCOMn), total dissolved oxygen and dry residue.

From the two enzymatic treatments, the values of physico-chemical parameters of the residual water were in accordance with the legislation in case were the sodium citrate was used. For the alkaline treatment, the data were even with 100 % higher compared to enzymatic treatments. For some parameters, higher values were registered also for the enzymatic scouring where EDTA was used as a complexing agent.

Key words: *wastewater, physico-chemical analysis, pretreatment, ultrasound, commercial enzyme product.*

1. INTRODUCTION

Cotton fibres are characterised by a trilamellar structure. It is considered that the second layer has in its composition de-esterified pectins. Those may be a result or contribute to the fibre cells elongation [1]. Both cotton and hemp fibres are characterised by a certain amount of native pectin. For further utilisation in the textile industry it is mandatory to remove all noncellulosic components, along with other impurities: lignin, waxes, natural pigments, or organic acids. Independent of the classical method chosen (acid, alkaline or peroxide scouring) the main objectives of the treatment are to be non harmful for cellulose fibre and remain with less impurities residues. In case of the hemp fibres it was shown that a scouring treatment which includes sodium hydroxide and sodium sulphite is recommended for the removing of both lignin and pectin and also to reduce the treatment time [2].

Using a conventional pretreatment on cotton/hemp fabric with high temperatures (80-90 ^{0}C) and aggressive alkaline (pH $\geq$ 10) will have a major negative impact on the ecosystems. In this situation the wastewaters resulted have to be subject to additional purge steps to accomplish the environmental requirements [3].

Impact of economic development - ecological balance rises numerous and complex problems for the textile industry. Textile ecological technologies occupy an important place in the research projects developed at national and international levels. The issue of environmental protection has become an essential part of the textile industry development strategy. Many studies in the field present alternatives for the conventional scouring. The applied ecological strategy is focused on process optimization and pollution prevention. The suggested treatments imply the utilization of enzymatic products which are not harmful, are suitable for the process, economically advantageous by decreasing the quantity of energy, water and chemicals used, and eco friendly [4]. Other advantages of using an enzymatic treatment are the lower fibres damage degree and the utilisation of biodegradable chemicals. Replacement of the classical scouring treatment with the enzymatic one reduces the pollution factors and also streamlines the technological process from an economic point of view. Another aspect which should be taken into account is the lower quantity of effluents resulted after bioscourig treatment [5,6].

It is known that all textile process needs important quantities of water and chemicals. This situation generates large quantities of wastewater which cannot be further use without additional treatments due to the fact that they will probably cause environmental problems. The specific regulations demand a serious of precise determinations for: COD, pH, turbidity, salinity, TDS, and others. Good results have been reported in case of using different physical methods for wastewater treatment. In case of the ultrafiltration-electrodialysis system the values of the determined parameters were lower than the detection limit. This suggests that the treated water could be reintegrated in the technological process [7].

Independently of the method used for the wastewater treatment (coagulation-flocculation, oxidation, photocatalytic, chlorination, adsorption, electrocoagulation-ozone) all present different inconvenient and requires additional costs. This suggests a different approach of the problem. A development of modern techniques and technologies for reducing the amount of pollutants in the resulting effluents are needed. A possibility is the development of an ecological process for the pretreatment of the fabrics by using enzymes and biodegradable reagents. The main advantages of using enzymes are associated with less severe reaction conditions, lower processing temperatures, reduced treatment time, non-toxic and biodegradable products. Also, the water consumption is lower compared with the classical treatment and the wastewater parameters are in the limits specified by the legislation. For example, in case of a bioscouring cotton knits the pH and CCOMn values registered for the waters resulted from the process could be with approximately 50 % lower compared with the alkaline treatment, and the TDS is 10 % of the one registered for the classical treatment [8]. The lack of supplementary treatment applied to the waters resulted from the technology imply the process costs reduction. It is believed that up to one fifth of the water pollution could be determined by different specific textile processes [9].

The bioscouring treatment applied in our case tends to reduce the aggressive conditions compared to the conventional one. The working temperature had lower value (55 ^{0}C) and the pH was close to 7. As presented in the literature, also in our study the pectinolytic treatment used show similar efficiency as the classical one regarding the specific parameters of the fabrics (wettability, tensile strength, elongation at break, etc.).

2. EXPERIMANTAL PART

2.1 Materials and experimental procedure

The wastewater analysed was resulted after the bioscouring and alkaline treatment on cotton/hemp materials with the following characteristics: width (120 ± 3 cm), weight (220 ± 10 g/m^2), warp density (10 yarns/cm), weft density B (10 yarns/cm), 100 % of cotton yarn, Nm 14 for warp direction and 100 % of hemp yarn, Nm 14 for weft direction.

The specific reagents have analytical purity and were purchase from: CHT Bezema Company (Beisol PRO-pectinolytic product, Denimcol Wash RGN- surfactant), Sigma-Aldrich (sodium hydroxide, sodium citrate, sodium carbonate, sodium silicate, sodium bisulfite), and Rotta Company (Sulfolen 148: S-148 alkyl polyglicol ether).

During the bioscouring treatment of the cotton/hemp material were used two different complexing agents EDTA or sodium citrate and the same enzymatic product (Beisol PRO-mixture of pectinase) in similar concentration and treatment time after an experimental program (see Table 1 and Table 2). The considered liquid to fabric ratio was 20:1, and the temperature 55 ^{0}C. The basic pH in case of the classical method was ensured with sodium hydroxide.

The pectinolytic product concentration used varied between 1-3 % o.w.f (over weight fiber) and the action time was between 15 and 55 minutes. The quantity of complexing agents (EDTA or sodium citrate) was 2 g/L and the surfactant (Denimcol Wash RGN) 0.5 %.

For the bioscouring treatments were used also ultrasound of 45 kHz in an Elmasonic X-tra basic 2500 ultrasonic bath from Elma Company, Germany. The classical scouring treatment used for comparison was done with 10 g/L sodium hydroxide, 1 g/L sodium bisulfite, 5 g/L sodium carbonate, 2 g/L sodium silicate and 2 g/L wetting agent (Sulfolen 148) for 1 hour at 100 ^{0}C in an AATCC Launder Ömeter.

2.2 Wastewater analysis

The wastewater quality indicators determined such as: pH, salinity, turbidity, TDS (total dissolved solids), conductivity, chemical oxygen demand (CCOMn), total dissolved oxygen and dry residue were chosen according to the EU specific regulations. A WTW multi-parameter inoLab Multi 740 was used for conductivity, pH, salinity, TDS, and total dissolved oxygen measurements. For turbidity determination was used a HI 88713 HANNA Instruments Turbidimeter. The dry residue was determined gravimetrically as difference in mass before and after the drying process. For evaporation was used a Pura 14 water bath from Julabo, Germany and dried at (105 ± 5) °C to constant mass in an oven, according to [10]. The CCOMn (chemical oxygen demand) was performed by titration with $KMnO_4$ as described by R. Ballance [11].

3. RESULTS AND DISCUSSIONS

The purpose of this research was to study the impact of the wastewater resulted from two eco-friendly scouring treatments compared to the classical alkaline scouring. Further on will be presented the comparative results obtain for the investigated parameters in case of using EDTA or sodium citrate as complexing agents in the bioscouring treatment, and for the traditional scouring with sodium hydroxide. Table 1 shows a comparative analysis of some quality indicators (pH, TDS, salinity, conductivity, total dissolved oxygen) of the residual water resulted from classical and enzymatic pretreatments of the cotton/hemp fabric.

Table 1: *Comparative analysis of some residual water quality indicators resulted from classical and enzymatic treatments of the cotton/hemp fabric*

Sample	Enzyme [%]	Treatment time [min.]	pH	TDS [mg/L]	Salinity	Conductivity [(μs/cm]	Total dissolved oxygen [mg/L]
Scouring with enzymes + sodium citrate							
1	1.30	21.00	8.02	1778.00	0.90	1780.00	5.27
2	2.70	21.00	7.81	1932.00	1.00	1936.00	5.43
3	1.30	49.00	8.18	1768.00	0.90	1776.00	5.04
4	2.70	49.00	8.05	1912.00	0.90	1917.00	4.92
5	1.00	35.00	8.53	1778.00	0.90	1785.00	4.82
6	3.00	35.00	7.82	2027.00	1.00	2030.00	4.23
7	2.00	15.00	7.65	1914.00	0.90	1918.00	6.86
8	2.00	55.00	8.30	1856.00	0.90	1863.00	5.27
9	2.00	35.00	8.05	1883.00	0.90	1888.00	5.26
10	2.00	35.00	8.15	1885.00	0.90	1893.00	5.15
11	2.00	35.00	7.93	1916.00	0.90	1923.00	4.91
12	2.00	35.00	7.99	1887.00	0.90	1891.00	4.93
13	2.00	35.00	8.10	1881.00	0.90	1886.00	4.76
Scouring with enzymes + EDTA							
1	1.30	21.00	4.849	1072.00	0.50	1071.00	5.34
2	2.70	21.00	4.864	1183.00	0.50	1182.00	5.53
3	1.30	49.00	4.933	1039.00	0.50	1038.00	5.15
4	2.70	49.00	5.082	1199.00	0.50	1197.00	5.65
5	1.00	35.00	4.849	998.00	0.40	997.00	5.71
6	3.00	35.00	4.931	1209.00	0.60	1209.00	5.77
7	2.00	15.00	4.887	1105.00	0.50	1105.00	5.79
8	2.00	55.00	4.920	1107.00	0.50	1104.00	5.64
9	2.00	35.00	4.836	1112.00	0.50	1111.00	6.17
10	2.00	35.00	4.868	1107.00	0.50	1104.00	5.93
11	2.00	35.00	4.927	1101.00	0.50	1101.00	6.26
12	2.00	35.00	5.010	1109.00	0.50	1108.00	6.13
13	2.00	35.00	5.018	1109.00	0.50	1109.00	6.29
Classical alkaline scouring							
1	-	60.00	13.50	53000.00	35.00	53000.00	4.16

In the textile processing units, pH is a very important factor and must be adjusted for each processing step for better results. The pH of the wastewater resulted from the three types of scouring treatments was found in a big range from ~ 4.50 to 13.50. In the case of pretreatment with sodium citrate, the pH of the wastewater is almost neutral, being in accordance with the legislation. Not the same situation is in the case of EDTA where the pH values are below 5, requiring a slight correction. As for salinity, this shows higher values for sodium citrate treatments. The highest value of pH shows the residual water resulting from the alkaline treatment (13.50), this being far beyond the limits allowed.

Electrical conductivity and TDS of wastewater from all enzymatic treatments were found to be in the range of ~ 1000 to 2000. Lower conductivity and TDS values were obtained in this case for the enzymatic treatments in which EDTA was used as a complexing agent. The same situation is for salinity values. Close values have been obtained for total dissolved oxygen in both cases of enzymatic treatments. In the case of classical alkaline treatment, with the exception of total dissolved oxygen, the other values obtained for conductivity, TDS and salinity exceed the admissible values.

In Table 2 is presented a comparative analysis of turbidity, dry residue and chemical oxygen demand values of the residual water resulted from the classical and enzymatic treatments of the cotton/hemp fabric.

Table 2: *Comparative analysis of turbidity, dry residue and chemical oxygen demand of the residual water resulted from classical and enzymatic treatments*

Sample	Enzyme [%]	Treatment time [min.]	Turbidity [NTU]	Dry residue [mg/L]	CCOMn [mg O_2/L]
Scouring with enzymes + sodium citrate					
1	1.30	21.00	2.85	19.26	19.64
2	2.70	21.00	2.98	26.36	21.71
3	1.30	49.00	2.49	29.28	29.07
4	2.70	49.00	2.61	28.00	32.34
5	1.00	35.00	2.63	25.64	22.86
6	3.00	35.00	2.71	36.70	27.81
7	2.00	15.00	3.31	15.16	18.96
8	2.00	55.00	1.92	57.60	25.28
9	2.00	35.00	2.48	34.96	27.81
10	2.00	35.00	2.60	36.88	22.64
11	2.00	35.00	2.90	35.96	25.28
12	2.00	35.00	3.09	38.40	25.28
13	2.00	35.00	2.74	40.86	28.96
Scouring with enzymes + EDTA					
1	1.30	21.00	1.64	34.34	644.64
2	2.70	21.00	1.59	46.56	620.80
3	1.30	49.00	1.49	32.00	379.20
4	2.70	49.00	1.56	60.06	606.72
5	1.00	35.00	1.61	31.06	379.20
6	3.00	35.00	1.41	37.20	442.40
7	2.00	15.00	1.83	20.44	265.44
8	2.00	55.00	1.20	64.82	689.60
9	2.00	35.00	1.36	34.44	151.68
10	2.00	35.00	1.51	35.26	145.36
11	2.00	35.00	1.46	37.98	170.64
12	2.00	35.00	1.84	33.32	139.04
13	2.00	35.00	1.60	36.00	169.60
Classical alkaline scouring					
1	-	60.00	84.00	1150	1180.00

Turbidity values are higher for sodium citrate treatments. Instead, similar values were obtained in the case of dry residue and much lower values for CCOMn compared to the treatments in which EDTA was used. In the case of classical alkaline treatment, the same high values are observed for all parameters (turbidity, dry residue, CCOMn) resulting high polluted wastewaters.

4. CONCLUSIONS

The main physico-chemical parameters of the residual water resulted from two types of enzymatic scouring treatments were analyzed in comparison with wastewater parameters of an classic alkaline treatment. Based on the experimental data obtained it was concluded that for enzymatic pretreatments (EDTA or sodium citrate) all the parameters are in the limits with the exception of the pH for treatments were EDTA was used. We can not say the same thing in the case of classic alkaline treatment were higher values were obtained for all parameters. A constant monitoring of water quality is necessary to avoid further dreadful conditions. The effluents which are toxic in nature are needed imperative treatment before disposal on water bodies to create less pollution and an eco-friendly environment.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

SC CORA TRADING & SERVICE SRL - GOOD PRACTICE MODEL IN THE FIELD OF SUSTAINABLE DEVELOPMENT OF THE TEXTILE SECTOR

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Abstract: *Awareness of the importance of reducing / slowing down, by any means, the level of pollution is steadily increasing and meeting this goal is an important objective at the level of the European Union. The use of natural resources is a measure that fits into this objective. SC Cora Trading & Service SRL is an example of a Romanian company focusing on the use of small and medium fineness sheared, tannery and recovered / recycled wool fibers in high value added products. The paper presents experimental results regarding the processing, on the existing technology at SC Cora Trading & Service SRL, of a 100% fibrous fiber mixture for obtaining 4 unconventional textile structures for thermal and sound insulation in the constructions area. The technological flow adopted consists of preliminary operations (sorting, cutting opening, willowing and blending), formation carded webs, cross lapped batts, 2 types of bonding operations (using steam and needle punching) and final finishing operations. The steam bonded structures are bulky: (density: 36 kg/m3 to 54 kg/m3), while the needle punching bonded ones are compact (density: 133 kg/m3 - 97kg/m3). The thermal conductivity of the obtained structures ranged from (0.0332 W/mK to 0.0392 W/mK), comparable to thermal insulation materials from basaltic fibers and does not support burning.*

Key words: *non-conventional textile structures, tanning wool, sheared wool, thermal conductivity, valorization*

1. INTRODUCTION

In Europe, each person generates annually about half a ton of waste, of which less than 40% is recovered. According to Eurostat, in some countries more than 80% of the generated waste is discarded [1]. The concern of mankind about the unprecedented environmental pollution (soil, water, air) with negative effects on climate change has convinced the authorities to take concrete measures according to the principles of the circular economy (industrial production, consumption, waste, etc.). This concern for our health and the generations to come is the desideratum of sustainable development, one of the measures being the transition to the development of ecological materials from renewable resources [2].

For millions of years, mankind has been using natural (animal and vegetable) textile fibers for current protection and comfort activities, food, health, energy, construction, art, and so on. In some industrial sectors, natural fibers are an alternative to synthetic ones, in addition have a low impact on the environment [3], they are human-friendly, the toxicity is very low (it does not generate hazardous wastes) are biodegradable and their responsible valorisation leads to a sustainable life [4].

Wool fibers are a natural source of raw material, whose local capitalization is quantitatively reduced. The wool can come from 4 major sources: sheep shearing (wool on first use with high quality fiber, not degraded); tanning of hides obtained from slaughtered animals (wool with degraded areas due to chemical and mechanical treatments applied for its extraction) [5]; reclaimed wool (obtained from pre-consumer textile waste resulting from technological processes), regenerated wool (obtained from post-consumer textiles, identified as finished products)[6]. The regenerated and recovered tanning wool shows less mechanical resistance compared to the sheared wool, under the conditions of mechanical operations.

The paper follows the technological presentation of non-conventional textile structures (NTS), designed for thermal insulation and obtained on the existing technology at company Cora Trading & Service SRL.

2. CONTEXT

2.1. SC Cora Trading & Service SRL

Among the Romanian companies that process the wool is SC Cora Trading & Service SRL, a company with Romanian capital, which has as its object the production of unconventional non-woven products (e.g. technical felts) with industrial applications. The company processed more than 50 tons of wool fiber in 2016. A significant part of the company's products are destined for export. The national competition environment and its policy required investment in high performance machines to improve the quality and productivity of products and services offered. These investments focused directly on the production of nonwoven and felts by offering both products with technical characteristics that are superior to competition and respecting dimensional characteristics through fieldwork in many sites and workplaces in the country. The company has implemented and maintains a quality management system in accordance with SR EN ISO 9000 families of standards for all product categories [7]. The company’s activity is based mainly on sheared wool fibers, thick tannery wool (considered waste of tanneries) and wool fibers recovered from the textile technological waste to develop the products with high added value. The use of natural resources and waste is a key factor in the circular economy, which stimulates innovation and recycling of waste and reduces the amount of waste dumped to landfills, fully understood by the company's management. The use of indigenous and wool textile waste by SC Cora Trading & Service SRL has environmental implications (reduction of soil, water and air pollution in areas where wool is usually burned in the field) and human health implications [7].

2.2. Wool fiber – valorization potential in construction area

The wool (natural textile fiber, which represents about 95-97% of the animal hair) has a significant potential for valorisation in technical fields due to the unique structure and properties. Wool fiber has the most complex chemical structure and is obtained by proliferation of new cells in the root (nontextile part) and subsequent migration of these cells to the stem (the textile part). The major component of the wool, which contains about 97%, is the protein (minerals with functional groups - α-amino acids) [8]. Structurally, wool fiber is made up of the cuticle (outer fiber coat, about 2-10% of its mass, which covers the fiber in its entirety, having a protective role), cortex (the basic fiber component of about 90% its mass, which determines almost all physico-mechanical and chemical properties), a medullary channel present on thick fibers with a role in the mechanical properties of it [9]. The wool fiber properties are unique, being influenced by the chemical structure, the supramolecular structure, and the morphological particularities. Among the physical-mechanical properties of wool fibers are: fineness within wide limits: 15 µm - 65 µm, length in wide limits: 30 mm - 350mm, number of crimps / cm: 1-13, hygroscopicity: <40%, etc [11, 13]. The wool exhibits good thermal insulation properties / thermal resistivity / thermal conductivity, both at low and high temperatures [10], due to the amount of stationary air between wool fibers [11]. Wool has amphoteric character, resistance to dilute mineral acids, <5% [12], good felting ability depending on fiber position relative to other fiber, heat, unity, pH, mechanical action; great spinning capacity etc.

Thanks to these characteristics, wool fibers have attracted the attention of manufacturers of thermal insulation materials at European level, which have produced fibrous products in the form of panels or rollers containing wool fibers. At national level, SC Cora Trading & Service SRL is an example of an innovation-oriented enterprise whose existing infrastructure allows the design and development of 100% wool NTSs with valorisation potential or thermal and sound insulation properties.

3. MATERIALS AND METHODS

For testing of NTSs, at Cora Trading & Service SRL, a blend of 100% fibers: 50% sheared wool, 50 % tannery wool with medium and low finesse has been established. The fiber blend was analyzed for average fineness (µm), average length (mm), breaking force and elongation at break (cN, %), content of impurities (%). Samples were taken from the impact technological flow operations (opening - sample A, willowing-mixing - sample B, carding - sample C). The NTSs were analyzed in terms of physical characteristics: thickness (mm), specific mass (g/m^2), density (kg/m^3) and thermal conductivity (W/mK).

4. EXPERIMENTAL PART

The technological flow adopted for the NTSs is shown in Figure 1. The cutting wool requires several preliminary operations (sorting, cutting + mechanical cleaning, opening) than tanned wool due to a high level of impurities. As a result of these operations, more than 50% of the vegetal and mineral impurities were removed.

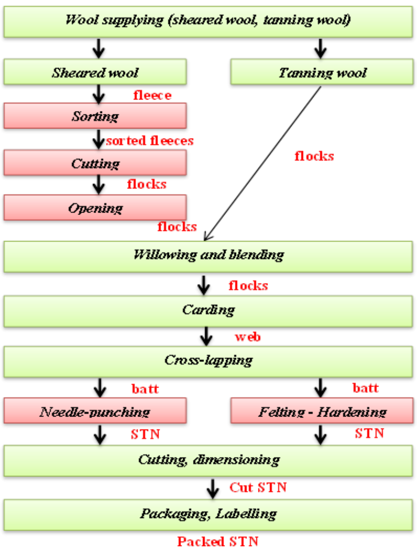

Fig. 1: *Fiber processing flow*

In the willowing operation, the two components are intensively blend, and this blend is fed to the card, where complete oppening takes place, deep cleaning, removal of a percentage of short fibers; blending, straightening, parallelizing and uniformizing and web forming of the fibers, conferring an advanced degree of individualization of the fibers. The crosslapping operation involves the overlapping of card webs under a folding angle in order to obtain semi-fabrics (fibrous layers) that can be consolidated/ bonded. Consolidation involves mechanical bonding between fibers, in order to increase the resistance of the fiber layer to the textile structure due to the progressive frictional forces between the fibers. For this research, two types of consolidation (using steam and needle punching) were used. The final operations are to prepare NTSs for use.

5. RESULTS AND DISCUSSIONS

The results of the physico-mechanical analyze of the fiber blend used for obtaining of NTS within SC Cora Trading & Service are presented in Table 1.

Table 1: *Fiber blend characteristics*

Characteristics	Reference document	Sample		
		A	B	C
Average fiber diameter (μm); CV (%)	SR ISO 137/2016	38,836; 40,162	34,693; 37,469	32,986; 36,855
Average fiber lenght (μm); CV (%)	SR ISO 6989:1998	116,65; 65,91	77,13, 90,87	64,33; 74,97
Average elongation to brerak (%); CV (%)	SR EN ISO 5079:2000	38,584; 0,227	33,266; 0,369	29,675; 0,460
Average breaking force (cN); CV (%)		56,272; 0,450	40,827; 0,612	0,637
Impurities content % -Vegetable; Dirt; Both	STAS 6710:1988	2,8; 2,7; 5,5	0,8; 3,1; 3,9	-; -; 0,8

After the fibrous processing and consolidation through the two processes (fig.1) 4 unconventional textile structures with specific masses and different thicknesses were obtained. Steam consolidation technology causes the agglomeration/bonding of the fibers from the closslaped layers as a result of simultaneous action of vibrational movement at high velocity in the presence of steam and under variable mechanical pressure. After consolidation, the thickness of the structure can be calibrated using buffers over which the oscillating plate will act. In this way, NTSs with low density (bulky) and high thickness, designed for thermal insulation are obtained. Mechanical consolidation by needlepunching involves entrainment of the fibers through the interstices of the fibrous layer. Consolidation is accomplished by reorienting / changing the direction of the fibers, which come in direct contact with the barbed needles. This type of consolidation has the effect of increasing the mechanical strength and decreasing the thickness of the fibrous layer (increasing the density). Thus, compact, higher density STNs are provided for thermal and acoustic insulation.

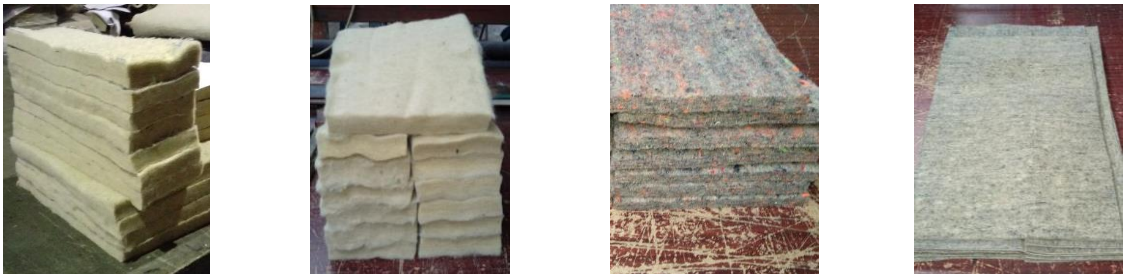

Fig. 2: *Obtained NTS*

a) S1 *b) S2* *c) S3* *d) S4*

The results of the physico-mechanical characterization of the structures obtained, encoded S1 - NTS1 steam bonded (Fig. 2); S2 - STN2 steam bonded, (Fig. 2b); S2 - STN1 needlepunching bonded (see Fig. 2c); S4 - STN2 needlepunching bonded (see Fig. 2d) are shown in Table 2.

Table 2: *Obtained NTS characteristics*

Characteristic	NTS			
	S1	S2	S3	S4
Mass/unit area, g/m^2	2100 ± 5%	1700± 5%	2700± 5%	900± 5%
Thickness, mm	40 ± 5%	50± 5%	20± 5%	10± 5%
Density, kg/m^3	54 ± 5%	35 ± 5%	130± 5%	95± 5%
Thermal conductivity, W/mK	0.0378	0.0362	0.0392	0.0332

In terms of specific mass, S2 has a specific mass 17.29% lower than S1, this being the minimum specific mass that can be obtained through this bonding technology. Below this value, keeping the bonding conditions constant, the mechanical bonds between the fibers are not assured, so the structure does not acquire mechanical resistance. In the case of S3 and S4, the bonding technology allows obtaining large specific masses at smaller thicknesses than the S1 and S2 structures. S3 has a specific mass greater than 203.15% compared to S4. The thickness of S2 is 22% greater than S1. The S3 and S4 structures are more compact, with smaller thicknesses than the S1 and S2 structures, as the needlepunching technology trains the fibers, for bonding, through the interstices of the fiber layer (rendering compactness). Structure S4 has a thickness 55% smaller than structure S3. The value of λ for structure S2 is 4.07% smaller than S1, which means that structure S2 is better isolated than structure S1 (it has a volume of air, which is larger in structure S2, which allows a higher convective transfer than the S1 structure). Structure S4 shows an λ value of 15.34% less than structure S3. In terms of fire behavior, it can be mentioned that the 4 structures obtained do not burn or remove dangerous substances

5. CONCLUSIONS

The study reveals the potential for the use of wool fibers in unconventional textile structures for thermal insulation in construction. The proposed fibrous blend to be experimented contains the tanning wool, as considered tanneries waste and sheared wool. Two technological flows for the processing of the fibrous blend were selected for the experiments, which included preliminary processing operations, web forming operations, bonding operations and final operations.
Due to the high content of impurities of mineral, animal and vegetal origin, it was insisted on the preliminal processing operations, where the own (invented) equipment of the beneficiary was used, or with specific technological adaptations for the processed fiber blend. There were 4 NTSs experimental models, formed by two bonding ways, which were analyzed from the point of view of

the specific functionalities. The steam bonderd textile structures are bulky: S1 (~density: 36 kg/m^3), S2 (~density: 54 kg/m^3), while the needlepunching bonded ones are compact S3 (~density: 133 kg/m^3), S4 (~density: 97kg/m^3). From the point of view of thermal conductivity, the values obtained (0.0378 W/mK - S1, 0.0362 W/mK - S2, 0.0392 W/mK - S3, 0.0332 W/mK - S4) are comparable to thermal insulation materials from basaltic fibers. The obtained textile structured does not support burning.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ANALYSIS OF THE FABRIC CHARACTERISTICS USING THE ANOVA MODEL

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Abstract: *In this paper, it's analyzed the surface characteristics of woven fabrics. Of these features, the pilling effect is a typical pattern of flat textiles, which consists in forming, on their surface, of clusters of adherent fibers consisting of three types of fibers: outer ends (fibers with one end fixed in the base structure), outer loops (with both ends in the base structure) and marginal / wild fibers (fixed at least at one end) as a result of the action of the friction forces, affecting their appearance. Pilling is recognized as major aesthetic attribute of a woven apparel fabric. The study presents a new approach to the problem of objectively evaluating woven pilling by employing image analysis techniques and ANOVA (analysis of variance) model. The number of pills resulted on the fabric surface after abrasion testing and handle has been used as dependent, respective independent variables for ANOVA regression model. Processing of the testing results allowed an objective hierarchical classification of woolen woven materials according to their pilling resistance. Based on employed ANOVA model we have been established that there are significant differences between mean pills number depending on the handle (soft, cold or rough) of woolen fabrics. The results revealed that the formation of the pilling is characterized not only by the rate of formation and the ease of removal of the fiber agglomerations but also by the total and residual amplitude of the pilling.*

Key words: *wool woven, adherent fibers handle, ANOVA model, pilling, surface characteristics*

1. INTRODUCTION

The Anova model is used to show the main and interface effects of independent variables on dependent variables. The primary effect has a direct effect on independent variables on dependent variables, points out the effect of the interaction on an already built base [1, 2]. The pilling phenomenon is one of the most serious visual imperfections of textile fabric because it causes not only bad appearance but also a bad touch, both being especially important for fabrics are used in clothing. It is generally recognized that pilling is more pronounced in fabrics made of synthetic fibers or blends of synthetic fibers and natural fibers [3, 4, 5]. Evaluating the pilling defects, we can assess these properties of fibers, yarns and fabrics and also the probability of problem occurrence in production line [6, 7]. Pills are formed by entangling fibres into discrete balls on the surface of fabrics which are usually the result of wear, abrasion, washing or a combination of all three [7, 8, 9]. At present attempts to classify and standardise textile quality requirements for textiles devoted to clothing manufacturing pilling tendency plays a very important factor [10].

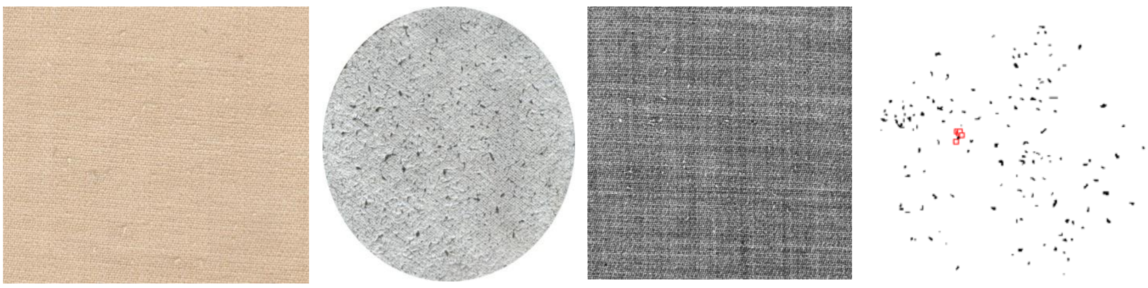
2. MATERIALS AND METHODS

The study was conducted on woven materials made of combed wool type yarns used for manufacturing outwear clothing, on 50 articles structured as follows. The variation limits of the composition and structural characteristics for the tested woven materials are indicated in table 1.

Table 1: *Variation limits of composition and structural characteristics*

Group/Fibrous composition		Nm_{Warp}	Nm_{Weft}	Coded article
Group A 100%Wool	min	50/2	30/1	A1-A10
	max	64/2	37/1	
Group B 45%Wool +55% PES	min	50/2	30/1	B1-B10
	max	64/2	64/2	
Group C 45% Wool + 50%PES + 5% Dorlastan	min	56/2	37/1	C1-C10
	max	50/2	50/2	

For pilling evaluation of woven fabrics type wool were proposed two original methods namely finger printing method followed by samples fingerprint scanning after testing and direct tested sample scanning method (Fig.1) and results interpreting through digital processing of images usinf CorelDRAW and Matlab programs. The experimental work was done under laboratory conditions on a Rubtester Metrimpex FF 25 machine in accordance with the SR EN ISO 12743-3-2003 standard. The sample size was determined by the fixation device. The samples were tested for homogeneous friction on one side. The indirect method of pilling evaluation involves the fabric weight and thickness measuring both before and after abrasion testing. Based on quantitative analysis of tested samples (Fig.1) were determined: initial/final sample weight; initial/final sample thickness; number of fiber agglomerations/unit area formed/detached; number of fiber agglomerations/unit mass formed/detached; agglomerations mass of detached fibers from unit area.
Experimental results concering quantitative analysis for the three gropus of woven fabrics that illustrated the pilling effect intensity obtained by objective methods were statistically processed using ANOVA model.



B10 (Nc=500, P=30 N)* | Sample print of B10 (Nc=500, P=30 N) | C9 (Nc=500, P=30 N) | Sample print of C9 (Nc=500, P=30 N)

* Nc= number of abrasion cycles: P= pressure force

Fig. 1. *Scanned images of tested and print samples*

3. EXPERIMENTAL PART

3.1. Collection, systematization and processing of experimental data

Econometric modeling is performed using numeric variables. To extend this restriction to non-numeric variables or attributive variables, are constructed alternative variables called dummy variables. For a nominal variable, it can be established one or more alternative variables, depending on the purpose or modeling interest. Also, is shown the differentiation of woven materials by the variation of the number of formed fiber agglomerations/surface unit and the number of formed and detached fiber agglomerations/surface unit, depending on the number of abrasion cycles and pressure force (P=30 N).

Based on the experimental data, the following variables were included in the ANOVA regression model: dependent variable (Y) representing the number of agglomerations/pilling effect; independent variable representing the woven material handle (soft, rough, cold) – two dummy variables.

3.2. Hypothesis formulation

H_0: There are no significant differences between the fiber agglomerations for woven materials having soft, rough or cold handle;

H_1: There are significant differences between the fiber agglomerations for woven materials having soft, rough or cold handle (H_0 is reject).

3.3. Formulation of the regression model

The ANOVA model with two dummy variables is defined by relation:

$$Y = \alpha_0 + \alpha_1 D_1 + \alpha_2 D_2 + \varepsilon \quad \textbf{(1)}$$

The regression, as a conditioned mean, has the following form:

$$\begin{aligned} M(Y/D) &= \alpha_0, && D_1 = 0, D_2 = 0 \\ M(Y/D) &= \alpha_0 + \alpha_1, && D_1 = 1, D_2 = 0 \\ M(Y/D) &= \alpha_0 + \alpha_2, && D_1 = 0, D_2 = 1 \end{aligned} \quad \textbf{(2)}$$

The notations for the model are μ_1 for the mean of fiber agglomerations for woven materials having soft handle, μ_2 for the mean of fiber agglomerations for woven materials having rough handle and μ_3 for the mean of fiber agglomerations for woven materials having rough handle.

The regression has the following form:

$$\begin{aligned} M(Y/D) &= \alpha_0 = \mu_1, && D_1 = 0, D_2 = 0 \\ M(Y/D) &= \alpha_0 + \alpha_1 = \mu_2, && D_1 = 1, D_2 = 0 \\ M(Y/D) &= \alpha_0 + \alpha_2 = \mu_3 && D_1 = 0, D_2 = 1 \end{aligned} \quad \textbf{(3)}$$

The dummy variables are defined in Table 1.

Table 1. *Definition of dummy variables*

Group	D1	D2	Handle
1	1	0	Cold
2	0	1	Rough
3	0	0	Soft

The coefficients defined in table 2 were determined for the established model. The t-test show if the variation between those three groups of woven fabrics is "significant" depending on number of fiber agglomerations formed on unit area.

The estimated ANOVA model has the following expression:

$$y = 27.345 - 14.456 D_1 - 24.468 D_2 \quad \textbf{(4)}$$

and the estimations for the considered parameters are:

$a_o = 27.345;\ a_1 = -14.456;\ a_2 = -24.468$ **(5)**

***Table 2**: Coefficients of the ANOVA model*

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	27.345	0.467		46.328	0.000
	D1	-14.456	1.132	-0.245	-8.251	0.000
	D2	-24,468	0.784	-1.001	-22.527	0.000

Dependent Variable: number of agglomerations/pilling

3.4. Model interpretation

The model interpretation is the following:

a) estimate a_o = **27.345** is the mean of fiber agglomerations for the woven materials with soft handle:

b) estimate $a_o + a_1 = 27.345 - 14.456 =$ **12.889** is the mean of the fiber agglomerations for woven materials with cold handle.

Values of Sig. associated to t-test for those two regression coefficients are less than 0.05 and therefore the coefficients have significant values. The coefficient values indicate that the fiber agglomerations number are 27.345 for fabrics having soft handle respectively 12.889 for those fabrics with cold handle. So the fiber agglomerations number of woven fabrics with cold handle is lower than 12.889 comparative with the agglomeration number of soft handle fabrics.

Based on the results presented in Table 2 the value of sig is smaller than 0.05 thus, the hypothesis H_0 it is rejected while hypothesis H_1 is accepted. Therefore, one can conclude that significant differences exist between the fiber agglomerations media of woven materials type wool having soft, rough or cold handle exists.

3.5. Hypothesis confirmation over errors

3.5.1. M(ε) = 0 (errors mean is null)

The hypothesis are the following:

H_0: M (ε) = 0

H_1: M (ε) ≠ 0 **(6)**

The results obtained in SPSS program used to estimate the errors of this model are indicated in Table 3.

***Table 3**: Descriptive Statistics*

	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Unstandardized Residual	30	0.000	9.35961372	0.244	0.221	-1.216	0.477

Estimates of distribution errors form are the folowing:

-Fisher asymmetry coefficient: sw = 0.244, for a positive asymmetry (sw > 0);

-Fisher vaulting coefficients: k = -1.216 for a flattened distribution (k <0).

Estimates of form parameters indicate a deviation of errors distribution form from normal distribution. The significance of these deviations is confirmed by Jarque-Bera test.

The Jarque-Bera statistic values is:

$$JB_{calc} = \frac{n}{6}\left(sw^2 + \frac{k^2}{4}\right) = \frac{30}{6}(0.0595 + 0.3697) = 2.146 \quad \textbf{(7)}$$

Theoretical value [7] is: $\chi^2_{0,05;2} = 5.99$

In conclusion $JB_{calc} > \chi^2_{\alpha;2}$, leading to the decision to accept the H_0 hypothesis with a probability of 0.95. Since the sample volume is large, the mean errors does not differ significantlly from zero and the errors are concentrated around the mean we consider that the violating the assumption of normality do not significantlly affect the estimated model quality.

3.5.2. V (εi) = σ² - homoscedasticity hypothesis

A non-parametric correlation test is applied between the estimated errors and the dependent variable (D1, D2). The correlation coefficient Spearman is calculated and the Student t-test for this coefficient is performed. The results are shown in table 4.

The hypothesis are the following:

H_0: the correlation coefficient is insignificantly larger than zero (the null hypothesis of the Student t-test is accepted);

H_1: the correlation coefficient is significantly larger than zero (the null hypothesis of the Student t-test is rejected).

Table 4*: Spearman test for verifying the homoscedasticity hypothesis*

			D1	D2	Unstandardized Residual
Spearman's rho	D1	Correlation Coefficient	1.000	-0.332**	0.002
		Sig. (2-tailed)	0.000	0.000	0.876
		N	30	30	30
	D2	Correlation Coefficient	-0.332**	1.000	0.063
		Sig. (2-tailed)	0.000	0.000	0.532
		N	30	30	30
	Unstandardized Residual	Correlation Coefficient	0.002	0.063	1.000
		Sig. (2-tailed)	0.876	0.532	0.000
		N	30	30	30

** Correlation is significant at the .01 level (2-tailed).

The values of sig. for the correlations D1-estimated errors *(0,000)* and D2-estimated errors *(0.000)* are equal and constant. The correlation Spearman coefficient *(r = - 0.332)* and the Student t-test for this Spearman coefficient are presented in table 4. The significance of the Student test *(Sig t= 0.000)* lead to the decision to reject the null hypothesis of Student test, that is the hypothesis corresponding to correlation coefficient is insignificantly different from zero. Therefore we reject the homoscedasticity hypothesis for the regression model between the number of fiber agglomerations as variable and handle as variable with a probability of 0.95.

3.5.3. εi ~ N (0, σ²) – normality hypothesis

Testing normality errors distribution can be done with a classic non-parametric test such as the chi-square test or Kolmogorov-Smirnov test. Significance test (Sig =0.473 >0.05) lead to the decision to accept the assumption of normality. So, we can accept the hypothesis of normality for the regression model between number of fiber agglomeration variable and handle variable, for a statistical certainty of 0.95.

4. CONCLUSIONS

According to the study, the phenomenon is more pronounced in textile products made of synthetic fibers or mixtures of synthetic and natural fibers, open and flexible textile structures, caused not only by the emergence of fibers but also by the persistence of clusters generated. Employing ANOVA on different groups of study has evidenced significant differences between the mean values of fiber agglomerations for woven materials having soft, rough or cold handle.

The results showed that the formation of the pilling is characterized not only by the speed of formation and the ease of elimination of the fiber agglomerations, but also by the total and residual overall amplitude of the pilling. The factors that significantly influence the piling resistance of fabrics are: the fibrous composition of the component yarns, the geometric structure of the fabrics defined by the structure phase (the yarn curl degree), the system of yarns on plane/side of the fabric that takes effort on friction, the yarn quality the yarn tickness.

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ANNALS OF THE UNIVERSITY OF ORADEA
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RESEARCH REGARDING THE INFLUENCE OF CHEMICAL FINISHING PROCESSES ON THE THERMOPHYSIOLOGICAL COMFORT OF FABRICS

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Abstract: *Due to "insensibilis perspiration" process of the human body, the textile materials for the garment products, must have vapour permeability. In order to feel the thermo physiological comfort during clothing wear, the vapour permeability values must be correlated with the environment, the body conditions and factor related to the fabrics (finishing treatments, structure, raw materials).Vapour permeability capacity through fabrics are important properties of fabrics that influence the comfort of thermo-physiological products for apparel products. Chemical finishing processes applied to textile materials can improve or reduce the vapour permeability capability depending on the destination. Textile dyeing and film finishing processes influence the vapour permeability and implicitly, the other thermophysiological comfort features (air permeability, thermal insulation) that determine the use of a textile fabric.The paper presents the results of the researches realized on samples of fabrics with different structures, made from polyester yarns in the warp system, with different length densities. The purpose of the research is to emphasize the influence of chemical finishing processes (dyeing and waterproofing through film coating) on vapour permeability values. The experimental values obtained for vapour permeability as well as the calculated coefficients of vaporization, as a direct indicator of this thermo physiological comfort feature, have allowed the determination of the range of use of the analysed fabrics.*

Keywords: *fabrics, yarns, polyester, water vapour permeability, finishing processes*

1. INTRODUCTION

The scope of use of a fabric, requires the analysis of specific characteristics [5, 3]. Thus, fabrics for curtains, roller shutters, blinds, high moisture protection clothing (for the army, police, fire brigade, gendarmerie, or for emergency response personnel) must meet, in addition to mechanical and aesthetic properties, a series of comfort properties such as: vapor permeability, air permeability, hygroscopicity, etc. Painting and coating treatments change the values of these features. In order to meet the requirements of the field of use, the fabrics analyzed are double acrylic layer coated. Are studied the permeability to water vapour through the fabrics, made of polyester yarn with different lengths densities, in different stages of chemical finishing (painting and double acrylic layer coated) [1, 2, 3, 4].

2.EXPERIMENTAL METHOD

The present research used three variants fabrics with polyester yarns, with different length densities in the warp and the weft (table 1).

The fabrics variants were denoted: V_{11} - Raw fabric;V_{12} - Painted fabric;V_{13} - Fabric coating; V_{21} - Raw fabric;V_{22} - Painted fabric;V_{23} – Fabric coating ;V_{31} - Raw fabric;V_{32} - Painted fabric;V_{33} - Fabric coating.

Table 1: *Experimental variants of fabrics*

Fabrics variants V_i		**Yarn characteristics**		**Density [yarns/cm]**	
		Warp Rotoset polyester yarns	**Weft** Rotoset polyester yarns	**Warp [yarns/cm]**	**Weft [yarns/cm]**
V_1	V_{11}	Tden=150den	Tden=300den	38	19
	V_{12}				
	V_{13}				
V_2	V_{21}	Tden=75 den	Tden=75 den	38	30
	V_{22}				
	V_{23}				
V_3	V_{31}	Tden=150x2den	Tden=300 den	19	19
	V_{32}				
	V_{33}				

* i - fabric option; j – finishing variant chemical fabric

The research studied fabrics made of polyester yarns set and rotoset with different densities of length, for outdoor clothing waterproof. All fabrics are quilted fabric and bond have made in two variants of number of yarns per unit length in the warp and two variants of number of yarns per unit length in the weft. In table 1 shows the main characteristics of the studied fabrics. Determination of the water vapour permeability of fabrics is carried out in accordance with STAS 9005/71 [5, 6].

3.RESULTS AND DISCUSSION

The experimental values of relative permeability P_v [g], absolute permeability P_{va} [%] and the calculated values of the evaporation coefficient μ [g / m^{2}h] are presented in tables 2, 3.

Table 2: *The experimental values of water absolute vapor permeability P_{va} [g] and relative values of water permeability P_v [%]*

The cod of fabricsV_{ij}^*	**The absolute vapour permeability Pva [g]**			**The relative vapour permeability Pv [%]**		
	Pva_{24} [g]	**Pva_{48} [g]**	**Pva_{72} [g]**	**Pv_{24} [%]**	**Pv_{48} [%]**	**Pv_{72} [%]**
V_{11}	1.18	2.431	3.480	0.945	1.947	2.786
V_{12}	1.283	2.709	3.383	1.204	2.543	3.635
V_{13}	0.523	1.082	1.568	0.428	0.885	1.283
V_{21}	1.062	2.279	3.316	0.831	1.784	2.596
V_{22}	1.283	2.612	3.736	1.036	2.109	3.016
V_{23}	0.526	1.075	1.561	0.447	0.913	1.326
V_{31}	1.060	2.213	3.230	0.741	1.546	2.257
V_{32}	1.176	2.461	3.556	1.103	2.307	3.334
V_{33}	0.620	1.262	1.828	0.466	0.948	1.373

Table 2 shows that the vapour permeability values of dyed fabrics, regardless of the fabric version, are bigger in comparison with the raw and coated fabrics.

In fhe fig.1 are presented the values of absolute vapour permeability for 9 fabrics variants using the values from table 1.

The dyed fabrics variants have, depending on the exposure time, a vapour permeability absolute value bigger than raw fabrics coated fabrics (table 2, fig.1) .

The V_{22} fabrics have vapour permeability bigger with 15,4% to 19.8% than V_{21} raw fabrics and with about 56,4% and 56,7% than V_{23} coated fabrics.

The dyed fabrics from V_{31} variant, have vapour permeability values bigger with 58,8% to 58.9% than coated fabrics from V_3 variant, depending the exposure time.

Regarding the vapour permeability variation at the 24 hours exposure time, the values of vapour permeability from dyed fabrics V_1, are bigger with about 8,39% than dyed fabrics V_3 and are bigger with 13,95% than V_2 variant.

Table 3: *Calculated values of vaporisation coeficificint μ [g/m^{2}h]*

Cod V_{ij}*	**Evaporation coefficient μ[g/m^{2}h]**		
	μ_{24} [g/m^{2}h]	**μ_{48} [g/m^{2}h]**	**μ_{72} [g/m^{2}h]**
V_{11}	17.389	17.912	16.618
V_{12}	18.907	19.961	17.094
V_{13}	7.707	7.972	7.702
V_{21}	15.650	16.792	16.289
V_{22}	18.907	19.246	18.352
V_{23}	7.751	7.921	7.668
V_{31}	15.620	16.306	15.866
V_{32}	17.330	18.133	17.468
V_{33}	9.137	9.299	8.979

The dyed fabrics variants V_{12} have a permeability value bigger with 64,5% to 65,2% then coated fabrics (fig.1, fig.2, fig.3, fig.4, fig.5).

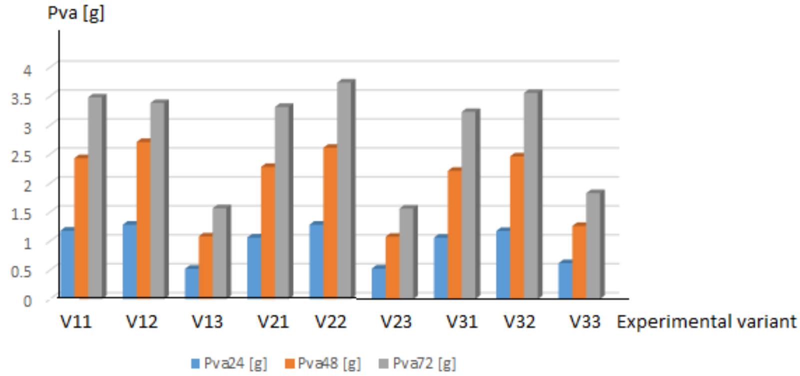

Fig.1: *Histogram of absolute permeability values*

The relative values of vapour permeability are presented in fig.2 as histograms in order to be analysed in comparison between different fabrics variants.

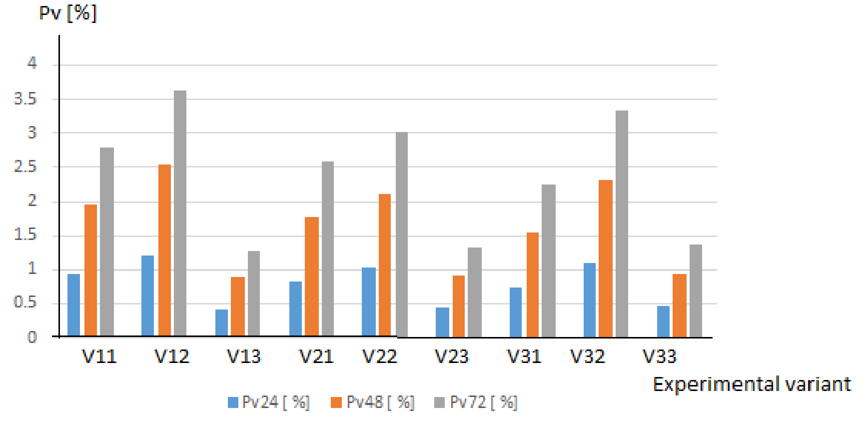

Fig.2*: Histogram of relative permeability values*

Fig.3, fig. 4 and table 2 show that the values of vapour permeability at 72 hours , grows from coated fabrics to raw fabrics.

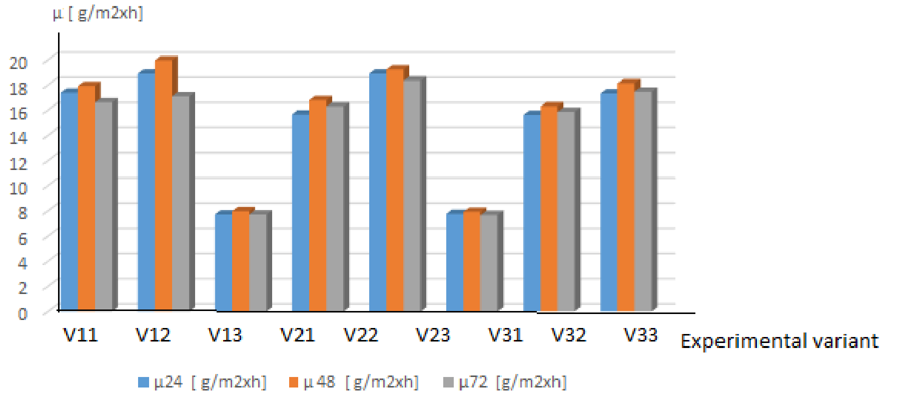

Fig.3*: Histogram of evaporisation coefficient values*

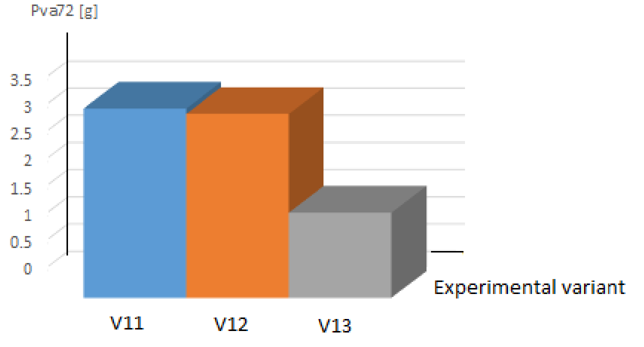

Fig.4 *: Histogram of permeability values at 72 hours for V_1 fabric variant*

After analyzing the time variation of the vapour permeability it was obtained a graphic as that from fig. 5. From this figure it can see that there is a linear variation between vapour permeability and time. The eqation for raw fabrics is y=1.1773x and the corelation coefficient is R^2=0.9968 which represents a strong corelation.

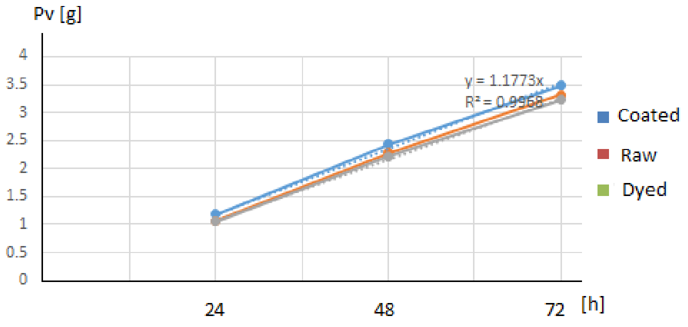

Fig.5: *The variation in time of vapor permeability for V_1 fabric*

The V_{32} variants have a vapour permeability bigger with 32,3% to 32,8% than raw fabrics $V_{31.}$

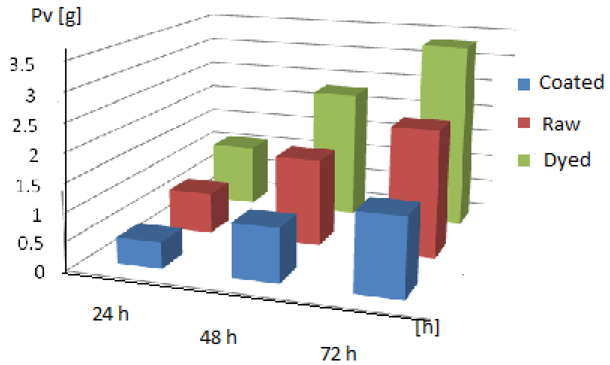

Fig. 6: *The vapor permeability for V_{31}, V_{32}, V_{33} fabrics variant*

The raw fabrics from V_1 variant have values for vapour permeability with 12.06% bigger than raw fabrics from V_2 variants and with 21,59% than raw fabrics V_3 variants (fig. 6). The coated fabrics V_3 have a vapour permeability bigger with 8.15% than V_1 variant and with 4.08% than coated fabrics variants V_2. At 48 hours, the vapour permeability of raw and dyed fabrics from V_1 variant is bigger than V_2, V_3 variant.

At 48 hours, the vapour permeability of raw fabrics and dyed fabrics from V_1 variant is bigger than V_2, V_3 variant and the coated fabrics variants have smaller values of vapour permeability. At 72 hours the vapour permeability values of V_1 variants are bigger than vapour permeability of V_2 and V_3 variants. The difference between the vapour permeability values are bigger at raw and dyed fabrics ant insignifiant for coated fabrics.

Fig.3 and table 2 show that the evaporation coefficient values range between 17,094 g/m^{2}h and 19,961 g/m^{2}h for dyed fabrics and between 16.618 g/m^{2}h and 17,912 g/m^{2}h for raw fabrics. At coated fabrics, the evaporation coefficient values are between 7,702 g/m^{2}h and 7,972 g/m^{2}h.

For dyed fabrics the evaporation coefficient values are bigger with 2,78% to 10,2% than raw fabrics depending the exposure time. So, the evaporation coefficient grows with 5.3% up to 48 hours for dyed fabrics and with 2.92% for raw fabrics. The values of evaporation coefficient fall within the range 48 hours and 72 hours for dyed and raw fabrics variants, as a result of a saturation phenomenon of the fabrics with vapours.

For V_2 dyed fabrics variant the values of evaporation coefficient are bigger with 58,2% to 59%, than those coated fabrics and with 12,75% and 17,23% than raw fabrics (table 1).

The evaporation coefficient for V_3 fabrics variants is bigger with 47,28% to 48,72% than coated fabrics and with 9,17% to 10,08% than raw fabrics from V_3 variant.

The values of evaporation coefficent of dyed fabrics are bigger than raw and coated fabrics. So, after 24 hours, the dyed fabric have evaporation coefficient values between 17,330 [g/m^{2}h] and 18,907[g/m^{2}h], the raw fabrics between 15,650[g/m^{2}h] and 18,907[g/m^{2}h] and the coated fsabrics between 7,707[g/m^{2}h] 9,137[g/m^{2}h].

The differences between evaporation coefficient values for V_1, V_2 and V_3 fabrics are relative small and the variation is between 8,34% and 10,17%.

4. CONCLUSIONS

The textile fabrics with technical destination are frequently used due to their diversity and complexity.

The paper presents the results of research regarding the vapour permeability of that are fabrics dyed and have coated treatments.

Take into consideration the results, it can concludes that the coated fabrics analyzed in this paper can be used for waterproof clothing

The research has been targeted on three fabrics with different structures (V_1, V2, V_3) (table 1) on three textile finishing ranges (raw fabrics $V_{i1,}$ dyed fabrics V_{i2} and coated fabrics with two acrylic layers V_{i3}).

It was experimentally determined the vapour permeability (relative and absolute values) and were calculated the values of evaporation coefficient as direct indicator for fabrics behaviour at vapour transfer.

The values for vapour permeability of V_1 fabrics are bigger than for V_2 and the V_3 fabrics variants.

The dyed fabrics in different variant has the biggest values for vapour permeability.

The evaporation coefficient has the smallest values for dyed fabrics from V2 variant (17,094g/m^{2}h and18,907g/m^{2}h).

Textile dyeing and film finishing processes influence the vapour permeability and implicitly, the other thermophysiological comfort features (air permeability, thermal insulation) that determine the use of a textile fabric.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

COLOR STRENGTH ESTIMATION OF COIR FIBERS BLEACHED WITH PERACETIC ACID

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Abstract: *The production rates of textile materials increase day by day due to the increasing population of the world. This rapid increase in production boosts the demand of raw materials to be used in textile manufacturing. The insufficiency of necessary natural fiber supply leads to new investigations of other natural fiber alternatives since the use of sustainable and inexpensive natural fibers presents an opportunity to protect the environment. Coir fiber obtained from the husk of ripe/matured coconut has various fields of use such as door mats, floor mats, brushes, matresses, upholstery padding, sacking and horticulture. In this study, in order to determine the optimum bleaching conditions for coir fiber, a wide variety of peracetic acid concentrations are applied at different bleaching processing times. Color strength values of bleached coir fiber fabrics vary under different conditions. This study aims to obtain the estimation of color strength values on the samples of coir fibers bleached with peracetic acid. In order to solve the problem, various mathematical function models are utilized. Then, an artificial bee colony algorithm is used to optimize the weights of the functions. Sample data of the fiber is used to verify the correctness of the color strength estimation model. The estimated results are compared with the results of experimental studies. Results show that the prediction model can fit the experimental results with a high precision. The model based on artificial bee colony is a good candidate to estimate the color strength of bleached coir fiber fabric.*

Key words: *Coconut fruit, Coir fibers, color strength estimation, swarm intelligence, artificial bee colony*

1. INTRODUCTION

Rapid growth of world population and the insufficiency of necessary fiber supply lead to new investigations of other fiber alternatives. The use of sustainable and inexpensive natural fibers presents a promising opportunity to protect the environment. Coir fiber obtained from the husk of ripe/matured coconut has a constrained field of use such as door mats, floor mats, brushes, matresses, upholstery padding, sacking and horticulture. Botanical name of Coir, a common name of coconut, is Cocos Nucifera and its plant belongs to Arecaceae family which is also known as palm [1]. Coconut trees grow up in the tropical zones of the world, but the main production is in the wet tropical area of Asia, including countries Indonesia, Phillipines, India, Sri Lanka, Malaysia and Thailand, covering about 86.7% of the total world coir fiber production [1].

Bleaching may be necessary for coir fibers in order to meet the demands of the end use application types since coir yarns and fabrics can be dyed with natural dyes and reactive dyes. In order to achieve repeatable colorometric results and pale shades during dyeing, bleaching, prior to dyeing, can be applied to coir fiber products. Morevoer, bleaching process may be necessary for special applications of coir fiber in composite materials. A review of the color measurements in the textile industry is presented in [2].

The degradation products of peracetic acid are oxygen and acetic acid and it is an environmentally safe bleaching agent since peracetic acid enables an ecofriendly bleaching with low water, energy and chemical consumption [3]. Therefore, in this study, firstly, bleaching of coir fiber fabric with peracetic acid at various conditions are performed and the color properties of bleached coir fabrics were measured.

Secondly, the color strength (K/S) values of coir fiber fabrics bleached with peracetic acid is estimated using an artificial bee colony algorithm, a swarm intelligence methodology since the treatment conditions require many experiments and thus, the use of such a technique would prevent the extensive amount of experiments which are costly and time consuming. The main purpose of using the artificial bee colony algorithm is to investigate and confirm its fitting capability to estimate the color strength values of bleached coir fiber fabrics. The performance of the artificial algorithm is demonstrated in detail against various approaches in the literature [4-6].

2. MATERIALS AND EXPERIMENTS

100% coir fiber plain woven fabric was utilized for this study. Prior to peracetic acid bleaching process, hydrophilization process was carried out to coir fiber fabrics at 1:20 liqour ratio and 95°C for 60 minutes with 10 g/l sodium hydroxide, 5 g/l sodium carbonate and 2 g/l wetting agent (DyStar, Germany). Afterwards, coir fiber fabrics were rinsed in hot water for 10 minutes and then, cold neutralization process was carried out at 1:20 liqour ratio with 1 ml/l acetic acid for 15 minutes. Finally, coir fiber fabrics were cold rinsed for 10 minutes and left to dry out at ambient conditions. Peracetic acid bleaching process was carried out at 70°C with 1:30 liquor ratio at about pH 5 (with sodium carbonate). 1g/l wetting agent (DyStar, Germany) was also added to the bleaching bath. In order to determine the optimum bleaching conditions for coir fiber, ther wide variety of peracetic acid concentrations (5, 10, 20 and 30 g/l) were applied at different bleaching processing times (30, 60, 90 minutes). Following the bleaching treatments, bleached coir fiber fabrics were rinsed for 15 minutes cold rinse, 5 minutes hot rinse and 5 minutes cold rinse, respectively. Afterwards, color strength values of the coir fiber samples were determined using a DataColor 600 spectrophotometer. Each sample was measured from four different areas, and the average values were calculated. The color strength (K/S) values of bleached coir fiber fabrics are shown in Table 1. In general, as the peracetic acid concentration increases and bleaching duration prolongs, the K/S (color strength) degrees of the bleached samples gradually decreases. For example, 30 g/l peracetic acid bleaching for 90 minutes resulted in relatively low K/S value of 7.25. Peracetic acid bleaching using 5 g/l peracetic acid for 60 and 90 minutes did not result in any reduction in color strength leading to comparable similar K/S results with the scoured coir fabric (Table 1). On the other hand, peracetic acid bleaching using 5 g/l peracetic acid for 30 minutes led to slight colour strength increase. This means that peracetic acid bleaching using 5 g/l peracetic acid for all studied durations (30 60 and 90 minutes) did not cause an expected bleaching effect. It was earlier reported that some lignocellulosic fibers such as raffia, jute and pineapple fibers may become yellower and less white after alkali treatments and significant color strength increase for treatments with increased alkali concentrations could be probably linked to chlorophyll degradation since chlorophylls are easily deteriorated with alkaline agents [7-9].

Table 1*: Color strength performance of coir fibers bleached with peracetic acid at pH=5*

Bleaching duration (minutes)	Peracetic acid concentration (g/l)	*L**	*a**	*b**	K/S
Scoured	-	48.1	9.11	27.12	12.15
30	5	48.4	7.87	28.91	13.32
30	10	52	7.09	28.56	10.54
30	20	53.6	5.05	28.57	10.55
30	30	55.6	7.58	32.42	9.97
60	5	50	8.46	29.92	12.25
60	10	55.6	9.08	33.44	10.70
60	20	62.3	6.65	34.69	7.82
60	30	64	4.21	30.72	6.37
90	5	51.1	9.46	31.67	12.14
90	10	57.1	7.06	32.13	9.28
90	20	63.5	6.02	36.74	8.97
90	30	65.8	6.36	36.23	7.25

3. ESTIMATION METHODOLOGY

The artificial bee colony algorithm, firstly proposed by Karaboga [10] is based on collective flock intelligence of swarms and is inspired by the social behavior of honey bees looking for food sources. The bee colony consists of three kinds of bees: employed bees, onlooker bee and scout bees. In this study, artificial bee colony algorithm [5, 6, 11]is utilized for color strength estimation according to the micro structure of coir fibers bleached with peracetic acid. The main steps of the algorithm are presented in Figure 1.

1	Randomly initialize a random bee population for the available food locations
2	Repeat
3	Employed bee phase: investigate the food sources in which the amount of nectar is high.
4	Onlooker bee phase: follow the nectar information shared by the employed bees to further exploit the food sources with high content
5	Scout bee phase: randomly discover new food locations once the nectar amount is fully consumed in an already discovered food source
6	Until stop conditions are met

Fig. 1*. The main steps of the artificial bee colony algorithm*

The algorithm is initiated via by Equation (1) where i represents a bee in the population, j represents the problem dimension and x_j^{max} and x_j^{min} represents the upper and lower limits of the problem search space, respectively (Step 1 of Figure 1).

$$x_{ij} = x_j^{min} + rand\ (0,1)\left(x_j^{max} - x_j^{min}\right) \quad \textbf{(1)}$$

Onlooker bees receiving the information about the food source from employed bees, probabilistically select the food source and using Equation (2), further exploit the food sources in the search where v_i represents a new solution in the neighborhood of the current solution, x_i represents the current solution, x_k represents a random neighbor of the current solution, ϕ_{ij} represents a random value selected in the range $[-1,1]$ and D represents the problem dimension. If the newly obtained solution value is better than the previous solution value, the new information about is stored, otherwise discarded (Step 3-4 of Figure 1).

$$v_{ij} = x_{ij} + \phi_{ij}(x_{ij} - x_{kj}), j = 1, \ldots, D \quad \textbf{(2)}$$

Once the nectar amount is consumed, i.e., the current solution cannot be further improved, the food source is abandoned, and scout bees are released to discover new food sources by using equation (1) (Step 5 of Figure 1). All these steps form one cycle of the algorithm and continue until the stopping criteria are met.

The mathematical functions used in the model are given in Equations (3-8). The aim is to optimize the weights ($w_1 - w_{10}$) of these equations in order to minimize the total error and reveal the most accurate estimation values since the values of the weights may greatly influence the estimation results. Here, six different functions; linear (Equation 3), quadratic (Equation 4), cubic (Equation 5), exponential (Equation 6), sigmoid (Equation 7) and exponential-trigonometric (Equation 8) are utilized for parameter optimization to estimate the color strength of coir fibers bleached with peracetic acid.

$$F_{linear} = w_1 + w_2X_1 + w_3X_2 \quad \textbf{(3)}$$

$$F_{quadratic} = w_1 + w_2X_1 + w_3X_2 + w_4X_1X_2 + w_5X_1^2 + w_6X_2^2 \quad \textbf{(4)}$$

$$F_{cubic} = w_1 + w_2X_1 + w_3X_2 + w_4X_1X_2 + w_5X_1^2 + w_6X_2^2 + w_7X_1^2X_2 + w_8X_2^2X_1 + w_9X_1^3 + w_{10}X_2^3 \quad \textbf{(5)}$$

$$F_{exponential} = w_1 + w_2{X_1}^{w_3} + w_4{X_2}^{w_5} \quad \textbf{(6)}$$

$$F_{sigmoid} = w_1 + w_2/(1 + e^{w_3X_1}) + w_4/(1 + e^{w_5X_2}) \quad \textbf{(7)}$$

$$F_{exponential-trigonometric} = w_1 + w_2e^{w_3X_1+w_4X_2+w_5}\tanh(w_6X_1 + w_7X_2 + w_8) \quad \textbf{(8)}$$

x_1: Bleaching duration (First input), x_2: peracetic acid concentration (g/l) (Second input)

Fig.2 presents the estimation results of various functions corresponding to the original experiments while detailed results are presented in Table 2. The cubic form has achieved the best results while exponential-trigonometric form has been the runner-up. As a result, in the worst case, average percentage gap was 9.34% between the estimation results and the original experiment results and in the best case, the cubic form achieved 2.78% gap between the estimation results and the original experiment results.

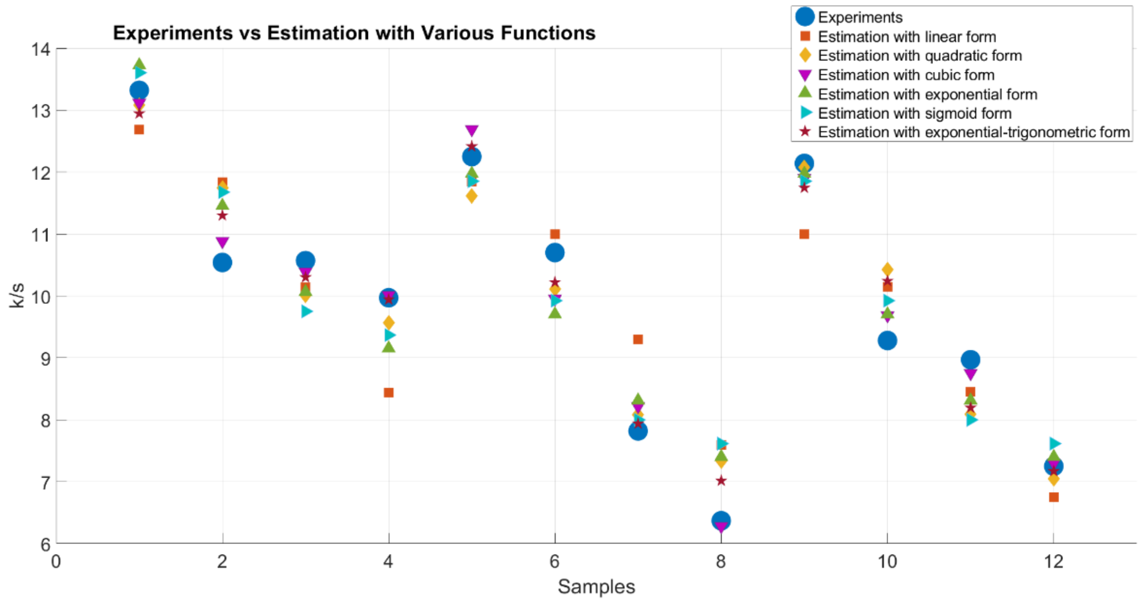

Fig. 2*: Experiments vs. estimation with various functions*

Table 2: *Estimation of color strength and error percentages of various functions*

Experiment	Linear Form	Quadratic Form	Cubic Form	Exponential Form	Sigmoid Form	Exponential-Trigonometric Form
13.32	12.69	13.09	13.12	13.73	13.60	12.95
10.54	11.84	11.74	10.88	11.46	11.68	11.30
10.57	10.14	10.01	10.39	10.06	9.75	10.30
9.97	8.44	9.56	10.01	9.15	9.37	9.94
12.25	11.84	11.61	12.69	11.97	11.85	12.41
10.7	10.99	10.11	9.95	9.70	9.92	10.22
7.82	9.29	8.08	8.22	8.31	8.00	7.94
6.37	7.59	7.33	6.28	7.40	7.62	7.02
12.14	11.00	12.07	11.90	11.97	11.85	11.75
9.28	10.15	10.43	9.68	9.70	9.92	10.24
8.97	8.45	8.09	8.75	8.31	8.00	8.20
7.25	6.75	7.04	7.30	7.40	7.62	7.17
Average Gap (%)	9.34	6.43	2.78	6.18	7.02	4.47

4. CONCLUSIONS

In this study, firstly, color strength of coir fibers was investigated after different peracetic acid bleaching processes. Peracetic acid bleaching on coir fiber resulted in lower color strength values. Peracetic acid bleaching process with varying application times result in different color strengths. In general, as the peracetic acid concentration increases and bleaching duration prolongs, the K/S (color strength) degrees of the bleached samples gradually decreases. Secondly, it was aimed to estimate the color strength of coir fibers bleached with peracetic acid by means of an artificial bee colony algorithm using various mathematical functions. The model achieved a successful fit on the samples. The results confirmed that the artificial bee colony algorithm provided high estimation accuracy to estimate the color strength of the fiber.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

FUNCTIONAL DIVERSIFICATION POSSIBILITIES FOR KNITTED USED IN HOMETECH PRODUCTS

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Abstract: *Knitted are successfully used in all human activities: industry, agriculture, army, medicine, sports, leisure, etc. (Agrotech, Buildtech, Clothtech, Hometech, Geotech, Medtech, Protech, Sporttech, Mobiltech, Indutech, Packtech, Oekotech). The technical knitted used in mattress manufacturing, upholstery articles and interior decorations (Hometech branch) comprise a wide range of products of different structures and raw materials, which must meet the specific requirements requested by the beneficiaries: constructive, aesthetic, thermal and sensorial comfort, health protection, harmful substances content, flammability, degradation capacity in a biological environment, availability requirements and for cleaning, remedy and reconditioning, etc.. These requirements stand at the base of the creation and design processes and they are stated in the documentation of the product. Evaluating product quality involves establishing representative features in relation to their intended use and applying standardized testing methods to select optimal variants.*
Regardless of the type of mattress, the upholstering can be made with either weft or warp knitted. These are characterized by an extremely varied design, structural diversity and raw materials of remarkable variety, including ecological and biodegradable ones, durability and versatility.
The purpose of this paper relies in presenting a collection of knitted structures intended for mattress manufacturing, along with their technological and functional characteristics, as well as an example of programming such a structure on an OVJA type knitting machine. 215

Key words: *Knitted, mattresses, structure, characteristics, programming.*

1. INTRODUCTION

Using knitted in all compartments of human activity is possible due to the many advantages offered [1, 2, 3]:

- diversity of presentation forms;
- reduced specific mass compared to other textile materials;
- creation of knitted structures combining the characteristics of woven fabrics (resistance to mechanical stress, reduced extensibility), with those knitted specific (spatial modelling capacity, voluminousness, possibilities for extended diversification, pleasant touch, high economic efficiency);
- development of new knitting technologies;
- possibility of directing specific characteristics;
- use of an extended range of yarns with superior features.

New uses are found daily for knitted that can replace traditional materials, costly ones, or those that are difficult to be made technically.

Technical knitted used for the confection of mattresses (the Hometech branch) have a large variety of products with different structures and primary materials that must meet the specific requirements solicited by the beneficiaries:

- Constructive requirements: dimensional correspondence, composition, structure, weight;
- Aesthetic requirements: the mattresses' appearance, the material that was used for the upholstering, the colour or colour scheme, the sewing, the seams, etc;
- Requirements concerning the thermal and psycho-sensorial comfort, flexibility, extendibility, elasticity;
- Requirements about health safety, the content of toxic substances, flammability, the rate of disintegration in the environment;
- Availability requirements: durability, the ability to maintain its shape, appearance, colours and size over time;
- Requirements concerning the cleaning, mending, refurbishing, decontamination, etc. of the mattress.

These requirements stand at the base of the creation and design processes and they are stated in the documentation of the product.

2. MATTRESS TYPES AND THEIR CHARACTERISTICS

Specialty literature [4 – 10] divides mattresses in multiple types: orthopedic, super-orthopedic, pocket, memory foam, latex, medical and children's mattresses.

Regardless to their type, mattresses can have the following characteristics:

- different variants of dimensions and thickness (14 – 24 cm);
- different degrees of firmness (firm, medium, soft);
- the possibility of using the mattress in both sides (one side for the warm season and another for the cold one);
- detachable cover or not;
- diverse fabrication technologies;
- with or without springs;
- variable warranty period.

Figure 1 ilustrates an example of a spring mattress.

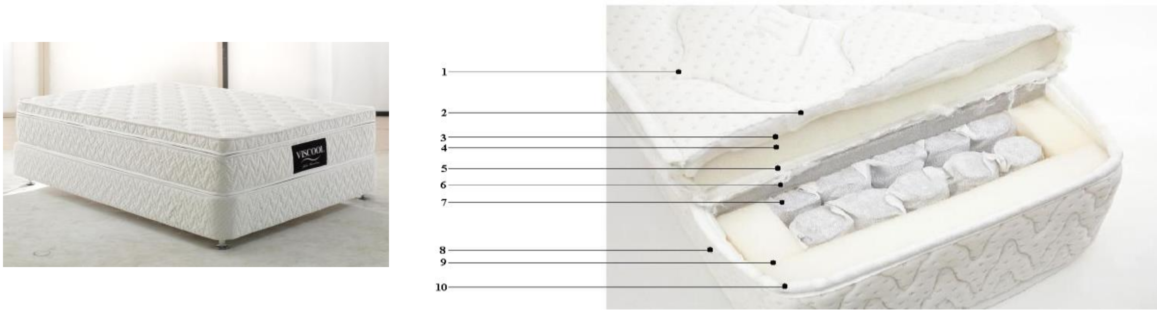


***Fig. 1**: Viscool mattress*

1. Double relief rib jacquard, with 99% PES, 1% PA, 375g/m^2; 2. Syntethis cotton 500g/m^2; 3, 5 Rolles of PU foam (1.5cm); 4, 6 PU foam plate (of 5cm and 3cm tchikness, respectively); 7. Pocket spring system – coils packaged in individual textile bags; 8. Ventilation capsule; 9. PU foam support frame (5cm thick si 15cm tall); 10. PU foam border (0.8 cm thick, 32cm tall)

In figure 2 another examples is presented – Dormeo mattress.

Dormeo Memory 2+12 Silver Plus mattresses are realized with Ecocell foam and memory foam, materials that have a benefic effect on sleep and health. The combination between the two innovative materials and the addition of silver fibers regulates excessive sweat for a relaxing sleep. The silver fibers have an antibacterial, antistatic and isothermal effect.

Dormeo Orthopedic [9] is a firm, anatomical and orthopedic mattress that sustains and encourages the correct position of the spine during sleep (figure 2). The innovative core made out of Eliocel is more rigid, but very light, ensuring at the same time a good support for the body.

Fig. 2*: Spinal support offered by Dormeo orthopedic mattresses*

1 The outside exterior is treated, offering protection against fungi, bacteria and dust mites.

2 The additional silicone layer ensures supplementary protection against bacteria, having anti-allergic proprieties.

3 The cellular structure of Eliocel ensures air circulation. As such accumulation of humidity inside the mattress and excessive sweat during sleep is prevented.

4 Eliocel (13 cm) is a last generation material that offers an optimal support fir the body during sleep and antibacterial protection.

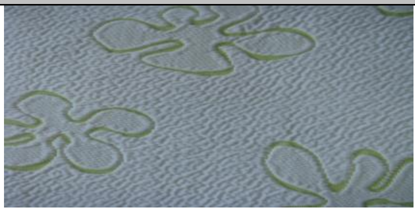
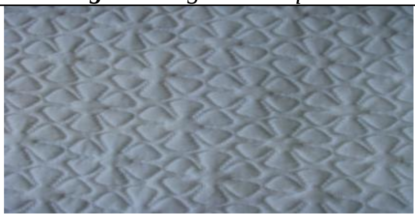
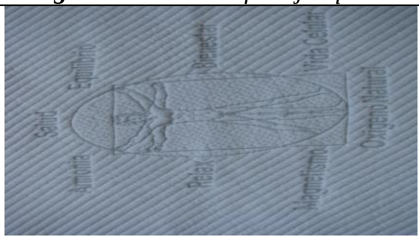
3. COLLECTION OF KNITTED STRUCTURES DESTINED TO MATTRESS MANUFACTURING – CHARACTERISTICS

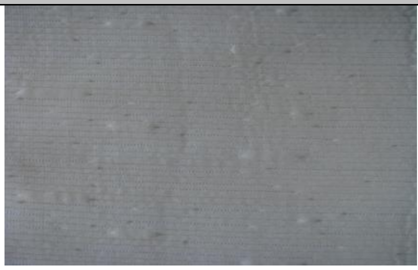
Integrated knitted fabrics are complex multilayer type structures. The fibers used for the fabrics are specifically chosen according to the final use of the fabric. Both faces of the fabric contain fibers with aesthetical, comfort, protection and durability features, while the filling fibers serve the purpose of thermic isolation and elastic rebound after compression.

In what follows a collection of knitted structures destined to mattress fabrication will be presented, produced on circular OVJA 1.6 E knitting machines, pertaining to Mayer&Cie firm, in one of the profile firms in Romania [11].

Table 1: *Knitted fabric models/ Characteristics*

No.	Knitted fabric model	Yarns processed	Constructive characteristics
1.	 ***Fig. 3*****:** *Double relief rib jacquard*	Front yarns: Bamboo-viscose 100% Nm 20/1; Back yarns: PES 100% 150 den; Filling yarn: PES 100% 600 den, Rapport 1/2	Width: 2,42 m Weight: 264 g/m^2 Thickness: 2,95 mm

No.	Knitted fabric model	Yarns processed	Constructive characteristics
2.	 ***Fig. 4:*** *Irregular Jacquard*	Front yarns: PES 100% Nm 18/1; Back yarns: PES 100% 150 den; Filling yarn: PES 100% 600 den, Rapport: 1/4	Width: 2,38 m Weight: 277 g/m^2 Thickness: 3,16 mm
3.	 ***Fig. 5:*** *Double relief rib jacquard*	Front yarns: Cotton 100% Nm 24/1; Back yarns: PES 100% 150 den; Filling yarn: PES 100% 600 den, Rapport: 1/2	Width: 2,20 m Weight: 263 g/m^2 Thickness: 3,34 mm
4.	 ***Fig. 6:*** *Irregular Jacquard*	Front yarns: PES 100%, Nm 20/1; Back yarns: PES 100% 150 den; Filling yarn: PES 100% 1200 den, Rapport 1/3	Width: 2,54 m; Weight: 305 g/m^2; Thickness:
5.	 ***Fig. 7:*** *Double relief rib jacquard*	Front yarns: Cotton Biofairtrade 100% Nm 20/1; Back yarns: PES 100% 150 den; Filling yarn: PES 100% 1200 dtex, Rapport: 1/4	Width: 2,30 m Weight; 270 g/m^2 Thickness: 3,11 mm
6.	 ***Fig. 8:*** *Jacquard through application*	Front yarns: Cotton Biofair 100% Nm 20/1; Back yarns: PES 100% 150 den; Filling yarn: PES 100% 600 den, Rapport: 1/2	Width: 2,30 m Weight: 280 g/m^2 Thickness: 3,25 mm
7.	 ***Fig. 9:*** *Irregular Jacquard*	Front yarns: PES 100% 18/1 Nm; Back yarns: PES 100% 150 den; Filling yarn: PES 100% 600 den, Rapport: 1/4	Width: 2,40 m Weight: 260 g/m^2 Thickness: 3,22 mm

No.	Knitted fabric model	Yarns processed	Constructive characteristics
8.	 ***Fig. 10:*** *Double relief rib jacquard*	Front yarns: Bamboo-viscose 100%, 20/1 Nm; Back yarns: PES 100% 150 den; Filling yarn: PES 100% 1200 den, Rapport: 1/4.	Width: 2,30 m Weight: 275 g/m^2 Thickness: 2,76 mm

4. PROGRAMMING INTEGRATED KNITTED (USED AS HOMETECH ARTICLES) ON OVJA 1.6 E MAYER&CIE MACHINES

Programming an integrated knitted – jacquard type on a circular knitting machine OVJA 1.6 E (Mayer&Cie) is illustrated underneath [11].

Fig. 11: *Double relief rib jacquard*

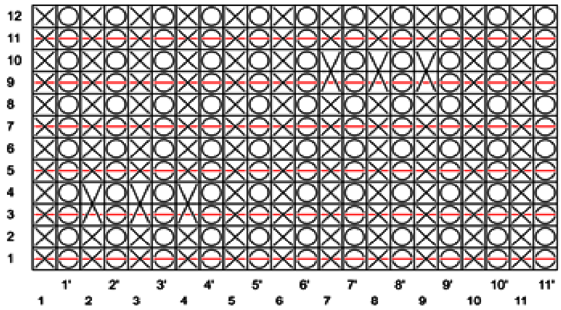


Fig. 12: *Representation through conventional signs of the structure's rapport*

Yarns processed

Front yarns: PES 100% 75 den;
Back yarns: PES 100% 150 den;
Filling yarn: PES 100% 300 den, Rapport: 1/2

Constructive characteristics

Width: 2,50 m; Mass = 145 g/m^2; Thickness:2,29 mm.

Structural parameters:

Ds/h = 45; Ds/v = 55;

Rând	D l	D s	C	Rând	D l	D s	C
R1	C2	C1	ZA	R13	C2	C1	ZA
R2	A2	A1	ZC	R14	A2	A1	ZC
R3	C2	C1	ZA	R15	C2	C1	ZA
R4	A2	A1	ZC	R16	A2	A1	ZC
R5	C2	C1	ZA ZC	R17	C2	C1	ZA ZC
R6	A2	A1	ZA ZC	R18	A2	A1	ZA ZC
R7	C2	C1	ZA ZC	R19	C2	C1	ZA ZC
R8	A2	A1	ZC	R20	A2	A1	ZC
R9	C2	C1	ZA	R21	C2	C1	ZA
R10	A2	A1	ZC	R22	A2	A1	ZC
R11	C2	C1	ZA	R23	C2	C1	ZA
R12	A2	A1	ZC	R24	A2	A1	ZC

ZA – utilizing individual selection for normal stitch formation;
ZC – utilizing individual selection for non-knitted stitches formation.

Fig. 13: *Programming Double relief rib jacquard*

5. CONCLUSIONS

Technical knitted used for the confection of mattresses (Hometech branch) come in a large variety of products that must meet the specific requirements solicited by the beneficiaries. These requirements stand at the base of the creation and design processes and finalised with filling the documentation of the product.

Taking into consideration that aesthetic and comport requirements are fist rank, in order to respond better to the user's solicitations, in mattress upholstery (regardless of their type) weft knitted are used. They are characterized by an extremely varied design, structural diversity, prime materials of remarkable variety, including ecological and biodegradable ones. All these leas to obtain satisfaction from the users during the visualisation of the mattress model, aspect, of knitted used, the colour or chromatic scheme, as well as improved performance during mattress usage.

In this paper a collection of weft knitted structures destined to mattress fabrication are presented, produced on circular OVJA 1.6 E knitting machines, pertaining to the Mayer&Cie firm.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

FABRICATION OF THREE-LAYER HEATING WOVEN FABRIC AND ANALYSIS OF THE EFFECT OF FABRIC STRUCTURAL PARAMETERS AND ELEMENT TYPE ON HEATING BEHAVIOUR

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Abstract: *Electrical heating garments are getting more and more attention in the last decades because of their wide range of application such as medical textiles, military textiles and domestic uses. These textiles are produced by integration of the heating elements in fabrics. There are some common ways to produce these textiles, for instance weaving, knitting and embroidery. In this research 12 groups of three-layer woven fabrics were produced using different weave pattern on the front and back layers, two heating element ratio and three kinds of heating elements namely the Nickel-Chrome, Tungsten, Aluminium-Chrome. The mentioned three layer fabrics were warp stitched woven fabrics in which the heating elements were embedded in the middle layer as wadded weft. After measurement of physical characteristics of the produced fabrics such as the areal weight, thickness, bending and air permeability, the heating ability of the fabrics under two different voltages was evaluated. In order to report the heating performance of fabrics thermal parameters such as the "maximum temperature" at different sides of the fabric and the "rate of temperature increment" were measured. According to the results the fabrics with similar weave structures on both sides of the fabric, have similar physical and heating behavior on both front and back layers. Moreover, among various heating elements which were embedded in the central layer of the fabrics, Tungsten presented the best heating performance from the view point of "maximum temperature" and the "rate of temperature increment", followed by Aluminium-Chrome with a considerable difference.*

Key words: *Heating Element, Thermal Behaviour, Weave Structure, Air Permeability, Bending*

1. INTRODUCTION

The Thermal comfort temperature range for the human body is between 15 to 28 °C. However, physiological comfort has narrower range about 22.2 to 25.5 °C [1]. Smart textile has the ability to receive environment condition data, process them and then adapt itself to it. Therefore, smart textiles can create a suitable condition for users. Because of this application, heating textiles have largely been expanded and getting more attention in the recent years. They are divided into four main categories; namely, electrical heating garment, phase change material (PCM), chemical heating clothing and heating clothing with fluid. The aim of using electrical heating textiles is to produce heat for the wearer. These textiles usually contain sensors, activator, data processor, and energy source and user interface [2, 3]. Kyacan et al. (2009) put forward heated fabric panels to investigate metallic textile structures. In this research, different kinds of fabrics were produced by incorporating steel yarns and their heating behavior was analyzed [4]. Hao et al. (2012) utilized conductive filaments for producing flexible heating fabrics and tried to develop a method to adjust conductive filament density in order to control the rate of power according to user's requirements [5]. Yen et al. (2013) studied the thermal conductivity of heating electric fabrics numerically to analyze heat transfer and thermal conductivity [6]. Roh et al. (2016), developed intelligent temperature regulation system for smart clothing applications in order to reach the best thermal comfort for the users [7].

2. EXPERIMENTAL

2.1 Sample Preparation

twelve kinds of three layer warp stitched woven fabrics were designed and produced on a handloom machine with 8 shafts, in the way that the front layer and back layer fabrics consisted of two kinds of weave patterns (Twill 2/2 and Plain) and the heating elements were embedded in the middle layer as wadded weft. Moreover, the presence of heating elements in the fabric structure had two conditions of 6 and 12 (for example after 6 weft yarn insertion, 1 heating element was embedded). Besides, three types of heating elements namely the Nickel-Chrome, Tungsten, Aluminium-Chrome was utilized in order to evaluate the heating performance of various elements. The specifications of the three layer woven fabrics are shown in Table 1.

Table 1: *fabrics specification*

Sample No.	Weight (g/m^2)	Thickness (mm)	Weave pattern "Front Layer"	Weave pattern "Back layer"	Heating element and (element ratio to weft)
1	572	3.08	Twill 2/2	Twill 2/2	Ni-cr (6)[1]
2	578	3.02	Twill 2/2	Twill 2/2	W (6)[2]
3	506	3.01	Twill 2/2	Twill 2/2	Al-Cr (6)[3]
4	493	2.64	Twill 2/2	Plain	Ni-Cr (6)
5	446	2.48	Twill 2/2	Plain	W (6)
6	453	2.51	Twill 2/2	Plain	Al-Cr (6)
7	538	3.15	Twill 2/2	Twill 2/2	Ni-Cr (12)
8	542	3.16	Twill 2/2	Twill 2/2	W (12)
9	573	3.18	Twill 2/2	Twill 2/2	Al-Cr (12)
10	485	2.88	Twill 2/2	Plain	Ni-Cr (12)
11	513	3.03	Twill 2/2	Plain	W (12)
12	559	3.08	Twill 2/2	Plain	Al-Cr (12)

As an example the weave pattern, drafting plan and the peg plan for weaving of the sample No. 4 is shown in Figure 1. It is necessary to mention that the heating element insert after 6 or 12 weft.

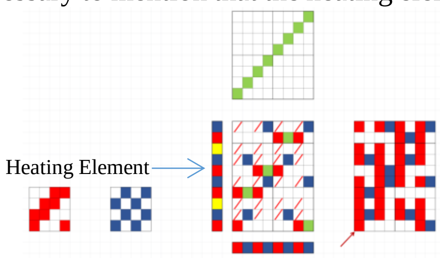


Fig. 1*: The weave pattern, drafting plan and the peg plan of sample No. 4*

[1] Nickel-Chrome
[2] Tungsten
[3] Aluminium-Chrome

As it was mentioned above, three kinds of heating elements were utilized to produce the fabrics. Heating element diameter was similar and it was chosen to be equal to 0.1 mm. All the samples were woven using 24/2 Nm Acrylic yarns for both weft and warp yarns of the front and back layers. It is obvious that bending of the heating element has a significant role on fabrics' flexibility and with regards to the wearer comfort; it is one of the most important parameters which needs to be considered in electrical heating fabrics. To measure the bending properties of heating element, the two ends of the elements were fixed between two stands and by the use of "Two Supports Beam System" proposed by Ghane et al. (2008) [8], the bending rigidity of the heating elements were calculated with the aid of MATLAB image processing toolbox. The measurement of the bending rigidity of heating elements was carried out at three different stand distances of 4, 6 and 5 cm (Table 2). The deflection gradient of the elements in each situation was reported as a measure of element bending rigidity. Furthermore, other properties, such as air permeability and thermal behaviour of different woven fabrics with various weave structures and element types were measured and analysed and the results are shown in Table 3 and 4.

3. Result and discussion

3.1. Fabric Physical Properties

Since the constituent yarns of the fabrics in the back and front layer are the same, the bending performance and the flexibility of the studied fabrics with similar weave patterns are directly influenced by the bending rigidity of the heating elements. Thus, the results obtained for the deflection gradient of elements can be used as guidance for prediction of fabrics' flexibility in each weave structure. The results of bending properties of heating elements (Table 2) show that the highest bending rigidity among the samples belongs to Al-Cr and the maximum flexibility was recorded for Ni-Cr element and Tungsten stands between the two mentioned elements.

Table 2: *Bending of heating elements*

Deflection Gradient			Element Type
6 cm	5 cm	4 cm	
0.2425	0.1460	0.0750	Al-cr
0.3879	0.2180	0.1934	Ni-cr
0.1256	0.1958	0.1343	W

Figure 2 also shows the ability of heating elements to bend. According to the Figure 2, similar trends were achieved at various distances of measurement stands. The lowest the value of the deflection gradient, the highest the bending rigidity of the heating element is. According to the results it can be predicted that for each weave structure, fabrics consisted of Ni-cr has the highest flexibility which results in higher movement comfort of the wearer.

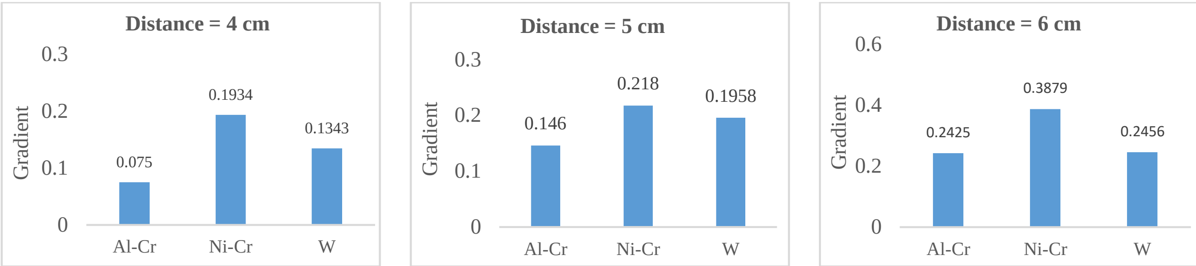


***Fig. 2**: Bending ability of heating elements*

As it is mentioned in Table 1, other physical properties of samples were also measured. According to the results gathered in Table 1, since the diameter of the heating elements was equal, this parameter did not affect the areal weight (g/m^2) and the thickness (mm) of the samples. The mentioned characteristics were mainly affected by the weave structure of the front and back layers. It can be concluded that fabrics with twill 2/2 weave structures on both layers had higher areal weight and consequently higher thickness compared to twill2/2-plain structures.

Besides the air-permeability of the fabrics from both side of the fabrics due to the change of weave structure at front and back layers were measured and the results are gathered in Table 3.

***Table 3:** Air permeability of samples ($ml/s.cm^2$)*

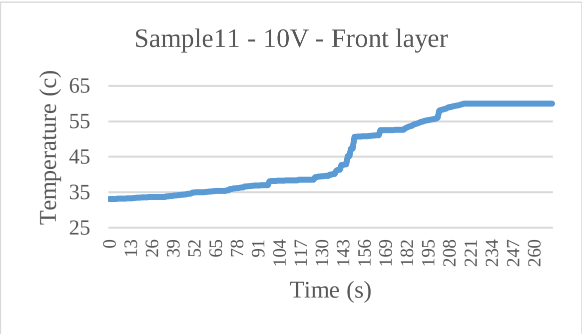
Sample No.	Air permeability “Front Layer”	Air permeability “Back Layer”	Sample No.	Air permeability “Front Layer”	Air permeability “Back Layer”
1	21.50	19.75	7	22.75	22.50
2	19.00	18.00	8	19.75	20.00
3	27.00	28.75	9	22.45	22.50
4	20.25	25.25	10	19.00	20.25
5	26.75	27.75	11	17.50	18.25
6	24.50	24.75	12	14.00	15.25

From the results it is clear that the samples with the same weave structures on their front and back layer have equal air permeability on both sides of the fabric. For the samples with different weave structures on the front and back layer, the layer with opener structure, and higher amount of air passing spaces, have higher air permeability. Analysis of results show that higher quantity of air can pass through the plain side of the fabric compared to the twill side. It should be noted that the thickness of twill 2/2 is more than plain, which results in more resistance against air passage from this side of the fabric. Besides, increasing the ratio and presence of heating elements embedded in the fabric structure, reduces the air permeability in fabrics. According to the results, type of element has no significant effect on air permeability of the fabrics.

3.2. Heat production ability of the fabrics

Heat producing and heat transfer are the most important features of the electrical heating textiles. In this regard, the heat produced in all of the fabrics was measured under two different voltages of 10V and 12V. The heating performance of sample 11 (twill2/2-plain with

Tungsten heating element) is shown in Figure 3.



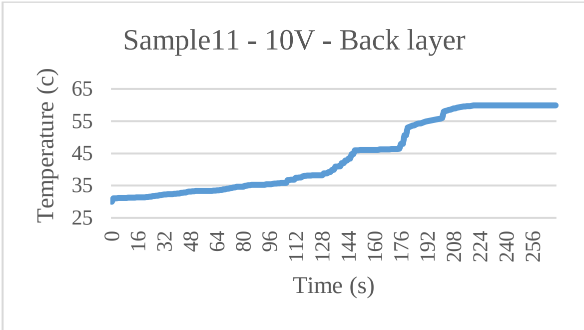


Fig. 3*: Maximum temperature and rate of temperature rise in sample 11*

From Figure 3 it is clear that the heating procedure of the fabrics commences with a gradual growing trend followed by a sharp rise, then it increases slightly and in the end it remains constant.

In order to report the heating performance of various samples, the “maximum temperature” obtained for the front and back layer and also the “rate of temperature increment” of fabrics in different conditions of testing was calculated and recorded. As it is obvious in Table 4, the results show that the heated samples subjected to 12V voltage has higher temperature and higher rate of heat production, compared to the heated samples exposed to the voltage of 10V.

Considering the results shown in Table 4, it is clear the “maximum temperature” and the “the rate of temperature increment” are much higher for the Tungsten heating element compared to the other incorporated elements. Thus, it can be concluded that the best heating performance can be achieved by utilizing tungsten. On the other hand, the weakest heating ability belongs to Ni-cr element.

Table 4: *Maximum temperature (°C) and rate of temperature increment (°C/S)*

Sample No.	Maximum Temperature (10V) “Front layer”	Maximum Temperature (10V) “Back layer”	Rate of Temperature Increment (10V)	Maximum Temperature (12V) “Front layer”	Maximum Temperature (12) “Back layer”	Rate of Temperature Increment (12V)
1	36.4	35.6	0.016	38.9	38.9	0.018
2	68.9	68.6	0.698	73.5	72.5	0.728
3	34.3	34.7	0.014	36.8	36.5	0.016
4	34.7	34.7	0.014	35.9	35.0	0.015
5	68.9	67.8	0.712	74.9	72.8	0.744
6	34.3	34.0	0.015	36.0	35.8	0.017
7	34.4	34.2	0.014	38.6	38.6	0.018
8	60.1	60.1	0.652	68.6	68.6	0.723
9	32.3	32.9	0.013	36.0	35.6	0.210
10	34.6	34.2	0.014	38.1	36.6	0.221
11	60.1	59.9	0.066	68.3	68.0	0.752
12	33.5	34.6	0.014	36.9	35.3	0.200

While analyzing the effect of fabrics structural parameters on the heating performance of fabrics, it was recognized that the fabrics with same weave structures on front and back layer have the equal maximum temperature on both sides. In comparison of the twill 2/2 and plain weave structures located on different sides of the fabrics (front and back layer) it was noticed that the samples with twill 2/2 weave structure on both sides, due to their higher thickness can save the heated air and have the higher temperature compared to plain weave structure.

4. CONCLUSIONS

In this study twelve groups of three layer warp stitched woven fabrics with three type of heating elements, two kind of weave pattern and two kind of heating element density were designed and produced and the effect of fabric structural parameters, element type and the voltage of the heating system was investigated on the fabric physical properties and the heating performance of the structure. According to the results, the highest temperature in equal voltage belongs to samples with Tungsten element used as the weft wadding. These samples have the most rate of increasing temperature, too. Moreover, the samples with equal weave structure on both sides of the fabric have the same physical properties and heating behavior. According to the results the fabrics with the weave structure of twill 2/2 on both front and back layer had better heating performance considering the maximum resultant temperature on both sides of the fabric.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

INNOVATIVE TECHNOLOGICAL SOLUTIONS FOR THE DESIGN AND PRODUCTION OF TACTICAL EQUIPMENT

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Abstract: *Clothing products and tactical equipment are ideal for personalization and customization according to consumer requirements, which do not fit into standard sizes (body size and atypical conformations or special requirements) and are an important niche for the garments sector.*
The paper presents the implementation of the innovative technological solutions for the design and production of tactical equipment, highlighting the importance of personalization and its competitive advantages, from the idea to the prototype or product and testing it. The purpose of the research was to increase the competitiveness and quality of the products obtained at SC TACTICA OUTDOOR SRL by applying innovative technological solutions for the design and production of tactical equipment, already validated by the National Research-Development Institute for Textiles and Leather - INCDTP.
Innovative technological solutions for the design and production of tactical equipment include a number of software such as virtual body drawing software (avatar), automated design software with Made-to-measure, simulation and virtual modeling software. These innovative technological solutions were applied in the process of manufacturing a tactic equipment, resulting in a personalized product according to the individual body size of the subject.
The paper promotes the application of intelligent clothing CAD, supporting the development of the garment industry.

Key words: *design, tactical equipment, innovation, virtual simulation*

1. INTRODUCTION

Nowadays the information became more easily accessible and the competition within the clothing industry also became more volatile. To be more competent, mass customization has risen to become one of the future trends of the industry [1].

Clothing products and tactical equipment are ideal for personalization and customization according to consumer requirements, which do not fit into standard sizes (body size and atypical conformations or special requirements) and are an important niche for the garments sector [2,3].

Worldwide, many companies have introduced customized fabrication technology for garments, which has allowed them to expand their business by taking over custom-made products to order. Market leadership of the Romanian clothing companies depends on their ability to introduce product innovation, to increase added value and to enter on new market segments.

Currently, at the industrial level, it can be seen that there is a lack of possibilities for customized tactical equipment, due to the increased production time (identical to a custom made garment) that cannot be accepted in a serial production company. Thus, through the implementation of the innovative technological solutions, it solves the specific problems of the companies, namely the rapid morphological analysis of subjects with body dimensions and atypical conformations and the automatic design of personalized tactical equipment, in a timely manner and according to the morphology of the wearer.

The paper presents the implementation of the innovative technological solutions for the design and production of tactical equipment, highlighting the importance of personalization and its competitive advantages, from the idea to the prototype or product and testing it.

The purpose of the research was to increase the competitiveness and quality of the products obtained at SC TACTICA OUTDOOR SRL by applying innovative technological solutions for the design and production of tactical equipment, already validated by the National Research-Development Institute for Textiles and Leather - INCDTP.

Innovative technological solutions for the design and production of tactical equipment include a number of software such as: virtual body drawing software (avatar), automated design software with Made-to-measure, simulation and virtual modeling software.

These innovative technological solutions were applied in the process of manufacturing tactical equipment, resulting in a personalized product according to the individual body size of the subject.

The paper promotes the application of intelligent clothing CAD, supporting the development of the garment industry [1].

The introduction of the innovative technological solutions for the design and production of tactical equipment within SC TACTICA OUTDOOR SRL represents a complex process, which includes a multitude of activities, which have as final objective the obtaining of optimal correspondence between the shape of the studied body/subject and the tactical equipment:

- subject selection with body dimensions which are in the limit of standard sizes;
- extracting the body dimensions for the studied subject, which facilitates the determination of the size of the garments and whether or not it conforms to the size standards [4];
- analysis and selection of the model for the tactical equipment in the current production of the company SC TACTICA OUTDOOR SRL;
- analysis of individual body specificities needed to design customized patterns.
- design and development of customized pattern for the selected tactical equipment using Gemini Pattern Editor, the Made-to-measure module;
- modeling 2D/3D patterns and simulating the tactical equipment on the virtual body;
- analysis of the tensions map and gathering the necessary information in patterns remodeling, in order to adapt them to the shape and body dimensions of the subject;
- completion of design that provides the best body-product correspondence;
- realization of the real prototype and its real fitting;
- evaluation of the body-product correspondence, in a static and dynamic regime and correspondence of the product with the functions it has to fulfill.

2. BODY MEASUREMENTS ANALYSIS FOR THE STUDIED SUBJECT

The individual body dimensions for the studied subject were taken over and the measurement protocol and virtual mannequin parameterization were generated, which was the basis for the design of personalized patterns in the Made-to-Measure system.

The selected subject has the following main body dimensions extracted from the measurement protocol:

- **Body height (Ic) 163 cm;**
- **Bust circumference (Pb) 78,5 cm;**
- **Waist circumference (Pt) 70 cm;**
- **Hip circumference (Ps) 90 cm.**

It was noticed that the bust circumference is at the lower limit of the standardized values according to standard SR 13545 - Clothing. Women's Body Measurement and Garment Sizes [5]. In this document, the standard bust circumference is 80 cm.

3. DESIGN AND PRODUCTION OF PERSONALISED TACTICAL EQUIPMENT

In the study, the model of the tactical equipment was analyzed and selected, which was then customized by the innovative technological design and production solutions. The company SC TACTICA OUTDOOR SRL selected the **COMBAT Costume for ground forces**, which is in its portfolio and has been developed according to the corresponding technical specification.

The tactical equipment is specially designed with certain technical modifications and is intended for antiterrorist and intervention forces of police, gendarmerie, MApN, SRI special services, SPP and other structures aimed at guarding, protecting, maintaining and restoring peace and public order.

The COMBAT costume is a woven ensemble composed of jacket and two trousers (Figure 1), which are carried by the military to training activities, shooting sessions and participating troops at international missions.

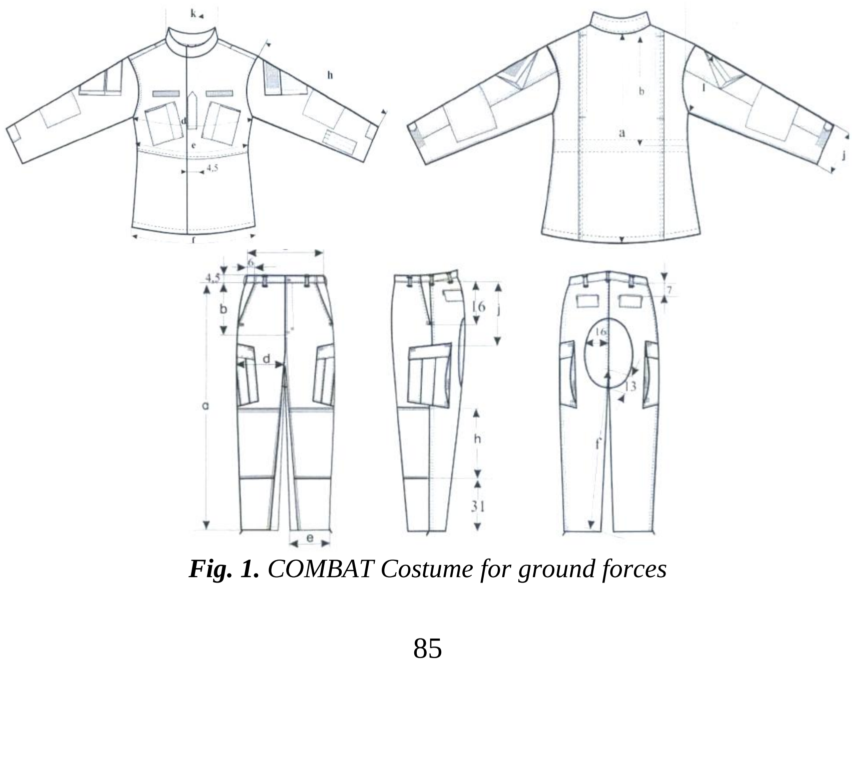

Fig. 1. *COMBAT Costume for ground forces*

The vest has a front closure with detachable zipper and velcro strap, waist-toe waist and oblique pockets. Upper side, waist adjustment is made with band, sleeves are provided with pockets, armrests and straps for adjusting the opening at the end.

The trousers are worn in COMBAT boots and have a straight shape that allows adjustment of waist circumference and end, pockets with oblique opening at the top and pockets with flap on the sides and back; the areas with the maximum knee and back load have duplicates of base material.

The COMBAT costume must meet the following operational requirements:

• ensure that the wearer is masked in the visible and infrared;
• allow maximum mobility of the wearer in the conditions of performing dynamic activities;
• provide resistance to wearing, thermal comfort, regardless of microclimate conditions;
• resistance of colors to repeated washing;
• keep functional features, shape, dimensions and color unchanged throughout use.

The Costume for the ground forces was made of the fabric for the COMBAT costume painted and imprinted in five-color mosaic: dark brown, light brown, green, khaki-beige and light beige.

Physical-mechanical and physical-chemical characteristics of the fabric were determined in the accredited laboratories of INCDTP. The elaborated test reports were used in textile material characterization in the 3D simulation.

The design of the basic and model patterns for the selected tactical equipment was based on the geometric method of pattern construction, using Gemini Pattern Editor's special CAD design software, the Made-to-Measure module. In this module, basic patterns are created for each type of clothing item, which are then modified by specific algorithms, depending on the model of the tactical equipment selected and the dimensions of the body taken from the measurement protocol (Figure 2).

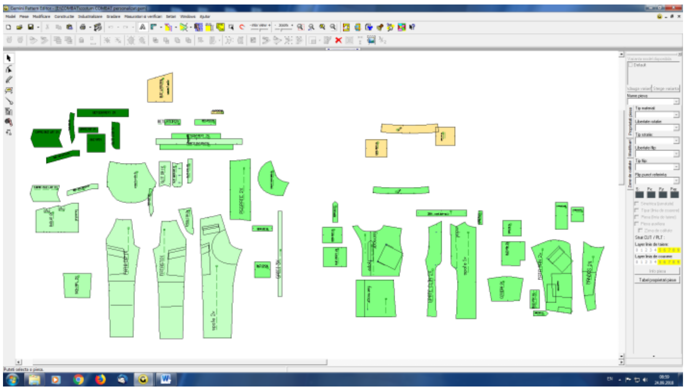

Fig. 2: *The design of customized patterns of COMBAT Costume in Gemini Pattern Editor*

Verification of personalized patterns matching, designed according to individual body dimensions, was accomplished by modeling 2D/3D patterns and simulating tactical equipment on the parameterized mannequin, by using Optitex PDS software for visualization, modeling and fitting the virtual body of the prototype. The virtual try-on system involves transferring and fitting tactical equipment to human body with various shapes and postures, with grade preservation. To achieve this goal, tactical equipment must be treated as elastic models and their deformation is controlled by the laws of dynamics [6].

Transforming patterns designed with the Gemini Pattern Editor into Optitex PDS from 2D to 3D, to obtain the virtual prototype of customized tactical equipment was done in the following stages [7,8,9]:

• parameterizing a virtual mannequin according to the anthropometric dimensions resulting from body measurement;

• shaping the surface of the patterns to obtain the 3D shape of the product with the addition of sewing lines and guide points (Figure 3);

• introduction of information about the materials from which the work equipment is made (fibrous composition, drape, shrinkage, mass etc.);

• virtual try-on of the product on the virtual mannequin (Figure 4);

• checking and modifying the pattern to ensure body-product correspondence.

In order to check the body-to-product correspondence, the software has a function that shows the degree of ease / adjustment of the product on the body, called the Tension Map (Figure 4), in which the red color shows that the product presses the body, the blue color show high legerity and green color show that the product corresponds to the dimensions. Thus, it can be seen that the jacket product corresponds dimensionally. Also, the trouser fits on the waist line and is slightly wide on the hips line and at the end. The degree of ease indicated by the simulation software is justified by the patterns chosen for the jacket and the trousers that have a semi-rigid figure on the body. With this information, the designer could return to 2D patterns by making the necessary corrections.

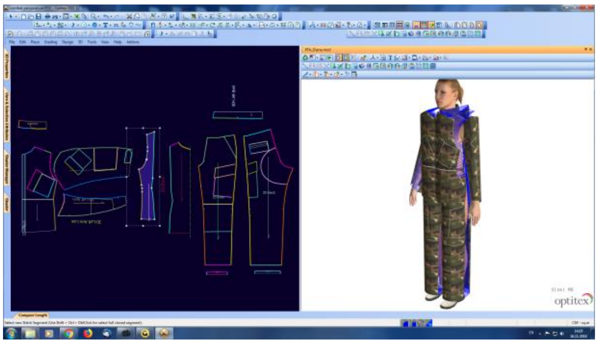

Fig. 3: *The 2D patterns of the customized COMBAT Costume with seam lines*

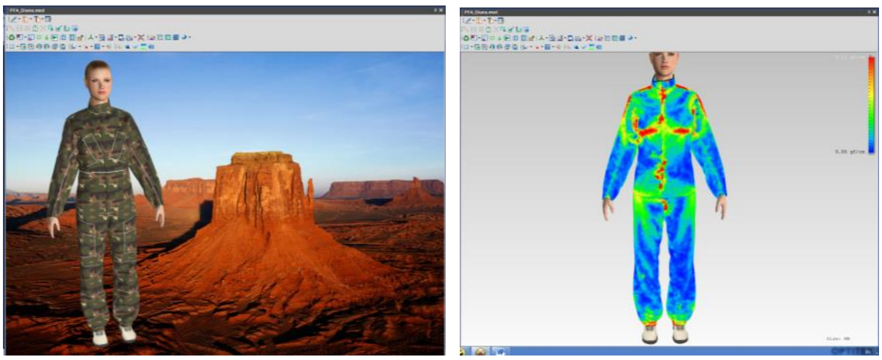

Fig. 4: *Virtual try-on and verification of the customized tactical equipment*

The real prototype of personalized tactical equipment selected by the beneficiary company SC TACTICA OUTDOOR SRL was tested on the actual body of the subject. Following the test, it was found that the outfit corresponds dimensionally, without forming unsightly creases or folds and without creating discomfort in wearing.

5. CONCLUSIONS

The research, through its objectives, introduced the concept of personalized tactical equipment within the beneficiary SME, applying the latest information in the field of information technology in the textile and clothing sector. The innovative aspect is conferred by the expansion of tactical equipment in an individual / personalized system, but using industrial production facilities.

The proposed innovative technological solutions are effective for pattern transfer and fitness evaluation, and can be potentially used in applications like customization or online shopping.

The main aim of this research is to encouraged the SME to invest in the R&D activity by producing and launching innovative products on the market, ie the personalized and verified tactical equipment on the virtual mannequin, produced using textile materials tested in the accredited laboratories of INCDTP, through specifics physical-mechanical and physical-chemical analyzes.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

A STUDY ON DEVELOPING THERMO-REGULATING DENIM FABRIC BY INTEGRATING OF MICROENCAPSULATED PHASE CHANGE MATERIAL USING EXHAUSTION METHOD

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Abstract: *A blend of octadecane and organic coconut oil were used as phase change material in core and melamine formaldehyde was used in shell to produce microencapsulated thermal storing material. A melamine resin containing methylol was used as crosslinker for the polymer shell. The microencapsulation was processed using in-situ polymerization method. The synthesized microcapsules (microPCM) were applied to a stretch denim fabric with composition of 98 % cotton and 2% elastane, which is widely used in daily life as jeanswear, by using exhaustion method in different concentrations. The core material, the microcapsule and the treated fabrics were analyzed by Fourier Transform Infrared Spectroscopy (FT-IR), Differential Scanning Calorimetry (DSC) and Scanning Electron Microscopy (SEM). FT-IR results revealed that the microcapsules were fabricated successfully. SEM images indicated that the microcapsules were yielded in spherical form with a particle size of 1-3 µm. and the particles were achieved to be exhausted in the fabric texture, comparing to untreated fabric. DSC results showed that the microcapsules stored latent heat of melting 111 J/g at a peak temperature of 28.1ºC and the treated fabrics possessed latent heat of melting 0.7-0.8 J/g at peak temperatures of 25.2-25.5 ºC which are in human comfort temperature range. It was calculated that the microcapsules were obtained with a 70.3% encapsulation yield in 63.4 % core content.*

Key words: *Denim, thermo-regulation, phase change material, microencapsulation, textile.*

1. INTRODUCTION

Functional smart textiles have been drawing attention increasingly. Phase change materials (PCMs) are thermal energy storing materials which have been using for functional textiles as well as in building materials, solar cells and panels, electronic equipment, etc. for thermal regulation purpose. PCMs can store or release high amount of latent heat during phase change. PCMs with melting point in between 15-35 ºC, which are close to human skin temperature are the most effective ones to use in textiles [1]. Linear long chain hydrocarbon paraffin waxes, polyethylene glycols and fatty acids are the most usable PCMs for textiles considering phase change temperatures. PCMs used for textiles are mainly microencapsulated within a polymer shell to prevent the leakage of the material during solid to liquid phase change and to provide a better thermal conductivity. PCMs are usually integrated to fabric with padding, coating or lamination as fabric treatment [2,3].

In this study, a blend of organic coconut oil and octadecane was investigated to be used as phase change material. Coconut oil consists of high amount of low molecular weight of saturated fatty acids which mainly come from lauric oil. It has high latent heat capacity to be used for thermal energy storage. Wi et al. prepared shape stabilized PCMs using palm oil and coconut oil as phase change materials, impregnated into exfoliated graphite nanoplatelets to use in buildings for saving energy [4]. Silalahi et al. examined the temperature of organic coconut oil vs. time by T history method during phase change from liquid to solid and revealed that phase change took place gradually depending on the oil composition of different kinds of fatty acids [5]. The main idea in this study was to obtain a thermal storing material in a wider phase change temperature interval to give comfort to the wearer in a wider temperature scale. In addition, the use of this blend also provided an economic advantage for the cost of the core material. Furthermore, exhaustion method was processed to give the microPCMs to the fabric texture, which was not widely studied according to the literature. The microencapsulation was processed by in situ polymerization which was one of the main encapsulation methods [6].

2. EXPERIMENTAL

2.1 Material

100% Organic Coconut Oil supplied by the LifeCo Company, Turkey and 98% crystalline mass/melt n-octadecane from Alfa Aesar were used as PCM core materials. Melamine (99% pure) from Aldrich, formaldehyde (37% aqueous solution by weight) from Merck were used as shell materials. Sodium dodecyl sulphate (SDS) from Neofroxx Gmbh was used as emulsifier surfactant. Melateks 700 containing methylol from Melamin Kemicna was used as a crosslinking agent for the melamine formaldehyde polymer shell, ammonium chloride (extra pure) from Riedel-de Haen was used as nucleating agent in encapsulation and triethanolamine (99% pure) from Merck was used for adjusting the pH in reactions. Stretch denim fabric with composition of 98% Cotton 2% Elastane, 280 g/m^2 was supplied from Çalık Denim, Turkey. Orgaresin HC 77 was used as acrylic binder, Orgafix DX New was used for fixing agent, Dispersant 850 K was used as dispersing agent which were supplied from Organik Kimya San. ve Tic. A.S., Turkey.

2.2. Microencapsulation of microPCM

A blend of 70% octadecane 30% organic coconut oil was used in core and encapsulated with melamine formaldehyde shell by in situ polymerization. A pre-polymer solution of melamine formaldehyde was prepared by dissolving 6 g. of melamine and 30 mL of formaldehyde in 30 ml of distilled water by magnetic stirring at 70 ºC. The pH of the solution was adjusted to 8.5-9 using triethanolamine. After the solution became transparent, 1 g of melamine and 10 mL of distilled water were added to the solution. The emulsion solution was prepared by emulsifying of 28 g octadecane and 12 g. organic coconut oil in 300 mL distilled water by mechanical stirring at 2500 rpm for 3 hours at 50 ºC, with the addition of 4 g of SDS as emulsifier and 1.5 g of Melateks 700 as crosslinker. The pH of the emulsion solution was adjusted to 3.5-4.0 with the addition of acetic acid. The pre-polymer solution was added to the emulsion solution while stirring at 600 rpm. The encapsulation reaction occurred at 60 ºC during 90 minutes. 2 g of ammonium chloride was used as nucleating agent. The reaction was ended by adjusting the pH of the solution to 8-8.5. The microcapsules were collected by filtering and washed repeatedly with 30% ethanol solution and then dried at 50 ºC during 24 hours.

2.3. Exhaustion of microPCM into fabric texture

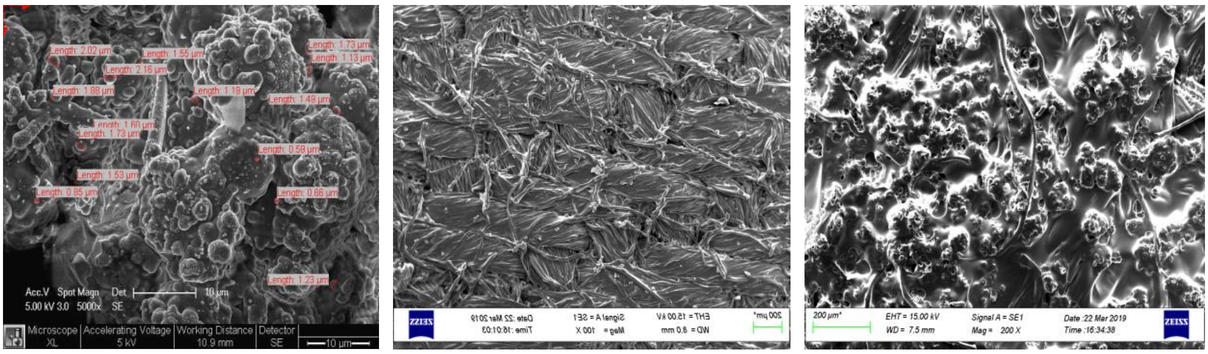
Two pieces of 4 cm x10 cm fabric were immersed in separate three tubes of Gyrowash machine and the recipes given in Table 1 were applied to 2.50 g of dry fabric samples in average. One fabric sample was treated with the solution without microPCM, the others were treated with different concentrations of microPCM as given in Table 1. The solutions were prepared with a well dispersing of microPCM with dispersing agent and distilled water by magnetic stirring. The exhaustion process was applied at 50 ºC during 1 hour.

2.4. Characterization

The core PCM material and the fabricated microcapsule were examined by Fourier transform infra red spectroscopy (Perkin Elmer Spectrum 100 FT-IR) to analyze the chemical composition in the frequency range of 380 cm^{-1} and 4000 cm^{-1} .The thermal storage capacities and the phase change temperatures during melting and crystallization of the core PCM, the microPCM and the microPCM treated fabric samples were measured by differential scanning calorimeter (Perkin Elmer Diamond DSC) at a heating or cooling rate of 10 ºC min^{-1}, in the temperature range of -10 ºC and 50 ºC, within nitrogen atmosphere 25 mL min^{-1}. The encapsulation ratio (R) which is the core PCM content of the microcapsules [7,8] and the encapsulation yield (EY%) which is the ratio between the mass of dry microcapsules (m_{MPCM}) and the total mass of the polymer shell components and the core (m_t) [9] were calculated using the equations of 1 and 2, respectively. The surface morphology of the microPCM treated nonwoven fabric layers were analyzed by scanning electron microscopy (Zeiss EVO-MA 10).

3. FIGURES AND TABLES

3.1. Figures



(a) ***(b)*** ***(c)***

Fig. 1*: SEM images of (a)microPCM, (b) untreated fabric, (c) treated fabric*

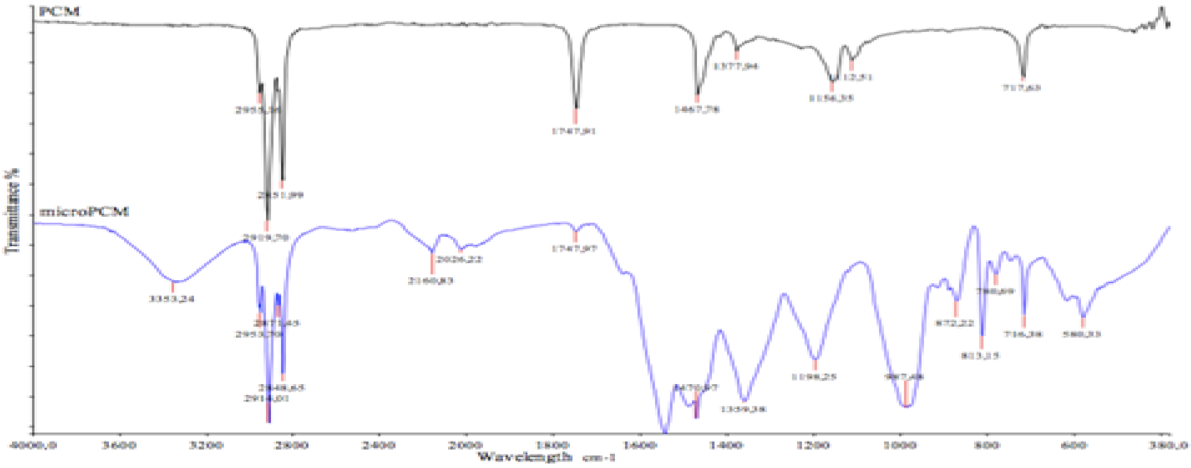
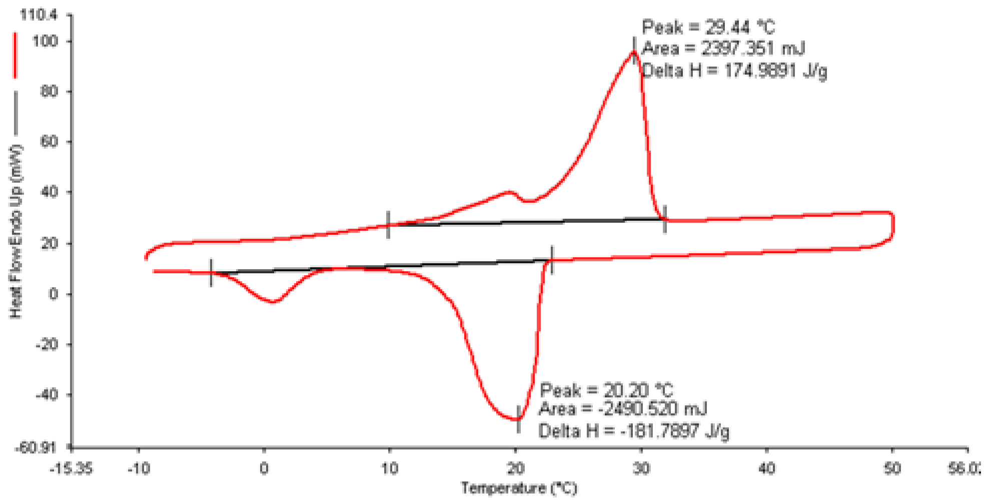
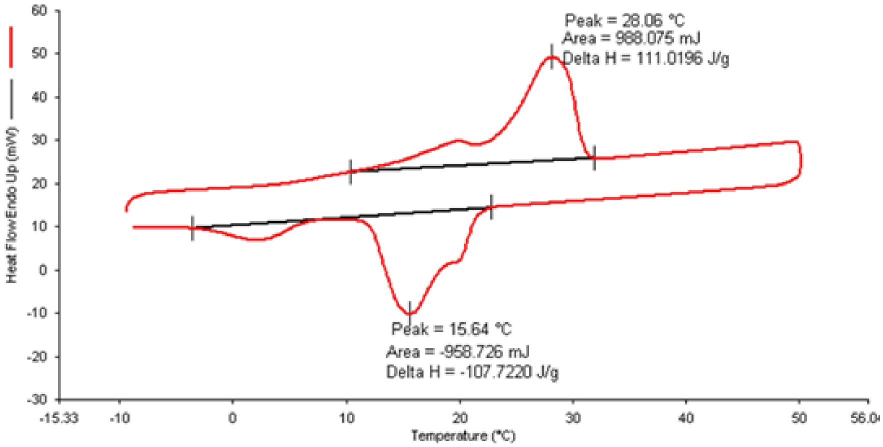


Fig. 2: *FT-IR Spectra of PCM core and microPCM*



(a) *DSC graph of PCM core*



(b) *DSC graph of microPCM*

***Fig.3**: DSC graphs of PCM core and microPCM*

3.2. Tables

***Table 1:** Recipes for the exhaustion process*

Chemicals	R1	R2	R3
Distilled water	50 mL	50 mL	50 mL
Dispersant K 850	3 g	3 g	3 g
Orgal HC 77	45 g	45 g	45 g
Orgafix DX New	4 g	4 g	4 g
MicroPCM	---	2 g	3 g

***Table 2:** DSC results of PCM core, microPCM and microPCM treated fabrics*

Sample Name	Melting Enthalpy ΔH_m (J/g)	Melting Peak Temp. T_m (ºC)	Crystallization Enthalpy ΔH_c (J/g)	Crystallization Peak Temp. T_c (ºC)
PCM core	175.0	29.4	-181.8	20.2
microPCM	111.0	28.1	-107.7	15.6
microPCM treated fabric with R2	0.68	25.2	-0.96	18.1
mcroPCM treated fabric with R3	0.80	25.5	-1.01	17.6

4. EQUATIONS

$$R= (\Delta H_{m,MPCM} / \Delta H_{m,PCM}) \times 100 \quad \textbf{(1)}$$

$$EY\%= (m_{MPCM} / m_t) \times 100 \quad \textbf{(2)}$$

5. CONCLUSIONS

In this study, organic coconut oil and octadecane were blended and used as phase change material to obtain a thermal energy storing material which would store or release heat in a wider temperature interval for thermal regulation in an optimum peak temperature for human comfort. Besides, exhaustion technique was experimented to integrate the microPCMs in the fabric texture, which was not majorly studied according to the literature. FT-IR spectra of PCM core and the microcapsule confirmed that the core material was encapsulated successfully. In spectra of the microcapsule, the absorption peak at 3353 cm^{-1} was attributed to O-H stretching vibration coming from the methylol content of the melamine resin crosslinked to melamine formaldehyde shell polymer. Calculations made by equations 1 and 2 showed that the microcapsules were obtained with an encapsulation yield of 70.3% in a core content of 63.4%. DSC results indicated that, the blend PCM core and the fabricated microcapsules stored latent heat of melting 175 J/g and 111 J/g at a peak melting temperature of 29.4 °C and 28.1 °C, respectively, which are remarkably high values. DSC results also showed that microPCM treated fabrics possessed latent heat of melting 0,7-0.8 J/g. which would be improved and optimized in future studies. SEM images revealed that the microPCMs were exhausted on the fabric surface and embedded in the binder material with a dense and uniform distribution.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

EVALUATION OF GRAPHENE WASHING FASTNESS ON CELLULOSE FABRIC AND METHOD TO IMPROVE IT

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Abstract: *Graphene is a recently discovered material that has attracted a great deal of attention in numerous fields, from electronics to textiles, including medicine and energy harvesting. Its use confers interesting properties to conventional textile substrates, providing them with great versatility and the opportunity to explore new areas and applications beyond their common uses. Despite the many properties it shows, it also faces some challenges regarding critical issues such as its stability throughout the procedures the textile is subjected to, such as rubbing, ironing or washing. In this study, the washing fastness of a cellulosic textile substrate to which a printing paste containing graphene had previously been applied was evaluated. After evaluating the behaviour of the samples after the washings by means of chromatic coordinates and the ISO 105:C06 Color fastness to domestic and commercial laundering, it came to our attention the deficient behaviour of the graphene regarding washing fastness. In order to improve it, a heat treatment was applied, which led to a significant increase of washing fastness behaviour of the samples with graphene printing, compared to non-treated samples. In this research, an efficient and affordable method to improve graphene's stability onto cellulosic textile substrates that can be carried out with common laboratory equipment is provided.*

Key words: *cotton, printing, thermal, luminosity, color, coordinates*

1. INTRODUCTION

Graphene is the name given to a flat monolayer of carbon atoms tightly packed into a two-dimensional (2-D) honeycomb lattice, first isolated in 2004. Graphene exhibits high electron and hole mobility, high thermal conductivity, as well as other features such as extremely high tensile strength, flexibility, stretchability and superior radiation hardness [1-3].

Possible applications of graphene materials include: flexible electronics, photonics and optoelectronics, spintronics, composite materials, energy generation and storage, biomedical applications, sensors, etc. [4-11].

There are four basic methods used for graphene synthesis: chemical vapor deposition; epitaxial growth of graphene on electrically insulating substrates; mechanical exfoliation of graphene from bulk graphite and reduction of graphene derivatives such as graphene oxide [12].

Mainly, three methods have been developed to produce graphene-based fabrics/yarns. The first one is the coating of fabrics/yarns with graphene materials such as graphene, graphene oxide, educed graphene oxide, etc. The second one consists in the chemical vapor deposition process of graphene on a metallic mesh (Cu normally) that is later removed by an acid treatment, remaining the graphene-fabric structure, these types of fabrics are named graphene woven fabrics. And the third one, includes the production of graphene fibers and its application on fabrics [4].

In the past few years, graphene applications within textile industry have gained researchers' attention and keep growing in number each year. Some examples of its usefulness comprise cotton fabric as flexible strain sensor based on hot press reduced graphene oxide [13], graphene nanoribbon coated flexible and conductive cotton fabric [14] and hydrophobic cotton textile surfaces using an amphiphilic graphene oxide coating [15] amongst others [16-21].

Nevertheless, it needs to be taken into consideration that textiles need to be able to undergo intense procedures such as washing or drying and keep their properties reasonably intact in order to last all their service life with a proper performance. Even though this is a critical issue to ensure graphene's industrial usage expansion, few researches have been focused on improving graphene's stability onto textile substrates so the lack of investigation within this area led us to develop an easily reproducible method to improve washing fastness on cellulose fabric.

2. MATERIALS AND METHODS

2.1 Fabric

For this research, a 100% cotton fabric with a grammage of 210 g/m2 and chemically bleached in an industrial process was used.

2.2 Chemicals

Graphene was supplied by Innovatec SC, S.L.

To obtain the printing paste, the following products were used:

- Lutexal CSN and Luprintol SE, supplied by Archroma
- Resina Center BC, supplied by Color-Center S.A.
- Ammonia 28%, supplied by Prolabo.

2.3 Procedure for graphene deposition onto fabric

Graphene deposition onto fabric was carried out by means of hand printing using the following recipe:

Product	Quantity (g)
Lutexal CSN	20
Resina Center BC	10
Luprintol SE	10
Ammonia	10
Distilled water	950
Graphene	12

Table 1: *Printing paste composition*

2.4 Washing test materials and procedure

Washing fastness was evaluated by a laundry according to the standard ISO 105:C06 for 30 minutes at 40º C. Treated sample was conveniently covered by a multifibre fabric.

2.5 Thermal treatment

Graphene-printed fabric samples were oven-dried at 100ºC until completely dried.

In order to improve washing fastness of graphene, a thermal treatment was applied to certain fabric samples for 3 minutes at 150ºC.

2.6 Color coordinate evaluation

In order to objectively compare color difference measurements, the chromatic coordinates (CIE L *, a *, b *) of the CIELAB color space of the printed samples were obtained using a MINOLITA CM-3600d reflection spectrophotometer. The measurements were made with the standard observer CIE-Lab 10^0 and the standard illuminant D65. According to ISO 105 J01:2000 Textiles -- Tests for color fastness -- Part J01: General principles for measurement of surface color

On the other hand, the color difference of the samples was obtained according to the following equation:

Color difference (ΔE*) = ((ΔL*)2 + (Δa*)2 + (Δb*)2)1/2

Where ΔL * = L * non treated fabric - L * treated fabric; Δa * = a * non treated fabric - a * treated fabric; Δb * = b * non treated fabric - b * treated fabric; "L *" describes the luminosity, "a *" measure of red-green hues, "b *" measure of blue-yellow shades. It should be noted that three measurements were made for each sample and the mean value was calculated.

3. RESULTS AND DISCUSSIONS

3.1. Visual comparison

Samples obtained after printing showed a considerable change in color as they were completely black**.**

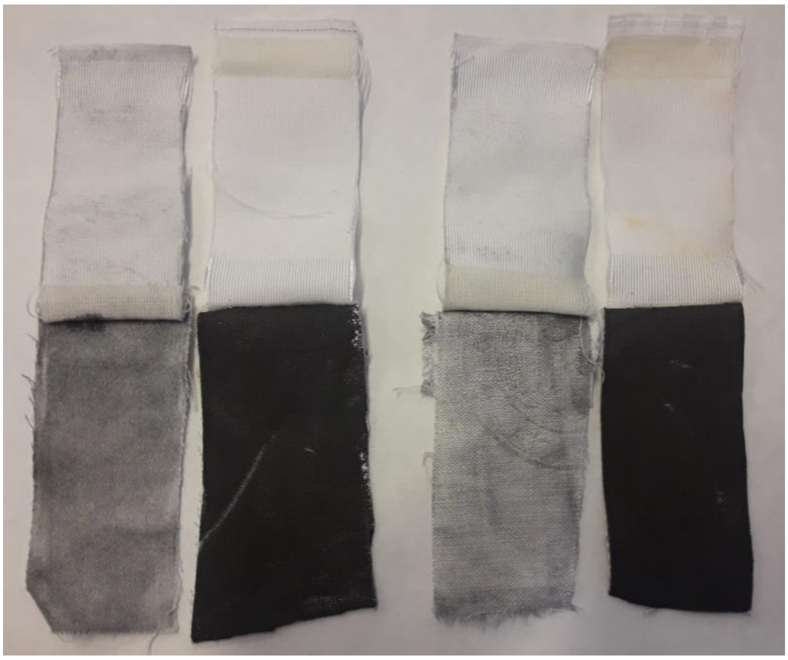

Fig. 1: *(From left to right) EG12-1-1000 without thermal treatment washed, EG12-1-1000 with thermal treatment washed, EG12-2-1000 without thermal treatment washed, EG12-2-1000 with thermal treatment washed.*

At a glance, the contrast between treated and non-treated samples is quite noticeable, as it can be observed in figure 1, where it seems quite evident that color of thermal treated samples remains almost intact, while non-treated samples lose a large amount of the stamping paste, thus reducing efficiency of graphene properties.

Not only have the non-treated samples lost more graphene than the treated ones, but also an important difference in the discharge towards the control fabric has been detected between them, with non-treated samples staining the control fabric slightly more than thermal treated samples.

3.2. Color coordinates

The chromatic coordinates obtained for each of the samples and the color differences are given in the following chart, where the abbreviation TT stands for thermal treatment and W for washed.

Sample	L*	a*	b*	DL*	Da*	Db*	DE*ab
Original fabric	93,228	-0,1247	4,406				
EG12-1-1000	29,6818	0,082	0,0536	-63,5462	0,2067	-4,3524	63,6954
EG12-1-1000– W	54,4692	-0,3646	-0,0455	-38,7588	-0,2399	-4,4515	39,0143
EG12-1-1000– TT – W	30,2406	0,0408	0,0188	-62,9873	0,1654	-4,3872	63,1402
EG12-2-1000	30,5858	0,0087	0,1039	-62,6422	0,1334	-4,302	62,7899
EG12-2-1000– W	67,5212	-0,5945	1,4332	-25,7067	-0,4698	-2,9728	25,8823
EG12-2-1000– TT – W	30,5086	0,0291	-0,1562	-62,7194	0,1538	-4,5621	62,8853

Table 2: *Chromatic coordinates for examined samples*

As it could be expected changes are appreciated only when analysing L* coordinate, and a* and b* remain practically constant. Thus, we can affirm that DE*ab is mainly due to the variation on L*. Checking the results obtained in the measurement of color, an important variation in the value of the luminosity is observed. Thermal-treated samples hardly show a difference in luminosity after washing, while in untreated samples this value increases remarkably, which indicates they are close to the value of the original tissue without stamping, having lost much of the deposited graphene.

3.3. Washing fastness evaluation

Once the samples had been washed and dried, it was compulsory to evaluate them considering both the color degradation (fade) and the stain on multifibre fabric.

Sample		WOOL	ACRILIC	POLYESTER	POLYAMIDE	COTTON	ACETATE
EG12-1	STAIN	4	4	4-5	4	4	4
	FADE	1-2					
EG12-1 THERMAL	STAIN	5	5	5	5	5	5
	FADE	4-5					
EG12-2	STAIN	4	4	4-5	4	4	4
	FADE	1-2					
EG12-1 THERMAL	STAIN	5	5	5	5	5	5
	FADE	4-5					

Table 3: *Color fastness to washing for tested samples*

According to the color fastness values, it is clearly observed the thermal treatment practically does not allow to miss graphene particles during the laundry, so a better performance of graphene is expected in this case; whereas samples without thermal treatment have missed a wide quantity of the printed graphene, consequently reducing the efficiency of properties given to the textile substrate by the graphene.

Moreover, as there is no affinity between graphene and the fibres, the stain on the multifibre fabric is not far away from the 5 value in non-treated samples but it is better in thermal treated samples, given the fact that there is almost no graphene miss that could stain the control tissue.

4. CONCLUSIONS

The main conclusion deduced from this research is that, when the proper amount of heat is applied, the printing paste cures, thus binding the graphene to the textile substrate. This leads to an outstanding improvement of washing fastness of the thermal treated samples.

Furthermore, being able to preserve almost all of the graphene applied to the textile substrate implies a better conservation of the properties provided by graphene deposition, such as its influence on thermal and electrical conductivity.

This research article demonstrates a fast, affordable and easily reproducible method to improve washing fastness of cellulose textiles with graphene, using common laboratory equipment, so it can be used at an industrial level, increasing graphene suitability for textile applications and its commercial worthiness.

In summary, it can be said that this study will expand the scope of graphene and open new research lines about its applications on cellulose fabrics. Future studies will be focused on the temperature and time optimisation.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

APPRAISAL OF THE OVERALL CONDITION OF ARCHAEOLOGICAL SILK FABRIC FRAGMENTS

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Abstract: *In order to preserve the cultural identity of a nation, it is imperious to take special care of the textile materials which are representative for a certain historical period. Environmental factors such as humidity, UV radiation, temperature, some enzymes and micro-organisms (bacteria and fungi) can cause serious damage to aged silk textiles, which could lead to the loss of the properties that make the said material historically valuable. To assess the level and type of degradation of archaeological silk samples, we used two types of analysis techniques. Scanning Electron Microscopy (SEM) was used to determine the morphological modifications of the fibers and also the types of impurities present on the materials' surface. Differential Scanning Calorimetry (DSC) was used to investigate the thermal behavior of the silk samples. The same analyzes were also performed on a reference unaged silk fabric sample for an easier and more accurate interpretation of the results from the archaeological samples. These methods are micro-destructive and do not require large amounts of sample, thus making them suitable for use especially in cases where very small amounts of sample are available or when the analyzed material is extracted from an important art piece. The evaluation of the state of deterioration of an archaeologic textile material is important for further restoration and determination of the optimum maintenance parameters.*

Key words: *SEM, DSC, silk, fiber, archaeology, textile, degradation*

1. INTRODUCTION

As a natural fiber, silk has played a significant role in humans' lives for over 5000 years [1] and continues to have great importance and uses in numerous domains. The main source of natural silk is a species of domesticated silkworm – *Bombyx Mori*, which is called mulberry silk [2]. Silk is a protein fiber which, in its natural, unmodified state, consists of a highly crystalline fibrillary protein – fibroin and an amorphous protein – sericin. The two fibroin filaments are encased in sericin, which acts as a cement for the fiber. Fibroin is the major protein component of silk fibers and contains glycine (45%), alanine (30%), and serine (12%) in a ratio of approximately 3:2:1, while sericin is composed mainly of glycine, serine and aspartic acid [3]. Aside from these two proteins, silk also contains wax, pigments and various inorganic compounds [4]. Degumming is the operation of removal of the sericin from the silk fibers and it is performed with the purpose of making them more lustruous and for improving their color and texture. In the case of archaeological silk, as in the case of any other material, it is imperative to determine the state of degradation in which it is found due to the serious implications this has on the methods of restoration and preservation needed in order to maintain the material in proper conditions.

2. MATERIALS AND METHODS

2.1 Materials

With the purpose of developing our work, four archaeological silk samples from the 16th century from two different sites were investigated, as following in Table 1:

Table 1: *The samples, their provenance and the time frame they belong to*

Sample label	Sample appearance	Sample provenance
S1		Archaeological excavations, Mirăuți Monastery/ Suceava - Romania
S2		Căpriana Monastery/ Republic of Moldova
S3 (red arrow)		
S4 (green arrow)		

Samples S3 and S4 were collected from the same fragment of textile fabric, but they were approached as two distinct samples: the golden area – S3 and the brown area – S4.

For an increased accuracy in the interpretation of the results, a new 100% silk reference fabric was assessed in parallel with samples S1 – S4.

2.2 Methods

Scanning Electron Microscopy (SEM)

SEM investigations of the silk samples were performed using a FEI Quanta 200 Scanning Electron Microscope. Each sample was placed on a specimen stub using double sided conductive carbon tape and analyzed using the following parameters: HV: 20.00 kV; detector: GSED; vac. mode: Low Vacuum.

Differential Scanning Calorimetry (DSC)

The thermal behavior of the samples was determined with a Perkin Elmer Pyris Diamond DSC Differential Scanning Calorimeter. Samples weighing between 1.7 and 2.7 mg were encapsulated in aluminum pans and heated. The temperature program was performed as following: holding the sample at 50 ºC for 1 minute, then heating the samples up to 500 ºC at a heating rate of 10 ºC min^{-1} and finally holding the samples at 500 ºC for 2 minutes. The heating of the samples was carried out in a 20 mL min^{-1} nitrogen gas flow and the DSC was equipped with a refrigerated cooling system.

3. RESULTS AND DISCUSSION

Morphological characteristics

All samples were extremely brittle to touch and had to be handled carefully to avoid further damage. This high degree of degradation was confirmed by the SEM analyzes.

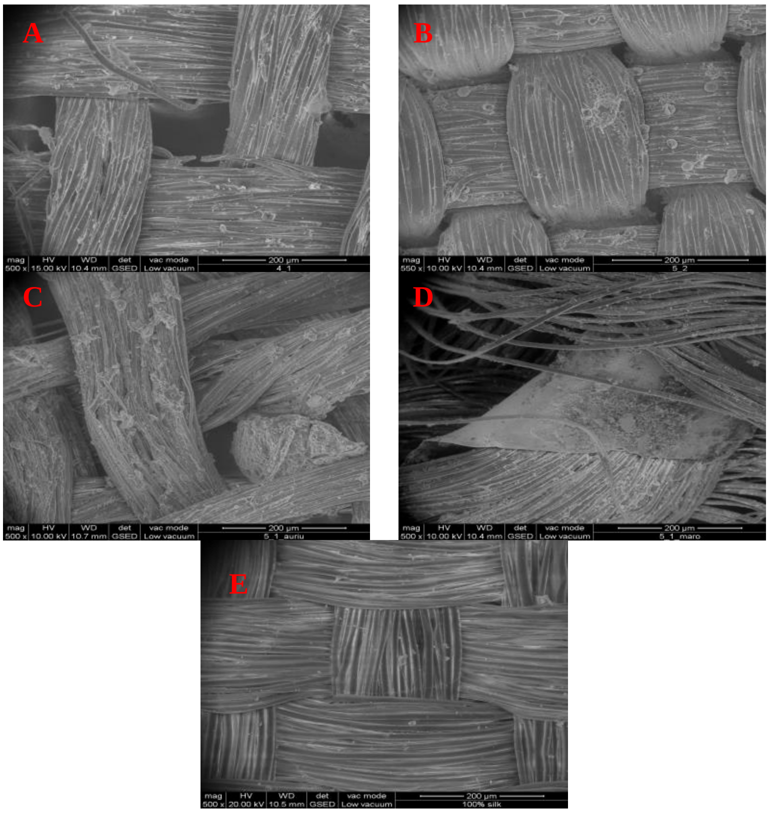

Fig. 1*: SEM micrographs of the silk samples, bar: 200 µm.* ***A*** *– S1;* ***B*** *– S2;* ***C*** *– S3;* ***D*** *– S4;* ***E*** *– reference silk*

As seen in Fig. 1 (A-D), all archaeological samples are soiled and deteriorated to some extent. The average diameter of the fibers from each sample is presented below, in Table 2:

Table 2: *Average diameter of the fibers*

Sample	Diameter, *µm*
S1	9.58
S2	8.84
S3	8.23
S4	9.31
Reference	9.48

In all cases, the diameters of the filament fibers indicate that all samples, including the reference, have *Bombyx mori* silkworm origin [5]. Most of the fibers from the archaeological samples presented signs of exfoliation along their length and some level of degumming.

Sample S1 was particularly deteriorated, taking in account that micro-fissures and cavities were present in the fibers' structure. These modifications of the surface characteristics determine the instability of the natural archaeologic silk filaments when mechanical stress is applied, resulting in the breakage of the filament [6]. In Fig. 2 (within the red circle) the fracture of the fiber reveals the fibroin microstructure [3].

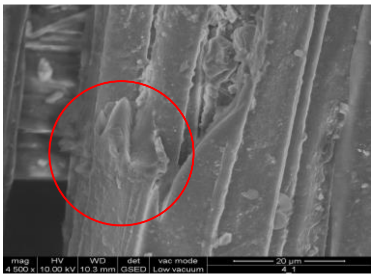

Fig. 2*: SEM micrograph of the fibroin microstructure in sample S1, bar: 20 µm*

The morphological assessment revealed in the case of all historic textile samples evidences of fungal infestation. These traces of infestation appeared as spherical shapes on the surface of the fibers either as individual fungal spores or as clusters [7], as shown in Fig. 3.

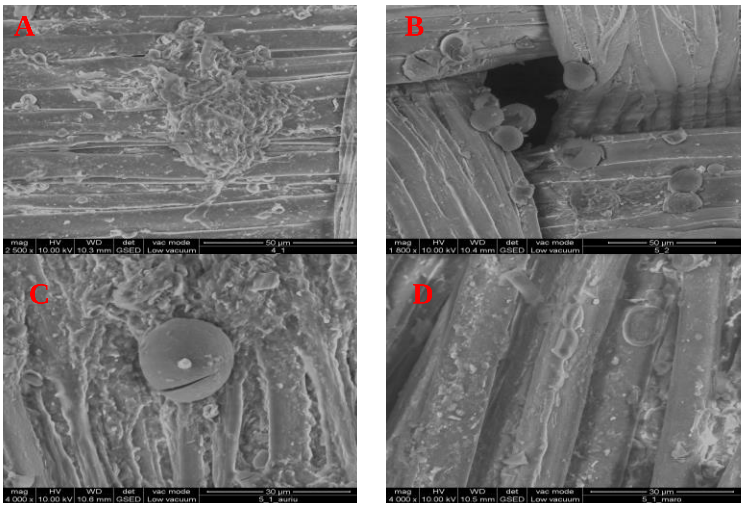

Fig. 3*: SEM micrographs of the fungal spores on the surface of the textile fabrics, bar: 50 µm for A and B; 30 µm for C and D.* ***A*** *– S1;* ***B*** *– S2;* ***C*** *– S3;* ***D*** *– S4*

Sample S4 stood out among the other samples due to the fact that some of the threads in its composition have metal strips twisted around the core represented by a bundle of silk filaments, as shown in Fig. 1 (D). The metal strips presented some depositions on their surface, possibly due to oxidation, among other impurities. Due to the fact that the metal strip was not tightly wrapped around the silk core, the core was still visible, this being called an ‘open’ metal thread [8].

Thermal properties

The characteristics determined by calorimetry confirmed the modification of the chemical structure of the archaeological silk samples.

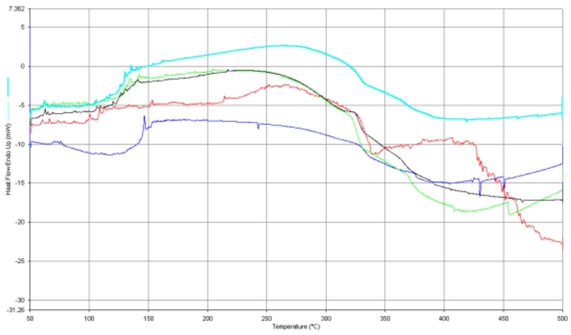

Fig. 4: *DSC MultiCurve thermogram of the samples, endotherms upwards. Red curve – reference silk; Dark blue curve – S1; Green curve – S2; Light blue – S3; Black curve – S4*

All of the samples have roughly the same allure, yet the DSC curve corresponding to the reference silk slightly differs from the others.

Table 3: *DSC temperatures and enthalpies*

Sample	Peak max. temp., ºC	ΔH, J/g
S1	336.99	-15.1249
S2	330.84	-36.3692
S3	332.84	-29.6721
S4	331.83	-26.7411
Reference	338.66	-77.1736

According to Table 3 above, the main exothermic event corresponding to the thermal decomposition of the materials occurred between 330 and 340 ºC. In the case of the reference sample, the maximum temperature of the peak is higher than in the case of any of the archaeological samples. This fact, along with the highest negative enthalpy among the samples, suggests the difference of the state of degradation of the samples S1-S4, in comparison to the reference sample [9]. The high negative enthalpy of thermal decomposition for the reference curve is caused by the fact that the undamaged protein structure of the unaged silk requires more energy to be thermally decomposed due to the stronger intramolecular bonds.

5. CONCLUSIONS

The morphological and thermal assessments of the archaeological silk samples were performed using two micro-destructive techniques – Scanning Electron Microscopy (SEM) and Differential Scanning Calorimetry (DSC). The SEM characterization revealed a high level of damage of the silk fibers and also a fungal contamination, possibly due to improper storage conditions. DSC analysis confirmed the SEM assessment of the silk samples. The damage of the protein structure was highlighted via DSC.

All these characteristics of the archaeological silk fragments that were determined can be useful for the development of decontamination and restoration methods.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

RESEARCHES REGARDING NEW APPROACHES OF PRODUCT DESIGN TO HELP REDUCE BACTERIA TRANSMISSION

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Abstract: *This paper is based on research regarding the identification and development of product concepts that improve the quality of consumer life, both aesthetically and attributing antimicrobial qualities to the concept created. The paper presents the results of some experiments on various types of leather parts, which later, through the designer's intervention, are processed and aesthetically improved by applications made with silver, silver wire or silver ion based paint. The resulted accessories are products that can be used independently or can be assembled on different objects, aiming at improving the aesthetic aspect of the product, while ensuring the quality of an antimicrobial product. The paper is based on studies of aseptic, technological and aesthetic properties of silver. The work, based on the experiments made, proposes a series of landmark variants, made of leather, which can be interchangeable. These proposed benchmarks can be easily assembled on various every day products. The sacred symbols, the mandala, the silver properties, the leather processed in different color shades and finishes represent challenges for product design in the development of product concepts capable of meeting the aesthetic requirements of the consumer, while identifying approaches to improve the quality of the user's life. Antimicrobial protection, style / fashion, accessories and objects that are used every day such as wallets, mobile phone, purse, bracelet, belt and more, are preoccupations in the aesthetic approach of a product.*

Key words: *Silver, leather, design, antibacterian, accesory*

1. INTRODUCTION

The paper is based on the speciality literature and the results of the experiments conducted within the Iasi design specialization. The documentation allowed the conclusion that silver can have both an aesthetic value material with superior processability properties [1] and it is material with antibacterial properties [2]. Experimental studies conducted on the aesthetic results that can be obtained by using leather in combination with wood [3] and silver in the creation of antibacterial packaging reveal the versatility of natural based materials to be used for aesthetic and antibacterial purposes. The antiseptic properties of silver are highlighted by studies and products on the market: silver ion filters, silver ion-based paints and varnishes, silver ion-based bandages [4]. A direction of study used by designers to achieve aesthetics of objects is the symbol [5], its power to transmit emotions and messages.

2. GENERAL INFORMATION

2.1 Conceptual elements

This paper combines through this experiment, the design process principles, the aesthetic and semantic value of the graphic sign, materials such as silver (in various forms of wire, foil, silver based paint [6]), or leather in different color variants finishes and personal use items. The purpose of the experiment is to create objects of personal use that, by touching the silver-based graphic element, contribute to reducing the potential for transmitting bacteria through the antibacterial effect of silver ions. The combination of silver and leather, both natural materials, allows the designer to create a vast range of product that can be assembled and interchangeable or assemblies to help improve the user's well-being. The product's success can be ensured by the designer's choice of the effect created by symbols with antistress effects: double spiral, mandala.

The paper incorporates the beneficial value of the properties of the materials used, their aesthetic proprieties as well as the role of the resulted accesories, their aesthetic and septic potential, on the finished products.

2.2 Experiment steps

The experimental route consists of choosing the materials used: wire / silver wire, silver foil and silver based paint, leather with different finishes **Fig.1**; of graphical symbols with semantic potential that could be applied **Fig.2**; tools used as well as the choice of accessories that can be applied to existing objects. The work technique used by the designer consisted of cutting the leather by selecting the pieces of material with the potential to be used (the leather semi-finished product is the result of the manufacturing of some other leather objects, technological debris) ornamentation by different methods: painting, glueing, engraving, silver-based graphics. The selection of the piesces of leather and the graphic symbol to be applied was aimed at achieving aesthetic effects with a beneficial emotional impact for the user. The role of the chosen mark, its shape, color, finish, aesthetic appearance and the combination of basic material (leather), applied material (silver) and graphic symbols have as main objective for the designer to ensure increased psychological comfort for the user. The experiments made with the proposed materials, tools and working techniques lead to the obtaining of ecoproducts. This is achived by environmentally friendly materials in the sense that they are natural, recoverable, recyclable, reusable materials. The working technique used is simple, without energy consumption, and the variants obtained can be numerous **Fig.3**. Ecodesign, represents for designer an important approach to product design. Thus, the versatility of the product, it can be used independently and as an accessory by applying to various basic products, the interchangeability of these elements, the great variety of finishes, graphic symbols and colors represent opportunities followed by decisions the designer can take after the proposed experiments (and their submission to a market survey). The route of the experiment consists in choosing the strategy of the design process as well as the materials and working techniques.

The resulted accessories can extend the life of existing products, or extend the life of new products due to the innovation of product aesthetics, antimicrobial effects and interchangeability that can prolong the life cycle of the product (the user may interfere with the aesthetics of the object). It is important that these accessories can be made from technological debris (reuse, recovery). The working technique used is hand made, with simple tools and without energy consumption.

Fig.1: *Tools and materials used for the experiments*

Fig.2: *Work steps: selecting the used materials, cutting the material, applying the graphic symbol to the silver ion-based paint, silver foil and wire / silver wire*

Fig.3: *Work steps for applying the silver foil to make the graphic symbol*

3. EXPERIMENTAL RESEARCH OF SILVER IN LEATHER DESIGN

3.1. Experimental data and proposals for accessories

The accessories proposed by the designer in his studies aim both at exploring the multiple possibilities of the shapes obtained by cutting, brading, piercing the leather and combining the restulted produc with silver foil, silver wire, silver ions based paint. **Fig. 4**.

Fig.4: *Techniques used by the designer to obtain aesthetic effects based on brading the leather with silver wire and the application of graphic symbols on the surface with the use of silver-based paint*

3.2. Creating leather accessories and improving them with silver aplications

Based on the leather semi-finished products obtained from the manufacturing process of other products, with the aim of reusing them and valorizing them, different ornamental objects can be created for the customization of daily-use products or accessories to improve existing items. In **Fig. 5**, there are highlighted the elements of aesthetic value that can be applied to different products. These ornaments are made of leather in different shapes, colors and different finishes from gloss to matte, and the subsequent application of graphic elements with silver foil or silver-based paint. The fitting of these elements can be achieved by gluing, staples or other jointing processes that can ensure their interchangeability.

Fig.5: *Ornamental elements applied with silver foil and silver ion based paint to create the graphic symbols*

Creating complex objects that can be independent as a product (bracelet, pendant, ornament) are made on the basis of leather texture assessment, which may be glossy, matte, printed with a certain pattern, made as a simple band or by brading, or by the application of silver wire, **Fig.6**. The effect is aesthetic and beneficial to health. Ornaments created can be applied on different objects: purses, **Fig.7**; mobile phone covers, **Fig.8**; wallets, **Fig.9**, etc.

Fig.6: *Techniques used to obtain accessories: bracelets, pendants, ornaments with different aesthetic effects: color, texture, joining, graphic symbols*

Fig.7: *Different ornamental elements with silver foil and silver ion based paint applied on purses*

Fig.8: *Different ornamental elements with silver foil and silver ion based paint applied on the mobile phone case*

Fig.9: *Different ornamental elements with silver foil, silver wire and silver ion based paint applied on wallets*

5. CONCLUSIONS

The experiments in this paper demonstrate the aesthetic and functional proprieties of materials that can be reintegrated into the production of new products or the enrichment of existing objects, thus prolonging their use. The paper demonstrates that the leather debris resuted from making other products can be used successfully and that new objects can be created from these debris, their aesthetic enrichment and their return to the usage circuit, extending the life of some products, managing to reuse and to be responsible for recycling. The aesthetic combination with silver in different forms offers both, aesthetic value and antiseptic effect. The life cycle of a product can be prolonged by the designer's intervention in each stage.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

THE INFLUENCE OF TEXTILE FINISHING TECHNOLOGY ON UPF

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Abstract: *The main goal of the study was to develop an ecological and comfortable textiles for summer clothes with increased Ultraviolet Protection Factor (UPF>50+) able to protect human body from harmful effects of UV rays. The identification of critical parameters to create new fabric structures, manufacturing of weaving and knitting samples, evaluation of the textile characteristics and optimization of dyeing and finishing technologies with setting of an efficient, cost-effective and eco-friendly method to enable really industrial dyeing and development of UV protective textile materials for summer clothes, sportswear and leisure equipment were took into consideration. New innovative aspects such as a new approach to produce comfortable UV shielding fabrics with UPF > +50 by engineering innovative structured textiles surfaces, combining natural selected dyes and modified nanoclays leading to high UV rays reflection and increased use of renewable resources (natural dyes) and safe natural minerals (clays) with high impact on human health and environment (avoidance of the substances excluded by eco-labels and the REACH SVHC candidate list) were envisaged. The paper presents the level of UPF obtained by using 100% viscose material treated with Nanomer I.31PS, Nanomer clay and Nanomer I.28 E, Nanomer clay.*

Key words: *ultraviolet protection factor, UV rays, protective textiles, comfortable.*

1. INTRODUCTION

According to WHO, 2-3 million non-melanoma skin cancers and 132000 melanoma skin cancers occur globally each year, the UV radiations contributing to 50%-90% of skin cancer and affecting especially the vulnerable category of children and adolescents. UV protective clothes represent one of the easiest and powerful solutions to avoid the negative effects of UV rays (cancer, DNA mutations, immune system damage, skin aging) and to improve the human health.

Despite multiple attempts to create protective textiles against the destructive effects of UV rays (UV absorbers, dyeing, design of tightly fabric structures) the results are not successful due to the multiple limitations of the current approaches: the reduced range of colors able to provide a high Ultraviolet Protection Factor (UPF>50 +)[1, 2]; the inability of textiles to ensure a comfort for hot and humid climate (generally, the UV protective textiles are heavy, have tight construction, low air/water permeability, low thermal transfer, high accumulation of static electricity)[3, 4]; the reduced use of natural yarns (most of UV protective fabrics are made in synthetic yarns); the rapid discoloration of the dyes under solar light, ozone, temperature, humidity, pollutants; use of toxic compounds (e.g. UV absorbers) to increase the solar protection [5, 6].

Many attempts were performed to create protective textiles against the destructive effects of UV rays: treatment with UV absorbers able to convert electronic excitation energy into thermal energy, acting as radical scavengers and singlet oxygen quenchers; inclusion into fibers or as finishes of metal oxide nano particles (TiO_2, ZnO) but used in low quantity, they have no effect on UV rays absorption and, used in large quantities, impair the textile properties and act as photocatalysts, degradating textiles; dyeing with different types of dyes: some dyes or pigments absorbs in UV increasing the UPF of textiles;design of tightly fabric structure: UV protection is strongly related to the fibres physico-chemical properties, presence of UV absorbers, construction, thickness, porosity, stretch, moisture content, color and the finishing of the fabrics.

2. MATERIALS AND METHODS

For the finishing with hybrid ceramic nanocomposites, we produced knitted fabrics whose characteristics are shown in table 1. The fabrics dyed with the reactive dye Red S-3B indicates an insufficient sun protection factor for the protection of the human body (UPF=5).

***Table 1:** The characteristics of the knitted fabrics*

No.	Characteristics/ Sample	Unit	Sample no. 1	Sample no. 2	Sample no. 3
1	Colour	-	white		
2	Composition	-	100% viscose	100% viscose 1% Red S-3B	100% viscose 4% Red S-3B
3	Structure	-	Single jersey	Single jersey	Single jersey
4	Mass	g/m^2	234	232	237
5	Thickness	mm	0,784	0,81	0,824
6	Wales Density	wales/10cm	128.5	122.5	128,0
7	Courses Density	courses/10cm	120,0	130,0	128,0
8	Bursting and Deformation Strength	Kpa	262.0	290.1	287.3
		mm	34.9	43.6	38.1
9	Water Vapor Permeability	%	38.1	43.0	33.0
10	Air Permeability	l/m^2/sec.	1670	1350	1284
11	Abrasion Resistance	no. of rubs	>5 000	> 5 000	> 5 000
12	Surface Resistivity	$\Omega cm \times 10^{13}$	3.72	4.49	4.22
13	Volume Resistivity	$\Omega cm \times 10^{14}$	2.46	2.15	6.13
14	Thermal Resistance	$m^2 \times K/W$	0.0306	0.0257	0.0274

The following nanoceramic composites were used for the experimentations:

- montmorillonite, Na-MMT: cation exchange capacity (CEC)/ Modifier Concentration: 97 meq/ 100g; d-spacing: 12.61 Å;

- Nanomer I.28E, a modified surface nanoclay containing 25-30% trimethyl stearyl ammonium, Sigma-Aldrich, USA;

- Nanomer I.31Ps, a montmorillonite whose surface is modified with 15-35% octadecylamine and 0.5-5% aminopropyltriethoxysilane, Sigma Aldrich, USA.

The inclusion of large organic cations such as octadecyl trimethylammonium bromide changes the properties of the montmorillonite from hydrophilic to hydrophobic/ lipophilic.

The following experiments were carried out:

Experiment 1: The sodium montmorillonite dispersion (Na-MMT) was prepared by introducing the powder gradually with strong stirring in the water so as to obtain 1 g/l concentration.

Experiment 2: A solution containing 1.018 g/L Imerol JSF (anionic surfactant) and 0.262 g/l

Brij L23 (tricosethylene glycol dodecyl ether, polyoxyethylene (23) lauryl ether, Sigma, Germany) was prepared. It was heated to 40°C for Brij L23 dissolution. The powder of I.28E nanomer was gradually added with strong stirring, to obtain the final concentration of 1.024 g/l.

Experiment 3: A solution containing 2.076 g/l Imerol JSF and 1 g/l Brij was prepared. It was heated to 40°C for Brij L23 dissolution. The powder of I.28E nanomer was gradually added with strong stirring to obtain 2.036 g/l concentration.

Experiment 4: A solution containing 1 g/l Imerol JSF and 0.25 g/l Brij L23 at 40°C for Brij L23 dissolution was prepared. The powder of I31PS nanomer was gradually added with strong stirring to obtain 1 g/l concentration.

Experiment 5: A solution containing 1 g/l Imerol JSF and 0.25 g/l Brij L23 at 40°C for Brij L23 dissolution was prepared. The powder of I31PS nanomer was gradually added with strong stirring to obtain 2 g/l concentration.

3. RESULTS AND DISCUSSION

The UPF protection factor was determined using Varian Cary 50 Agilent UV-VIS equipment and the results are shown in Table 2.

The innovative design of the Cary 50, which incorporates a Xenon flash lamp, enables it to offer many advantages over traditional UV-Vis spectrophotometers.

The Cary 50 is controlled by the new Cary WinUV software. This Windows based software features a modular design which makes it easy to use.

Table 2: *UPF protection values*

Experiment	Sample notation	Components	UPF with filter UG11	Evolution from the original	UPF without filter UG11	Evolution from the original
Exp. 1	1.1E1	100% viscose + 1g/l Na-MMT	5	5	10	5
	1.2.1E1	100% viscose + 1% Red S-3B + 1g/l Na-MMT	10	5	30	20
	1.2E1	100% viscose + 4% Red S-3B + 1g/l Na-MMT	30	25	50+	40+
Exp. 2	1.1E2	100% viscose + 1g/l I-28E	5	5	5	0
	1.2.1E2	100% viscose + 1% Red S-3B + 1g/l I-28E	25	20	45	35
	1.2E2	100% viscose + 4% Red S-3B + 1g/l I-28E	25	20	50+	40+
Exp. 3	1.1E3	100% viscose + 2g/l I-28E	0	0	10	5
	1.2.1E3	100% viscose + 1% Red S-3B + 2g/l I-28E	25	20	50+	40+
	1.2E3	100% viscose + 4% Red S-3B + 2g/l I-28E	20	15	50^+	40
Exp.4	1.1E4	100% viscose + 1g/l I-31PS	10	10	15	10
	1.2.1E4	100% viscose + 1% Red S-3B + 1g/l I-31PS	45	40	35	25
	1.2E4	100% viscose + 4% Red S-3B + 1g/l I-31PS	50+	40+	50	40
Exp. 5	1.1E5	100% viscose + 2g/l I-31PS	5	5	10	5

	1.2.1E5	100% viscose + 1% Red S-3B + 2g/l I-31PS	30	25	15	5
	1.2E5	100% viscose + 4% Red S-3B + 2g/l I-31PS	50+	40+	50+	40+

In Figures no. 1-5 is presented the evolution of UPF within the experimental schemes 1-5. By analyzing these figures, the following aspects results:

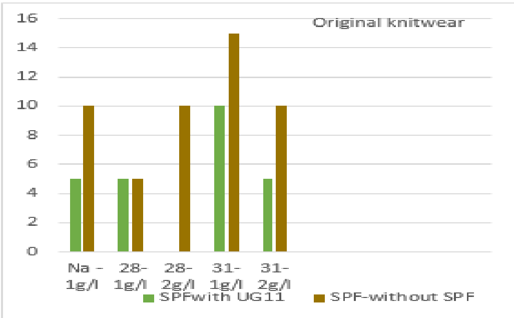

Fig. 1: *UPF for original fabric*

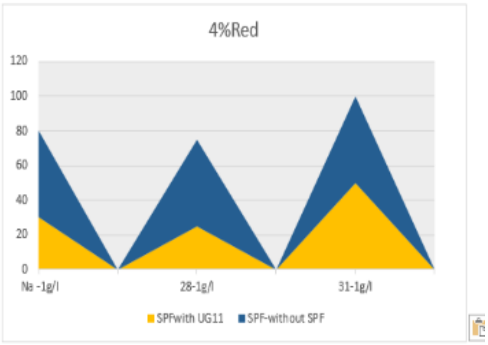

Fig. 2: *UPF for 1% Red+1g/l NP*

Fig. 3: *UPF for 4% Red + 1g/l NP*

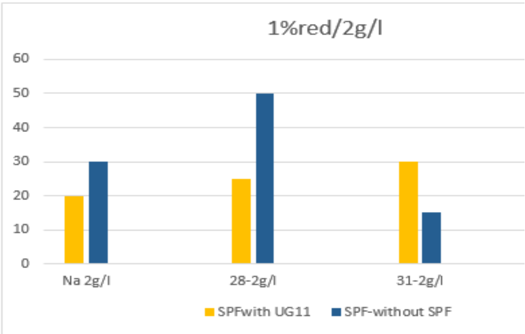

Fig. 4: *UPF for 1% Red + 2 g/l NP*

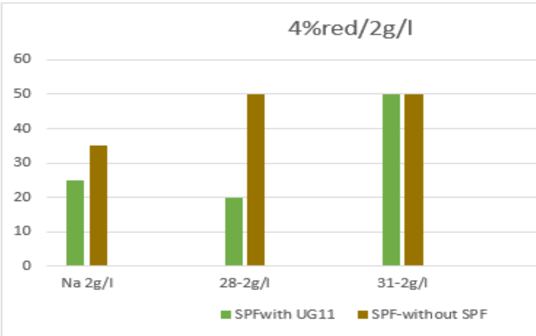

Fig. 5: *UPF for 4% Red + 2 g/l NP*

The UPF values were evaluated according to the Australian/ New Zealand standard (AS/ NZS 4399-1996), for the ultraviolet spectral range with a wavelength of 290-400 nm using the Varian spectrophotometer equipped with an integrated sphere accessory and a support for fabrics. For each sample, UPF is calculated according to the following equation:

$$UPFi = \Sigma E\lambda S\lambda \Delta\lambda / \Sigma E\lambda S\lambda T\lambda \Delta\lambda \quad \textbf{(1)}$$

where E is CIE relative spectral efficiency; S is the solar spectral radiation; T is the spectral transmission of the fabric; Δλ is the difference of the wavelengths expressed in nm and λ is the wavelength expressed in nm.

The assessed UPF of the sample is calculated by introducing a statistical correction. Starting from the standard deviation of the UPF average, the standard error of the UPF average is calculated for a 99% confidence level. The UPF rating will be the UPF average minus the standard error, rounded to the nearest multiple of 5. According to the Australian classification scheme, the textiles can be considered as providing a good, very good and excellent protection if the UPF ranges from 15 to 24, 25 to 39 and, respectively, more than 40. For the UPF rating of 55 or higher, the term 50+ is used.

4. CONCLUSIONS

- The treatment experiments of the knitted fabrics made of 100% white and dyed viscose (with 1% and 4% RED S-3B dye) were made using 3 types of Nanomers: Na-MMT, Nanomer I.28E, Nanomer I.31PS in different concentrations 1 g/l and 2 g/l).

- The best of UPF values were obtained for the fabrics made of 100% dyed viscose with 1% or 4% Red S-3B dye and treated with Nanomer I31PS for both 1g/l and 2 g/l concentration.
- Experiments will continue for knitted and woven fabrics made of 100% cotton, 100% polyester and cotton/ polyester blending.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ALTERNATIVE FIBERS I: FEATHER FIBERS AND PEANUT HULL FIBERS

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***Abstract**: Even though various fibers are used today in textile production, researchers have started to search out alternative resources for natural fibers. Air, water and land pollution occurring because of overconsumption of fibers such as polyester, nylon, acrylic, polypropylene that are pretty much used in textile has created quite negative effects on the environment. For this reason, alternative environment-friendly fibers have been gaining importance in recent years.*

Alternative fibers are less known fiber types that exist in the forms of animal and cellulose fibers in nature. With some of their properties such as keeping warm, lightness etc., these fibers can be an alternative to the fibers used today. As these fibers decrease the burden of waste load thanks to their reuse, it is also possible to consider them significant for the protection of the environment. In this study, feather fibers and peanut hull fibers have been investigated and presents some information about obtaining, production and usage areas of these fibers by the method of literature review. At the end of the study, it has been concluded that the usage areas and production of these fibers should be increased.

***Key words:** Feather, Down fibers, Peanut Hull, Environment.*

1. INTRODUCTION

Even though there exist a lot of fibers in the form of textile fibers, the researchers have been working on plant or animal fibers that already exist in the natural environment. These fibers are composed of products found in nature and used in industries such as feed industry or those disposed directly. The reuse of these waste materials as fiber is also important in terms of less environment pollution. This study examines some fibers that are not commercially used by means of literature review method. In the first part of the study, the feather fibers obtained from the poultry have been examined. In the second section, the fibers obtained from peanut hull fibers and in the third section, the fibers obtained from the banana tree have been analyzed.

2. FEATHER FIBERS

Poultry processing industry produces approximately 2268 million tons feathers per year. The chicken feathers obtained in the processing plants can generally be reused by the feed industry. The

sales value of the feathers obtained after processing amount to approximately 0.25 dollar per pound for the factories. As a fiber, on the other hand, this value can be between 0.5-2 dollars [1], [2].
Feather fibers, particularly goose down, are used as a filling material. As far as the structure of feather fibers is considered, it is possible to mention their potential usage areas include isolation, filtration and absorbent structures [3].

Though there exists a lot of fiber types in nature, all of them consist of β-keratinous [4]. What differentiates feathers from each other is the way they are formed. The feather types can be in seven different forms according to bird type or the position of the feather (Figure 1).

Fig. 1*: Feather types according to body structure of birds and the position of feather [5].*

Feathers are generally divided into two parts. One of the parts is pennaceous section that is more flat, stiff and thick while the other is plumulaceous section that is softer and thinner. Also, barb that branches from the main body as well as the feather and barbules that are linked to these barbs are the other parts that compose the feather (Figure 2) [1], [5]. Table 1 shows the physical features of pennaceous and plumulaceous sections.

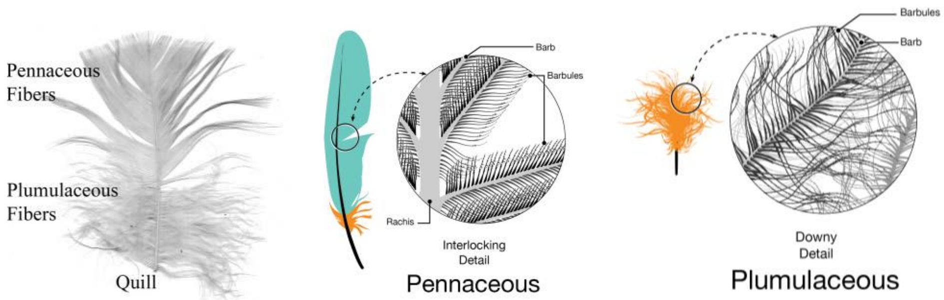

Fig 2: *Schematic display of pennaceous and plumulaceous sections, barb and barbules [1], [5].*

Table 1: *Linear density and mechanical properties of pennaceous and plumulaceous sections [1].*

Feather fiber	Maximum length (cm)	Average denier (g/9000m)	Average tenacity (g/den)	Average strain (%)	Average modules (g/den)
Plumulaceous	4.1	55.2	0.36	16.43	4.47
Pennaceous	5.2	142.0	0.83	7.96	15.55

In the studies, it was found out that the feather fibers were quite absorbent, flexible and light. They also have the property of increasing volume. These properties enable the fiber to become a valuable material for air filters. In addition, that the fibers are of 6-micron thinness makes their usage charming [1], [2], [6].

2.1 Goose Down

China is in the first place in the production of goose down with its export rate of 35.2% in the external trade of the world. The USA, on the other hand, is the leading importing country in the world with its import amount of 27.7%. Even though goose down is now known as a material used in clothing industry or as bed materials, it has been used for several purposes for ages. For instance, it was used as a writing tool in the western world from 6th to 16th century, and as a playing tool called "plectra" in string instruments such as qanun and lute [3].

Goose and similar birds have air absorbent fibers in their bodies. These special fibers provide them lightness and high heat absorbing feature [7]. Goose down is quite an interesting material and composed of multi barbs, each of which branches out from a central point. On each of these barbs, there exist thin fibers on which there are barbules (Figure 3). These barbules on the fibers enable thousands of fibers to be linked to each other and create a three-dimensional structure. Because of its magnificent filling performance and perfect insulation ability, goose downs are one of the mostly preferred filling materials in bedclothes, winter clothes, curtains and jackets [3], [4], [8].

When compared to wool, the surface of goose down is more hydrophobic and provides better thermal isolation in humid places. In thermal measurement, it was seen that goose down displayed better isolation than wool, cotton and polyester (PET) [8]. In a study, the young's modulus was measured as 1.31 GPa for goose down and 2.21 GPa for duck down. On the other hand, their flexibility is not as good as that of wool, they break at approximately 12% extension [4].

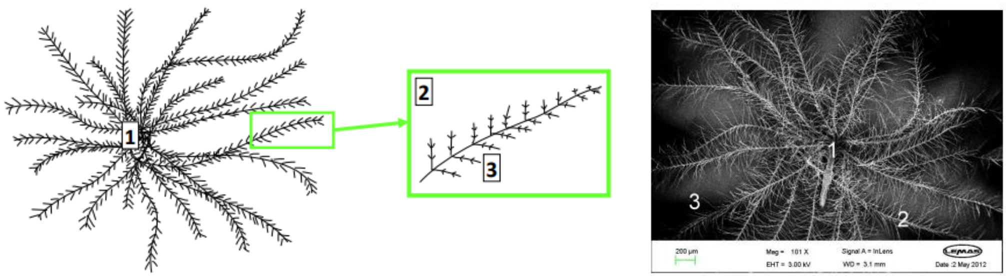

Fig 3: *Parts of goose down and appearance of goose down in electron microscope. 1- goose down core, 2-barb, 3-barbules with prongs [4].*

Feathers obtained from various parts of goose have different values in terms of economy. The feathers obtained from the chest of down are the most valuable one. The feathers collected from its wing and tail parts are shag and have less commercial value [9]. In addition, feathers of down, goose, mallard and swan are divided into two colors: white and grey [8].

2.2. Turkey and Chicken Feather Fibers

Even though chicken feather fibers are more easily found, turkey feathers are more suitable fibers for textile production because they are longer [10]. Chicken and turkey feathers are generally used in yarns, nonwoven and composite structures. While yarns are uses by being blended with synthetic yarns, surfaces are obtained alone or by being blended in nonwoven sector [11-13].

The amount of chicken feathers, which is the by-product of chicken meat production, is approximately 15 million tons each year throughout the world. Chicken feathers have a unique structure and properties that do not exist in natural or synthetic fibers. Because of their complex structure, chicken feathers cannot be processed as wool or silk. However, their barb and barbules sections make them suitable to be used as natural protein fibers. Chicken feathers' low density, perfect compressibility and flexibility, sound reducing ability, heat absorbing and distinguishing morphological structure make them unique. For instance, while the density of the chicken feathers is 0.8 g/cm^3, it is about 1.5 g / cm^3 for cellulose and about 1.3 g / cm^3 for wool. These unique features of chicken feather enable them to be preferred by the automotive industry for many applications such as textile and composites.

In order to obtain chicken feather fibers, it is required to separate barb parts from more rigid and thick parts called rachis. For this separation procedure, Gassner and his friends took patent [15]. Barb length of chicken feathers is approximately 0.3-1.3 cm, but this is not enough to produce a yarn. The chicken feathers can be used in the production of nonwoven and composite surface. They can also be used in such areas as automotive, construction, packaging, filter, isolation material, erosion control, winter outdoors clothing [2, 13-16].

Ye and Broughton [2] compared the isolation properties of nonwoven fabrics made from chicken feather, down feather and polyester fiber. In the study, chicken feather fiber was turned into nonwoven surface by having been blended with other fibers. At the end of the study, it was found out that chicken feather fiber provide better isolation than polyester and goose down fibers. Bessa et al. [16] examined thermal and acoustic isolation properties of chicken feather supported composites. The composite structure was obtained with chicken feather fibers and thermoset resin like epoxy. Blending the epoxy resin with the chicken feather in three different amounts (80-20, 70-30 and 60-40), composite structures were created. With the increase in the chicken feather amount, thermal resistance increased proportionately. It was also mentioned that these materials could be used in sound isolation for supporting purposes. Experimental results showed that the chicken feather fibers had high potential to be used as supporters in the production of composite materials.

As turkey feathers and the feathers of the plumulaceous section is very light and the feathers at pennaceous part is very stiff, they are not alone suitable for yarn production. It becomes possible to produce yarn by blending them with other types of fibers. In the study carried out by Evazynajad and George [12], turkey feathers were turned into yarns by having been blended with nylon in different amounts. At the end of the study, it was found out that as turkey feather amount of the yarn increases, its tenacity and elongation increase while its young's modulus decreases. It was also concluded that the obtained yarns did not have the required properties to produce clothes, but could be more suitable to be used in technical textile applications such as filtration. In another study carried out by Evazynajad et. al. [11], knit fabric was produced after turning the turkey feathers into yarns. After that, thermal insulation values of this fabric were evaluated, and it was seen that the increase in turkey feather fiber amount affected thermal insulation values positively.

In a study carried out by George et. al. [10], turkey feathers were used to produce erosion preventing nonwoven surface. In this study, an erosion-preventing nonwoven surface was obtained by using the turkey feathers and these surfaces were compared with jute and coir fibers that are commercially sold. Even though the fabrics obtained from the turkey feathers were weaker than other fabrics, they displayed similar results in terms of water and light permeability and erosion prevention. In addition, the turkey feather fabrics increased humidity amount in land.

3. PEANUT HULL FIBERS

Peanut is one of the most important foods produced in the USA. The body of the peanut is composed of cellulosic fiber layer. Most studies on peanut have usually focused on the separation of fiber from the hull and producing erosion preventing nonwoven fabrics [1].

The fibers range in length from 0.64 centimeters (cm) to 6.4 cm (Figure 4). Its average tensile strength is lower than many textile fibers. As the peanut is fairly stiff, it becomes difficult to process them, which subsequently makes it hard to card them effectively or punch them with needle in the production of a nonwoven fabric.

Peanut fibers should be separated from their hulls in the first place. With the machine patented in 1982, the fibers are milled from the plant bodies by the rod mill and thus the fibers are separated. This separation results in two separate fibers from the outer and inner parts of the hull.
Inner fibers are shorter than external ones [1], [17].

Some researchers have made a fiber spun by using the peanut hull. In one of these studies, Merrifield and Pomes [18] obtained regenerated fiber, whose trade name is Serelon, from the peanut hull in 1946. The hand feeling of the obtained fibers and their thermal properties were at desired values. These fibers can be dyed with acid, vat, direct and acetate dyes. As with all synthetic protein fibers, the weak point of these fibers is their low strength.

Imperial Chemical Industries (ICI) made a fiber spun from the peanut hull, whose commercial name was Ardil. This fiber was used in clothing, curtains and carpets. Due to its low wet strength compared to wool and its high price, its production ended in 1957 [19].

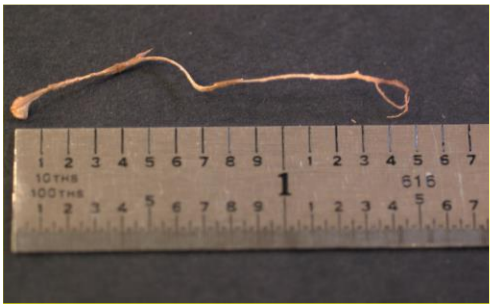

Fig 4: *The average peanut fiber length [17].*

4. CONCLUSIONS

As environmental problems increase day by day, efforts to reduce plastic based production have gained importance. Therefore, the use of alternative fibers will most likely expand. In this literature study, feather and peanut hull fibers were examined. In the light of the obtained data, it can be concluded that these fibers can be an alternative to conventional fibers and can be used commercially. As increasing the usage of these fibers will decrease waste load, they are considered important for the environment.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ANALYSIS ON COLORS OF FOLK COSTUME AND THEIR APPLICATION IN CONTEMPORARY TEXTILE DESIGN

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Abstract: *The traditional colors and motifs of folk costumes will always be extremely inspirational and always viable for fashion design. Reinterpreted and stylized in unprecedented contexts, they are highly appreciated due to the authentic and fresh air they emit.*
*In this paper, the authors present a study about the possibility of using the colors and traditional motifs of folk costumes in contemporary textile designs. The primary and secondary colors of the folk costumes from the Strandja region, Bulgaria, were analyzed. Folk costumes were vectorized in the Inkscape program. 4 basic elements have been selected from folk costumes, saved as bitmap images in *.BMP file format and stylized. The colors of each element of folk costumes were extracted in the RGB model and were combined with modern colors presented by Pantone for Spring/Summer 2019 at New York Fashion Week. Two textile designs for each element were made in 3 variants of colors. After that, we conducted through a developed Google Forms tool, a survey regarding the consumer's opinion in order to evaluate the designs already created. A total of 80 respondents from Romania, Bulgaria, Serbia and Macedonia were interviewed. They were randomly selected regardless of education, employment and gender. The results obtained were processed by the ABC analysis method.*

Key words: *Folk elements, textile patterns, ABC analysis, colour similarity*

1. INTRODUCTION

Traditional clothing plays an important role not only in highlighting the community's own identity, but also in other communities in the same region, reflecting a range of beliefs and rich functionality and application in everyday life and holidays. [1].

The motifs and their elements of traditional clothing can be used in the design of modern clothing [2, 3]. Each motif and element on which it is applied has its origin, meaning and variety in form, color and manner of representation.

The design of modern textile fabrics related to weaving, embroidery, dyeing, printing uses well-known motifs and elements of culture, religion, the environment and the history of textiles. In order to achieve the final decision - which elements of folklore to use when creating modern textiles, a number of steps are required, such as studying fashion trends, finding appropriate elements and motifs that have not been used so far.

Women's folk costume has regional and even local varieties in Bulgaria and Romania. It consists of a suckman, a tunic-shaped cut with a deep cut out, an apron decorated with many decorative elements - geometric, natural, stylized, abstract.

The colors of the folk costume are supposed to be associated with emotions, human qualities, seasons, festivals and by this society interprets the location of the person wearing it. Using the colors of folk costumes in modern textiles and combining this colors with contemporary color trends, requires research and analysis of designers' opinions as well as consumer interest in them, [4, 5, 6].

By analyzing the possibility of applying elements and colors of folk costume it can be summarized that: there are few publications related to the use of traditional costume colors in modern textiles due to their specific application reflecting symbolism rather than combinations suitable for textile design; it is necessary to analyze the opinion of experts and to study the consumer interest in the use of traditional costumes in combination with the contemporary color trends; due to the constantly changing tendencies in the colors, it is necessary to summarize a methodology for analyzing the consumer demand.

2.MATERIAL AND METHODS

Folk costumes from the region of Strandja, Bulgaria, were used for the purposes of the study. This costume belongs to the suckman type. It consists of: a shirt; suckman, a woolen dark garment with closed tunic; a front apron and a woolen belt with a red, orange, dark-wine color. The skirts and bosoms of the suckman are decorated with a velcro, sewn with colored sutures. The decoration is intertwined with colorful walks, braids, laces. The apron is colored, standing on the black background of the suckman, combining colors like red, green, yellow, white. There are embroidery in the wearing varieties.

Folk costumes are vectorized in the Inkscape program (Inkscape, GPLv2 +, https://inkscape.org). Vectorization module developed by Selinger [7] that uses a polygon trace algorithm, included in Inkscape program is used. Elements of used costumes are selected and separated. The elements are saved as bitmap images in *.BMP file format. In the GNU Octave [8] program environment, their colors are extracted in the RGB model as shown in position 4.

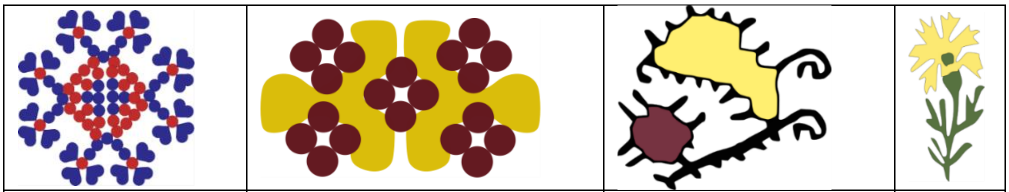
The contemporary colors include those presented by Pantone (Pantone LLC) for Spring/Summer 2019 NYFW (New York Fashion Week) and neutral colors. In table 1 are presented the colors used (numbered 1 to 16), their Pantone catalog numbers, general appearance, RGB color values and L *a*b* values representing the specific colors. The color components of the RGB color model (RGB [0 255]) were converted to Lab (L [0 100], a [-86.18 98.23], b [-107.86 94.47]).

Table 1: *Colors of Pantone Spring / Summer 2019, NYFW color palette and neutral*

Color Number	Pantone Number	General View	R	G	B	L	a	b
1	PANTONE 17-1564 Fiesta		221	77	67	53,05	55,53	36,64
2	PANTONE 19-1862 Jester Red		157	55	68	38,41	43,35	15,25
3	PANTONE 15-1264 Turmeric		254	132	42	67,83	41,05	64,93
4	PANTONE 16-1546 Living Coral		252	118	106	65,51	50,19	31,31
5	PANTONE 18-2045 Pink Peacock		200	62	115	48,22	58,41	0,99
6	PANTONE 17-0542 Pepper Stem		145	150	73	60,17	-13,24	39,57
7	PANTONE 13-0850 Aspen Gold		251	199	72	82,82	6,23	67,48
8	PANTONE 19-4150 Princess Blue		45	92	158	39,04	7,02	-40,56
9	PANTONE 18-1031 Toffee		117	87	65	39,55	9,29	17,59
10	PANTONE 15-0960 Mango Mojito		217	159	60	69,38	12,30	57,68

11	PANTONE 18-0416 Terrarium Moss		104	105	67	43,44	-6,94	21,28
12	PANTONE 14-2808 Sweet Lilac		231	182	207	79,01	21,62	-5,80
13	PANTONE 13-0919 Soybean		215	196	157	79,82	0,72	22,05
14	PANTONE 19-3810 Eclipse		59	58	80	25,37	6,05	-13,18
15	PANTONE 11-0106 Sweet Corn		242	237	215	93,60	-1,99	11,26
16	PANTONE 19-0805 Brown Granite		86	64	62	29,40	9,22	4,93

Figure 1 shows the stylized elements used of folk costume. The elements are stylized and in this process they conform to their original appearance on folk costumes. There are 4 basic elements with combinations of 2 colors, in 3 combinations, according to their coloring on the costumes. When choosing a number of colors for an element, it is necessary to take into consideration the possibilities of the weaving, embroidery, jacquard machine, on which the textile pattern with the elements used will be made.



e1 e2 e3 e4

Fig.1: *Stylized elements of folk costume*

In Table 2 the values of RGB color components are presented. The primary color is the color of most of the elements and the secondary color, it is the one that the small details on it are colored.

Table 2: *Values of RGB color components of folk costume elements*

e1_1	**R**	**G**	**B**	**e1_2**	**R**	**G**	**B**	**e1_3**	**R**	**G**	**B**
Primary	255	255	245	*Primary*	46	44	140	*Primary*	240	104	184
secondary	255	98	200	*secondary*	191	44	44	*secondary*	97	184	139
e2_1	**R**	**G**	**B**	**e2_2**	**R**	**G**	**B**	**e2_3**	**R**	**G**	**B**
Primary	40	46	129	*Primary*	218	189	11	*Primary*	29	45	35
secondary	255	255	254	*secondary*	100	26	33	*secondary*	21	85	62
e3_1	**R**	**G**	**B**	**e3_2**	**R**	**G**	**B**	**e3_3**	**R**	**G**	**B**
Primary	33	113	38	*Primary*	255	239	112	*Primary*	118	51	65
secondary	179	55	88	*secondary*	118	51	65	*secondary*	33	113	38
e4_1	**R**	**G**	**B**	**e4_2**	**R**	**G**	**B**	**e4_3**	**R**	**G**	**B**
Primary	160	65	64	*Primary*	252	233	114	*Primary*	43	31	140
secondary	252	233	114	*secondary*	87	114	64	*secondary*	252	233	114

A color similarity method has been applied in the analysis of the consumer's opinion on the textile designs created here. The color similarity n is defined by the mathematical dependencies presented in [9]. The greater value of the coefficient n means closer color vectors; the lower values of n show a lesser similarity; when $|C_2|$ is equal to $|C_1|$, the coefficient n has a maximum value of 1:

$$n = 1 - \frac{||C_2| - |C_1||}{|C_1|} \quad \textbf{(1)}$$

$$|C_1| = \sqrt{{R_1}^2 + {G_1}^2 + {B_1}^2} \quad \textbf{(2)}$$

$$|C_2| = \sqrt{{R_2}^2 + {G_2}^2 + {B_2}^2} \quad \textbf{(3)}$$

In the present work, a survey of consumer opinion was conducted in order to evaluate the designs already created, combining colors of elements used in folk costumes with modern ones. A total of 80 respondents from Romania, Bulgaria, Serbia and Macedonia were interviewed. They were randomly selected regardless their education level, employment status and gender. All respondents were informed regarding the purpose of the survey and the purpose of using the received data. The survey was conducted through a developed Google Forms tool, because it is a free Google application used to create an online form or test that can be completed online from a mobile device or a desktop computer. The obtained results are in real time on-line. All the patterns were created by Digital Fabrics online tool [10].

The obtained results were analysed with the ABC analysis method [11]. The ABC analysis was put in application in the following order: The sum of all the respondents′ answers was determined and then the obtained data was sorted in descending order; A share in the total value was calculated as the ratio between the amount for a given pattern and the sum of all amounts.

The fraction of the total was determined by a cumulative sum of the share in the total value - the values were obtained as the sum of the two previous ones; The data was devided into three categories A, B and C. Category A conprised 0-75% of the data, 75-95% category B and 95-100% category C. The patterns corresponding to category A were selected.

This data was processed at a level of significance α=0,05

3. RESULTS AND DISCUSSION

The selected color combinations are represented in the Table 3. There are 4 basic elements with two combinations. The color similarity with the background is shown: between the primary color and the background (CDP), and between the secondary color and background (CDS).

Table 3: *Color combinations and difference between Pantone's and element colors*

e1_1				**e1_2**				**e1_3**			
PC	**4**	**12**	**13**	*PC*	**6**	**7**	**13**	*PC*	**5**	**12**	**8**
CDP	0,32	0,18	0,24	*CDP*	0,49	0,25	0,24	*CDP*	0,45	0,18	0,57
CDS	0,12	0,06	0,02	*CDS*	0,35	0,03	0,02	*CDS*	0,29	0,06	0,44
e2_1				**e2_2**				**e2_3**			
PC	**1**	**7**	**13**	*PC*	**3**	**6**	**8**	*PC*	**5**	**7**	**8**
CDP	0,44	0,25	0,24	*CDP*	0,34	0,49	0,57	*CDP*	0,45	0,25	0,57
CDS	0,28	0,03	0,02	*CDS*	0,15	0,35	0,44	*CDS*	0,29	0,03	0,44
e3_1				**e3_2**				**e3_3**			
PC	**7**	**8**	**13**	*PC*	**6**	**8**	**13**	*PC*	**3**	**7**	**13**
CDP	0,25	0,57	0,24	CDP	0,49	0,57	0,24	*CDP*	0,34	0,25	0,24
CDS	0,03	0,44	0,02	CDS	0,35	0,44	0,02	*CDS*	0,15	0,03	0,02
e4_1				**e4_2**				**e4_3**			
PC	**3**	**6**	**8**	*PC*	**1**	**3**	**4**	*PC*	**1**	**3**	**5**
CDP	0,34	0,49	0,57	*CDP*	0,44	0,34	0,32	*CDP*	0,44	0,34	0,45
CDS	0,15	0,35	0,44	*CDS*	0,28	0,15	0,12	*CDS*	0,28	0,15	0,29
CDP – primary color similarity; CDS – secondary color similarity; PC – Pantone color; e - element											

The survey data showed that 42% of respondents chose patterns with Drop repeat and 58% half drop, resulting that the selected color of the patterns should be analyzed individually.

The figure 2 presents the results of the ABC analysis of the two data sets for patterns with Drop and Half drop repeats.

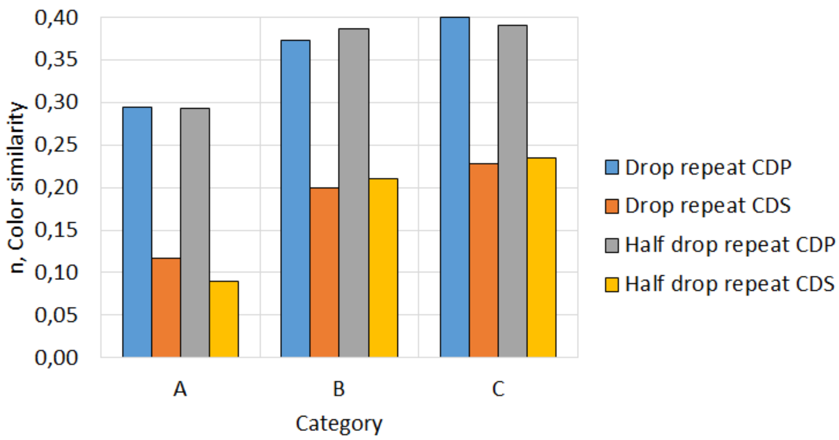
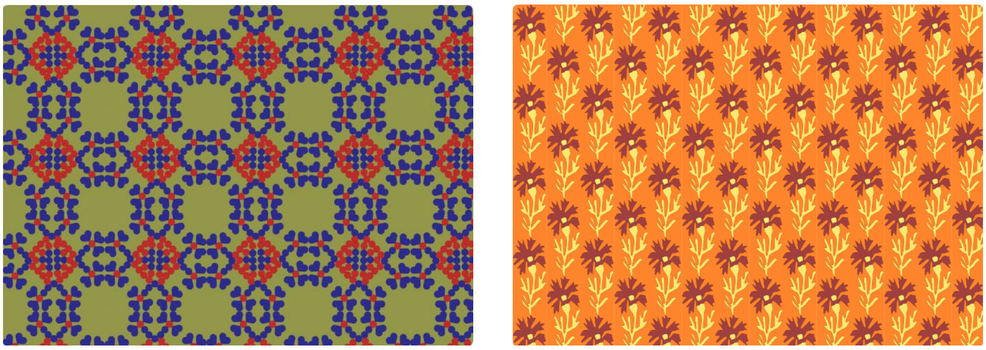


Fig.2: *Results from ABC analysis*

It can be seen that in category A, the most commonly selected patterns are those with up to n=0,3 similarity to the color for the primary color and to n=0,12 for the secondary. The same trend is preserved when selecting colors for Half drop repeat. In the rest of the groups, the results are identical to group A. Patterns with a higher similarity between the primary color and the background and a lower similarity between the background and the secondary color are selected. Category A comes with combinations with less similarity to those in the rest of the categories.

Most selected patterns according to the survey with drop and half drop repeat are presented in figure 3. As it can be seen, regardless of the repeat, the resulting trend primary element is similar to the background color, and secondary to be more contrasting.



e1_2 Drop repeat, with Pantone color 6 e4_1 Half drop repeat with Pantone color 3

Fig.3: *Two of most selected patterns from the survey*

4. CONCLUSION

The brands adopt a color strategy in order to transmit their values to consumers but the commercial success in fashion production is often related to consumers' perception and not always to the quality of the design. By the analysis of the available literature and the results obtained in this paper, the authors consider that:

1.The use of the colors similarity is a suitable tool for evaluating consumer opinion when analyzing colors for modern textile design.

2.The presented analysis method can be used when designing contemporary textile patterns using folk elements.

3.The study demonstrates the intricacy in investigating and clarifying the patterns and it might be utilized to create inventive approaches by designers, marketers, instructors etc.

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POTENTIAL TANNING AGENTS FROM INDIGENOUS FLORA

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Abstract: *At present, about 90% of global leather is tanned with basic chromium salts, but public and authorities concern on the chromium toxicity forces tanneries to produce chrome-less or chrome-free leather. Lately, the old craft of vegetable tanning, which claims to be the most environmentally-friendly, has enjoyed a noticeable revival. At the same time, there is increasing interest in finding new vegetable sources for tannins from the European flora, as susatinable and cheaper alternatives to the expensive exotic species such as mimosa, quebracho or myrobalan. Along time, tanners have used barks and woods of different plants, but their properties are seldom documented. In this paper, some qualitative and quantitative tests on water extracts of* Alnus glutinosa*, (the black alder, Betulaceae family) and* Prunus spinosa *((blackthorn, Rosaceae family) were performed, in order to evaluate their tannin contents and potential tanning ability. Extraction was performed at a plant material:water mass ratio of 1:10, at 60°C, with extraction yield of 22.5% for adler extract (AE) and 8.9 % for blackthorn extract (BE). Spot tests were performed with positive responses. The total polyphenol contents (TPC) was determined by the Folin-Ciocalteu method, and expressed in terms of gallic acid equivalents(GAE). The TPC was 502.1 mg GAE/g AE and 249.72 mg GAE /g BE. The tannin content was estimated by a modified hide powder method, and was 155.43 mg GAE/g AE and 199.91 mg GAE/g BE. Given the working conditions, the extraction yield and tannin content of both species can be considered as satisfactory. Further leather tanning experiments are required to confirm their possible use as tanning agents.*

Key words: *vegetable tannage, leather, tannin extract, Prunus spinosa, Alnus glutinosa, renewable resources*

1. INTRODUCTION

Leather has been used by mankind from the ancient times to nowadays, due to its unique qualities: thermal insulation, breathability, durability, pleasant sensory and aesthetic characteristics. The core of the leather-making process is the tanning operation. Today, almost 90% percent of the leather on the market is tanned with basic chromium (III) salts, but concerns regarding chromium toxicity are growing and pressure is put on tanneries both from environmental legislation and aware consumers, to apply environmentally-friendly alternative tanning processes. [1].

Lately, vegetable tanning has been particularly paid attention as a cleaner alternative to chrome tanning. Vegetable tanning is the oldest, the most natural, and claims to be the most environmental-friendly, even if the long duration of the process, high water consumption, and high concentration of slowly biodegradable phenolics of the spent floats are still issues of debate [2].

The actual interest in vegetable tanning is proved by the increasing number of small vegetable tanneries across Europe [3], and notable research on finding new plant sources for high quality tannins [4]. The drive for reconsidering the tanning potential of European flora is the intensive exploitation and depletion danger of exotic species with high tannin content, and the need to find cheaper sources, which are renewable resources at the same time. The limiting factor is the extraction yield and the tannin content of the extract. On the tannins market, it is generally accepted that species with more than 10% tannin content are suitable for commercial exploitation [5].

Extraction with hot water, in a temperature range of 40–90°C, is the most common method for producing tannins for leather industry, as the water solubles are the compounds of interest. Disadvantages are the lower yield of extraction and the co-extraction of non-tannin compounds.

Along time, apart from commercial tannins from exotic species, tannery practice have reported the use of different barks and woods, even if on limited small scale, and seldom documented. Amongst these, are the bark of alder tree (*Alnus glutinosa*) and branches of blackthorne (*Prunus Spinosa*), species from the European flora.

Historical use of alnus bark as a tanning agent in small tanneries in southeastern Europe was reported, due to its high tannin content of 9 to 16%, but the usage was limited because it imparts an objectionable reddish-brown color to the leather, and also tends to make the leather brittle. When used in combination with exotic tannins, the results were satisfactory [6] Blackthorn bark and branches have been traditionally used to tan leather and to prepare a dark color ink [7].

This study aims to draw attention upon the potential tanning ability of two indigenous plant species. In this respect, qualitative and quantitative analysis of polyphenolic and tannin phytoconstituents present in aqueous extracts of *Prunus spinosa* thorns and *Alnus glutinosa* bark were performed.

2. EXPERIMENTAL

2.1. Plant materials and chemical reagents

Fresh thorns of *Prunus spinosa* and bark of *Alnus glutinosa* were collected from Barnova Forest near Iasi. The plant species were identified with help of Botanical Atlas [8]. The wooden materials were first shade dried and then oven dried for 72 hours at 60 - 65°C, and grinded with an electric grinder. The 0.4 – 0.6 mm fraction was collected by sieving and stored in an exsicator. All the reagents and chemicals – Folin-Ciocalteu's phenol reagent and gallic acid monohydrate (Scharlau, Spain), sodium carbonate, ferric chloride, sodium chloride (Chemipar, Romania), slightly chromated hide powder and gelatin powder from (Merck, Germany) were of analytical grade.

2.2. Extracts preparation

Extracts were obtained by a three-stage, batch extraction method, with hot water as solvent. The plant material:water mass ratio was 1:10. A quantity of 10 g sieved vegetable material was mixed with 40 g distilled water (DW) and mixed for 60 min at 60°C. After that, the liquid was drained and the procedure was repeated two more times, with equal amounts of 30 g DW. The total recovered liquid of 80 mL was first concentrated on a water bath at 60-70°C and finally freeze-dried.

2.3. Spot tests

For tannin extracts, several common qualitative tests were performed, as follows [9]:
Lead acetate test: To 3ml of of 1:10 extract solution, 3 ml/a few drops of 10% lead acetate solution is added. The occurrence of white precipitates indicates the presence of tannins and phenols.

Ferric chloride test. To 3 ml of 1:10 extract solution, a few drops of 5% w/v ferric chloride solution are added. The blue – black color indicates the presence of hydrolysable tannins. A brownish green precipitate indicates the presence of condensed tannins. If the extract contains both types of tannins, a blue color is produced, which changes to olive-green as more ferric chloride is added.
Fehling's test*:* is used for the detection of reducing carbohydrates Fehling A and Fehling B reagents are mixed in equal volume and few drops of extract is added and boiled. Appearance of a brick red colored precipitate of cuprous oxide cofirms the presence of carbohydrates.
Gelatin precipitation test. A few drops of 1% tannin extract solution are added to a 1% gelatin in 10% sodium chloride solution. A white-yellowish color precipitate indicates the presence of tannins.

2.4. Determination of total extract, total phenol (TPC) and tannin material

The total extract or extraction yield was determined gravimetrically, and calculated as the ratio between the extract mass and the mass of the starting plant material (eq.1.):

$$Yield\,(\%) = (\,mass\ of\ \ solid\ extract / mass\ of\ \ plant\ material\ ) \times 100 \qquad \textbf{(1)}$$

The total phenolic content (TPC) was quantified by the the Folin-Ciocalteu photocolorimetric method, using gallic acid (GA) as standard [10]. Fresh solutions of 400 mg/L AE and BE were prepared.The procedure was as follows: 1 mL of extract solution was mixed with 9 mL DW and 1 mL Folin-Ciocalteu reagent; after 5 min, 3 mL of 20% Na_2CO_3 was added and the volume was completed to 25 mL, in a volumetric flask. After 60 min incubation at 20°C, the solutions absorbance were measured on a UV VIS HACH DR/2010 spectrophotometer, at maximum absorption wavelength of 760 nm. Calibration curve was determined over a concentration range 0 - 500 mgL^{-1} GA. The TPC in the plant extract was expressed as mg of gallic acid equivalents (GAE)/ g of freeze-dried extract, and was calculated using the formula (eq.2):

$$TPC\ =\ \left(C\ \times\ V\right) /\ M \qquad mgGAE\ /\ g\ extract \qquad \textbf{(2)}$$

where: C = concentration of gallic acid established from the calibration curve, mg/L; V = volume of extract, L; M = weight of water extract of the plant, g.
Tannin contents. The tannin contents was determined by a modified hide powder method, based on measuring the TPC in the tannin solution, before and after the adsorbtion on hide powder, by the Folin-Ciocalteu method [11] Solutions of 5 g/L *AE* and 6 g/L *PE* were prepared. An equivalent of 3.2 g dry substance of slightly chromated hide powder was mixed with 100 ml tannin solution and agitated in a reciprocal mixer for 1 h at 20°C. The suspensions were filtered through a white band Whatman filter paper and the absorbance of filtrate was measured at 760 nm The tannin content of the extract was determined as the difference between the TPC of initial extract solutions and filtrate.

3. RESULTS AND DISCUSIONS

3.1. Extraction of water-soluble matter

The starting plant materials and final extracts of alder and blackthorn are given in Fig. 1. The alnus extract shows the characteristic reddish color, is very hygroscopic and has a sticky feel, due to the presence of sugars that were detected by the spot tests. The extraction yield at the working temperature and using water as solvent are high enough, namely 22.5% for adler extract (AE) and 8.9 % for blackthorn extract (BE), as given in Table 1 The temperature of 60°C was chosen to avoid the degradation of active compounds and to provide a convenient extraction yield. [12]. Water was chosen as solvent, as it was proved that the maximum yield of tannin was in water and the alcohol solvents have a negative influence upon the hydrolysable tannins - ellagitannins and gallotannins, which play the main role in the leather tanning process [13].

***Fig. 1**: Alnus glutinosa* bark and extract (left) and *Prunus spinosa* thorns and extract (right)*

3.2. Spot tests

Spot tests are simple qualitative chemical procedures which uniquely identify a substance. Results of spot tests for studied tannins are given in **Fig.2**. The lead acetate showed a positive result for phenolics and tannins. The ferric chloride test showed an intense dark blue coloration, which changed rapidly to green and precipitate formation. The gelatin test showed intense precipitation in

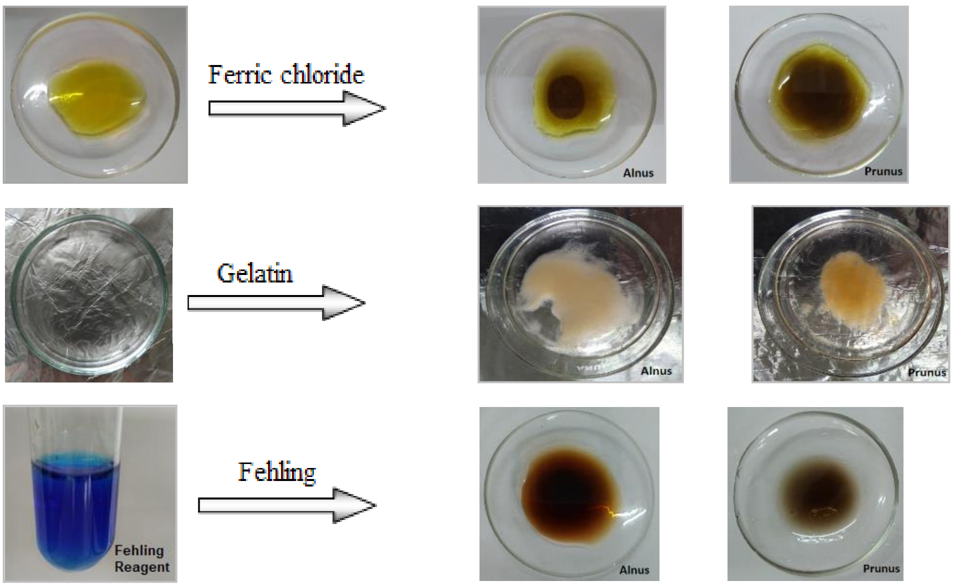

***Fig. 2**: Spot tests on* Alnus glutinosa *and* Prunus spinosa *water extracts*

both cases. Hence, it can be safely concluded that the phenolics also contain tannins. The presence of coloring matter is obvious in the *Prunus* extract. The Fehling test indicated a high content of reducing sugars in the *Alnus* extract and was negative for the *Prunus* extract. The presence of reducing sugars can impair the extract properties and hinder the tanning process, for instance our experimental observations showed that it was much more difficult to solubilize the alnus extract than the blackthorn extract.

3.1. Phenol contens and estimation of tannin contents

The experimental points and linear regression equation of the standard curve are given in **Fig. 1.** The experimental values of total phenols and tannins are given in **Table 1.** Available literature does not provide values of TPC of alder, but the high value of 502.07 mg GAE/g AE was expected, given the reported high contents of tannins [6]. The TPC of blackthorn is lower than those of 499.23 reported elswhere [14], but the differencence may be due to the fact that and in the present paper extraction was performed from thorns and not from the entire branches, using water instead of water-acetone mixture for extraction.

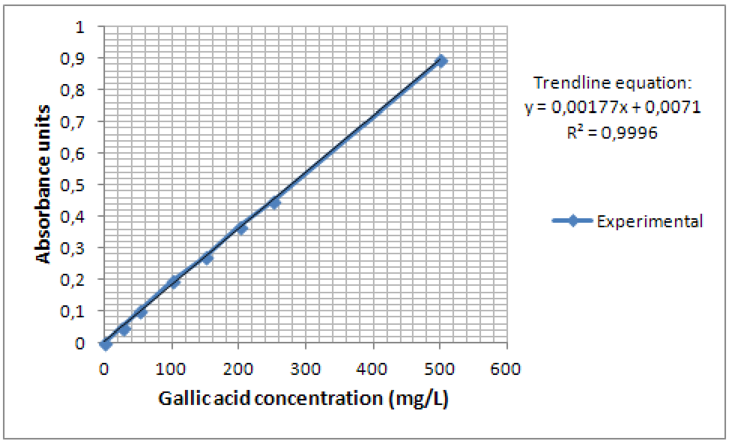

***Fig. 3**: The gallic acid standard curve for Total Phenolic Content by Folin-Ciocalteu method*

The tannin content of the alder extract is common for bark extracts, while the tannin content of blackthorn is unusualy high. This could be related to the presence in the total extract of coloring matter, which might be adsorbed by the hide powder substrate, and to the interferences that affect the photocolorimetric measuring method. Gravimetric determination of hide-binding power, i.e. the tannin fraction that is ireversibly binded to the hide powder, is further required.

***Table 1:** Characteristics of tannin extracts*

Vegetable Species	$FeCl_3$ test	Gelatin test	Fehling test	Extraction yield %	TPC mg GAE/ g extract	Tannins mg GAE/ g extract	Tannins % of TPC
Alnus glutinosa	+	+	+	22.5	502.07	155,43	30.95%
Prunus spinosa	+	+	-	8.9	249.72	199.91	80.05%

5. CONCLUSIONS

The revival of vegetable tannage determined an increasing interest in finding or reconsidering vegetable species from the European flora with high tannin content, as cheaper and sustainable alternative to conventional tannins, extracted from exotic plants.

Two indigenous species, *Alnus glutinosa* and *Prunus spinosa*, historically used for leather tanning, were assessed regarding the extraction yield, and phenolic and tannin content.

The extraction yield was 22.5% for the *Alnus* bark and 8.9% for the *Prunus* thorns, which can be satisfactory, taking in account the mild extraction working conditions.

The tannin content of the *Alnus* extract was 30.95%, while *Prunus* extract exhibited a very high measured value of 80%, which might include interfering compounds.

Practical leather tanning experiments are required, to confirm possible use of these tannins in leather-making processes.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

SUSTAINABLE TANNERY EFFLUENT TREATMENT SYSTEM WITH TDS MANAGEMENT

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Abstract: *Sustainable tannery effluent treatment system in achieving required discharge standards including Total Dissolved Solids (TDS) is one of the major challenges faced by the World Leather Industry. Conventional treatment system reduces Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), heavy metals etc. and not the TDS and salinity. To achieve the TDS level, the tanneries in South India were forced to adopt Zero Liquid Discharge (ZLD) system by incorporating Reverse Osmosis (RO) system and Multiple Effect Evaporator (MEE). Though recovery of water is beneficial to certain extend in adopting ZLD system, the major challenges are high energy consumption, huge operation & maintenance cost and no safe disposal method for large quantity of mixed/contaminated salt generated from MEE. In view of the challenges faced in adoption of ZLD system, sustainable major technological developments have been made to control more than 50% of TDS in the effluent by adopting cleaner tanning process, segregation of saline streams, treatment and recovery of chromium and salt for reuse by the member units. The balance composited waste stream with low TDS is further treated and taken for mixing/dilution with treated domestic sewage to achieve all discharge standards including TDS. This development is being implemented in many tannery clusters in India such as Pallavaram in South India and Jajmau, Unnao, Banthar, etc. in North India. The Common Effluent Treatment Plants (CETPs) are being upgraded with financial support from Govt. of India and respective State Governments.*

Key words: *Tannery effluent, Chromium, ZLD, CETPs, Water recovery*

1. INTRODUCTION

Conventional treatment system reduces Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids (SS), heavy metals etc.[1] and not the Total Dissolved Solids (TDS) and salinity. The TDS limit in the discharge standard is being enforced in India and other parts of the world depending upon the final mode of disposal.

There are limitations for mixing/dilution of the treated industrial effluent with domestic sewage to achieve all discharge standards where required quantity of treated domestic sewage is not available. Hence the tanneries in land locked locations such as North Arcot in Tamilnadu were forced to adopt Zero Liquid Discharge (ZLD) system [2]. For achieving ZLD system incorporation of energy intensive membrane system for water recovery and thermal evaporation for the management of saline reject generated from the Reverse Osmosis (RO) system is required. Though the recovery of water is beneficial to certain extend in adopting ZLD system, the major challenges are high energy consumption, huge operation & maintenance cost and no safe disposal method for large quantity of mixed/contaminated salt generated from the Multiple Stage Evaporators (MEE).

The life of the membrane system, MEE and other monitoring systems are less than 3 to 5 years and require frequent replacements with huge investment.

In view of the challenges faced in adoption of ZLD system, sustainable major technological developments have been made to control more than 50% of TDS in the effluent by adopting cleaner process, segregation of saline streams, treatment and recovery of chromium and salt for reuse by the member units. The balance composited waste stream with low TDS is further treated and taken for mixing/dilution with treated domestic sewage in a feasible level to achieve all discharge standards including TDS. This development is being implemented in many tannery clusters in India. The upgradation of Common Effluent Treatment Plants (CETPs) is being implemented with a financial outlay of more than 200 million US Dollar. The Govt. of India, Department of Industry Policy and Promotion (DIPP), National Mission for Clean Ganga (NMCG) and respective State Governments provide major contributions to the tune of more than 150 million US Dollars.

2. SUSTAINABLE & ALTERNATIVE OPTION TO ZLD SYSTEM FOR TDS MANAGEMENT

In general, the treated tannery effluent is mixed/diluted with treated domestic sewage or discharged into backwaters/Sea, wherever feasible for managing the TDS aspects [3]. The Pollution Control authorities in South India insisted upon ZLD scheme incorporating membrane system for water recovery and evaporation for saline reject from RO system [4]. Accordingly, nearly 10 CETPs in Leather Sector implemented the ZLD projects incorporating membrane system and MEE with huge investment of more than Rs.600.00 crores (i.e. about 100 million USD) with financial support from DIPP, Govt. of India and respective State Government during the period 2008-2015. The major challenges in adopting ZLD system are high energy consumption, huge operation & maintenance cost which is in the range of Indian Rupees 400 to 500 per m^3 (i.e. 6 to 8 US Dollars per m^3) without the depreciation cost. There is no viable solution for safe disposal of the mixed / contaminated salt generated and accumulated in the CETPs. In addition to this within 5-6 years of the ZLD implementation, the CETPs are faced with replacement of membranes and MEE. For this purpose, the CETPs are seeking once again financial support from Govt. of India and State Govts. In technological angle, the performance of membrane system and MEE are not matching the design parameters in the field conditions. The ZLD system especially the MEE installed was not suitable in some of the CETPs where the member tanneries adopt semi-finish to finishing operations.

To overcome the technical challenges in ZLD system, disposal of large amount of hazardous category sludge from the treatement system and to achieve sustainable option for TDS management the following technological upgradations have been designed and are being implemented in the CETPs located in Pallavaram (South India), Jajmau, Banthar & Unnao (North India).

i. Adoption of cleaner production, integrated chrome tanning process, etc. to reduce the TDS and pollutional load at source [5, 6]
ii. Two stage biological treatment with improved aeration using jet aspirators
iii. Minimize the chemical usage by 60-70% which results in reduction of sludge generation
iv. Tertiary treatment including low pressure membrane system (Ultrafiltration / MBR) for removal of residual suspended solids and turbidity.

3. SEGREGATION OF STREAMS & CLEANER PRODUCTION

For sustainable TDS management, adoption of cleaner productions practices such as desalting, segregation of spent chrome liquor for chrome recovery, etc. are being practiced in tanneries. The balance composited stream with low TDS is collected separately for treatment in the

CETP and discharged the treated effluent in to public sewer or mix with treated sewage for managing the TDS are proposed to be followed in some of the locations such as Dindigul, Pallavaram & Uttarpradesh in India similar to the practices adopted in other international locations such as Italy, Spain, etc. Alternatively, the treated effluent can be discharged into sea or back water wherever feasible (i.e. Kolkata Leather Complex and Nellore Leather Complex in India, Istanbul and Izmir in Turkey, Italy etc.) for TDS management.

The limitations in the technologies to adopt ZLD concept has been taken in to account in designing and adopting future systems for TDS management in the upgradation plan of CETPs.

The following technological developments are being implemented in tanneries connected to the CETPs:

- Collection of segregated saline soak liquor as per the directions of pollution control authorities to control TDS and conveyance through separate line to CETP.
- Adoption of Cleaner production technologies such as desalting of hides and skins at individual tannery or by providing common facility with special equipments for the use of all the units.
- Improved chrome recovery system and recovery of chromium in the form of cake for reuse.

The segregated spent chrome liquor from tanneries is collected through special tankers fitted with Global Positioning System (GPS) to the Common Chrome Recovery System (CCRS) established as a central facility for the cluster of tanneries. The spent chromium is pass through screens and pH level is increased to more than 8 by adding sodium hydroxide solution in the main reactor. The chromium is precipitated in the reactor and settled as sludge in the bottom of the reactor. The supernatant with high TDS (i.e. 30000-40000mg/l) which is free from chromium is separated and further treated by using Dual Media Filter (DMF) and membrane system for reuse in the pickling process [5].

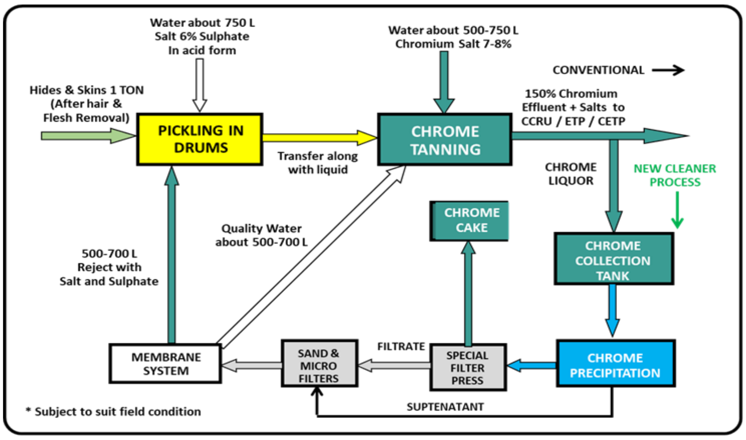

Fig. 1*: Improved Common Chrome Recovery System (CCRS)*

The chrome slurry is collected in the bottom of the reactor and passes through chamber filter press. The chromium is recovered in the form of cake and disposed to the authorized vendors for further process and distributed in the form Basic Chromium Sulphate (BCS) to the tanneries. The CCRS is becoming popular and is being implemented in many tannery clusters in India.

4. UPGRADATION OF COMMON EFFLUENT TREATMENT PLANTS (CETPS) FOR TDS MANAGEMENT

4.1 Saline soak stream segregation, separate treatment under sustainable ZLD system

The segregation of saline soak stream, separate physiochemical and biological treatment and further adoption of membrane system, partial reuse of saline stream for pickling and separation of salt using MEE for obtaining quality salt has been successfully developed in pilot scale. The following sustainable upgradations are being implemented in many tannery clusters in India [7,8].

A separate wastewater collection line has been being provided for saline soak stream from individual tanneries to the CETP. The composited streams excluding soak and chrome are continued to be collected in the existing conveyance system.

A separate centralized treatment system is established with two stage biological treatment, membrane system and TDS management including recovery of quality salt. The quality water is recovered using RO system and reused in the tanning process. The concentrated saline stream is used partly for pickling process and the balance stream is passed through MEE to recover quality salt. The salt with 99% purity is sold for industrial uses. The process flow diagram of saline stream treatment for sustainable TDS management is shown below:

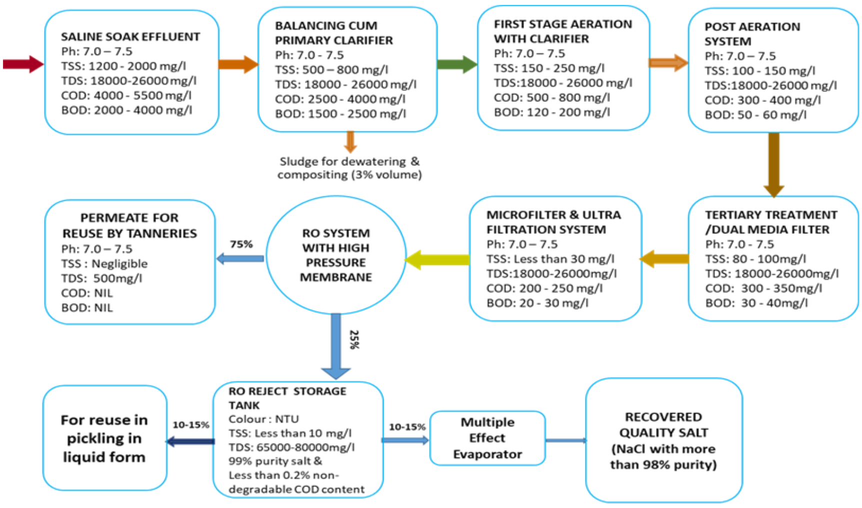

***Fig.2**: Treatment flow chart – Saline Soak Stream*

The separate treatment of saline soak stream and successful recovery of water and quality salt which is being implemented in tannery clusters of India would become a sustainable ZLD system and first of its kind in the world.

4.2 Sustainable TDS management of the composite stream excluding soak and chrome liquor

The TDS of the combined streams is reduced from about 15000mg/l to less than 8000mg/l by segregation and separate treatment of soak and chrome liquor. The upgradation of biological and tertiary treatment units for the combined stream with low TDS at the CETP is done by utilizing the existing treatment units.

The tertiary treatment systems including microfilters, UF units etc. have been incorporated for achieving the prescribed parameters except TDS. The treated effluent is being conveyed and mixed/diluted with treated effluent from slaughter houses and treated domestic wastewater generated from the nearby area to achieve the TDS level within 2100mg/l and meeting all discharge parameters [7].

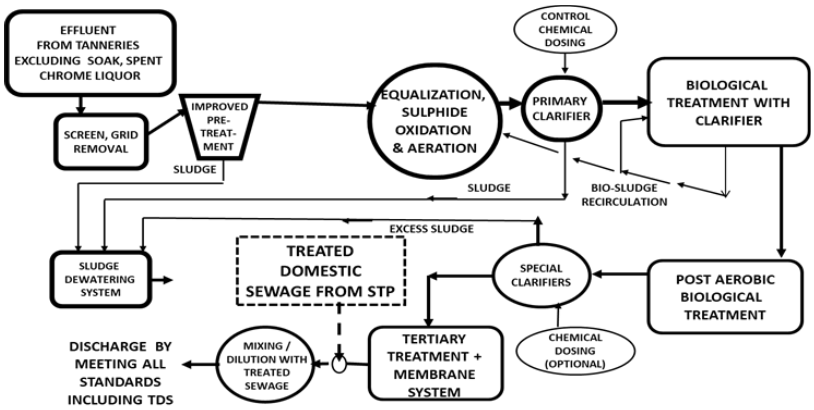

***Fig.3**: Process flow diagram for upgradation of CETP – Dilution / Mixing with treated domestic sewage for TDS management and disposal*

The upgradation projects are under implementation in many tannery clusters with financial support from Govt. of India and respective State Governments.

5. IMPROVED MARINE DISPOSAL OF TREATED SALINE EFFLUENT

A novel technological development has been made for the drawl of Seawater of 30,000m^3/day from nearby Sea for the desalination plant integrated with a major leather complex in South India. Out of the total water quantity, freshwater of about 10,000m^3/day will be generated and the remaining 20,000m^3/day will be discharged into sea with special bio-control and dispersion system to safe guard the aquatic life. The leather complex will be using the quality water generated by desalination plant for its process requirements. About 9,000m^3/day wastewater generated from the tannery units will be collected and treated in the centralized treatment plant. The treated effluent is mixed with saline reject of the desalination plant, stored in a water tight pond for a capacity of about 10 days and discharged into the Sea by laying 5 km pipeline using high pressure HDPE pipe and special sprinkling system. The combined treated saline stream with a quantity of about 29,000m^3/day will be discharged once in a week under the overall control of environmental protection authorities [7,8].

***Fig. 4**: Treated effluent discharge – Improved mode of disposal into Sea*

With the support of many National Institutes and other organizations, model studies were carried out in finalizing the novel marine outfall. The spreading of an effluent cloud released in a marine environment is governed by advection caused by large scale water movements and diffusion caused by comparatively small scale random and irregular movements without causing any net transport of water. Hence, the important physical properties governing the rate of dilution of an effluent cloud in coastal waters are bathymetry, tides, currents, circulation and stratification.

A five port diffuser systems with 0.18 m diameter is planned with a jet velocity of 2.5 m/sec, for the release of treated effluents and reject water from the proposed desalination plant. The Environmental Clearance (EC) has been accorded to this unique integrated project with water recovery using desalination process, industrial wastewater treatment, novel and safe saline reject disposal into Sea without affecting the marine life which is first of its kind in India.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

MASS CUSTOMIZATION NEARSHORING PROGRAM FOR CLOTHING MANUFACTURERS

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Abstract: *Mass customization offers considerable potential for increasing the notoriety of a brand, acquiring new markets and generating significant profits. But, before reaching or exceeding customer expectations, important steps must be taken. We discuss in this paper a nearshoring approach to more effectively implement a mass personalization program. Agility and flexibility remain essential to this concept because the demand is more and more volatile. Nearshoring is an interesting avenue for allowing manufacturers to adapt and transform their business practices and manufacturing strategies in a context of fast prototyping. To succeed, this approach must implement automated processes that also create new tradeoffs and challenges in terms of structure, operating model, sustainability and supply. The biggest challenge now is to procure raw materials in optimal quantities and on time. In addition to this challenge, available technologies are taking more and more space and allow a more intelligent mass personalization approach in terms of productivity and digitization via automation, thus making the supply chain more efficient, agile and customer-focused.*

Key words: *Clothing Industry, Mass Customization Program, Nearshoring, Automatization.*

1. INTRODUCTION

The fashion and clothing industry, although strongly affected by globalization, is still trying to reinvent and restructure itself with new business models and new ways of operating. For several years now, in order to gain a strong competitive advantage, a large majority of major brands have turned to Asia to expand their manufacturing strategies focused on reducing costs and volume. This allowed clothing manufacturers to provide mass-produced products for consumers at attractive and highly competitive prices. However, a series of factors have changed this business strategy in recent years by forcing brands to market new products and collections more quickly without necessarily considering trends, cycles and seasons. This has had the effect of disrupting distribution and thereby making competition more aggressive than ever. Globalization and Internet shopping have the clothing industry competing with social networks and thus destabilizing supply and demand, while at the same time creating significant market stagnation.

2. MANUFACTURING SITUATION

One of the problems highlighted by this situation is the management of inventories and unsold products caused mainly by high-volume production methods. The vast majority of manufacturers is trying to reduce batch size and replenish, but often without success, as this affects among other things, the productivity of subcontractors who require large batches of manufacturing to be more efficient. Without guaranteed volume, it becomes almost impossible to maintain and develop a long-term synergistic relationship with foreign producers. Companies must put forward pull-level methods, focus their business models on demand, and reduce the ecological footprint of external sourcing. In order to do this, they must also integrate technologies to optimize and digitize processes and review all logistical principles, which sometimes require a complete reorganization of processes already in place. The main challenge the proximity of manufacturing. At the moment, the salary increase abroad, besides the emergence of new taxes, customs and transport fees, cause serious headaches for clients, in a context where production in Asia is not as profitable as it was the last 10 years. In addition to this mass production, there is the pressure coming from consumers who are aware of overproduction, waste and above all, the environmental impact of producing in this way. The fashion and apparel industry faces the urgent need to rethink and strengthen its strategy and identify alternative avenues for sustainable growth.

2.1 Major shift

For manufacturers in the fashion and apparel industry, it has become increasingly difficult to offer distinctive products and services and to meet the specific needs and wants of customers. The globalization effect saturated, in some cases, the supply of fashion products thus creating a lack of interest in the consumer. There is constant pressure on the markets to seduce consumers with new tempting offers equally based on style, price and origin. This results in a major shift in the marketing and merchandising approach for manufacturing companies. They can no longer spread trends because their influence is no longer determined by the companies themselves, but through consumers and users of branded products. Aware of traditional marketing methods, consumers are increasingly reluctant to mass consumption, but still want to get closer to the manufacturers and their know-how. For the consumers, the value of the proposition lies in the expertise of the manufacturers. This confirms that the fashion sector must add real value to previously standardized products, in the form of customer-specific services, in order to better meet the demand for authenticity, individuality, traceability and connection with the customer. It is in this regard that mass customization is discussed in this text and that several key implementation strategies can be put forward for the manufacturers in the sector.

3. THE CUSTOMIZATION OF THE OFFER

Mass customization is defined as “the mass production of individually customized goods and services” [1], specifically aligning customized design and manufacture with mass production efficiency and speed. By postponing production to a late stage, mass customization can provide with more accuracy what customers want [2].

The examination of the literature on this topic tells us that the fashion and clothing industry is focused on the unique and distinctive character of personalization in the context of mass production. In search of authenticity, consumers are increasingly demanding and desiring quality products. The success of mass personalization relies primarily on the successful integration of the value chain. To increase responsiveness to customer demands, it is critical that manufacturing systems offer custom parts features and standards for a flexibly assemble [3].To implement this approach, the manufacturer must consistently be able to offer consumers affordable, attractive, well-fitting products, and deliver them as quickly as possible. Previous researches have shown that it is important to understand the mass personalization approach that forces fashion and apparel players to review their organizational strategies to better perform in this increasingly competitive market. They need to develop new manufacturing strategies by directing local production to a flexible, agile and responsive system to handle several specific and unique types of orders. Producers will have to adapt capacity and short-cycle production (quantities, short lead times, skilled labor, etc.) and focus on the adaptability and traceability of their production in time [4].

3.1 Manufacturing strategy

According to Tseng et al [3], mass customization implies a shift of design and production paradigm from "made-to-stock" to "made-to-order". It challenges the conventional product development and supply chain management, calling for adopting mass production approaches to accommodate "high-variety-low-volume" production. In order to support the paradigm shift derived by the customization process, the enterprise should reconsider the entire value chain to leverage upon three pillars: time-to-market, variety, and economy of scale [3]. Mass personalization must be seen as a long-term integrative manufacturing strategy, with the aim of reinventing itself and finding new ways to satisfy customers. To introduce new customizable products, the company sometimes has to test the market and even expect to lose some money in the first year of operations. And this is what discourages manufacturers on average to keep and push the model of mass customization. The volume remains the key in this approach and without manufacturing volume there is no profit. Manufacturing for mass customization also relies on the availability of flexible manufacturing system. In addition, the system should be incorporated with the advent of modern Information and Computer Technology (ICT) as well as the flexible or reconfigurable manufacturing tools, to reduce the response time from designing a new product to the production ramp-up [5]. According to a study we made with 10 manufacturers in 2016, it takes an average of more than two years to implement a mass customization program at a manufacturer. During this period, six months serve as a pretest for the market and a whole year is devoted to the adaptation of production to the control system. This is also the time to measure the profitability and efficiency of the business model. To introduce this new practice, the manufacturer must commit to sustainable development with as clear a vision and strategic direction as possible. The development of the program must respond well to the market and thus adequately satisfy the customers so an operational level for the business model can be profitable as quickly as possible. A new manufacturing strategy in this approach is to rethink logistics to optimize the garment production model. Here (figure 1), the trend towards nearshoring and the automation of just-in-time (JIT) process and personalization allow for a better manufacturing integration of mass customization.

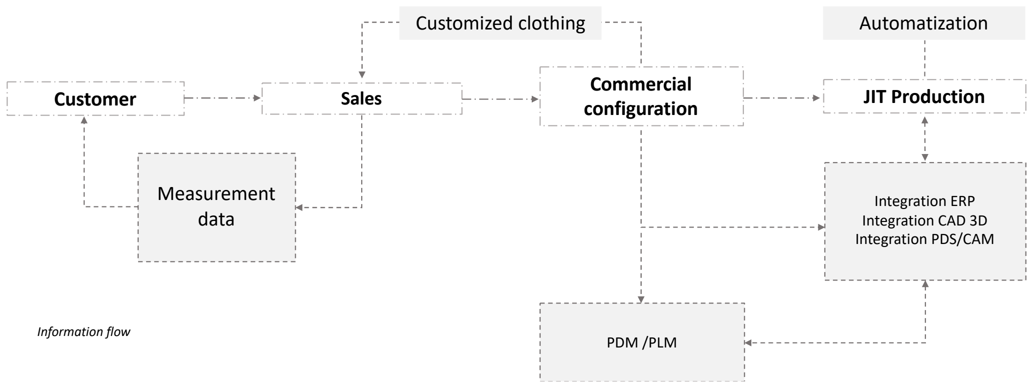

Fig. 1*: Mass Customization Nearshoring Program*

Requirements specifications by the configuration can avoid communication problems between the producer, the supplier, the buyer, and the retailer. Digital technologies available on the market-allow small manufacturers to distribute their products more easily and to spread their offer at a low cost. Social networks can be organized later to push the rest of the brand and make the commercial experience known. Currently, we are finding new players on the market as pure-play online start-ups that can produce garments in rapid prototyping and deliver efficiently. One of the important manufacturing strategies in the mass customization approach is the nearshoring. The nearshoring perspective can be economically feasible if it is applied appropriately and if it is planned with a clear goal of customer satisfaction and value creation that translates into the margin delivered to partners. By reducing time to market, companies can produce more in line with demand. There is still a need to review supply management, transportation costs and tariffs while reducing excess raw material inventory and increasing full-price sales, but still with shorter turnaround times. The real benefits of mass customization nearshoring program for clothing manufacturers are: proximity, cost-savings in labour and freight spending, better access to skills, quality control, greater speed to market and quick response, improved control over the supply chain and improved control over the intellectual property and customized service.

4. DISCUSSION

If the vision of Industry 4.0 is to be realized, most business processes must become more digitized. A critical element will be the evolution of traditional supply chains toward a connected, smart, and highly efficient and agile supply chain ecosystem. But to succeed in this shift, it is necessary to consider the needs for production capacity at the outset and take into account the expertise of the workforce creating a huge operational performance challenge, and this directly affects the organizational structure. As a result, the intelligent configuration and mass customization production become a more complex and demanding task as the customer requirements increase and options and components multiply. When the configuration requires many variations, the possibility of errors also increases, which can lead to production delays. Mass personalization creates a variety of technical challenges that must be overcome before custom mass clothing can be produced.

The critical element remains the supply of materials and components to serve the production quickly and flexibly so it can remain nimbly strong for logistics and mass production. By implementing a mass customization program, this optimizes the co-localized value chain. Today, consumers, customers, collaborators and partners expect you to have an enhanced and especially different experience. On the other hand, from the outset, we must review the potential of automation and encourage employees in this chain to become partners and invest in capacity building while aiming at medium-term volume.

In recent years, we have been working with manufacturers on configuration and automation for product manufacturing. Our goal was to develop clothing mass customization tools integrated into the apparel industry using computerized numerical information systems, which could be used to analyze and decode measurement data from devices to identify information necessary to produce a well-fitting garment. To date, the apparel industry is lagging behind in automation and mass customization as automation presents significant challenges for this sector (one of them evidently being accessibility to a competitive labor force that needs to remain "economical") The consequence being that the undertaking of automation does not become a priority. What is often misunderstood, is that automation of processing plants can also be beneficial to employees who do not have to focus on repetitive, less rewarding tasks. Notwithstanding the later, techno-scientific development, automation becomes more and more possible. And it is in the quality and speed of the information and the transformation in real time that this approach is played out. We are currently seeing nearshoring approaches to mass customization for the preparation of standardized parts for jackets, pants and dresses. But, the fact remains that the knitting and additive manufacturing sector is getting stronger. These results should encourage the players that make up this industry to readjust to the difficulty of recruiting the workforce. We find that automation can reduce work time by an average of 50%, and fully automated smart factories should be available soon. At a time when innovation and technological developments are playing an increasingly critical role in countering the effects of lower wages in other countries, the purpose of this paper is to explain the importance of mass personalization and rapid manufacturing systems adapted to the needs of all actors in the garment industry. In order to realize the industry's vision, most business processes need to be further digitized.

A key element will be the evolution of traditional supply chains towards a connected, smart, highly efficient and agile supply chain ecosystem. Access to talent will be a major success factor in creating the supply chain of the future. At present, the largest talent gap is likely to be in digital or advanced manufacturing and smart procurement decision management in the more complex value chain of clothing. To succeed in having a sustainable, competitive advantage, the company has no choice but to build high-quality collaborations, because partnerships will be essential. The basic rule is to invest responsibly in mass customization because nearshoring and automation go hand in hand. We must understand that the more we automate, the more skilled employees, technicians and engineers will be needed to make the transition in the manufacturing process. After discussing and meeting with industry experts, we are able to say that a company must demonstrate its ability to adapt in terms of creativity, production, quality, synchrony and price. But, to position themselves to succeed, they must take four steps: define their future sourcing and production strategy, develop new skills and capabilities, create an ecosystem of partnerships, and commit to accelerated learning.

5. CONCLUSIONS

In summary, the specific context of some companies in the fashion-clothing sector has meant that they have suffered over time from failures in the implementation of mass customization, due to a lack of long-term vision. It is therefore important to better understand how a manufacturer could more specifically meet the needs of their customers, while focusing on the nearshoring approach, automation and sustainability. Nearshoring and automation could create a true circular value chain for companies in this sector. Manufacturers will have to adopt efficient and effective processes using the best technologies available to them. By bringing their production closer together, and investing in advanced manufacturing, manufacturers will become more sustainable and, above all, less wasteful by reducing overproduction. For mass customization to succeed in a market that constantly demands swift results, it becomes essential to focus more on flexibility and consequently, on speed which is key to nearshoring. The manufacturer must commit to sustainable development with strong leadership. The coming upheavals are so profound that the companies who are making big changes and enjoying the benefits of nearshoring and automation will have a huge advantage as first-tier players. Business models in this industry should drive growth and be more distinctive and integrated into their supply chain. The potential from an application perspective will directly target a consciousness towards lean manufacturing process, innovation approach, inventiveness methods, design thinking and know-how of its workforce and sustainability.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

IDENTIFICATION OF BENEFICIARIES REQUIREMENTS ON ON-LINE TRADE

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Abstract: *The development of e-commerce and the emergence of virtual enterprises have led to the possibility of transforming traditional businesses into virtual enterprises for which the IT system no longer constitutes a complementary element, but even the foundation of the organizational structure. According to the concept of marketing, the most important stakeholders in an organization are customers. A questionnaire was developed to carry out the case study. It wants to identify whether the population purchases online products and whether they are willing to buy online footwear from the Republic of Moldova. To conduct the survey, the specialized website www.isondaje.ro was accessed. The survey was conducted nationwide, and the data collection method applied is on-line. The study was conducted on a sample of 60 people, of which 75% were feminine and 25% male, aged 15-53 and living in rura and urban. It is certain that the data obtained identified that respondents were actively involved in e-commerce. The advantage of this finding may also be an opportunity for the native shoe manufacturer, which is based on an intelligent approach to sales strategies and the development of distribution channels, as the market share to which it should tend to not be the maximum but the optimal one. The direction of the domestic shoe manufacturer's e-commerce must motivate the management of the enterprise to marketing and innovation, to change, where the client-producer relationship is not just a fictitious image but also a surplus.*

Key words: *questionnaire, poll, consumers, Internet, benefits*.

1. INTRODUCTION

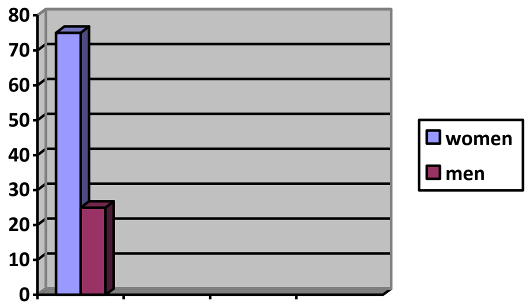
The Internet explosion has allowed the development of a new form of e-commerce trade. The Internet, the development of e-commerce and the emergence of virtual enterprises have led to the transformation of traditional businesses into virtual enterprises for which the IT system is no longer a complementary element, but even the foundation of the organizational structure. Thus, the development of traditional trade is driven by a modern form of commerce - electronic commerce [1-2].

According to the concept of marketing, the most important stakeholders in an organization are customers. Starting from this concept, we accept the idea that the client is the starting point of the organization's overall strategy [3].

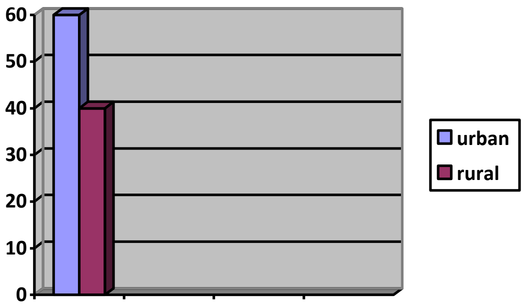
2. RESEARCH METHOD

The questionnaire was used as a tool for collecting information [4-6]. To conduct the survey, the specialized website www.isondaje.ro was accessed [7]. The survey was conducted nationwide, and the data collection method applied is on-line. The data collection was done by applying the questionnaires from May 14 to July 2, 2018. This opinion poll is intended to identify whether the population purchases online products / services and whether they are willing to buy online footwear from the Republic of Moldova.

The study was conducted on a sample of 60 people, of which 75% were feminine, and 25% male, aged 15-53 and living in rural (40%) and urban (60%) (fig. 1). The questionnaire on e-commerce consists of 20 questions, 13 questions were selectively presented in the paper.



Sex of the respondents



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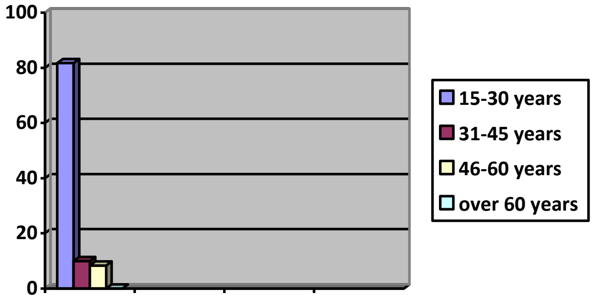

Age of respondents

Fig. 1. *Sample structure by sex, place of living and age*

3. RESULTS AND DISCUSSIONS

Survey results were statistically processed and represented in figures 2-12.

Question 1. Have you ever purchased products over the Internet? Thus, 78,3% purchased products online and only 21,7% of respondents never made purchases (fig. 2).

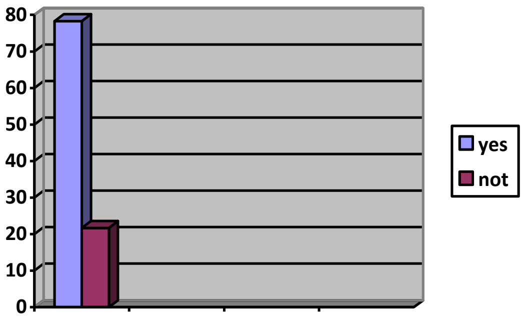

Fig. 2. *Number of people who do / do not make online purchases*

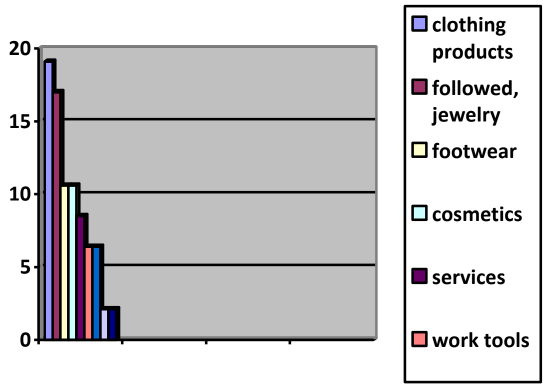

Fig.3. *Product categories*

Question 2. If Yes, in what category? Among the people who purchased online preference is clothing products 19,1%; followed by jewelry, 17% gifts and mobile phones or accessories for them; 10,6% footwear; 10,6% cosmetics and perfumes; 8,5% services (tickets, reservations, holidays etc.); 6,4% work tools; 6,4% electronic or household appliances; 2,1% computers / software / IT; 2,1% of food (fig. 3).

Question 3. How often do you purchase products over the internet? It was found that 38,3% purchased monthly products, 21,3% about once every 3 months; 19,1% once every 6 months; 17% about once a year; 2,1% weekly and once every few years (fig. 4).

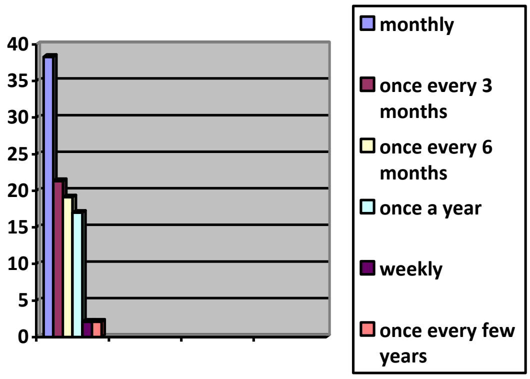

Fig. 4. *Frequency of purchasing products through online trade*

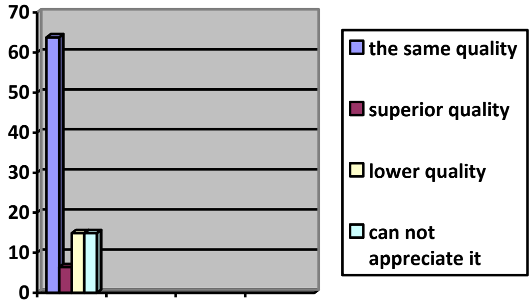

Fig. 5. *The quality of the products purchased on-line*

Question 4. How do you rate the quality of on-line products compared to direct trade? Analyzing respondents' satisfaction with the quality of products purchased online, 6,4% say they are superior; 63,8% say they have the same quality; 14,9% are inferior to quality and can not appreciate (fig. 5).

Question 5. What were the main problems encountered when buying products on the internet? Among the most common problems, respondents received the product with a delay of 39,6%; there were differences between the received and commissioned 9,4%; the product received was defective and did not receive what they claimed 5,7%; the product was lost during transport of

3,8%. About 35,8% of respondents confirmed that they did not have problems because they chose a safe seller (fig. 6).

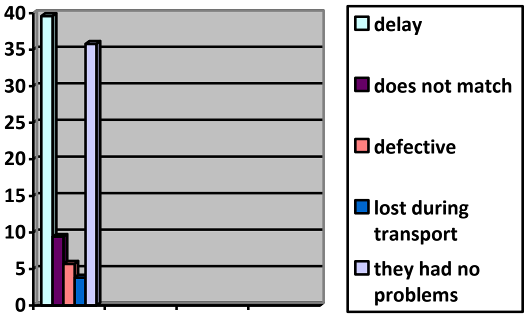

Fig. 6. The main problems encountered in purchasing online products

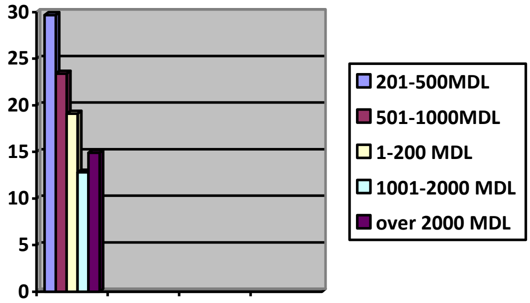

***Fig. 7.** The value of products purchased online in the year*

Question 6. What is the value of online products bought in the last year? Of the respondents, 29,7% make purchases in the amount of 201-500 MDL; 23,4% from 501-1000 MDL; 19,1% from 1-200 MDL; 12,8% from 1001-2000 MDL; 14,9% over 2000 MDL (fig. 7).

Question 7. What is your occupation? 48,3% are employed; 41,7% represent students and 10% unemployed (fig. 8).

***Fig. 8.** Occupation of respondents*

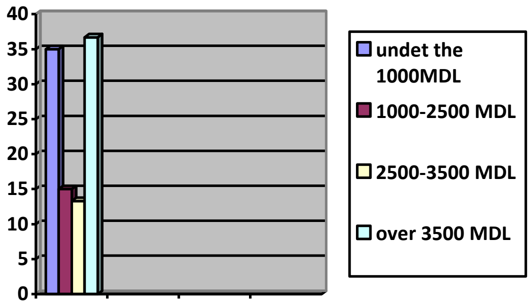

***Fig. 9.** Revenue of respondents*

Question 8. Do you have a steady income? According to the income level, it was found that 36,7% had an income over 3500 MDL, 35% - less than 1000 MDL, 15% between 1000-2500 MDL and 13,3% from 2500-3500 MDL (fig.9).

Question 9. Do you know the size of the shoe? 96,7% know the size of the shoe, and 3,3% do not know (fig. 10).

Question 10. Do you know the width of the shoe? Data analysis reveals that consumers do not know what the width of the shoe is and how it is measured (fig. 11).

Fig. 10. *Knowing the size of the shoe*

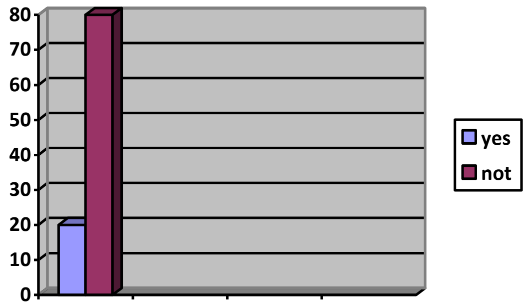

Fig. 11. *Knowing the width of the shoe*

The analysis of the results of the opinion poll led to the following conclusions:

- that women procure online more than men;
- the most active respondents browsing the Internet are aged 15-30;
- depending on the residence characteristic, it is noticed that the largest share of the respondents is from the urban area;
- respondents know the benefits of online commerce and are in step with changes in information technology;
- products purchased on-line are clothing, gifts, phones and footwear; the inhabitants of the Republic of Moldova are making on-line purchases on a monthly basis;
- most respondents say that there are no differences in the quality of the products procured on the Internet from domestic products;
- the most common problem encountered in buying products on the internet is that the product is being received late;
- analyzing the value of the products bought in the last year is found to vary within the limits of 201-1000 MDL, with this amount shoes products (sandals and shoes) can be purchased from domestic producers;
- online trade is an occupation to the liking of many, both to employees and students;
- even if the respondents have an income below 1000 MDL these are the most active on e-commerce;
- most respondents know the size of the shoe, which can not be said about the width of the shoe;
- knowing the size and length of the consumer contributes to the correct choice of footwear and the minimization of returns.

5. CONCLUSIONS

E-commerce has a rising dynamics as more and more consumers connect to the web. Ecommerce allows people to exchange goods and services, overcoming time and space barriers - at any hour of the day and night you can connect and buy almost anything you want. Under these circumstances, you can sell at any time, any day, to a customer from any part of the globe. An e-commerce site can be accessed by businesses or end-users interested in any country in the world where there is a computer connected to the Internet.

Looking at what has been analyzed, we can assert with certainty that native shoe manufacturers have to review the development course along with its objectives in order to establish the overall enterprise strategy. We can also consider that footwear producers can contribute more actively to the formation of a competitive activity on the footwear market, showing their interest because the Moldovan consumer is in training and can be successfully applied to loyalty practices.

It is certain that the data obtained identified that respondents were actively involved in e-commerce. The advantage of this finding may also be an opportunity for the native shoe manufacturer, which is based on an intelligent approach to sales strategies and the development of distribution channels, as the market share to which it should tend to not be the maximum but the optimal one. The direction of the domestic shoe manufacturer's e-commerce must motivate the management of the enterprise to marketing and innovation, to change, where the client-producer relationship is not just a fictitious image but also a surplus.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

CONCEPT OF CORPORATE SOCIAL RESPONSIBILITY AND APPLICATION IN THE INDUSTRY OF TEXTILE AND CLOTHES

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Abstract: *Social responsibility is applied in many industrial branches around the world, and in recent decades, various aspects of corporate social responsibility have been analysed in the apparel and textile industry. The textile and clothing industry is rapidly developing branch of the industry, so modern corporations must be able to respond to market demands and place products on the market as soon as possible. In doing so, they must be aware of their environment and actors who are involved in the process in any way and must adapt their business in order not to cause harm to others and do not pollute the environment. However, in spite of the efforts of organizations to be socially responsible, we still meet today with textile and clothing companies, which behave very unethically towards their actors. As long as there is an opinion that the realization of a profit is on a far higher scale and that it is far more valued by employees, consumers, investors and other stakeholders, there will exist a problem of implementing a socially responsible business. Organizations tend to reduce all critical aspects that negatively affect the production itself and are often criticized by the community. They try to behave ethically towards all actors, but the unethical reflection in the business is present to a lesser extent. The aim of this paper is to study the textile and clothing industries through the prism of corporate social responsibility at the national level. Particularly important is the way companies in this sector are dealing with social responsibility issues.*

Key words: *corporate social responsibility, textile industry, clothing industry, ethical behaviour, organizations.*

1. SOCIAL RESPONSIBLE BUSINESS IN CONTEMPORARY CONDITIONS

Nowadays, the new role of business in the wider social sphere is being recognized. All successful global companies have been implementing the concept of corporate social responsibility for decades. One way for companies to acquire a large number of customers is to involve themselves and solve community problems through involving themselves in solving the problems humanity encounters, i.e. their employees, consumers, suppliers and brokers. Many companies have begun to invest money to help at least address a social problem. The most common help is education, health, culture, sports and art. Companies thus integrate into the local community. Modern companies in the world are aware that such investments benefit them, as they become more intimate with their clients, clients become more loyal, and the company successfully builds itself a positive image. All this brought socially responsible business into the forefront [1]. One can not ignore the fact that the relevance of corporate social responsibility is today stronger and that corporations suffer more pressure when it comes to expressing their ethical side [2].

Corporate social responsibility (CSR) is more than an investment, it involves the implementation of its activities and all business processes above and beyond the statutory norms, which includes special treatment of employees, investment in training programs aimed at protection at work and raising awareness of employees, performing all processes in line with business ethics, environmental protection and investment in the development priorities of the local community, transparency, access to information and similarly [3].

Corporations that are socially responsible, gain a lot, but in the same way a wider community also gains. In today's situation, when a market game leaves no room for further growth and development of the company only on the basis of price and quality, the company's responsible behavior towards its employees and all actors that are involved in some kind of business is coming to the fore. Charles Handy claims that the implementation of CSR is very important for the environment because of consumers, but the most important because ignoring the lives of people can contibute to losing key members of the workforce. Since business is not possible without employees, they become the main aspect to which the most attention is paid [4]. By following this way of thinking, every corporation, especially those operating in the industrial sector and employing millions of workers, such as the textile and clothing industry, should give priority to creating a suitable work environment for its employees in the supply chain. By implementing social responsible business companies create a positive image and become able to attract appropriate employees. Shafiqur Rahman stresses out ten dimensions of CSR present in the 21st century, which are in this paper illustrated in the Figure 1 [7].

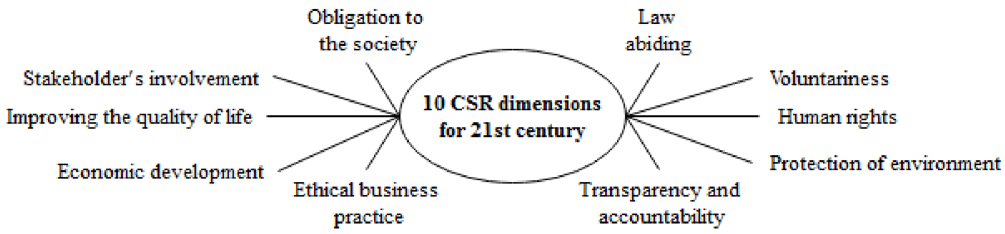

Fig. 1: Ten dimensions of CSR for 21st century [7]

The concept of socially responsible behavior in business brings multiple benefits, not just to the company, but also the whole world. At the global level, the tendency towards stable and sustainable business has already begun to change both the business culture, the business entities themselves, and even the lifestyles of ordinary citizens. Many companies today tend to be seen by the public as socially responsible. Social responsibility should be, not only part of the strategy, but also part of the identity that will differentiate the enterprise from its competitors.

2. SOCIAL RESPONSIBLE BUSINESS OF TEXTILE AND CLOTHING INDUSTRY

Behind the glamour, the fashion and textile industry is characterized by long working hours, monotonous tasks and difficult working conditions. These working conditions can cause serious ethical issues and problems, if not addressed, and this is a segment in which CSR plays a major role.

Fashion brands are currently heading to the fast fashion segment, a new trend within the industry, which provokes the way fashion companies have so far managed the requirements of the fashion industry and working conditions without creating ethical problems. Moving towards fast fashion has created new challenges to an already fierce industrial competition that faces increasingly demanding consumers every day, as well as the need to produce better, cheaper and faster. These are just some of the reasons why many textile manufacturers turn to low resource costs, such as cheap labor or biologically non-degradable materials [5]. Bearing in mind the economic, social and environmental aspects of society, the above mentioned practices can be considered as unethical, especially in relation to their workers, who must endure, among other things, overtime or dangerous and unsafe jobs. This is mostly the case in underdeveloped countries where production is being shifted in order to reduce costs. Also, apart from examples of unethical behavior in underdeveloped countries, large giant textile industry are often criticized, because although they are making great efforts in implementing corporate social responsibility, somehow they manage to be accused of unethical business [2].

This industry is generally characterized by a quick and innovative atmosphere and it is under the influence of constant changes in customer tastes and styles, which makes the environment extremely competitive. Supplied goods are products that have a short life cycle, especially in the mass market. In other words, lower production and labour costs mean lower costs as a whole, resulting in lower prices [6]. Since fast fashion has been spontaneously encouraged by compulsive customers, low prices have become an important requirement. Fast fashion brands are focusing on producing the latest trends to meet the rapid demands of customers and supporting the production chain and the supply chain with a large capacity covering several types of products and meeting the quantitative requirements in a very short time. This change in fashion combined with greed for newer clothes at a cheaper price has led to a loss of understanding of the importance of high-quality materials and good workmanship. This creates a cycle in which we buy more, but we throw more, either because the trend has changed or that the garment is so poorly designed that it can carried a limited number of times, and it breaks down after a few wearing because it's bad quality does not allow more washing [7].

In order to cope with mass production, the fashion industry moves its production facilities in developing countries where costs can be reduced by employing cheap labour [8]. The consequences of doing business under these circumstances are often the drivers of bad conditions for employees, where workers are often subject to overtime and are bargaining about wages that sometimes even do not cover their basic needs. Besides, wworkers often have to work in factories that are not adapted to working conditions or do not possess all the security procedures required by law, since the production of textiles and clothing is a very unsafe work sector. Accordingly, elements of CSR on the workplace, which need to be addressed in textile and clothing industry, are involvement of employees, workplace diversity, human capital development, human rights, labour rights, health and safety, quality of life, and gender issue as well [9].

The consequences of moving towards fast fashion have raised several ethical issues related to industry participants. The constant pressure, such as competition and the need for efficiency, creates a work environment that often violates several human rights. The working environment of the global brand in the supply chain often includes severe working conditions, which relate to a work environment that is dangerous and extremely difficult conditions where human rights violations occur [10]. Catastrophic events, like the case of Rana Plaza, a ruined factory in Bangladesh, is just one of the examples highlighting the serious problems of this sector in the 21st century. In this incident, 1,200 workers died when the factory collapsed, leaving evidence that many workers in the textile industry are facing dangers day by day [11].

Additional problem of the textile industry is connected with environment preservation, because the textile industry is not the most favourable for the environment due to the excessive use of pesticides and chemicals. In spinning, dyeing yarn, weaving, finishing and tailoring, chemical products are used which generates waste, high consumption of energy and water is present in the production process, all this can be related to violation of human rights through terrible working conditions [12]. Obviously, conversations with designers and top executives show that they are aware of the problem and are actively seeking a solution. Every year, the apparel and textile industry causes suffering to millions of animals, which are unethically killed for fashion and fashion trends. Silk, cashmere, leather, fur and wool are materials for which, unfortunately, animals have to pay the price of fashion. Although certain materials are still used in the fashion industry today, like leather, fur and wool, there are many ways to ensure the welfare of animals. Companies must adopt a business policy that protects the welfare of animals, and thus reduce the use of unethical products, as it will result in greater loyalty of their consumers.

The link between the textile industry and corporate social responsibility appears to be quite controversial due to the fact that, on the one hand, retailers want to take advantage of the new opportunities which would increase their profits, but do not have real control over factories, and on the other hand, consumers are pushing companies to encourage their manufacturers to meet the requirements of the users as soon as possible in order to improve their reputation, and yet remain competitive on the market. Implementation of a socially responsible business brings trust, support and loyalty of consumers who are later ready to pay more for a new product of the company and support it to continue to operate socially responsible.

3. EXPECTATIONS FROM THE TEXTILE AND CLOTHING INDUSTRY IN THE COMING PERIOD

Consumers spend enormous amounts of money every year on clothes. On a daily basis, they buy needed items, but also those clothing that will temporarily provide satisfaction. However, the question arises: How many times do we look at the declaration when buying? How many times do we wonder which raw material is used for the desired garment? In most cases, the answer is rarely, and perhaps never. This is just one evidence of irresponsible consumer behavior. The main problem arises when the research concludes that most customers are not familiar with the notion of social responsibility and socially responsible business. They state that the criterion of socially responsible business is not important when choosing and buying clothes, and that they would not pay more for products if they meet the criterion of social responsibility. Most consumers pay more attention to quality and product characteristics in terms of price. On the one hand, it is important for consumers to have the object made of natural materials and not tested on animals, but also to purchase a garment from natural fur rather than artificial. Consequently, it is evident that customers do not know and are not fully aware of what social responsibility is. They are also not aware of the global problem, which they, by their irresponsible behavior, make for the environment, community and society [13]. A large number of consumers are unaware of how socially irresponsible behavior affects all stakeholders and creates negative effects for the corporations themselves. They need to be educated to be aware of the impacts of their environment. It's a costly and time-consuming process, but the ultimate results are invaluable. If more people know about socially responsible business and their positive effects, it will contribute to the development of a growing number of corporations that adhere to this criterion, and thus create better living and working conditions.

Today, businesses are aware of challenges such as human rights violations and non-compliance with a number of legal regulations, and additional engagement is needed to minimize such problems. Being ethical does not just mean doing business the right way, but how to behave when things go wrong. In this regard, it is very important to comply with business law and regulations. Violation of any law can have serious consequences, both for the company and for responsible individuals. This primarily relates to legal provisions on imports and exports, provisions on the prevention of boycotts, sanctions in force, trade embargo and compliance with the laws of each country.

Companies understood the core of social responsibility and socially responsible business and slowly started with initiatives, primarily for the protection of nature, the environment, and humans themselves. It's important to start from the very beginning, or cotton growing. In order to turn to socially responsible business, the cultivation of cotton must be environmentally sound, without the use of pesticides. Also, it is necessary to try to reduce the use of artificial materials and dyeing of textiles without the use of water. Clothing should be made from environmentally friendly materials, because it contributes to the preservation of nature. In this regard, it is necessary to support "green marketing", which implies the necessity of appreciating the natural environment. Green marketing is a form of marketing where products, services and all activities are carried out, taking into account the action and impact that it can have on the environment and society as a whole. The recycling of worn out textile products, garments and waste generated during the fabrication of textile products, as well as the use of textile and clothing items, deserves more attention than the one currently being dedicated to it. Textile industry today is one of the largest environmental polluters [14]. Recycling reduces the number of wild waste of textiles, which reduces environmental pollution.

In line with market pressures, it is necessary to regulate and harmonize the working hours of workers. Each company should organize training for its new employees and provide them with professional training. It is necessary to harmonize professional and personal goals, and to ensure equal opportunities for all employees, without any discrimination. The company should be aware of the importance of the quality of people's lives and to pay salaries based on the capabilities and results of employees. Also, in order for employees to be more motivated, their proposals need to be included when making management decisions, and that the company is committed to improving the quality of life of employees. An increasing number of companies is making efforts in responsibility towards employees, taking into account consumer attitudes, especially in areas where strong competition exists, there are clear declarations about content and characteristics of products on all products, child labor is not used, many companies encourage the development of local entrepreneurship, but problems remain, such as disregard of contractual obligations, inadequate servicing of products within the warranty period, and so on [15].

However, the situation in Serbia is not so ideal. The CSR practice is underdeveloped, apart from the small number of companies that take into account the impact of their business on society and the environment and report on the effects of these activities, far more companies contribute to further expansion and deepening of social and environmental problems. The main reason for the low level of socially responsible business of Serbian companies is insufficient state involvement [16].

5. CONCLUSIONS

The concept of socially responsible business is becoming universally accepted in contemporary society. Due to the high pressure of international institutions, governments, non-govermental organization (NGOs) and consumers, pressure on businesses and entrepreneurs for implementing the concept of socially responsible business and contribution to the society and the community in which they operate is being increased. Generally speaking, CSR is defined as an obligation of the corporation to create wealth in a way that allows avoiding causing damage and at the same time improving the property of society and leading to the preservation of the environment. This responsibility is important for the success of the company itself. Applying socially responsible activities increases the image of the corporation, creates a good reputation, increases profit, loyalty of consumers and the company itself becomes competitive in the market. Employees, investors, NGOs and consumers should be familiar with the concept of socially responsible business and how it can contribute to the community and the environment in which the company operates. Companies are increasingly turning to this concept and endeavouring not to endanger their environment and actors, who are in any way connected with the company. Corporations are aware that this is a long, difficult, painstaking and expensive process, but only by its application it can improve the business and the environment in which they operate. Enterprises of textile and clothing industries realized the core of social responsibility and socially responsible business and slowly started with initiatives, primarily for the protection of nature, the environment, and humanity itself. Textile enterprises should be socially responsible. They need to introduce this concept to their employees, and to involve them in it, because the good practice of CSR leads to improved productivity and commitment to the corporation, while contributing to business success and sustainability.

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