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ANNALS OF THE UNIVERSITY OF ORADEA
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ROMANIAN TEXTILE INDUSTRY IN THE CONTEXT OF GREEN, DIGITAL AND SMART TRANSITIONS

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Abstract: *This paper presents aspects concerning digital, smart and green transition of the Romanian textile sector. This survey was conducted in the framework of the ADDTEX Erasmus+ project, between August and December 2022, involving mainly qualitative research methods (group activities and questionnaires, presenting concepts, meanings and perspectives) in the framework of the desk & field research and living lab sessions for ADDTEX Erasmus+ project. In order to conduct this survey several workshops were organized in situ or online (Meetup and living labs) concerning digital technologies to companies and HEI. In addition, we asked them to define their past, actual and future roles in the context of the green, smart and digital economy. Digitalization, integration of smart things and sustainable development are priorities for Romanian research and innovation sector and several initiatives such as implementing digitization, smart and green technologies and methods for innovative learning are ongoing. In addition, the main objectives including carbon footprint reduction and integrating digital and smart things (electronics) using IoT.*

Key words: *smart, digital economy, green, innovation, sustainability*

1. INTRODUCTION

INCDTP developed the analysis of the textile and leather sector in relation to the green, smart and digital technologies implemented in Romanian SMEs and universities in relation to:

-the main green, smart and digital technologies that can be applied to the textile and leather industry;

-the importance of implementing processes based on green, smart and digital technologies;

-Importance of implementing and disseminating the aspects of green, smart, digital knowledge;

-already implemented green, smart, digital technologies in textile companies; existing courses on green, smart and digital technologies;

-specific needs for companies and universities in the green, smart and digital economy; impact of COVID-19 in higher education institutions:

-rethinking of courses and online methods of control and transmission of information; impact of COVID-19 in SMEs:

-rethinking of production capacities, stocks and infrastructure for physical and online operations;

-Interest of Romanian SMEs and universities in participating in courses on the development of advanced smart/green/digital materials;

-Interest of Romanian SMEs and HEIs in participating in national and European learning, research and innovation projects.

Mainly qualitative research methods (group activities and questionnaires on open questions, concepts, meanings and perspectives) were used within the Desk & Field Research and Living Lab sessions. Within the workshops (Meetup and Living Labs) organized on-site or online, we presented to companies and universities the ADDTEX project objectives, main activities, expected results and benefits of green, smart and digital technologies. Furthermore, we asked them to define their past, current and future roles in the context of the green, smart and digital economy.

In the framework of the workshops organized in situ or online (Meetup and living labs), we presented the ADDTEX project objectives, main activities, expected results and the advantages of the green, smart and digital technologies to companies and HEI. In addition, we asked them to define their past, actual and future roles in the context of the Green, smart and digital economy.

In the context of the green, digital and smart transition, several technologies/solutions have already been implemented by companies such as the use of recycling, waste management (selective collection of textile waste), energy from renewable resources (photovoltaic panels) and hybrid cars for product transport (Figure 1).

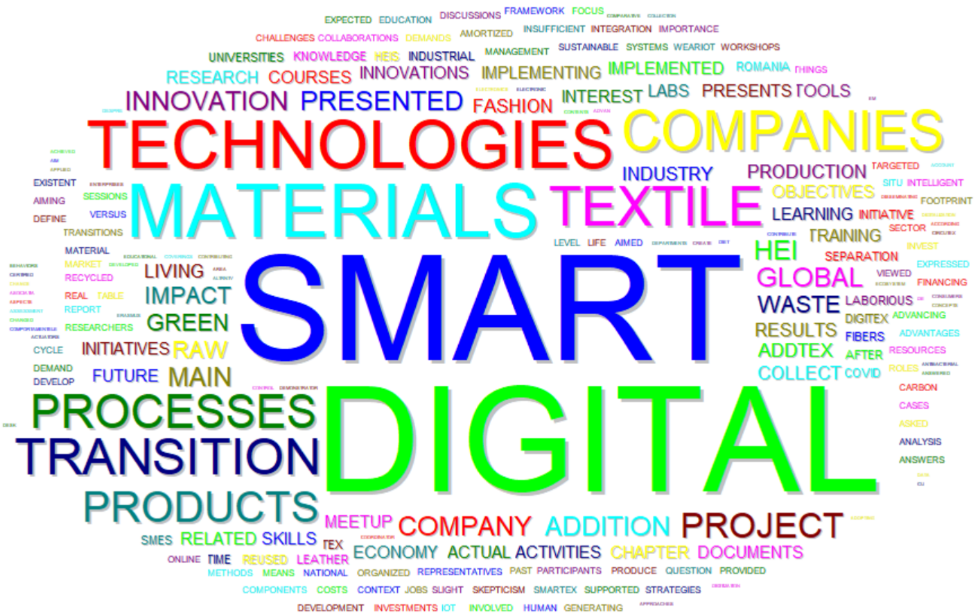

Fig. 1. Digital-Smart-Green transition based new technologies for advanced sustainable textiles

At the same time, companies already use fleet telematics systems based on GPS, video surveillance technologies of production lines, automatic cutting machines, access to databases with digitized patterns in the company, 3D design of shoe patterns and computer-aided design of patterns (e.g. , Lectra, Optitex, GERBER). In addition, the companies indicated that they use 3D design of shoe patterns, management, administration and production (ERP) programs and are interested in developing customized products (e.g., shoes for diabetics).

The invited companies believed that digital innovation would consist of automating the process of detecting defects in raw materials or products, using semi-automated workstations to manufacture military uniforms, using computer-aided design and 3D modeling, and the virtual environment. Also, most companies believe that it is necessary to implement new ICT technologies to create innovative products with high added value and national and global demand.

In this context was performed a text data analysis using text mining techniques based on text link analysis, proximity distances analysis and terms frequency in text in order to observe the interest of the companies interviewed and who responded to questionnaires.

Text link analysis is based on a pattern matching technology that allows rules to be defined for patterns and to compare them with actually extracted concepts and relationships found in the analyzed text [1-3].

In this case, extracting ideas about digital, green and smart transitions in the textile sector through linkages between these concepts (smart, digital, green) and other terms (materials, textiles, advanced materials, pattern design and projects) can be interesting.

2. TEXT MINING ANALYSIS

The Text Link Analysis feature (Figure 2) enables the visualization of the connections between important words using a network diagram to explore the relationships and identify underlying patterns and structures of co-occurrences using three layout types: a multidimensional scaling, a force-based diagram, and a circular layout [1]. In Figure 2, the concept (terms) are represented as nodes, and the relationship between nodes is represented as a line connecting those nodes (also called an edge), with the thickness of this line representing the strength of that relationship [1-3].

Shown in Figure 3 is the proximity chart, which accurately displays the distance between objects by displaying the measured distance from a selected object to all other objects on a single axis. In this way, the information is extracted from the vast amount of data stored in the distance matrix at the origin of the multidimensional scaling plots. The distance from point 0 represents all distances. The 0 point indicates the lack of similarity or co-occurrence [4-5].

Table 1 presents the frequency of survey results indicating a significant frequency for digital, textile, smart and green terms [4].

Table 1: Principal words frequency

	Frequency	Shown	Processed	Total	No. cases	Cases	TF • IDF
DIGITAL	122	3.59%	1.86%	1.18%	2	100.00%	0.0
TEXTILE	110	3.24%	1.68%	1.06%	2	100.00%	0.0
SMART	108	3.18%	1.65%	1.04%	2	100.00%	0.0
GREEN	98	2.88%	1.49%	0.94%	2	100.00%	0.0
MATERIALS	92	2.71%	1.40%	0.89%	2	100.00%	0.0
TEXTILES	72	2.12%	1.10%	0.69%	2	100.00%	0.0
PROJECT	70	2.06%	1.07%	0.67%	2	100.00%	0.0
PRODUCTION	64	1.88%	0.98%	0.62%	2	100.00%	0.0

Text link analysis can be used to find relationships between different terms selected by respondents in a survey study [6-9].

By analysing the association strength between terms in Figure 2, it can be observed that the co-occurrence of the terms Smart and Digital Transitions and Smart Textiles/Learning represents a strong association of 0.408, and between Smart and Digital and Pattern Design has an association strength of .408, respectively 0.405, meaning that respondents often associate the concept of smart/digital transition with technology-based CAD/CAM and virtual pattern design/modelling.

Furthermore, the association of smart/digital with smart textiles and learning stems from the fact that several initiatives involving universities promote e-learning methods on smart textiles.

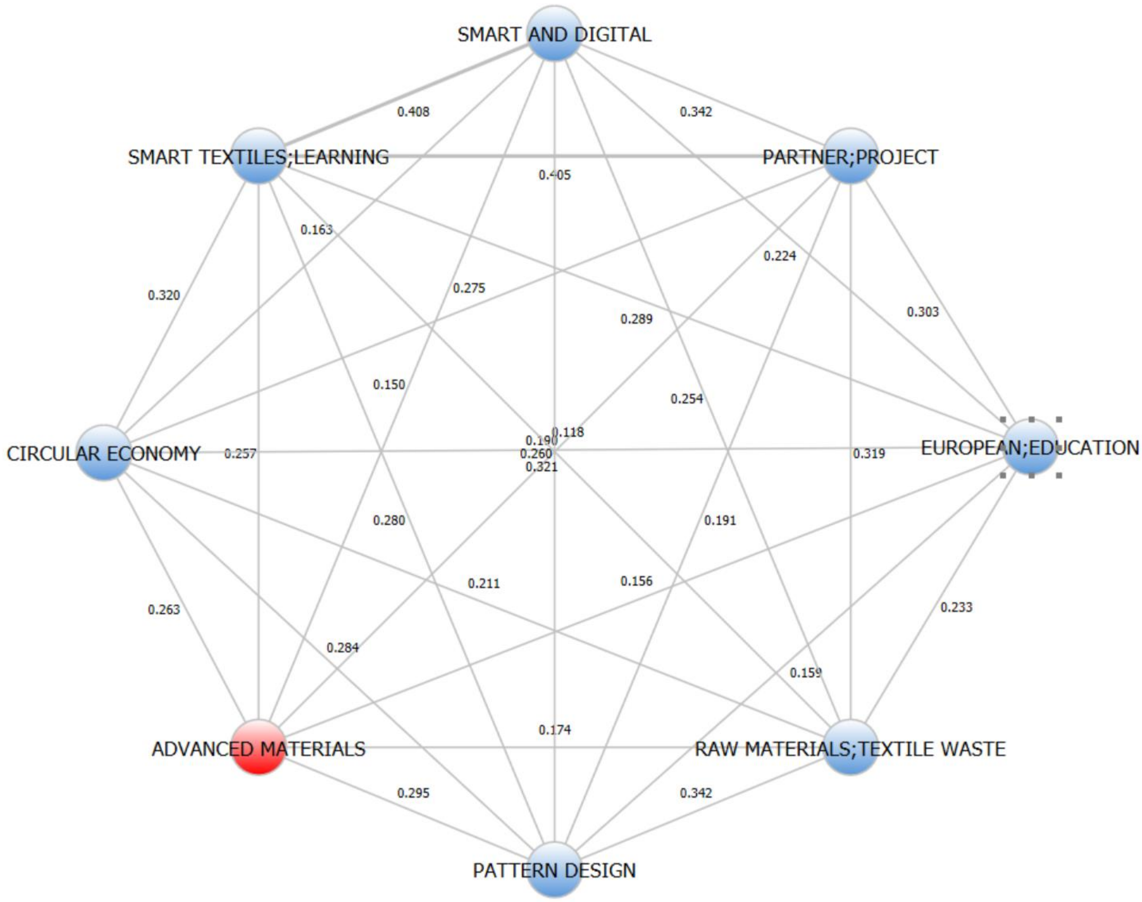

Fig. 2: Text link analysis

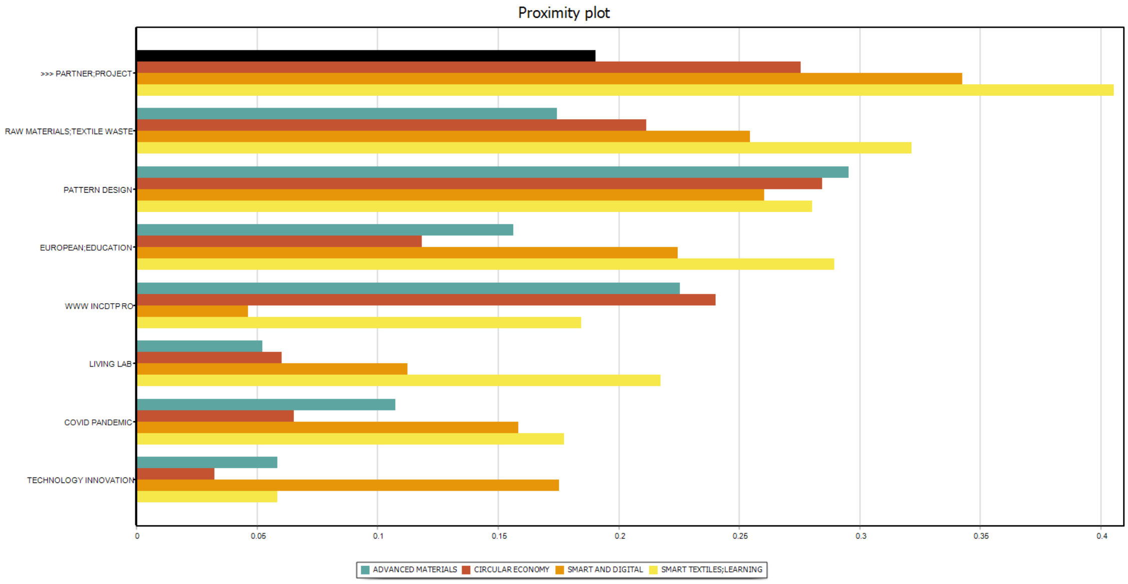

Fig. 3: Proximity plot

5. CONCLUSIONS

After the discussions in the Meeting Sessions/Living Labs with companies and universities about the goals and results of the ADDTEX project, the participants expressed a interest in courses and collaborations in new projects aimed at the smart, digital and green transition. Although for researchers and universities, this green-digital-intelligent transition is seen as generating new products, technologies, jobs and research or innovation projects, the company representatives indicated that these investments are made in new technologies or human resources to produce smart, advanced materials or the market requirements for these products must also support products. In some cases, they have viewed this transition with some skepticism, given the inadequate funding to the cost required for investments in means of production that would need to be recouped over time when there is a demand for those products. The meetings (Meetup and Living Labs) allowed the exchange of ideas and the adoption of common points of view, consisting of the need to improve the soft skills (writing of projects/patents, marketing analysis) of employees in companies and the development of new textile materials through the Employing groups of specialists for the co-design and co-creation of new materials and products, incorporating a multidisciplinary and interdisciplinary approach.

The companies were very enthusiast to add smart and digital technologies but not in the same way to introduce green transition because they considered important green transition for reducing the cost for energy through photovoltaic systems, but not through recycling textiles/waste and reusing for new products.

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ANNALS OF THE UNIVERSITY OF ORADEA
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OPPORTUNITIES AND CHALLENGES OF SUSTAINABLE LOCAL WOOL PRODUCTION IN QUEBEC: AN EXPLORATORY STUDY OF SUPPLY CHAIN AND DEVELOPMENT STRATEGIES FOR THE FASHION INDUSTRY

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Abstract: *The fashion industry has a negative impact on the environment and society, leading consumers to seek more responsible alternatives. As a natural and durable material, wool is gaining popularity, but local wool sourcing is often overlooked. This article explores the opportunities for sustainable local wool production in Quebec and the challenges in developing a new local wool supply chain. The study draws on a pilot project by Fibershed Quebec, which collected feedback from 75 participants to better understand the challenges faced by new actors in the fashion industry in this logistics chain. The results show that local companies in the textile and apparel ecosystem need to assess best practices and adopt new perspectives and strategies to support local wool production and strengthen the local supply chain. An additional survey was conducted to capture the real challenges of creating a fashion collection using local fibers for a specific market. The results emphasize the importance of training and support for new actors in the wool and fashion industry to help them overcome obstacles and succeed in a highly competitive market. Finally, the article explores the challenges and opportunities of sustainable local wool production in Quebec. It examines current efforts to diversify wool production and analyzes the challenges and opportunities facing local businesses. This study highlights the importance of wool production in Canada. It highlights the need for scientists and stakeholders in the sheep industry to find new ways to make this activity profitable.*

Keywords: *Fashion Apparel Industry, Product Development, Sustainable Fashion, Local Fibers, Local Sourcing, Sheep Farmers*

1. INTRODUCTION

The fashion industry's impact on the environment, local communities, and workers worldwide is significant, if not alarming. However, a trend toward change, and consumers are becoming increasingly aware of the consequences of their clothing consumption, actively seeking more sustainable and responsible alternatives. In this context, the use of natural and sustainable materials in clothing production has become essential, with a growing interest in wool fibers. However, local wool sourcing is often neglected in favor of mass production and international competition. This article explores the potential of local wool production in Quebec, examining the opportunities and challenges of developing a new sustainable local wool supply chain.

A pilot project implemented by Fibershed Quebec, a non-profit organization promoting the use of local and sustainable fibers in fashion, gathered the testimonies of 75 participants through discussions to better understand the challenges faced by new actors in this supply chain. Many of the participants expressed their desire to access locally sourced products and clothing brands. However, they faced obstacles such as a lack of knowledge in managing a transformation business, difficulty in standing out in a market saturated by products from other countries and increasing pressure to produce low-cost clothing. To address these challenges, local companies in our textile and clothing ecosystem must evaluate best practices and adopt new perspectives and strategies to support local wool production and strengthen the local supply chain. In an additional survey carried out in Quebec between March and April 2023, five interviews were conducted to better understand the real challenges of creating a fashion collection with local fibers for a specific market. The results showed that one of the preliminary initial obstacles was the quality of materials in local sourcing, followed by variability in transformation, affecting design and consistency in developing a collection for specific markets. Additionally, there was a low volume per batch, and there was a lack of understanding of the process and value of stakeholders in the chain so that everyone could benefit. Participants reported that implementation was tedious, and it was sometimes difficult to make decisions in the procurement phase, material selection, and ensure standardization in fashion product development. These results emphasize the importance of training and support for new actors in the wool and fashion industry to help them overcome obstacles and succeed in a competitive market. Canadian wool production is a topic that deserves the attention of scientists and sheep industry actors. In a difficult economic context marked by high production costs and low selling prices, it is important to find new ways to make this activity profitable. In this exploratory research, we examine current efforts to diversify wool production in Quebec and examine the challenges and opportunities for local businesses.

2. SHEEP INDUSTRY DIVERSIFICATION IN QUEBEC AND CANADA

The wool industry in Canada, especially in Quebec, has been considered a less significant activity for sheep farmers over the years. Research conducted by the Wool Canadian Council and Fibershed Québec shows that the price of wool is too low to cover the cost of shearing. This has resulted in a decrease in the size of sheep herds intended for wool production in the past 20 years. This shift has led to replacing several fine wool breeds with meat-producing breeds, which has resulted in a decline in the quality of wool produced in North America. Additionally, ewes are shorn more frequently to accelerate lambing, resulting in shorter and coarser fibers. Consequently, the quality of wool available in our markets is of lower quality. However, in recent years, some breeders have turned to wool production as their primary activity. We have observed that some of them have converted their sheep herds destined for lamb meat production into flocks focused on wool production. Thus, there are farm models that produce purebred sheep wool and sell 100% local and natural skeins or balls of wool, allowing them to add value to their raw materials. Despite this, we have also noticed that the vast majority of skeins presented as locally sourced on our markets are not entirely made from local raw materials. Customers are often confused about the origin of raw materials, the percentage of fiber blends, the quality of the products, and the treatment of dyes and finishes. They are also unsure whether the wool used is sourced locally or not. One of the main reasons for this is that breeders face obstacles in wool transformation, such as washing the fleeces. Mills that have lost their production volume have mostly been shut down. In some cases, it is necessary to send the wool to other provinces to be washed, which increases processing costs. However, the main challenge for wool production in Quebec is the poor quality of wool produced due to intensive management focused on the meat market. This requires a rigorous selection of sheep breeds to obtain superior-quality wool that can compete with Australia, New Zealand, and Africa. Additionally, wool processing requires significant investment in carding and spinning equipment. This situation can create gaps in processing and integration issues in the value chain.

3. LITERATURE

The literature confirms that the wool market in Canada is struggling, facing competition from synthetic fibers, inadequate infrastructure, and difficulties in setting prices for wool. In 2021, Canadian wool producers continued to feel the effects of the COVID-19 pandemic and associated international supply chain issues. The volume of raw wool purchased directly from Canadian producers was 883 tonnes in 2021, a decrease of 1.0% from 2020. The average price paid for wool to Canadian producers in 2021 was $0.76 per kilogram, an increase of 9.2% from 2020 [1]. Several groups and researchers have looked into the problems and opportunities to revive the wool industry in Canada. The quality of wool largely depends on sheep's living conditions and their fleece treatment [2]. As stated in the literature notes that animal welfare is essential for producing quality wool, and sheep must have access to good pasture, water, and healthy and varied food to produce quality fleece. In Canada, there are no specific tools to objectively evaluate wool quality [3], with most people relying on the "blood system" method [4]. Only a few are using tools such as a microscope to obtain a better approximation of the micron count of the fleece [5]. There is, therefore, a need for infrastructure and tools to improve the production of quality wool in Canada.

The transformation of fleece into fiber is a key step in producing quality wool, and it is important to have suitable equipment and specific know-how to carry out this transformation. According to Klepp *et al.* [6], this could represent an opportunity for local producers to stand out in the market by offering superior-quality wool. The Canadian wool market is largely oriented towards exports, with China being the main importer of Canadian wool, followed by India. Data loss and rejects of Canadian fleece are not available. Indeed, several producers prefer to directly discard the fleece rather than transform it. According to Burgess [7], there is a lack of infrastructure for the production of quality wool. As it is in Canada, the United States has faced a comparable situation where wool production has declined since the 1920s due to synthetic fibers' emergence and incentive payments' removal in 1995. Although recent data on wool production in the US is limited, it is evident that there has been a decrease in wool production in this country too. In addition, significant buyers are not interested in Canadian wool, preferring to purchase directly from New Zealand. The wool arrives already washed and graded, allowing for precisely selecting the necessary wool type. Overall, the lack of specific tools in Canada highlights the need for further research and development in this area. Studies have estimated that the environmental impact of a single use of a wool garment can be significant, with one estimate suggesting a carbon footprint of 0.17 kg CO2 equivalent for wool produced in Australia, processed in China and India, and worn in Europe [8].

Despite the challenges the Canadian wool industry faces, there is potential for growth and innovation. One promising development is the emergence of sustainable and local wool production, prioritizing animal welfare, environmental stewardship, and community involvement. As noted by Burgess [7], consumers are increasingly interested in buying ethically and environmentally responsible products, and wool fits well into this trend. Moreover, local wool production can support small-scale farmers and artisans, who can collaborate to create unique and high-quality products that stand out in the market.

Enhancing the production of sustainable and domestic wool in Canada requires addressing the current dilemmas with infrastructure and market. The wool supply chain lacks coordination and communication between farmers, shearers, spinners, weavers, and retailers, which necessitates improvements. To support these actors, it is proposed to establish regional wool cooperatives or networks and provide technical assistance, training, and marketing support. There are opportunities for job creation and increased transparency in the wool supply chain through investment in local wool processing facilities. Scouring plants and spinning mills are instrumental in adding value to raw wool and reducing the dependence on foreign countries for processing. Therefore, it is imperative to make such investments.

To keep wool production sustainable and local, it's key to employ inventive technologies and practices that minimize the environmental impact. For instance, research has shown that using regenerative grazing practices can improve soil health, biodiversity, and carbon sequestration while increasing wool quality and quantity [9]. Similarly, using natural dyes and avoiding harmful chemicals in wool processing can reduce pollution and promote eco-friendliness [10]. Furthermore, incorporating digital technologies, such as tracking system and blockchain, can enhance transparency and trust in the wool supply chain, allowing consumers to make informed choices about the products they buy [11].

In conclusion, the Canadian wool industry is facing challenges but also opportunities for growth and innovation. By prioritizing sustainable and local wool production, investing in infrastructure and technology, and fostering collaboration and communication among stakeholders, creating a more resilient, equitable, and environmentally responsible wool supply chain is possible.

4. OVERVIEW OF THE STUDY AND ITS PRELIMINARY RESULTS

This exploratory study was conducted over a period of 12 months, from April 2022 to 2023, to understand the challenges and opportunities related to the use of local wool in Quebec. Everything was done to reduce wool waste and recover and promote our materials in our local markets. Panels and interviews were conducted with 75 people from the processing, sheep farming, and garment manufacturing sectors in collaboration with Fibershed Québec. Toward the end of the project, five respondents were selected to share their experiences and perspectives on the issue.

The present study highlights various results on the current situation of Quebec sheep wool sector, alongside the viewpoints of designers and distributors regarding sustainable measures within this field. The results show that most sheep producers are interested in integration into the value chain and the transformation of their material but under certain conditions.

The results of the study show that the sheep wool sector in Quebec is facing several obstacles. Only eight shearers are active in Quebec, mostly as breeders and shearing three days a week or less. Currently, few producers recover the wool, which encourages breeders to leave it on the ground, as the person who requested it never returns due to the washing and cleaning work it represents. Only one major buyer is known in Quebec. It is noted that producers from remote regions sometimes organize collective transport of wool to be more profitable. This major player pays the producers 6 to 8 months after delivery, and thus low-quality Romanov wool is difficult to sell.

On average, one ewe produces about 3 pounds of wool, and the income per kilogram varies greatly depending on the quality. The current shearing cost is around $4 per ewe, but some breeds, like Dorsett, are more expensive but yield more wool. Some have reported receiving less than $0.76 per kilogram, with the lowest reported amount being $0.18 per kilogram. Ninety percent is exported to Great Britain, France, Germany, Spain, Japan, the United States, China, and India. Quebec is the third-largest wool-producing province (in quantity). Quebec currently represents 23% of Canadian raw wool production, which is around 310 tonnes per year. The 1350 tonnes of wool from Canada represent only a fraction of the world’s production, with 90% being exported to various countries. Therefore, wool producers face many challenges in integrating the value chain and make a profit from their material, including finding local buyers and reducing wool waste.

Regarding the opinions of designers and distributors, most of them have a positive perception of wool and sustainable practices but are concerned about production challenges and potential costs associated with it. Most respondents acknowledge the issue of environmental overproduction and overconsumption and deem it crucial to embrace sustainable practices. However, opinions vary on the most effective methods and various factors to be taken into account. Despite these challenges, there are opportunities to be explored for wool producers in Quebec, particularly by focusing on producing fine wool sheep breeds and developing management techniques to improve wool quality. In addition, there seems to be a growing demand from consumers for natural wool offers, another path for wool production. Nevertheless, the accessibility of small-scale wool for fashion designers is currently minimal, if not entirely unavailable.

5. DISCUSSION AND FINDINGS

Our exploratory study confirmed that the absence of efficient carding mills and spinning facilities in Quebec had made wool processing complex, complicated, and unprofitable for farmers. Currently, those wishing to sell their wool often must sell it in its raw form or transport it outside the province for processing, resulting in additional costs. This finding highlights problems in the supply chain, work silos, and long-term expertise abandonment. During our interviews, participants emphasized that high-quality fibers, such as alpaca and lamb, are currently being stored in bags, awaiting sale through wholesale and market outlets. This increased storage can cause waste management problems and additional costs for farmers. Despite their efforts to process the fiber themselves or partner with others, these initiatives have failed due to the lack of specialized equipment needed for wool processing.

Furthermore, we found that some local spinning mills in Quebec, while able to sell yarn at competitive prices, import their fiber from abroad rather than buying local Canadian wool. This situation is partly explained by the inconsistency in Canadian wool quality and the absence of fiber-washing facilities in Canada. Several participants noted that mills often prefer to send their fiber to China for washing and then bring it back to Canada as it is cheaper than processing it locally. Moreover, the inconsistency in Canadian wool fiber quality, which varies from farmer to farmer, results in additional costs for mills that must process it, limiting the competitiveness of local wool in the market. These obstacles are detrimental to the supply chain and impede the growth of the wool industry in Quebec.

In contrast, we note that a few recent initiatives are leading to a revival of the wool industry in Quebec. Passionate farmers have begun raising wool breeds to produce superior-quality wool and encourage local production. Carding mills and spinning facilities have also emerged, offering on-site wool processing services and facilitating the marketing of Quebec wool. However, these initiatives are still on a small scale and need to be increased to meet the needs of the local wool industry.

Table (1) highlights the ongoing initiatives to diversify wool production in Quebec and the associated challenges and opportunities. The initiatives include the launch of local brands and certifications, the development of new sheep breeds and crosses, the use of cutting-edge technologies, consumer education, and the creation of wool production cooperatives. Challenges to be addressed include the high costs associated with research and development, technology, and cooperative creation. However, these efforts also offer opportunities to improve the quality and quantity of wool produced in Quebec. The aim is to stimulate, encourage and promote innovation in the local economy. It is essential to reduce the dependence on imports and the establishment of a collaboration mechanism between wool processors and sheep farmers is necessary.

Table 1: Challenges and Opportunities in Diversifying Wool Production in Quebec: Current Efforts and Strategies

Current efforts to diversify wool production in Quebec	Challenges	Opportunities
1. Launching new local wool brands and certifications	▪ Competition from established brands and supply versus production costs	▪ Increase in distribution and demand for local products
2. Developing new sheep breeds and crossbreeds	▪ Cost of research and development	▪ Production of superior-quality wool and traceability of materials
3. Using advanced technologies for wool production	▪ High initial cost of technologies and their deployment	▪ Improvement of the quality and quantity of wool produced in Quebec
4. Educating consumers about the benefits of local wool	▪ Raising awareness of wool attributes and the importance of buying local	▪ Stimulating the local economy and reducing dependence on foreign imports
5. Creating wool production cooperatives	▪ High startup costs and lack of resources and expertise	▪ Strengthening collaboration between producers and sheep farmers

Stakeholders in Quebec recognize the need to develop a marketing strategy for introducing new local wool brands to meet growing demand but face fierce competition from established brands. Another option is to invest in researching and developing new breeds of sheep, possibly with collaboration from Eastern European countries like Romania, and utilizing advanced technologies to improve the quality and quantity of wool production on a smaller scale. Educating consumers about the benefits of buying locally produced wool and creating wool production cooperatives could also increase demand and collaboration, although these efforts require significant investment to overcome low consumer awareness.

The recent study confirms the importance of raising public awareness about the importance of Quebec wool and supporting breeders working to produce higher-quality wool. Initiatives like Fibershed should be encouraged and replicated to value our province's natural and cultural heritage. In most cases, finding a local mill to produce a 100% Quebec product is impossible. However, some individuals cherish buying the necessary equipment to card and spin their wool. However, this project would require an investment of about CAD 350,000. According to them, a valorization of agriculture can only be achieved with political will. Others insist on the importance of launching major advertising campaigns to promote local fibers to create genuine enthusiasm for natural wool since the beginning of the pandemic. Although some have managed to double their turnover, growth remains limited. Despite these challenges, there are opportunities to be exploited by wool producers in Quebec. Breeders can focus on producing fine wool sheep breeds and developing management techniques that improve wool quality. In addition, the direct purchase of washed and graded wool from New Zealand allows for a precise selection of the required wool type. It is also possible to focus on natural wool production, which is increasingly sought after by consumers.

Our research contribution has highlighted the challenges facing the wool industry in Quebec. In fact, the loss of identity and value of Quebec wool is due to its mixing with foreign wool, not to mention the variability in the materials. In addition, we stressed the importance of promoting the ecological and social benefits of local wool production to raise consumer awareness of the harmful effects of synthetic fibers compared to wool, a renewable and biodegradable material.

We have also emphasized the importance of supporting breeders and small craft businesses that maintain the tradition of producing 100% Quebec wool. By collaborating with these local actors, it is possible to promote an efficient, simple, and expert transformation of wool and thus contribute to the development of Quebec's rural communities. The key to success lies in expertise, which is crucial to supporting those involved to obtain tangible benefits.

This article reflects on the urgent need for deep transformations of the globalised textile industry dominated by fast fashion and growth logic, and the emergence of a local wool economy. The article presents three main conclusions. Firstly, the local wool economy by itself cannot challenge the global fast fashion and textile industrial complex built on economic growth. It needs much more structural support from society at large, including governmental policies aimed at de-growing the economy, and a widespread social movement to push for change in consumers' fast fashion addiction. Secondly, the inherited injustices between the global North and South will not go away even if the global North relocates its production/consumption and its environmental impact back home. There is a need to support workers attached to the global industry for wool to sustain their lives in place-based economies. Thirdly, new economies that break with the current logics of the growth economy do not emerge 'from below' by chance. They require hard work, strategic planning and visions, collaborative efforts at multiple levels and scales, and the support of meta-organisations such as Fibershed. The article emphasizes that trying to break with old systems does not happen overnight, but is work that is 'under construction,' and we need to care more for the land and each other by caring for the socio-environmental impacts of our clothes.

In addition, the article highlights the importance of a holistic approach to sustainable and local wool production. This includes the production, processing and sale of wool itself, as well as the impact of the whole process on the social environment. Collaboration and transparency are key when considering the diverse stakeholders involved in the supply chain. From growers and artisans, to processors and consumers, all parties should be taken into account. By adopting a systems perspective, it is possible to create more sustainable and equitable practices for local wool production while meeting consumer needs and preferences. Ultimately, this approach could create a fairer and more sustainable economy for the entire local wool supply chain.

6. LIMITS

The presented research has several limitations that deserve to be highlighted. Firstly, certain aspects related to sheep breeders have been omitted due to the complexity and scope of the subject. Additionally, the research focuses on a category of actors who wish to offer materials focused on fashion, which may limit the external validity of the results obtained. Finally, although the number of participants is limited, the proportion of affected participants is deemed satisfactory for drawing interesting conclusions. These limitations open the door to many avenues for future research.

7. CONCLUSIONS

In conclusion, although Quebec wool industry may not have fully regained its former glory, it is generating renewed interest in local wool and a growing awareness of the environmental impact of synthetic fibers. Initiatives have been launched to revitalize the industry, such as the creation of a wool processing group with Fibershed Québec, support programs for breeders, and the promotion of Quebec wool to consumers. With good valorization and adequate marketing, Quebec wool could have great potential to meet the growing demand for sustainable and local alternatives to synthetic fibers. However, it is important to note that Quebec has lost certain practices and knowledge to the industrialization and globalization of markets. Overall, the future seems promising for Quebec wool and the fashion industry as they strive toward sustainability and innovation. Thus, it is important to consider the practices and knowledge of other countries, such as Romania, to developing new sustainable and innovative approaches for the wool industry in Quebec.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

COMPARATIVE ANALYSIS OF THE TREATMENTS ATTACHED TO THE MATERIALS IN THE COMPOSITION OF THE MATTRESS COVERS

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Abstract: *In the present paper, the materials for making three mattress covers (an antibacterial mattress cover, a mattress cover intended for hospital use and a hypoallergenic mattress cover) were treated and tested in order to obtain basic information about the chemical treatment of fibers in the new mattress covers. The constituent components of the three mattress covers were each undersampled by cutting each layer then, it was passed to the collection of samples in small, labeled bags. Each sample was sampled over its entire layer depth, with section areas of about 1-2 cm. This paper highlights the difference in finishing treatments, depending on the areas of use of knitted materials intended for mattress covers. Thus, in addition to the differences between the solutions that are applied to these materials, we can also observe that those intended for hospital use are without preservatives and are not washed, because the whole solution is eliminated from the treatment process, the ones that are contrary to the materials from which the hypoallergenic mattress covers are made, which after each wash becomes more and more beautiful and qualitative. On the machine called Squeezing Pader Machine of Tai Ping Yang, the treatment of the materials analyzed in this work was performed, both by treatments applied to the surface of the materials and by immersion, obtaining a load with 100% solution.*

Key words: *mattress cover, treatment likroll, antibacterian, hypoallergenic agent, ecoSHIELD.*

1. INTRODUCTION

If consumers are looking for a deeper understanding of their products, including how they are manufactured, what they contain and where they come from, certification labels can provide a useful shortening. Consumers may think that certiPUR-US (certifies just the foam components a company uses in mattresses) certified mattresses have undergone rigorous testing and do not contain hazardous substances. Flame retardants in the components of the mattress without foam must be labelled if they are for young children or infants [1]. In this aspect, it is not clear whether substances such as fiberglass are considered a flame-retardant chemical using current guidelines [2, 3]. However, certification and testing do not seem to include mattress covers [4].

2. GENERAL INFORMATION

In this paper, the materials for making three mattress covers (an antibacterial mattress cover, a mattress pouch intended for hospital use and a hypoallergenic mattress cover) were treated and tested in order to obtain basic information about the chemical treatment of fibers in the new mattress covers.

The constituent components of the three mattress covers were each undersampled by cutting each layer then proceeded to collect the samples in small, labeled bags. Each sample was sampled over its entire layer depth, with section areas of about 1–2 cm.

Sample preparation and analysis were carried out using an internal standard operating procedure for the analysis of the fibrous content of the materials in the three mattress covers.
All samples were made with a Motic brand light microscope with 5000 x magnification [5]. Thanks to the modular system, this stereo microscope series can be easily configured and adapted to the application needs and working environment.

Fig. 1: Equipment for the treatment of textile materials - Squeezing Pader Machine

On the Squeezing Pader Machine, the material treatment of the three mattress covers was carried out (an antibacterial mattress cover, a mattress cover intended for hospital use and a hypoallergenic mattress cover). After the knitting process, the material must be split from the tubular shape to the flat shape and after that it can be subjected to the specific treatments requested by the customer.
The main components of each mattress cover tested and their observed compositions are summarised in Table 1, Table 2 and Table 3.

Table 1: Treatment of antibacterial pouch (mattress)

Treatment	**Likroll**
Supplements	EcoShield 1.5% EU
Recipe	Citric Acid 0.2% Elastofin STO501 1.4% ecoShield EU 1.5%, Temp:150˚C
Request width	229-231 cm
Request weight	267-278 gr/m^2
Composition	18%Viscose 82%Polyester
Color	Natural, Ciment

For the antibacterial mattress cover, the treatment was made with charging with 50% solution (LIKROLL - type of treatment on the surface of the material) Fig. 3.

Citric acid 0.2% is ph corrector, Elastofin STO501 1.4% is the balm used, ecoShield EU 1.5% -Eco antibacterial solution (action to combat bacteria). EcoShield is a recycled Polyester membrane made from 85% Polyester film waste + 15% recycled bottles Fig. 2. The treatment was carried out at the temperature of 150˚C, as evidenced by Table 1. The hypoallergenic and anti-mite treatments applied to the pouch are very important because in this way, we will protect the little ones from possible allergic reactions.

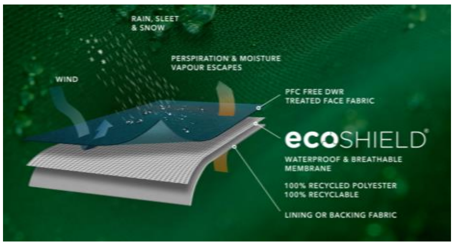

Fig. 2: ecoSHIELD is a recycled polyester membrane [6]

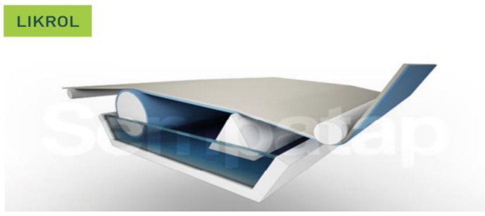

Fig. 3: LIKROL- treatment applied by rollers [7]

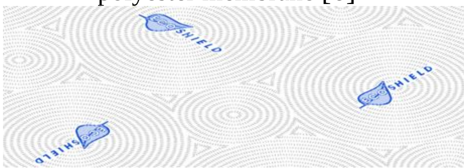

Fig. 4: Material treated for antibacterial pouch (mattress)

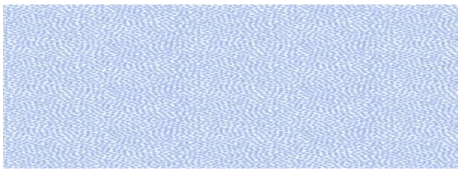

Fig. 5: Material treated for pouch (mattress) for the hospital

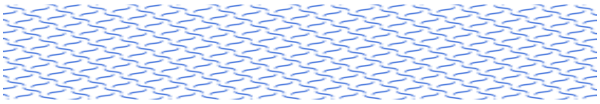

Fig. 6: Material treated for hypoallergenic pouch (mattress)

Table 2: Pouch treatment (hospital mattress)

Treatment	PADDER FR + LIKROLL – COATING FR (on back)
Supplements	Abioflame Polyester, Laminated with 20grm PP.
Recipe	AbioFlame JASMINE 14%, no softener no citric acid / pick-up 100%, Temp:130˚C.
Request width	234-236 cm
Request weight	330-343 gr/m^2
Composition	100%Polyester
Color	Latte, Natural

Treatment for the mattress cover intended for hospital use, children's and/or the elderly was carried out at 130˚C because at a temperature higher than 130˚C the material is burned. The lamination cover is carried out on the back of the material, polyethylene substrate for waterproofing. For this mattress cover the tratamet was made by loading with solution in a proportion of 100%, by immersion (pick-up100%). Long-term sun exposure is not recommended, as it can turn green.

Table 3: Pouch treatment (hypoallergenic mattress)

Treatment	HAPPY SCOUR FR + LIKROLL – COATING FR (on the back)
Supplements	Eco Clean Permanent & Chimical free FR.
Recipe	Happy scour 0,2% Citric Acid 0,2%, No Elastofin, Max 75˚C/167 Fahrenhelt/0,2% citric acid/Framing once, or twice if needed, Temp:150^{0}C.
Request width	219-221 cm
Request weight	592-616 gr/m^2
Composition	98%Polyester 2%Elastane
Color	Natural, Metal

Hypoallergenic (means that something is less likely to trigger an allergic reaction) mattress cover, prevents the formation of bacteria, mold, mites and unpleasant odors. The treatment for the mattress cover was done at a temperature of 130˚C. Special washing of this cover has the role of eliminating all volatile substances. Washing is done at a temperature of 90° in order to remove all the absorbed oil from the knitting needles and from the paraffining on the thread.

The apparent omission of mattress covers from the criteria for chemical-free mattress certifications suggests that improvements are needed in terms of mattress labelling and also correct consumer education [8].

5. CONCLUSIONS

Several scientific studies show that covering mattresses with certified anti-mite covers reduces exposure to allergens by 100 to 1000 times in a month, with objective and measurable benefits for allergy sufferers.

This paper highlights the difference in finishing treatments, depending on the areas of use of knitted materials, intended for mattress covers.

An important peculiarity of the covers for hospital use is that it is without preservatives and is not washed, since all the solution would be removed from the treatment process.

Substances that are not dangerous, can develop bacteria, too.

A great advantage of the hypoallergenic mattress cover is that after each wash it becomes more and more beautiful and qualitative.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

STUDY OF THE PARTICULARS OF POSITIONING OF PREMATURE BABIES FOR THE DEVELOPMENT OF FUNCTIONAL CLOTHING PRODUCTS

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Abstract: *The aim of the study is to present the functionality of clothing products intended for premature babies, developed in accordance with the requirements of care, positioning and monitoring during their stay in the neonatal therapy ward.*
Methods: The analysis of the medical personnel involved in the care of premature children was carried out; analyzed which types of positions are recommended for growth and development. All the positioning procedures were performed in the premises of the Gheorghe Paladi Chisinau Municipal Hospital, by the specialized medical staff.
Therefore, the functionality of the proposed clothing products is aimed at meeting the requirements of neonatal care and facilitating some medical procedures in the case of examination of patients by medical personnel.
Video recordings were made to observe the correctness of the positioning of the children, which will be a source of information for parents who will have the opportunity to get involved, so it can contribute to improving the care of premature children.

Key words: *specific positions, medical procedures, care assistance.*

1. INTRODUCTION

The premature child shows great deficiencies in the basic functions of the body: thermoregulation (it cannot ensure a constant body temperature), breathing, blood coagulation, enzyme, liver and kidney systems, acid-base balance or defense against infections. The appearance of the premature baby changes in the first days. The edemas disappear, which highlights the lack of subcutaneous adipose tissue, the ribs are prominent, the abdominal tone is not developed, etc. Care and correct positioning will ensure normal growth and development.

The Neonatal Intensive Care Unit (NICU) is a hospital intensive care unit specializing in the care of premature and sick newborns.

Within it are specialist doctors, nurses, other professionals and equipment for the care of premature children (figure 1.). When premature babies no longer need the care and specialized equipment of the NICU, they are transferred to the special care ward for premature babies. Each child is closely monitored by an on-call nurse and other specialists.

In the NICU there may be times when the lights are dimmed and it is quiet. This is due to the fact that premature babies need silence and as little noise as possible so as not to create anxiety and discomfort. Most premature babies will be placed in specially designed incubators and covered with a special blanket or will have a heated open cot. These will keep their body at the right temperature, but at the same time they will be monitored by the medical staff.

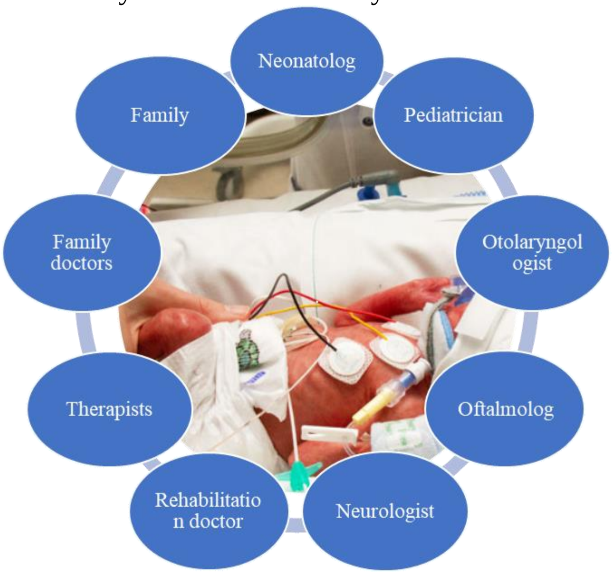

Fig. 1. The staff involved in the care and monitoring of the premature babies

The monitors will beep to alert staff if the child's breathing or heart rate is outside normal limits.

The following participate in the care and monitoring of premature babies:

- Specialized nurses: Each child in a NICU has an individual nurse at the bedside. This nurse is highly qualified, having additional studies in breastfeeding newborns, in addition to a nursing degree. The child nurse will be able to tell the most things about the condition of the child, the parents.
- There are also section managers NICU usually a nurse who is in charge of the whole unit.
- Neonatologists: Facilitate the adaptation of the premature baby and monitor the vital functions. Recommends nutrition and prescribes treatment, makes recommendations to other specialists.
- The Otorhinolaryngologist: treats infections of the nose, throat and ears, indicates audiological testing.
- The Ophthalmologist: performs the ophthalmological examination in the maternity ward, establishes the diagnosis, treats and dynamically follows the changes related to retinopathy of prematurity, prescribes the treatment.
- Neurologist: periodically examines for the detection of neuro-motor, social, cognitive developmental delay, prescribes treatment and makes recommendations if necessary.

- Therapists: a physiotherapist participates who positions the child, does gymnastics and corrects bad positions; the speech therapist helps to recover swallowing/feeding deficits; the psychologist participates in the attention deficit testing and the occupational therapist in the acquisition of life skills.

In the NICU there are also other professionals to help both parents and premature babies, these are social workers and pastoral workers. These staff can communicate and help with answers to some of the challenges of having a baby in the NICU – for example, worry and anxiety, family complications or concerns about the baby's development.

The care of the premature child in the NICU is aimed at the assessment and individualized care for the development of premature children. It focuses on the needs of the child and their family.

The need to reduce the child's stress during daily medical care by protecting sleep, reducing noise and providing body and soul warmth through the involvement of parents.

Parents are the ones who create a family environment full of love, warmth in which both parents are involved in the growth and development of the child.

Nurses follow each baby carefully and determine all their individual needs, form a complete picture of how the premature baby reacts and copes.

2. THE IMPORTANCE OF FAMILY INVOLVEMENT IN THE CARE OF PREMATURE INFANTS.

Family-centered care in the NICU is considered the best approach to care. It is a method of having a team that has a common goal, the well-being and proper development of the premature. Choosing the treatment and monitoring the condition of the premature child with the involvement of family members is a considerable support.

Positioning and handling premature babies are important for developing movement and helping the baby feel safe. Premature children are observed to be physiologically hypotonic [1-3], subject to the effects of gravity and immobilization on a firm surface for prolonged periods. Malpositioning can lead to postural disturbances, such as muscle imbalances and the development of a “flattened posture” [3-4], which have the potential to impact future development [5-7]. Correct positioning of preterm infants can reduce these disorders without harmful effects [6], [8-10]. The benefit of correct positioning is increased comfort and reduced stress in children [8-11].

The therapeutic positioning represents the recommended positions (table 1.) for the care of premature babies, these are the following inclined, supine and side lying. Some assistive tools are also used only in the hospital premises such as a blanket roll and the nest.

A nest gives the premature baby boundaries to push, which will remind him of the limits he had in the womb. Pushing against the edge of the nest will make him feel comfortable, safe and calm. It will also strengthen their bones and muscles.

Creating a nest is done in a few simple steps (figure 2):

• A "nest" is created using diapers or rolled blankets (depending on baby's size) in a "U" shape to provide boundaries against and minimize the effects of gravity.

Fig. 2. Steps in Creating a "Nest"

• Cover the rolled blanket with foil, flattening the top of the "U" shape and emphasizing the curve by conforming the wrap around the curve.

Premature babies love the feeling of a nest around their body and head. The child should be able to freely move his hands towards his face or change his position. A "cocoon" can be used to make the baby feel even tighter. This is done by placing a sheet over the baby's back and around the nest.

3. RESEARCH METHOD

The study focused on identifying the main positions recommended by the medical staff who care for premature babies that contribute to their growth and development. The preparation of some guides for parents would be useful sources of information and satisfaction of an efficient mechanism of collaboration between parents-children-medical staff.

Newborn positioning guidelines and practices should support optimal infant positioning and sleep while performing essential care giving activities. When developing guidelines for positioning practices, the following are recommended:

• appropriate standardized positioning strategies using alternative positioning media. Children positioned with alternative supports rather than traditional positioning methods (blanket rolls) have less asymmetry at hospital discharge [12];

• the premature baby positioned and handled in flexion, maintains alignment during all nursing activities;

• the position of the premature infant is evaluated with each experience and modified to support symmetrical development;

• positioning supports are removed in preparation for sleep.

Table 1. The recommended positions are as follows:

Position description	Figure
The inclined position (Figure 3.): a. Keep the head in a neutral position or with the chin slightly tilted towards the chest, to avoid hyperextension of the neck. b. Hands are allowed to be in close proximity to the face. c. Keep the shoulders rounded and fall forward using a baby nest (or similar positioning aid). d. The legs are kept hidden under the body and supported with limiters. e. Total hip abduction (frog-leg position) is avoided. f. A linen roll is placed under the chest and abdomen for support. g. Ensures hips are positioned below head level.	 **Fig. 3**
Lateral lying position (Figure 4.): a. Keep the head in the middle position. b. Supports the back and neck in a "C" shape. c. Keep the upper shoulder in a neutral (not retracted) position. d. Support is provided so that the back is slightly rounded. e. Hip and knee flexion is encouraged. f. Keep the legs flexed with limits for leg support. g. Support the side-lying position with swaddling or a heavy blanket roll around the infant's flexed back, this position will promote hands-together or hands-to-face movements in the midline.	 **Fig. 4**.
The supine position (Figure 5.): a. Keep the head on the midline or as close to the midline as possible. b. Avoid excessive neck flexion/neck extension and maintain slight neck extension especially for extreme preterm infants in order to have the head in a neutral position. c. Keep the shoulders rounded forward. d. Support (a roll of linen) is provided behind the shoulders to keep them slightly forward. e. Support the legs in flexion against strong limits for the leg to support. f. Hip and knee flexion is encouraged. g. Aids are used to achieve optimal positioning, such as a nest, blankets, linen rolls, and sheepskin.	 **Fig. 5.**

Bent and symmetrical postures are promoted by encouraging:

• Flexion and adduction of the shoulder and hip.

• Neutral ankle alignment with dorsiflexion. Neutral alignment of the head and neck whenever possible. Trunk flexion.

• Providing positioning aids and bedding according to the individual needs of the preterm: soft bedding such as sheepskin, nests and safe limits or swaddling should be used to maintain a comfortable position and prevent skin problems. Water blankets or gel or water pillows are recommended to avoid abnormal head formation.

• Alternating position every 2 to 3 hours or when care is needed.

• Avoiding the use of oversized diapers, which can lead to hip external rotation and "frog leg" abduction.

• Ensure proper positioning of lines (such as endotracheal tube, nasogastric or nasogastric tubes, cardiac leads, or intravenous lines) to prevent tension, which can lead to deformation.

• Monitoring of breathing, color, oxygen saturation, heart rate, respiratory rate.

• Monitor the infant for behavioral cues that suggest discomfort and the need to change position.

• Observing each developing infant's ability to determine appropriate positioning and bed positions.

• Preparing the child before discharge by gradually removing limits and positioning aids.

• Initiate supine positioning before discharge so that children can adapt to sleeping positions at home [13-17].

4. RESULTS

The models developed as a result of the research carried out are original and designed in accordance with the requirements imposed on clothing for premature babies.

The clothing products were made of natural materials (100% cotton), which will allow the child's skin to breathe and provide protection against various chemicals and pathogens. The elements of the products were processed by edging, and the ends of the products were processed by covering seams. The designed products meet all the requirements and standards related to the manufacture of clothing for premature babies who have low weight.

Therefore, the functionality of the products was achieved by:

- structural elements for folding the front and back elements;
- closing systems positioned on the ends of the products, by simply attaching staples to the side lines, shoulders, product termination, etc.

The functional products proposed for this category of wearers are shown below and were dressed on a 44 cm mannequin:

a) b)

Fig. 6. Functional clothing products: a) overalls with sleeves; b) bodysuit with sleeves.

As a result of the recommendations and observations made by the medical staff, the clothing products were designed according to the need to facilitate the provision of medical assistance in a short time and efficiently to premature babies in the NICU. The development of models of clothing products for prematurely born children took into account the following aspects:

• They meet the requirements, are functional and ensure good thermal insulation and monitoring of the child. and perform the following functions: functionality, thermal insulation and monitoring;

• Facilitates the following medical procedures:

- connecting to medical equipment for monitoring temperature, cardio-respiratory system, heart rate, respiratory rate;
- fixing therapy equipment (catheters, etc.);
- medical control to monitor the health status of the child.

5. CONCLUSIONS

Premature babies in the NICU are recommended the following: less noise, suitable lighting, minimizing pain, minimizing handling, avoiding strong smells, involving parents, relaxing as much as possible; care must be in quiet, separate, comfortable areas, and performed by the same responsible medical staff.

The benefits of the products depending on the correct positioning of the children.

The positioning of the premature baby in the NICU will be carried out by the competent staff, special attention will be given to those born prematurely under 32 weeks of pregnancy.

It is proven that the correct positioning of the premature has the following benefits:

✓ To provide postural support that has both an immediate and lasting impact on child development.
✓ To improve the shape of the head.
✓ To help protect fragile skin and joints.
✓ To promote flexion, proper alignment, isolation and comfort.
✓ To promote neurobehavioral and neuromotor stability of the infant.
✓ To improve oxygenation and support reduced activity and crying.
✓ To restore the state of sleep and increase the time spent in peaceful sleep.
✓ To reduce unnecessary energy expenditure and stress.
✓ To facilitate self-soothing behaviors and help the infant's organizational ability.
✓ To provide sensory exploration of self and environment.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

CREATIVE SOLUTIONS FOR THE USE OF TEXTILE WASTE

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Abstract: *The paper provides practical information on the process of valorization of textile waste. Different types of products are made from industrial and consumer waste, such as redesigned clothing, women's accessories, bags, women's purses, etc. The work presents the way of making several small accessories, respectively necklace models and earrings, made from the waste resulted in the workshop. The authors chose to make denim accessories because as we know denim is a type of fabric, usually made of cotton, and cotton is a vegetable fiber. Cotton fabrics are versatile, with good durability, breathable, hypoallergenic, with very good capacity of retaining dyes, with good resistance to abrasion, all this making it a material preferred by those who make accessories, because it provides wearing comfort. Unlike other textiles, cotton lets the skin breathe, especially during warm periods, thus naturally preventing the appearance of sweat. Both the necklace and the earrings are made from a piece of material extracted from denim waste. It was unfolded and checked from an aesthetic and qualitative point of view, on the grounds of texture and uniformity of color, then strips of material were cut out, which were assembled piece by piece, twisted, glued, and at the end for added value, decorative elements were applied.*

Key words: *waste, clothes, upcycling, accessories, denim.*

1. INTRODUCTION

According to the analysis conducted by Boston Consulting Group [1] for the Copenhagen Summit "Pulse of the Fashion Industry 2017" out of a total of 2.1 billion tons of waste produced annually worldwide, 4%, representing 92 million tons, is produced by the fashion industry.

Over 35% of the pre-consumption waste is generated in the primary processing phase of the raw material, of which 9% is in the production of fibers and 91% in the technological operations of product manufacturing (spinning, knitting, weaving and textile manufacturing).

This analysis also shows that the processing and recycling of post-consumer textile waste is quantitatively and technologically limited. In this case, 80% of post-consumption waste ends up in landfills and incinerators, and only 20% is recycled or reused [1].

Textiles are a fundamental part of our daily lives and an important sector of the global economy [2]. However, the current system of production, distribution and actual use of textiles generates a lot of waste and pollution, putting the planet at risk and contributing, along with other factors, to global warming [2].

Moreover, it puts pressure on current resources, pollutes and degrades the environment and creates a negative impact at local, regional and global level.

2. GENERAL INFORMATION

Less than 1% of the materials used to produce clothes are recycled and converted into new clothes, and only 13% of all these materials go through a downcycling process and end up being reused as different creative objects [3]. Downcycling is the term used to describe a recycled product that is not as structurally strong as the original product made from virgin materials. Downcycled materials can therefore only be used to make a different type of product than the original [4].

Fig. 1: Recycled materials and products

In recent years, industry and small workshops have become much more aware of the negative impact that the overconsumption of textiles has on the environment and have begun to take steps towards adopting a sustainable policy, encouraging the collection and recycling of waste through its reuse [5].

The economic necessity but also the pandemic period, determined us to start working with textile waste, giving it another destiny, approaching different creative techniques, then this habit even became a priority in our own workshop. Each piece of material has its value and can be used no matter how small and insignificant it may be to create something special and unique [6].

The result of clothing manufacturing is a fairly significant quantity of textile waste of different sizes, textures and shapes, which can be reused in the manufacturing of other products, equally useful, such as: bags, key chains, brooches, necklaces, earrings, mats, accessories. Quality execution of all the above, will ensure both the aesthetic appearance and the resistance in exploitation.

The waste resulting from the manufactures is to be sorted and classified from a dimensional, chromatic and textural point of view [7].

In the textile industry there are currently studies that offer useful solutions for understanding the product development processes for the fashion industry in order to rethink, reuse or recycle waste at the production stage [8].

These studies propose a new connection between the different components of the value chain: design, production, marketing to create fashion items so that, where possible, this waste is used to create new products, and the advantages of implementing this solution are highlighted [8]. This strategy can be successful by integrating the vertical value chain, by strengthening the creative department, fashion design and by engaging in marketing and sales [8].

A number of basic principles are observed in the process of creating objects, namely:

- ✍ choosing the object with the proposed one;
- ✍ rational waste sizing;
- ✍ correlation of the shape of the product with the shapes of the component parts;
- ✍ the appropriate choice of materials from a textural point of view;
- ✍ chromatic choice.

After selecting the pieces of material, the harmonious images are outlined in mind, then a sketch of the model is drawn reaching the desired shape, then it is proceeded to execution using different techniques depending on the need, either gluing, sewing, twisting, rolling, cutting, or combined with each other and at the end the shape will be improved, retouched and finished to give birth to totally original accessories. Extremely important are also elements of décor, which must be in symmetry and in harmony with the proposed model. Another extremely important aspect is the economic one, to be evaluated from a financial point of view. The material, the duration and complexity of the execution together with other components that contribute to the final result are all taken into account.

In this paper we chose to show how to make several small accessories, namely necklace models and earrings, made from the waste resulting from the workshop.

We chose to make denim accessories because as we know denim is a type of fabric, usually made of cotton, and cotton is a vegetable fiber.

Cotton fabrics are versatile, with good durability, breathable, hypoallergenic, with very good capacity of retaining dyes, with good resistance to abrasion, all this making it a material preferred by those who make accessories, because it provides wearing comfort.

Both the necklace Figure 1.a, and the earrings Figure 1.b, are made of a piece of material extracted from denim waste that was unfolded and checked from an aesthetic and qualitative point of view, on the grounds of texture and uniformity of color. Then strips of material were cut out and were assembled piece by piece, twisted, glued, and in the end for added value, decorative elements were applied as evidenced by Figure 1.a. Figure 1.c shows the complete set of accessories.

The necklace made of various synthetic textiles Figure 1.e, is thought out and sketched in such a way that it can be worn at the neck. This necklace is made of a variety of small textile wastes that have been rolled piece by piece Figure 1.d, keeping a chromatic, after which they were glued together and finally attached to each other with wire for fastening. Two more rolls were attached at the end to be able to support the necklace at the neck as evidenced by Figure 1.f.

The necklace in Figure 1.h, is made of felt Figure 1.g, a textile waste resulting from the manufacture of previous garments. Green and turquoise color was chosen because these colors are extremely vibrant. For example, the color green is the color of hope and balance, it is a balm for the soul and body, it offers the feeling of freedom and those who have problems accepting some situations need this color. Turquoise is a mixture of blue and green color, which gives a feeling of calm, it is associated with meanings of femininity, sophistication and energy. For the execution, the technique of rolling the material was chosen, then the edges were finished for a clean look, and at the end a silk ribbon was attached so that it could be fixed to the neck as evidenced by Figure 1.i.

5. CONCLUSIONS

The volume of textile waste is constantly increasing due to multiple factors such as population growth, the adoption of Western consumption patterns by developing countries, etc.

A significant percentage of textile waste is represented by materials made of cotton and polyester, which are the most studied materials in research on waste recovery.

In most cases, the recycling of textile waste consists of a mixture of chemical, mechanical and thermal processes.

The recovery and reuse of textile waste can be done permanently, down to the smallest details and through their recovery we can create objects from decorative to the most useful.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

THEORETICAL ASPECTS REGARDING THE EUROPEAN LEGISLATIVE ACTS RELATED TO TEXTILES

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Abstract: *The textile industry is one of the most flourishing and developed at the level of the European Union and as a result, being such an important field, it is imperative to have some legislative acts at the European level in order to regulate and harmonise the conduct of the Member States. The main goal of the Regulation No 1007/2011 of the European Parliament and of the Council is to set up common rules on both fabric names and the composition of textile products and, at the same time, to harmonise the indications that appear on the labels, markings and documents which accompany such products throughout the process of their production and distribution. In addition to this Regulation, there are other normative acts at the level of the European Union with a particular impact on the textile industry. We are taking into consideration, alongside with the above-mentioned Regulation, the Directive 2001/95/EC of the European Parliament and of the Council, which refers to the general product safety and other acts in connection with these. The aim of this paper is to briefly present the provisions of these legislative acts, as they are closely connected to the textile industry.*

Key words: *legal framework, textile products, labelling, making, safe product*

1. INTRODUCTION

As the textile and clothing industry is one of the most important in the European Union, a special attention must be given to the legal acts that are related to it. First of all, we are talking about the Regulation (EU) No 1007/2011 of the European Parliament and of the Council on fibre names, related labelling and marking of the fibre composition of textile products, but there are also other legal acts that we will take into consideration.

2. REGULATION NO 1007/2011

This Regulation is a very important one and it has been applied in the European Union since 8 May 2012. Its importance results from the fact that it emphasizes the element of a proper information of the consumers. At the same time, another aim of this Regulation is to guide the proper functioning of the internal market by eliminating obtacles such as different provisions at the level of internal law of the Member States, by creating a unitary legal framework regarding the names, the labelling and marking the fibre composition of textile products.

In article 3 of the Regulation there are presented the definitions of some used terms, like "textile product", which means "any raw, semi-worked, worked, semimanufactured, manufactured, semi-made-up or made-up product which is exclusively composed of textile fibres, regardless of the mixing or assembly process employed" and "textile fibre", which means either of the following "(i) a unit of matter characterised by its flexibility, fineness and high ratio of length to maximum transverse dimension, which render it suitable for textile applications; (ii) a flexible strip or tube, of which the apparent width does not exceed 5 mm, including strips cut from wider strips or films, produced from the substances used for the manufacture of the fibres listed in Table 2 of Annex I and suitable for textile applications". Also, "labelling" means "affixing the required information to the textile product by way of attaching a label" and "marking" means "indicating the required information directly on the textile product by way of sewing, embroidering, printing, embossing or any other technology of application" [1].

Regarding the subject of labels and marking, article 14 provides that "textile products shall be labelled or marked to give an indication of their fibre composition whenever they are made available on the market. The labelling and marking of textile products shall be durable, easily legible, visible and accessible and, in the case of a label, securely attached". It can be easily observed that all of these provisions are for the benefit of the consumers and have the role of protecting them.

The article 15 of the Regulation contains the obligations that are on the behalf of the manufacturer, "when placing a textile product on the market, the manufacturer shall ensure the supply of the label or marking and the accuracy of the information contained therein. If the manufacturer is not established in the Union, the importer shall ensure the supply of the label or marking and the accuracy of the information contained therein. A distributor shall be considered a manufacturer for the purposes of this Regulation where he places a product on the market under his name or trademark, attaches the label himself or modifies the content of the label" [1].

The textile fibre composition description "shall be indicated in catalogues and trade literature, on packaging, labels and markings in a manner that is easily legible, visible, clear and in print which is uniform as regards its size, style and font. This information shall be clearly visible to the consumer before the purchase, including in cases where the purchase is made by electronic means" [1], as shown in the article 16 of the Regulation.

To summarize, the Regulation (EU) No 1007/2011 on textile fibre names and related labelling and marking of the fibre composition of textile products provides a multitude of legal requirements on the use of textile fibre names and related labelling and marking of fibre composition of textile products that have to be fulfilled when they enter on the European Union market. Therefore, textile labels must [2]: be labelled, marked or accompanied with commercial documents in compliance with the Regulation, according to its article 4; be easily legible and visible, in order to be accessible for the consumer; be durable in time and securely attached to the product; give indications of the fibre composition; use only the textile fibre names provided by the Regulation for the description of fibre compositions; the situation of the presence of non-textile parts of animal origin in the textile products, shall be indicated by using the phrase "Contains non-textile parts of animal origin" on the labelling or marking, at the time that these types of products are made available on the market; use the official language/languages of the Member State in which the textiles are made available on the market.

However, there are some exceptions for listing the fibre composition, for example, in the case of visible, isolable fibres which are purely decorative and, at the same time, do not exceed 7% of the weight of the finished product do not have to be considered in the fibre compositions. Besides this, wash care labels, country of origin, size label, and manufacturer identification are not specifically required by the Regulation (EU) No 1007/2011. As a consequence, it is strongly recommended to include this information as certain individual Member States may require such information, or they might be covered by other legislations or industry standards.

The Regulation also lays down rules on checking the conformity of the fibre composition of textile products with the supplied information related to the fibre composition of those products in accordance with the European provisions. This activity of verifying is carried out by the countries´ market surveillance authorities.

3. DIRECTIVE 2001/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

Another European act that can be considered as having a connection with the textile industry, more precisely with the protection of consumer rights is the Directive 2001/95/EC of the European Parliament and of the Council, which is applicable since 2002 and had its last update in 2010 [3]. This Directive refers to the general product safety. The Directive reveals the importance of consumers´ health and safety protection, by assuring that only safe products will be available on the market. In the terms of the Directive, the "product shall mean any product — including in the context of providing a service — which is intended for consumers or likely, under reasonably foreseeable conditions, to be used by consumers even if not intended for them, and is supplied or made available, whether for consideration or not, in the course of a commercial activity, and whether new, used or reconditioned" [4].

At the same time, "safe product shall mean any product which, under normal or reasonably foreseeable conditions of use including duration and, where applicable, putting into service, installation and maintenance requirements, does not present any risk or only the minimum risks compatible with the product's use, considered to be acceptable and consistent with a high level of protection for the safety and health of persons, taking into account the following points in particular: (i) the characteristics of the product, including its composition, packaging, instructions for assembly and, where applicable, for installation and maintenance; (ii) the effect on other products, where it is reasonably foreseeable that it will be used with other products; (iii) the presentation of the product, the labelling, any warnings and instructions for its use and disposal and any other indication or information regarding the product; (iv) the categories of consumers at risk when using the product, in particular children and the elderly" [4].

It is obvious that the provisions of this Directive refer to a large category of products or goods, including the textile ones. There are identified a number of rules that have to be taken into account when classifying a product as being safe and shows which types of goods should not be sold into the internal market. Producers have the obligation to put on the market only safe products, taking into consideration the European provisions regading the safety of the product in question, the specific rules of the national law of the State Member in whose territory the product is marketed, but also the consumers´ expectations regarding the safety of the product. The Directive also points out the fact that there exists a European network of the authorities of the Member States competent for product safety, which works under the European procedures, especially RAPEX.

In accordance with article 5 of the Directive, "producers shall provide consumers with the relevant information to enable them to assess the risks inherent in a product throughout the normal or reasonably foreseeable period of its use, where such risks are not immediately obvious without adequate warnings, and to take precautions against those risks" [4].

Regarding textile products, we can think, for example, of the cases when different chemicals are used in the procees of producing the product. In close connection to this subject, there is the Commission Decision of 5 June 2014 establishing the ecological criteria for the award of the EU

Ecolabel for textile products. As it is shown, "the Ecolabel criteria reflect the best environmental performing products on the market of textiles. Whilst the use of chemical products and release of pollutants is part of the production process, a product that bears the EU Ecolabel guarantees the consumer that the use of such substances has been limited to the extent technically possible without prejudice to the fitness for use" [5]. Also, the REACH Regulation 1907/2006 was adopted to improve the protection of human health and the environment from the risks that can be posed by chemicals, while enhancing the competitiveness of the EU chemicals industry.

Last, but not the least, the Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) has a connection with the treated subject. As we have already shown in a previous paper [6], 10% of the global greenhouse gas emissions is caused only by the fashion industry, even more than the international flights and maritime shipping together. As it is mentioned in the Directive, "in order to prevent, reduce and as far as possible eliminate pollution arising from industrial activities in compliance with the 'polluter pays' principle and the principle of pollution prevention, it is necessary to establish a general framework for the control of the main industrial activities, giving priority to intervention at source, ensuring prudent management of natural resources and taking into account, when necessary, the economic situation and specific local characteristics of the place in which the industrial activity is taking place" [7].

4. CONCLUSIONS

As a conclusion, the European Regulations and Directives presented have a great importance on the well-functioning of the internal market, as they set up rules that apply to all of the Member States and have the role of harmonising the provisions related to the textile industry. It is crucial that the consumers are well informed about the textile products that are available on the market, so that can make the best choices in their interest.

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ANNALS OF THE UNIVERSITY OF ORADEA
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EFFECTS OF DIFFERENT FINISHING AGENTS ON COLOR STRENGTH VALUES OF SUBLIMATION TRANSFER PRINTING OF COTTON FABRICS

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Abstract: *Sublimation transfer printing is based on printing the disperse dyestuff onto the transfer paper and contacting the printed transfer paper with the fabric under temperature and pressure. The dispersed dyestuff in the transfer paper is transferred to the fabric by passing from the solid phase to the gas phase with temperature. Sublimation transfer printing has some advantages such as low investment cost compared to conventional printing machines, less space requirement, etc. However, sublimation transfer printing is only suitable for synthetic fibers, especially polyester fibers. This limits the use of this type of printing. In recent years, research on the possibilities of using sublimation transfer printing in the printing of natural fibers has been increasing. The present work investigated silicone agents for the sublimation transfer printing of cotton in terms of color and fastness properties. The process variables were also investigated, such as printing temperature and time. In this study, hydrophobic macrosilicone, hydrophobic microsilicone, hydrophilic macro silicon, hydrophilic microsilicone, dimethylol dihydroxy ethylene urea, and fluorocarbon were used. Two concentrations of finishing agents were applied (30 g/l before printing and 15 g/l before printing + 15 g/l after printing). Three different printing times (30 sec., 50 sec. and 90 sec.) and temperatures (180ºC, 200ºC and 220ºC) were also applied. Color strength values of printed fabrics were investigated.*

Key words: *silicone, dimethylol dihydroxy ethylene urea, fluorocarbon, dispers dyes, cotton, sublimation printing.*

1. INTRODUCTION

Recently, sublimation transfer printing has attracted attention due to advantages such as, simplicity of process, space requirement, and relatively investment cost. The process is based on the transfer of dispersed dye in the vapor form from paper to fabric. Sublimation transfer printing was first discovered coincidental by a researcher name was Kartaschoff, who was from Celanese, during a set of experiments with disperse dyes and acetate fibers However process has important limitations that disperse dyes have no interaction with natural fibers. A few studies were done at using sublimation transfer printing for cellulosic fibers. Three prominent processes are focused by researchers. The first one is changing the ink formulation using appropriate polymers, the second one is using a sandwich layer, which is a film, and the third one is modifying the cellulose using resins, finishing agents , etc [1-4]. Cellulosic/polyester fibre blends, such as linen/polyester and cotton/polyester, also had been attracted by researches due to the difficult applicability of disperse dyestuffs [5,6]. Recently, nano-level coating processes such as layer - by - layer offer the opportunity to apply in this area [7].

2. EXPERIMENTAL

2.1 Material

In this study, 100% cotton, 240 g/m^2 unit weight 2x2 panama woven fabric was used. The fabric was provided to be ready for dyeing. Untreated packing paper, which had 50 g /m^2 unit weight, was used as a transfer printing paper. Inks (CMYK) were provided by Dyestar. The silicones were kindly supplied by Rudolf Duraner, which are listed in Table 1.

Table 1: Silicones

Trade Name	Chemical Structure	Function	Curing Conditions
RUCOFIN GWE	Polysiloxane compound nonionic	Hydrophobic macrosilicone	2 min. at 150°C
RUCOFIN GWS	Polysiloxane compound nonionic	Hydrophobic microsilicone	1 min. at 170°C
RUCOFIN GES	Quaternized Polysiloxane compound cationic	Hydophilic microsilicone	3 min. at 150°C
RUCOFIN GSQ 200	Polysiloxane mixture cationic	Hydrophilic macrosilicone	3 min. at 150°C
RUCON FAS	Dimethylol dihydroxy ethylene urea	Crosslinking agent	1 min. at 170°C
RUCOSTAR EEE6	Fluorocarbon dendrimers	Fluorocarbon	2 min. at 150°C

2.2 Methods

Application of finishing agents was done by the padding method using a vertical flouard (Ataç, Turkey). The take up value was 90%. After padding, all samples were dried at 105 °C using a laboratory type oven. The pH of the distilled water to be used before the process was adjusted to pH 4.5 with acetic acid. Two experimental sets were formed. The first set was the application of finishing agent at 30 g/l concentration before printing and the second set was application at 15 g/l concentration before and after printing. Printings were made at different temperatures and times to investigate the influence of these variables on the print quality. Therefore, printings were applied at 3 different temperatures such as 180°C, 200°C and 220°C. Variables were 30 seconds, 50 seconds, and 90 seconds for time. The printing process was done only the top plate, which was heated in the sublimation test equipment with SDL Atlas M2478 iron. The color strength of the printed fabrics was determined according to Kubelka-Munk formula (1) using a Minolta (3600D) spectrophotometer (D65, 10°).

$$K/S = (1-R)^2/2R \quad \textbf{(1)}$$

3. RESULTS AND DISCUSSION

Color strength (K/S) values of untreated printed fabrics are depicted in Figure 1. The highest value was obtained at 200 °C and 90 s.; however, all values were observed below 1. This situation is well known because of no affinity of disperse dyes to cellulose.

Figure 2 shows the color strength values of hydrophilic microsilicone -treated fabrics. The results were higher than the untreated fabrics and the highest value was obtained at 200 °C and 90 sec.

in the case of 30 g/l concentration of finishing agent. Color strength values of hydrophilic macrosilicone - treated fabrics are depicted in Figure 3. The highest color strength value was obtained in the case of 30 g/l finishing agent concentration (before printing), 30 sec. printing time and 200ºC printing temperature. The differences between macro and microsilicone are not significant.

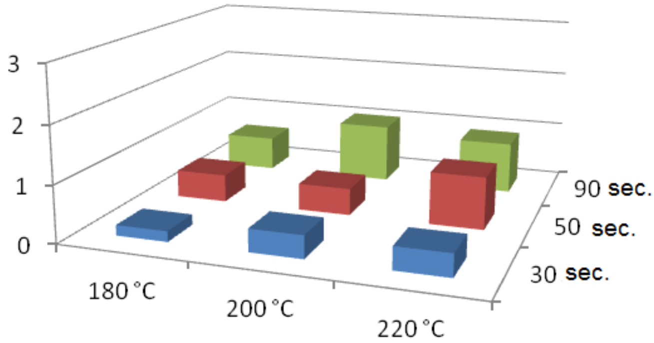

Fig. 1: K/S of Untreated Fabrics

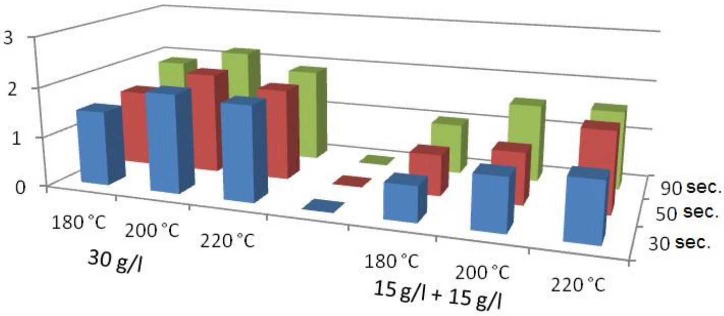

Fig. 2: K/S of Hydrophilic Micro Silicone Treated Printed Fabrics

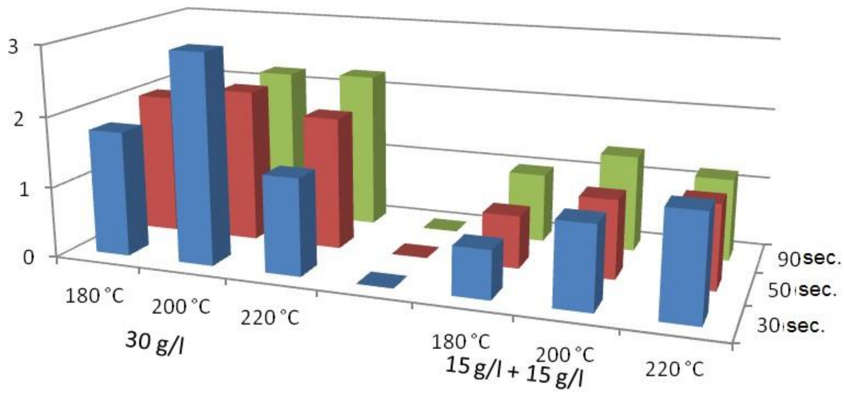

Fig. 3: K/S of Hydrophilic Macro Silicone Treated Printed Fabrics

Hydrophobic macrosilicon applied samples are exposed to sublimation transfer printing with different concentrations, temperature and process time. K/S values of the samples after printing are given in Figure 4. When the values are examined, the effects on K/S of concentration difference of these two values are found to be lesser than the sample hydrophilic finishing treatment applied. The highest K/S value is obtained from the concentration 15 g/L+15 g/L. printing conditions in 220°C and 30 seconds. K/S values of the that is hydrophobic microsilicon applied samples after sublimation transfer printing are given in Figure 5. The highest K/S value is obtained from the concentration 15 g/L+15 g/L in 200°C and 90 seconds.

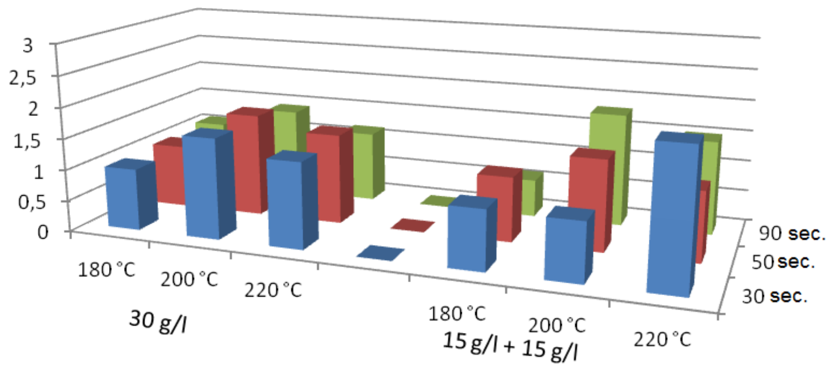

Fig. 4: K/S of Hydrophobic Macro Silicone Treated Printed Fabrics

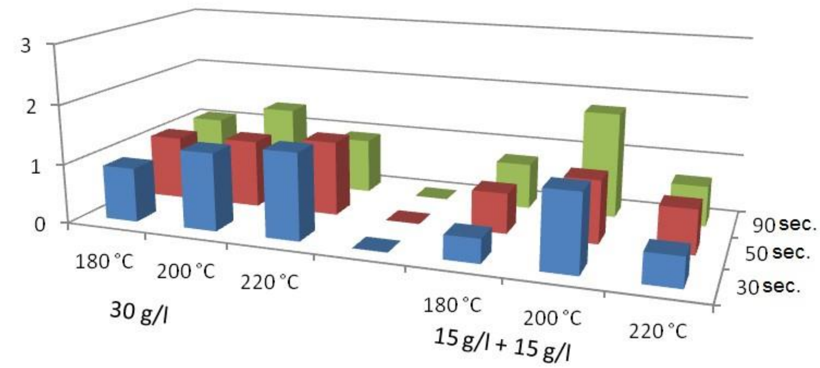

Fig. 5: K/S of Hydrophobic Micro Silicone Treated Printed Fabrics

K/S values of the RUCON FAS, which is a crosslinking agent (DMDHEU) applied samples after sublimation transfer with different concentrations, temperature, and process time, are given in Figure 6. The optimum process temperature is determined as 200°C. The highest K/S value is obtained in 30 g/L concentration and 90 seconds printing time.

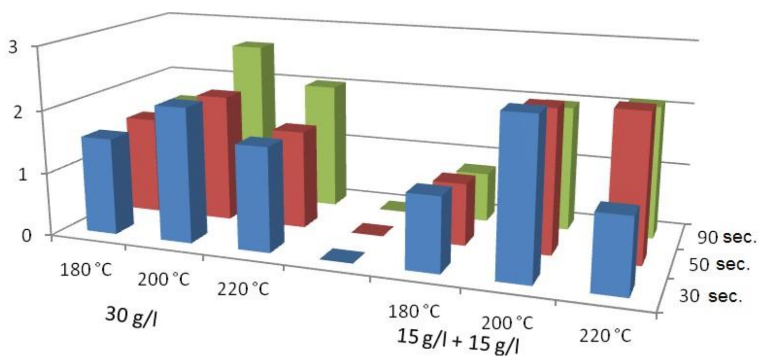

Fig. 6: K/S of DMDHEU Treated Printed Fabrics

K/S values of the RUCOSTAR EEE6, which is a fluorocarbon agent applied sample after sublimation transfer printing with different concentrations, temperature, and process time, are given in Figure 7. The highest K/S value was obtained in 30 g/L concentration, 220°C process temperature, and 30 seconds printing time

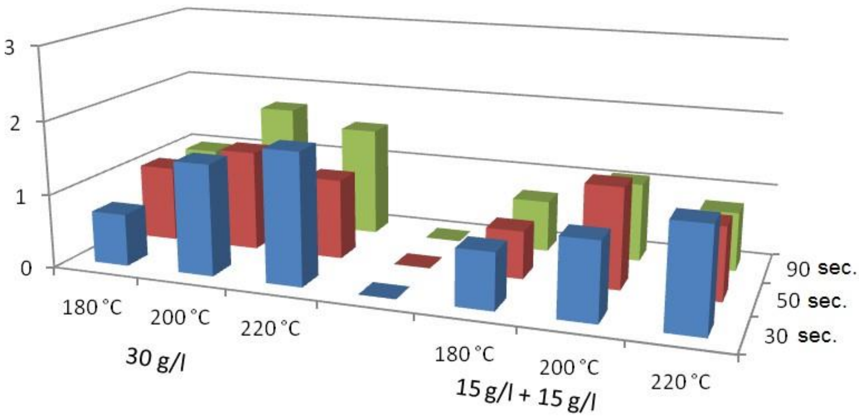

Fig. 7: K/S of Fluorocarbon Treated Printed Fabrics

4. CONCLUSIONS

The reformative effect in color strength (K/S) of the finishing processes is stated when the color yields of the samples (K/S) values were compared with control samples. K/S values of samples treated with especially, hydrophilic silicone and DMDHEU, were determined markedly better according to other samples.

The highest K/S value of the sublimation transfer printing the samples treated with DMDHEU was measured in 200°C, 90 seconds and 30 g/L specific temperature, time and concentration, respectively. However, the highest K/S value of the sublimation transfer printing those samples treated with hydrophilic silicone was measured in 200°C, 30 seconds and 30 g/L. Based on these measurements, the optimum sublimation printing process temperature can be evaluated as 200°C. The optimum sublimation printing process time varies according to the type of finishing treatment. Among the applied finishing treatment concentration, 30 g/L was chosen as the most suitable one.

Especially in the last 20 years, the use of inkjet printing systems in the textile industry has been increasing. Although only applicable for 100% polyester and high polyester content blended products, the fact that sublimation transfer printing has relatively low investment costs, requires very little space, and the method is fast indicates that research on the printing of natural fibers with sublimation transfer printing will increase in the future.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

INNOVATIVE BIO-DYEING TECHNIQUES FOR THE PROMOTION OF TRADITIONAL MOTIFS

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Abstract: *Brands, collections, colors and styles are increasingly being created every season, changing accordingly to the many trends' society generates. People and lifestyle transform rapidly, and so their expectations. With all the demanding adjustments this sector has to currently face, it seems, the industry is facing unprecedented challenges to meet consumer needs. The textile industry is one of the many industries that has the capacity to have a big impact on the environment and society. In the presents that impact leads toward the negative side. It is known that the fashion industry is responsible for 10% of global annual carbon emissions. This creates an urgency for us to reduce the effects the industry has as much as possible. One way is going back what we know from our ancestors and that is bio-dying. The processes of bio-dying successfully exploit the potential of natural biological systems, making industrial activity more environmentally friendly. This paper is the result of using the bio-dying method as a way to be sustainable and, at the same time, bring back the knowledge we have while using contemporaneous technology, by creating a project and products that balances the past and present with the aim of offering people the possibility to preserve memories of the past and now, in the present.*

Key words: *bio-dye, modifiers, semi-natural, fibers, natural ingredients.*

1. INTRODUCTION

Natural dyes offer a sustainable and eco-friendly alternative to synthetic dyes, which can have a significant impact on the environment. The production of synthetic dyes involves the use of petrochemical-based dye intermediates, which can generate hazardous and toxic chemicals that pollute the environment. In contrast, natural dyes are derived from renewable sources, such as plants, insects, and minerals, and their production involves fewer chemical reactions and energy consumption. By using natural dyes, textile products can be produced using a more environmentally friendly process. Bio-mordant and natural finishing agents can also be used in the process, further reducing the environmental impact. Such eco-friendly textile products are considered sustainable because they begin and end their life cycle without causing harm to humans or the environment. Many researchers worldwide are investigating methods to produce more eco-friendly natural dyed textile products to promote the use of sustainable textiles. The use of natural dyes can contribute to a cleaner and greener environment, making it an attractive option for those who want to promote sustainability. [1-3, 10]

Bio-dyes are becoming increasingly popular in the textile industry, as there is a growing demand for sustainable and environmentally friendly products. Bio-dyes can be used to dye natural fibers such as cotton, wool, and silk, as well as synthetic fibers such as polyester, nylon, and acrylic.

One advantage of using bio-dyes is that they can create a wide range of colors, and many of them have excellent color fastness properties. Bio-dyes can be applied to fabrics using a variety of techniques, including exhaust dyeing, cold pad batch dyeing, and continuous dyeing. Another advantage of using bio-dyes is that they can have beneficial properties for the skin. For example, some natural dyes, such as indigo and henna, have anti-inflammatory and anti-bacterial properties that can benefit the skin. [4-6, 10]

2. GENERAL INFORMATION

Bio-dyes refer to dyes that are derived from natural sources and are considered eco-friendly because they do not contain harmful chemicals or pollutants and their production does not harm the environment. Overall, the use of bio-dyes in the textile industry is a promising area of research, and it offers a sustainable and eco-friendly alternative to conventional synthetic dyes. [4-6, 10]

Based on this an experiment was started with different natural materials and modifiers to see what can be obtain by bio-dying natural fibers and textile.

2.1 Bio-Dyeing. First trial

The first step in any dying process is to prepare the fibers and textiles. This is done by weighing the fibers (WoF). We will need the WoF for future recipes for the dyeing process. Everything begins with the scouring process, that is a process in which we clean our fibers.

For the vegetable fibers, unbleached cotton and linen, sodium bicarbonate is used, 2 spoons of sodium bicarbonate to 4l of water. For the animal fibers, wool and silk a warm bath was given to the fibers. [7] The next part is the mordanting step. This is a substance, typically an inorganic oxide, that combines with a dye or stain and thereby fixes it in a material. Alum was selected as the mordant. The ratio is for animal fiber 10-20% of WoF, for plant-based fibers is 10-15% of WoF. After all of the above is done, the preparation of the dye bath was started. Through the vast majority of different natural dyeing options, it was decided to use the next ones: Onion peels, blueberry, red cabbage, avocado pits and hibiscus. Based on this the following colors were obtained. Figure 1 shows the colors obtained by using different coloring substances (onion peels, blueberry, red cabbage, avocado pits and hibiscus), for four types of textile materials (wool, silk, linen, cotton), for three variations of time periods (30 min, 2 hours, overnight).

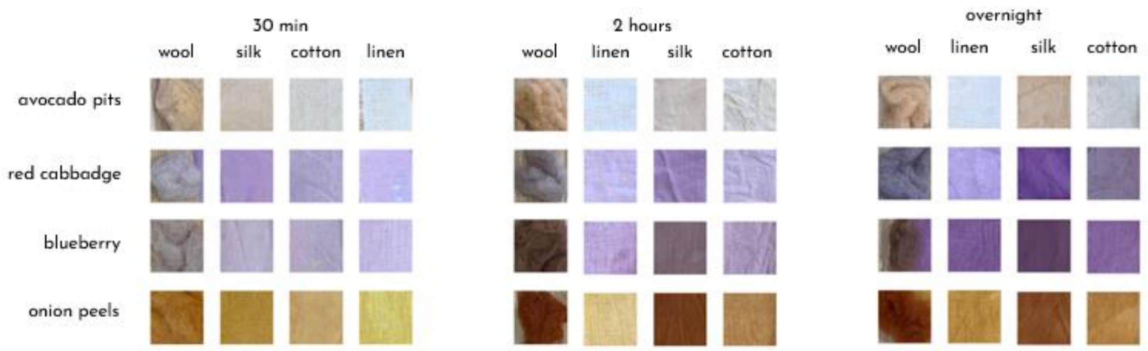

Fig. 1: Bio dye results for simmering the textile in the dye bath 30 min, 2 hours and overnight.

To create even more colors, it was decided to use 4 color modifiers: vinegar, baking soda, iron and citric acid. The used recipe to create the modifiers is: 100 ml vinegar +200 ml water; 25 gr backing soda + 300 ml water; 10 gr iron + 300 ml water; 10 gr citric acid + 300 ml water. Next are the obtained results using these mediums. (Fig.2) [7]

Fig. 2: Results on color modification applied to different type of textile

2.2. Bio-Dyeing. Second trial, semi natural fibers.

Based on the first trials, it was decided to try bio dyeing some semi natural threads. For this the exact same steps mention previously were followed.

First, semi natural threads were selected, 50% cotton and 50% acrylic. Then the threads were weighted. For the semi natural threads 2 spoons of sodium bicarbonate to 4l of water was used. As for mordant Alum Was elected. The ratio was 10 % of WoF.

The most important and interesting part was the dyeing process. Based on the previous experience with the color modifications specific ingredients were used to obtain the wanted colors.

For the greens the blueberry, red cabbage and hibiscus were selected. For a beige and brown colors avocado pits and onion peels were used. And for the red and violets colors beetroot and red cabbage were chosen.

Because the thread is semi-natural, it can be seen that as a result of bio-dyeing the colors are not as intense as in the previous trial. The obtained colors are calmer and pastel. Thanks to the preparation of the fibers and doing the mordant step the fastness of the dyed samples is guaranteed (Fig.3)

Fig. 3: Results of the dye process of seminatural threads

As a way to better see the outcome and to add value to this experiment, it was decided to create a project was the main idea is the combination of the past and the future, the research on these issues being current in the conditions of globalization. [8]

Based on this the work started by first creating working canva by using a laser to cut the canva from felt. (Fig.4) [9]

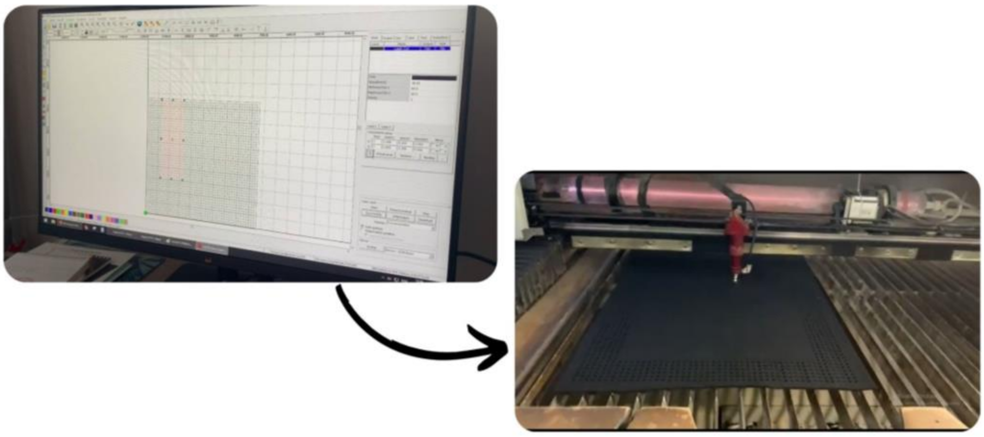

Fig. 4: The process of laser cutting the felt for the canva.

The next step consists of choosing the object that reflect the past and traditions. And so, a traditional embroidery was selected. After carefully selecting the embroidery, the conversion of the pattern began and a virtual embroidery pattern was created, by taking into account the obtained bio-dyed threads and their color. (Fig.5)

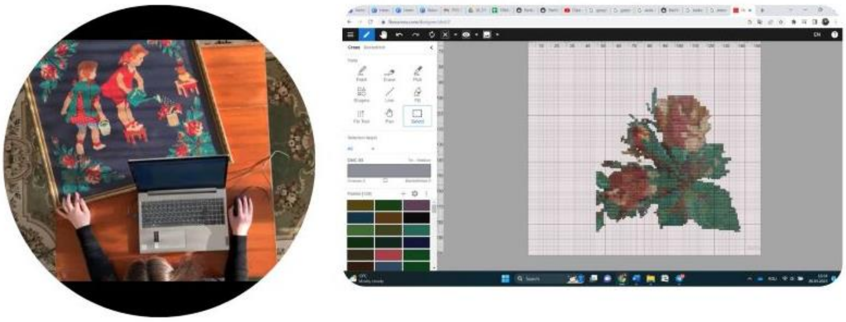

Fig. 5: The process of creating the pattern for the embroidery.

After preparing all the necessary tools and components, the embroidering work started. (Fig.6)

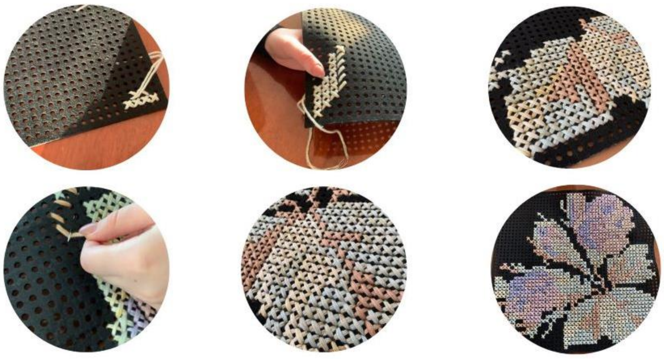

Fig. 6: The process of creating the embroidery.

This project was created with the intention to reflect on the beautiful memories, returning to the primary roots and values of childhood. It is a project that balances the past, traditions, present, and future. The project is a combination of traditional and innovative techniques, created with the aim of offering people the possibility to preserve memories of the past and now, in the present. (Fig.7)

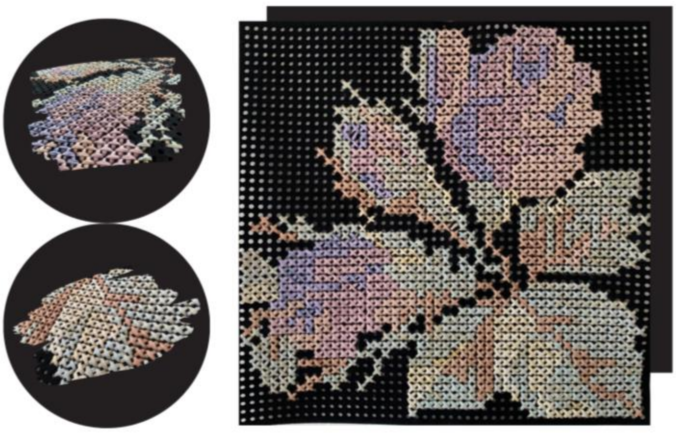

Fig. 7: Embroidery done using the bio- dyed and bio-modified color threads.

5. CONCLUSIONS

The obtained results shows that we bio-dyeing can be used as a way to be sustainable and care for the environment. Additionally, by using bio-dyes we can help support local farmers and communities who grow the natural sources used in the dyeing process. Based on the results we can confirm the semi-natural threads, can be a good option for bio-dyeing. While the natural ones can absorb the dyes better, semi-natural threads can have the advantages of both natural and synthetic fibers, allowing for a wider range of dyeing options. Overall, using bio-dye on semi-natural threads can be a sustainable and eco-friendly choice that supports both the environment and local communities.

As a further research direction, it is proposed to determine the characteristics of the obtained dyed samples.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

A EUROPEAN PERSPECTIVE ON CIRCULAR ECONOMY FOR FIBROUS COMPOSITES AND TECHNICAL TEXTILES

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Abstract: *This paper presents aspects on circular economy of fibrous composites and technical textiles, in the framework of the Erasmus+ project CircuTex, under reference number 2021-1-ES01-KA220-HED-000032075. The project envisages the following results: 1) An e-learning course on circular economy of fibrous composites and technical textiles will be addressed to HEI students and aims to develop the skills in circular economy practices concentrated in fibrous composites and technical textiles. 2) A virtual laboratory for the implementation of virtual experiments was built, to test and apply experiments related to the circular economy of fibrous composites and technical textiles. The laboratory includes virtual "digital twins" of actual laboratory equipment, enhanced with 3D representations and virtual movement. Students will be able to access the virtual laboratory online through their virtual reality glasses. 3) A roadmap to microcredentials created to work on a quality assurance framework for the elearning course and a methodology to apply ECTS points to the course. Actions for the validation of the course and the issuing of digital certificates with the potential to be included in the new European-wide digital format of "Europass Digital Credentials" will be taken.*

Key words: *Erasmus+, CircuTex, technical textiles, fibrous composites, e-learning course, virtual laboratory, microcredentials*

1. INTRODUCTION

High levels of resources, e.g., water, energy, chemicals, raw materials and fibers are used in the textile industry. Sustainable sourcing of fibers, sustainable production technologies, waste and quality control, etc. are becoming important factors for textile companies in terms of sustainability and circular economy, but they must learn continuously to be able to update their expertise on these issues [1].

The circular economy action plan, promoting waste reduction, empowering consumers, and pushing more environmentally friendly product design, such as by establishing a right to repair was presented by the European Commission in March 2020 [2]. The focus of attention is on the industries that use a lot of resources, such as electronics and ICT, plastics, textiles, and building.

A resolution on the new circular economy action plan was adopted by the Parliament in February 2021. It called for additional steps to be taken, such as stricter recycling regulations and binding targets for material use and consumption by 2030 [3], in order to establish a fully toxic-free, environmentally conscious, and carbon-neutral circular economy by 2050. As part of the circular economy action plan, the Commission published the first set of measures in March 2022 to hasten the transition to a circular economy. Improving sustainable products, educating consumers about being green, and looking over building product regulations, and developing a sustainable textiles strategy are some of the proposals.

Created for functionality rather than for aesthetics, technical textiles serve as a raw material for a variety of industries, including the automotive, geotextile, medical device, and agro-food sectors [4]. Technical textile materials are used in specific industrial applications (earthworks, construction, civil engineering, transport, defense, medical, and healthcare) and have a high level of physical, mechanical, thermal, and/or chemical properties.

Textile reinforcements combined with a binding matrix (typically polymeric) create textile composites, which represent a family of materials used in numerous industrial sectors for load-bearing applications. The word "textile" in this context refers to a knitted structure made of yarns, as well as to fibers, filaments, yarns, and the vast majority of items made from them [5]. Textile composites contain a variety of textile structures, including braids, weaves, knits, and nonwoven fabrics.

Technical textiles are ubiquitous in our daily lives and can be found in a variety of settings, including our homes, hospitals, sportswear, cars, and farms. Technical textiles are a practical option for many applications thanks to technology and contemporary materials. However, there are also detrimental social and environmental effects of the industry. The textile industry uses a variety of dangerous chemicals, contributes about one-fifth of the world's industrial water pollution, and produces an important amount of greenhouse gas emissions, especially during the manufacturing and finishing processes [6]. Technical textiles, which have seen rapid growth in recent years, have received much less attention than has been documented. Businesses, consumers, and the environment have all benefited from opportunities for sustainable production. With regard to textile materials in particular, innovation may lead to circular solutions.

2. CIRCUTEX ERASMUS+ PROJECT - MATERIALS AND METHODS

The EU has emphasized the significance of the shift towards a circular economy; consequently, the European Commission adopted the Circular Economy Package, giving industries specific deadlines to meet very precise targets regarding the same. The creation of a micro-credential approach is also a top priority for the EC in order to strengthen the role of higher education institutions in lifelong learning by facilitating more flexible and modular learning opportunities.

The European Erasmus+ project CircuTex has a consortium of 5 European partners (4 universities and 1 Greek company dedicated to learning) being implemented within 2 years starting from March 2022:

- UPV - University Polytechnic of Valencia, from Spain
- KTU - Kaunas University of Technology, from Lithuania
- UNIWA - University of Western Attica, from Greece
- UO - University of Oradea, from Romania
- IDEC - a consulting company, from Greece

The project's goal is to create an online course on the circular economy for technical textiles and fiber composites to assist students in developing their sustainability skills and increasing their awareness of how to lessen the environmental impact of these materials. Additionally, the project will strengthen the training by building a virtual laboratory that will give students the feel of being present in a real lab. A road map for course validation and accreditation will also be developed as part of the project, and this will produce a set of policy recommendations for the adoption and recognition of micro-credentials in the universities of the project partners.

3. RESULTS

The partners were involved in all planned activities, having various tasks, and the activities within the consortium have been distributed based on their previous work experiences as well as their expressed interest. Even after the project is finished, the activities will be carried out to achieve the project results and achieve the project objective.

3.1. IO1. E-learning course on circular economy of fibrous composites and technical textiles

The project's first output was the creation of a 5-module e-learning course titled "Circular Economy of Fibrous Composites and Technical Textiles," as shown in figure 1.

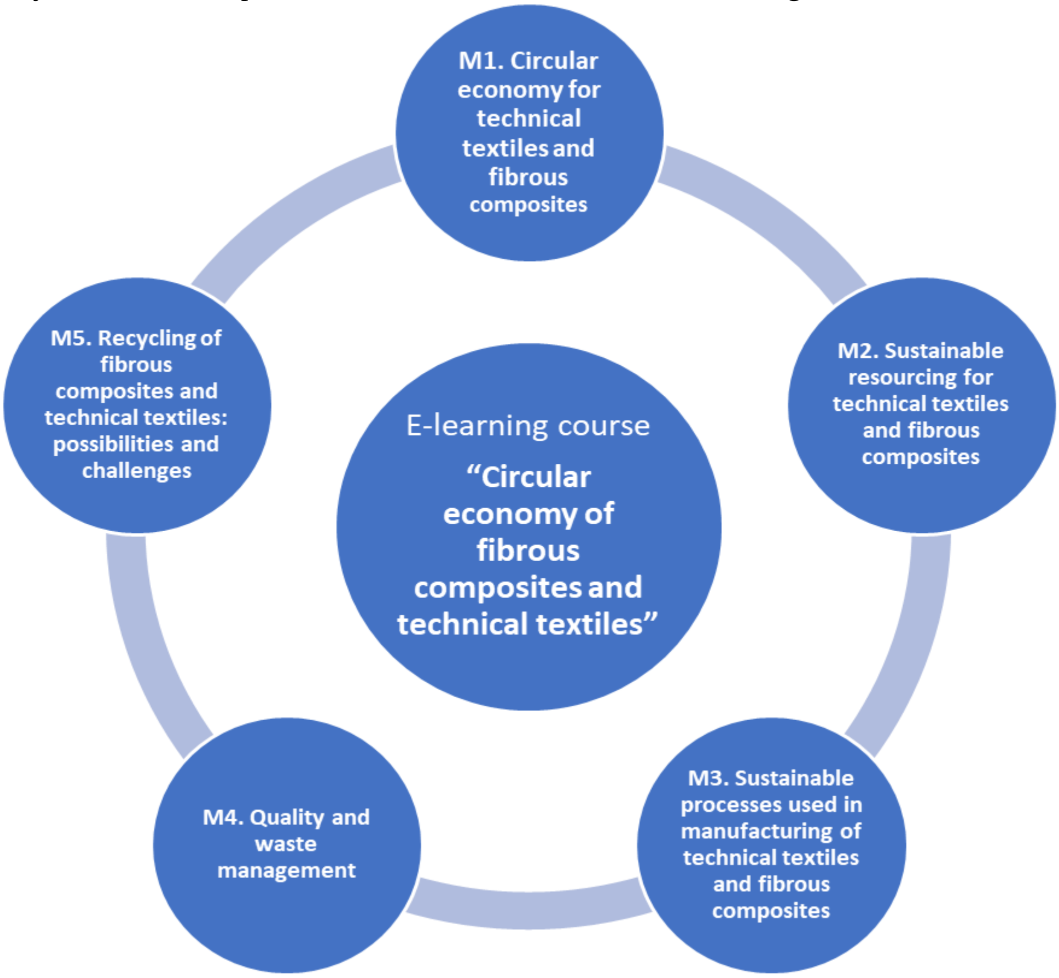

Fig. 1: The modules of the e-learning course

In this way, the project will aid in promoting awareness of the environmental difficulties associated with the use of technical textiles and fibrous composites in the textile industry, as well as their impact on climate change.

The CircuTex project aims to address the need for specialized training on the circular economy for fibrous composite materials and technical textiles by integrating circularity into the curricula of the partner universities. To achieve this, it will develop and deliver and an online course to help students of textile engineering and related degrees develop management and innovation tasks related to the circular economy and the sustainable growth of textile industry companies. The course's goal is to help HEI students become more proficient at using circular economy and sustainability practices in the creation, manufacture, use, and recycling of fibrous composites and technical textiles. The project is anticipated to improve educators' sustainability competencies as well as those of the students who will be taking the course. The e-learning program will also be based on learning outcomes, better meeting the needs of students enrolled in textile-related programs at the participating universities. The e-learning course will use online assessment tools to determine whether students have met the learning objectives. It will last for one semester and be a supplement to the students' fundamental studies. The students will improve their comprehension of how to apply sustainability measures to fibrous components and technical textiles.

3.2. Virtual laboratory for the implementation of virtual experiments

A virtual laboratory will be created for the second intellectual output and added to the online course. The virtual laboratory's specifications and graphic designs, as well as the experiments that will make up the course material, have already been developed (see figure 2)

Fig. 2. Virtual laboratory

Through the virtual laboratory, participants in the online course will be able to test and implement experiments related to the circular economy of fibrous composite materials and technical textiles.

The lab will have virtual reproductions of real lab equipment that have been developed with 3D renderings and motion. Furthermore, workshops will be held at the universities of the project partners, giving students the chance to use virtual reality technology to enter the virtual laboratories. Students will be able to conduct virtual experiments through the lab, without having to be physically present in a real laboratory. They will use their virtual reality glasses devices to access the online virtual lab.

3.3. Roadmap to microcredentials

The roadmap for micro-credentials is the third output. We will develop policy recommendations for the introduction of microcredentials in partner universities. It will be developed a methodology for applying ECTS points to the online course. The partners will make efforts to validate the course and issue digital certificates that may be included in the new digital "Europass Digital Credentials" format at the European level. Finally, partners will offer a set of policy recommendations in support of the European approach to micro-credentials.

4. CONCLUSIONS

The most prevalent production model in today's textile industry utilizes resources to create products that are used and then thrown away. This model is unsustainable and has a negative impact on climate change and biodiversity, putting the world in danger. Due to the very low percentage of separate collection and recycling of textile products, the majority of them are disposed of in landfills. Europe has created an action plan for a circular economy that includes the textile industry. Professionals in the textile industry need specialized training in the circular economy in order to acknowledge the use and end-of-life phases of a textile product.

It is essential that future graduates enhance and expand their knowledge of sustainability and circular economy through learning and training. Therefore, technical textiles and fiber-based composite products will be more sustainable and under a circular model, able to be reused and recycled in an efficient and environmentally friendly way.

CiruTex project will improve the target groups' competencies in recycling methods for technical textiles and fibrous components as well as circular economy. - The circular economy concept will gain students' interest and attention by incorporating the topic of recycling fibrous components and technical textiles into laboratory activities. This will also encourage their active participation in the solution of environmental problems.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

EMERGING TECHNOLOGIES FOR WASTEWATER TREATMENT IN THE TEXTILE INDUSTRY: FUTURE PROSPECTS

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Abstract: *The textile industry is one of the largest water-consuming industries, and it generates a significant amount of wastewater that needs to be treated before being discharged into the environment. To address this challenge, there has been a growing interest in the development of state-of-the-art technologies for wastewater treatment in the textile industry. Physical treatments such as sedimentation, flotation, and filtration are commonly used to remove suspended solids and organic matter from textile wastewater. Chemical treatments such as coagulation/flocculation and oxidation are effective in removing dyes and other colorants. Biological treatments such as aerobic and anaerobic treatments have been shown to be effective in treating organic matter and other pollutants. Moving Bed Biofilm Reactor (MBBR) technology has become increasingly popular in the textile industry for treating wastewater. This technology uses a combination of biological and physical processes to effectively remove pollutants from textile wastewater. The use of MBBR technology in textile industry wastewater treatment has several benefits. It is highly efficient in removing pollutants, including organic matter, color, and suspended solids. It can also handle high variations in flow and organic loads, making it suitable for the highly variable wastewater generated by the textile industry. The use of MBBR technology in the textile industry offers a cost-effective, efficient, and sustainable solution for treating wastewater, making it an increasingly popular option for textile manufacturers worldwide.*

Key words: *wastewater, textile industry, MBBR, treatment technologies*

1. INTRODUCTION

The textile industry is one of the largest polluters in the world, and one of the main contributors to water pollution. Textile production requires large amounts of water, and the wastewater produced by textile manufacturing processes contains a variety of pollutants that can have significant environmental and health impacts. The main pollutants found in textile industry wastewater include chemicals such as dyes, detergents, surfactants, and finishing agents [1]. These chemicals are used in the production process to achieve specific colors, textures, and properties, but they can be harmful to the environment and human health when they are released into water bodies.

One of the most significant pollutants in textile industry wastewater is synthetic dyes [2]. These dyes are widely used in textile production and can cause serious environmental problems when they are discharged into water bodies. Synthetic dyes are typically made from petroleum-based chemicals and are not biodegradable, meaning they can persist in the environment for a long time. Other common pollutants in textile industry wastewater include heavy metals such as lead, cadmium, and chromium. These metals can be toxic to aquatic life and can cause serious health problems in humans if they are ingested or absorbed through the skin. Textile industry wastewater also contains organic pollutants such as polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs). These compounds are produced during the production process and can cause respiratory problems and other health issues in humans and animals.

Recent statistics show that textile industry wastewater is a major source of water pollution. According to the World Bank, the textile industry is responsible for up to 20% of global industrial water pollution, and in some regions, textile production can account for up to 90% of all wastewater generated. In addition, a report from the United Nations Environment Programme (UNEP) found that textile dyeing and finishing processes are responsible for up to 17-20% of industrial water pollution globally. The report also notes that up to 72 toxic chemicals are released in the process of textile dyeing and finishing, with some of them being highly persistent in the environment and bio-accumulating in aquatic organisms.

The current state of the art for wastewater treatment involves a combination of physical, chemical, and biological processes to remove pollutants from wastewater. Some of the latest advancements in wastewater treatment technology include the use of membrane filtration [3], advanced oxidation processes, and innovative biological treatment methods such as anaerobic digestion and bio-electrochemical systems, and adsorption method, using specialized adsorbent materials [4](Fig. 1). In addition, there is increasing interest in decentralized and sustainable wastewater treatment approaches, such as constructed wetlands and ecological sanitation systems. Overall, continued research and development in wastewater treatment technologies are essential for improving the efficiency, sustainability, and cost-effectiveness of wastewater treatment processes.

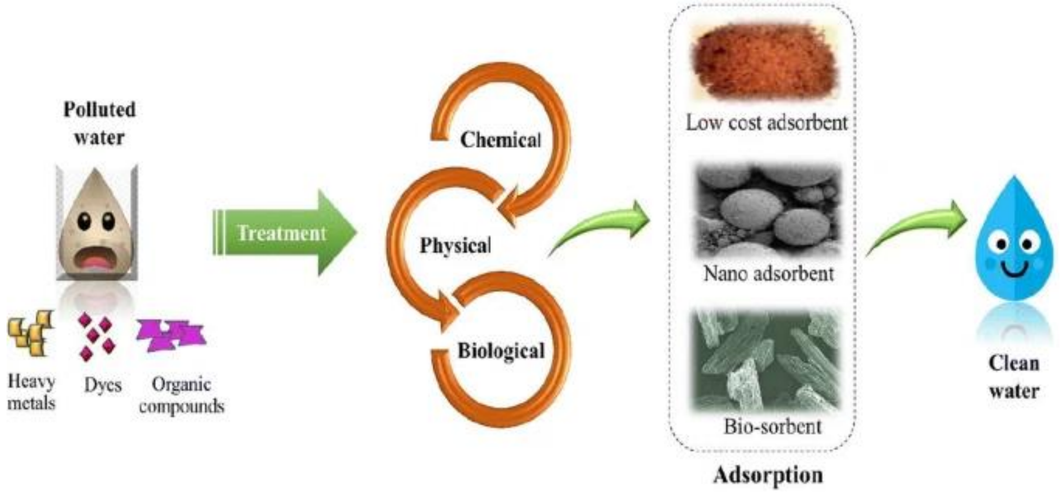

Fig. 1: Wastewater treatment technology using adsorption method
(Source: Rashid et al., 2021)

2. CURRENT TREATMENT TECHNOLOGIES

The textile industry is known to be one of the most polluting industries globally, generating large volumes of wastewater with a high concentration of organic and inorganic pollutants. Wastewater treatment for the textile industry is crucial to reduce the negative impact on the environment and public health. In recent years, several treatment methods have emerged to address this issue. One of the most common methods used for textile wastewater treatment is the physical-chemical process. This process involves the use of chemicals to coagulate and flocculate the suspended solids and then separate them through sedimentation or filtration. The treated water can be further treated by activated carbon adsorption, reverse osmosis, and UV radiation for final polishing. This method has been widely used due to its effectiveness in removing both organic and inorganic pollutants. However, the use of chemicals can lead to the formation of sludge, which requires proper disposal (Fig 2).

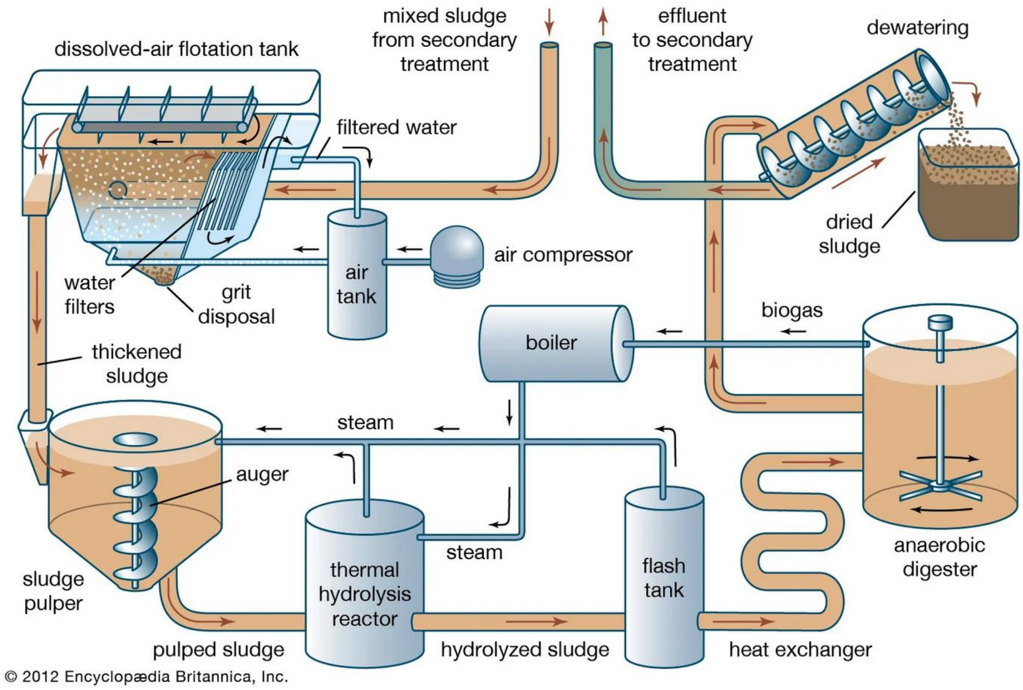

Fig. 2: Scheme for sewage sludge treatment
(Source: www.britannica.com)

Another method used for textile wastewater treatment is biological treatment. This method involves the use of microorganisms to break down the organic pollutants in the wastewater. The most commonly used biological treatment methods are activated sludge, biofiltration, and anaerobic digestion. Activated sludge is a widely used method, which involves the use of aerobic microorganisms to break down the organic matter. Biofiltration is another method that uses microorganisms in a fixed-bed reactor, where the wastewater is passed through a filter bed that contains microorganisms. Anaerobic digestion is a process that involves the decomposition of organic matter in the absence of oxygen. This method is particularly useful for high-strength wastewater with a high concentration of organic matter [5].

In recent years, advanced treatment methods such as membrane filtration, electrocoagulation, and ozone treatment (Fig 3) have gained popularity for textile wastewater treatment. Membrane filtration involves the use of a semi-permeable membrane to separate the pollutants from the wastewater. This method is particularly useful in removing dyes and other small molecules from the wastewater. Electrocoagulation is a process that involves the use of an electric current to coagulate and flocculate the suspended solids. Ozone treatment involves the use of ozone gas to oxidize the pollutants in the wastewater. This method is effective in removing color, odor, and taste from the wastewater.

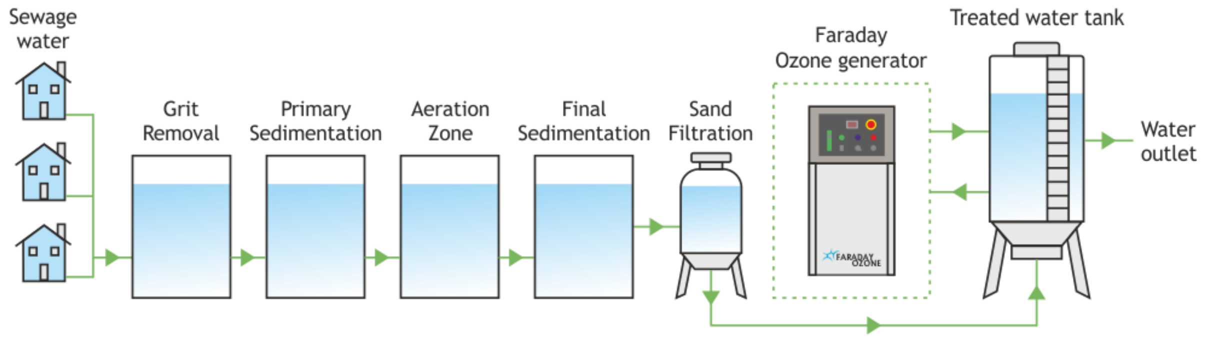

Fig. 3: Faraday Ozone company treatment technology
(Source: www.faradayozone.com)

3. MBBR TREATMENT TECHNOLOGY

Moving Bed Biofilm Reactor (MBBR) is a biological wastewater treatment technology that uses a combination of suspended and attached growth bacteria to treat organic and inorganic pollutants from wastewater [6]. The technology was first developed in the late 1980s and has since become widely used in the treatment of municipal and industrial wastewater. The working principle of MBBR technology involves the use of plastic carriers, known as media, to provide a surface for bacterial growth (Fig. 4). These carriers are designed to be kept in motion through the reactor by the use of aeration and mixing systems, which promote the transfer of oxygen and nutrients to the bacteria. As wastewater passes through the reactor, bacteria attach themselves to the surface of the media and form a biofilm. The bacteria in the biofilm then metabolize and break down the pollutants in the wastewater, converting them into less harmful byproducts.

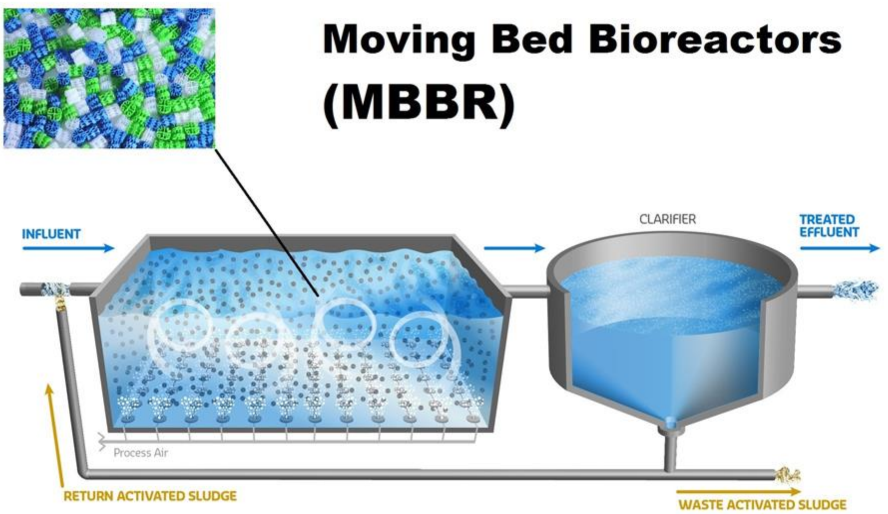

Fig. 4: MBBR treatment principle (by Hebei Lanyu company, China)
(Source: www.gustawater.com)

The textile industry is a major contributor to global water pollution due to the large volumes of wastewater generated by its manufacturing processes. Many textile companies have turned to

Moving Bed Biofilm Reactor (MBBR) technology to treat their wastewater, as it offers an efficient and cost-effective solution for removing pollutants. MBBR technology is becoming an increasingly popular choice for textile companies seeking to reduce their environmental impact and comply with local wastewater discharge regulations. With the help of companies such as OxyMem, EnviTec Biogas AG, and Aqua-Aerobic Systems (which involves a complex system based on biological treatment, cloth media filtration and ultrafiltration membranes – Fig 5), textile companies can implement efficient and effective MBBR systems to treat their wastewater and reduce their impact on the environment [7].

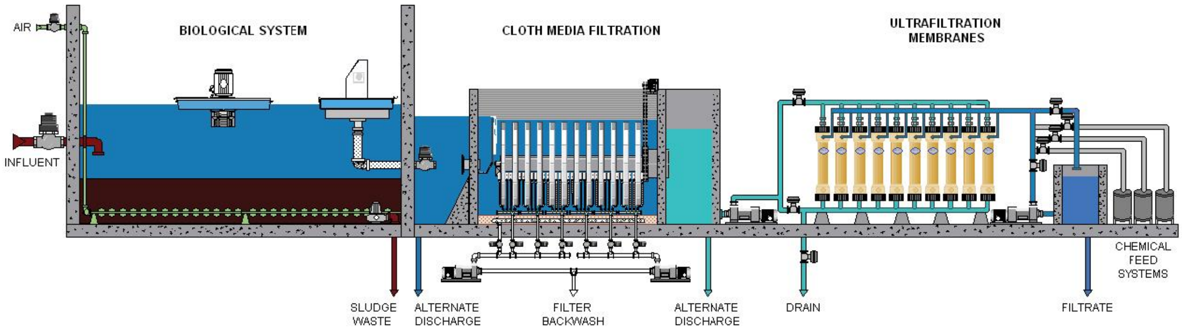

Fig. 5: Aqua-Aerobic Systems' wastewater treatment technology
(Source: www.aqua-aerobic.com)

National R&D Institute for Textile and Leather (Bucharest, Romania) carried out a research project called "Exploiting fungi potential for recalcitrant compounds removal from cellulosic wastewaters", acronym Funcell, within Manunet III international competition, with parners from both Romania and Italy. The main objective of the project was the development of an innovative mycobased tertiary treatment for tannery and papermill wastewaters efficient in removing tannins and absorbable organic halogen (AOX), not depleted by consolidated bacterial based processes. One of the results of the project were the development of new generations of HDPE carriers, based on talcum, for MBBR treatment systems, by Romanian SME DFR Systems (Fig. 6).

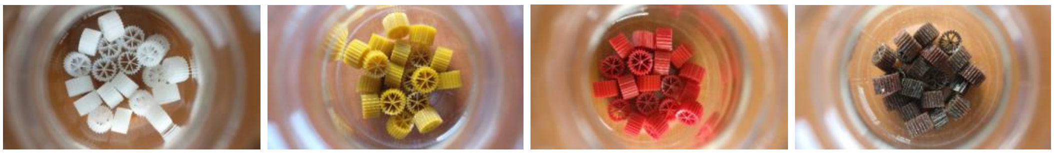

Fig. 6: Novel HDPE cariers manufactured by DFR Systems (Romania)
(Source: www.dfr.ro)

MBBR technology has several advantages over other wastewater treatment technologies. It is highly efficient, compact, and requires less space than traditional treatment systems. It is also highly adaptable and can be easily modified to handle different types and volumes of wastewater. MBBR systems can achieve a high level of treatment efficiency, with removal rates of up to 90% for organic matter and 70% for nitrogen. Additionally, MBBR technology is relatively low cost, making it an attractive option for many applications. Overall, MBBR technology offers an effective and reliable solution for the treatment of wastewater in a variety of industries. MBBR systems produce less sludge compared to other processes, due to the fact that the bacteria in the biofilm are self-immobilized and do not require the use of settling tanks.

4. CONCLUSIONS

In conclusion, the textile industry is a major contributor to water pollution, with textile industry wastewater containing a variety of harmful pollutants. It is important for the industry to adopt more sustainable practices and for governments to regulate and enforce environmental standards to reduce the impact of textile production on the environment and human health. As a treatment technology, MBBR is an innovative and effective solution for removing organic and inorganic contaminants from wastewater. The use of MBBR technology offers several advantages for textile industries. Firstly, it is a cost-effective and efficient solution for the treatment of high-strength wastewater. Secondly, it requires less space and produces less sludge than traditional treatment methods. Thirdly, it is a scalable technology that can be easily adapted to meet the changing needs of the textile industry. Overall, MBBR technology is a highly effective and efficient wastewater treatment process that is widely used in a variety of industries. Its ability to handle variable flow rates and organic loads, low energy consumption, small footprint, minimal sludge production, and easy maintenance make it an attractive option for wastewater treatment plants and industries around the world.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ECOLOGICAL METHOD OF WOOL WASHING

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Abstract: *The textile industry is considered a polluting industry due to the use of chemicals in production and excessive use of energy and water, plus the generation of toxic waste. In present, the significance of environmental pollution and related problems in the world had led to development and application of environmental friendly production methods that less polluted environment.Wool fibers are subjected to a number of water-based treatments that pollutes the environment. In a desire to make the wool industry to become more sustainable, this paper reports an ecological wool washing method by using three alkaline solutions based on ash obtained from burning wood type beech/oak/hornbeam and water. The mixture solutions used for manually wool washing has different concentration of lye (10% to 30%) and pH, respectively. The higher the pH of the alkaline solution, the more impurities are removed.The optical images of washed wool fibers presented in the paper show no damage on surface structure. Wastewater collected after wool washing was used as natural fertiliser for watering seeds of grass. Some measurements on blades of grass were done to see the effect of wastewater. The number of grass blades/unit area, average lenght and the uniformity regarding the lenght increased when watering was done with wastewater.*

Key words: *wool, alkaline solution, ash, pH, washing, blades of grass*

1. INTRODUCTION

The sheep farming for wool, meat, milk and skins dates back many years and form an important component of rural economy. For the rural population, wool, a valuable natural fiber has been the raw material for textile purposes. Also, the sheep provided a dependable source of income to the shepherds through sale of wool and animal.

The textile industry is the one of environmental polluting agents as a result of the large chemicals amounts employed for its production and the excessive use of energy and water.

Wool fibers are subjected to a number of water-based treatments, such as scouring, bleaching, carbonizationand functional finishing [1,2]. Therefore, wool production has been constrained not only by its poor environmental performance related to sheep grazing but also the polluting fiber industrial processing [3,4].

In the world, the significance of environmental pollution led the industrial companies and scientific enterprises to research alternative wool clean production methods. Thus, these methods should involve low energy consumption that pollute the environment less by releasing less wastewater and by using less chemical materials and water.

In recent times, wool production in Romania has declined considerably and shepherds have mainly limited themselves to breeding the Turcana breed, characterized by rusticity, mobility and resistance to environmental conditions.

Between 2017-2020, in Romania, has been collected over 15000 tonnes/year (80% wool from Turcana breed) by some collection centers at a low price [5]. But a large wool quantity is unused and polluting the environment by landfill or burned At present, wool can be regarded as renewable resource with various engineering/technical applications like thermal and acoustic insulation material, as reinforcement fiber in polymer-fiber composites, adsorbents for heavy metals [6], short-term geotextile for steep slopes protection [7] or as fertiliser [8].

Turcana body conformation is dolicomorphic, mixed wool, thin and thick, conical strand, having different distribution on the body (see Fig. 1).

Fig. 1.Sheep Turcana breed

During the growth, the wool coat it becomes coated with grease (lanolin wax), sweat salts and contaminated with dirt, dust, dung and vegetable matter (burrs, seeds, twigs and straw) [9,10]. These impurities, which may be up to 40% (or more) by weight, must be washed off before the wool can be used as a textile fibre and therefore wool scouring is an important process that is carried out on a large scale [11].

Plant and mineral impurities are products that, if recovered, could be used as an agricultural bio-fertiliser: as fertilisers (mineral ones) and the vegetal ones can be dry naturally and the briquette for own use, at the sheepfold.

The main purpose of raw wool scouring is to remove the wool contaminants at maximum efficiency, with efficient energy utilisation and with minimum impact on the environment. Therefore, in this paper, we report a wool ecological washing method by using an alkaline solution based on water and ash. Finally, the potential of resulting solution after wool washing as grass fertilizer has been reported.

2. MATERIALS AND METHODS

2.1 Materials

Raw wool of Turcana breed and contamined with impurities (suit &dirt, vegetable matter, lanolin wax) has been subjected washing (see Fig. 2).

The components of alkaline washing solution were (i) ash obtained from burning wood type beech/oak/hornbeam (see Fig. 3) and (ii) tap water. Ash is composed of non-combustible inorganic substances such as mineral salts.

Fig. 2. Unwashed Turcana wool

Fig. 3. Ash

2.2 Methods

In order to obtain lye/alkaline solution, ash and tap water (pH 7.5, Voltcraft PHT-01 ATC pH Meter) were boiled for 3 hours and then allowed to cool for 24 hours. The pH of the resulting solution was 12.35.

The wool mass before and after washing was measured in grams using a Kern weighing scale.

Three mixtures solutions having different concentration of lye (10% to 30% lye) have been used for raw wool washing. Addidionaly, tap water up to 100% has been used to obtain final washing alkaline solution. The washing alkaline solution temperature was 21^0C. The details of composition and pH of mixtures coded as A1, A2 and A3 are shown in Table 1.

Table 1: Components of alkaline solution

Solution code	Composition of washing solution, lye/water (%)	pH of alkaline washing solution
A1	10/90	9.8
A2	20/80	9.9
A3	30/70	10.0

Wool washing was done manually through agitation in containers full with alkaline solution heated to a temperature of 55^0C (added water from final alkaline solutioniswas heated to above the melting point of wool grease, which is about 40°C). After 24 hours, the wool was manually squeezed (mechanical damage of wool fiber to be minimal) and dryed. The wool drying has been performed naturally, on upright supports exposed to sun.

The efficiency of the scouring/washing process can be determined by different analyses [12]. In this study, the effect of washing on the surface morphology of wool fibers was done via Optika microscope with optical camera B5 to a 50x and 20x, respectively magnification degree.

Wastewater was collected for reuse as natural fertilizer for watering grass seeds.

In order to observe the effect of wastewater on grass seeds, two seedling boxes having a surface area of 290 cm^2 each has been used. Sowing was done manually using the same type of soil and amount of seeds, respectively.

The seeds in one box coded S1 were watered with wastewater while the seeds from the other box coded S2 watering have been done with tap water.

The orientation of the boxes was north-south, with south at window. The watering conditions and period were the same for both cases studied.

3. RESULTS AND DISCUSSION

The efficiency of washing (R) was calculated acording to the relation:

$$R = \frac{Qww}{Qrw} \times 100(\%) \quad \textbf{(1)}$$

where Qww – washed wool quantity/mass in g, Qrw – raw wool quantity/mass in g.

Table 2 shows the experimental average values of quantity of raw wool and washed wool, respectively and also the washing efficiency for three expriments of washed wool in conjunction with alkaline washing solutions.

Table 2: Experimental average values

Experiment	pH of alkaline washing solution	Qrw (g)	Qww (g)	R (%)
I	9.8	50	46	92
II	9.9	50	45	90
III	10.0	50	41	82

The values from Table 2 reveals that as the pH of the alkaline solution increases the mass of washed wool decreases compared to raw wool mass. This means that more impurities (dirt, greases) have been removed from the raw wool which leads to cleaner wool even if R (%) value decrease.

Particles of dirt were removed from the fibre by: (i) agitation of the solution and (ii) being washed away with the grease droplets.

Wool is a relatively weak fibre, compared to other staple fibres. During washing, wool experiences various adverse conditions which can lead to fibre damage. One possible source of fibre damage could be pH of washing solution. A value of pH>9.5 will cause yellowing and damage to the fibre [9].

Microscopic images of wool fibers before and after washing are indicated in Fig. 3 and Fig. 4.

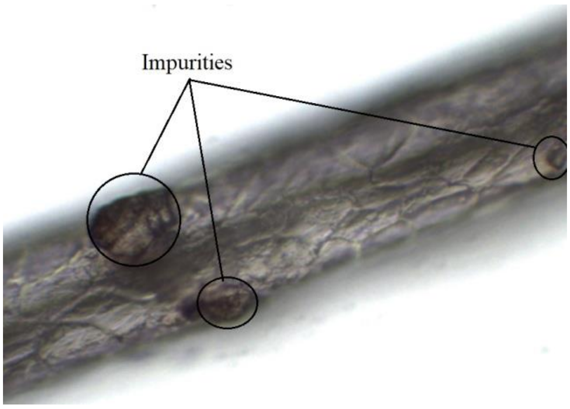

Fig.3. Microscopic image of unwashed wool fiber (50x magnification degree)

Fig.4. Microscopic image of washed wool fiber (30% lye/ 20x magnification degree)

The image in Figures 4 shows the effect of washing, evidencing the fact that washed fibers are not damage by the alkaline solution, have less grease droplets and brighter (slightly whitening of fibers) then raw fibers.

At 7 days after sowing in those two seedling boxes, measurements were done on the number, average length at ground level as well as the density/cm^2 of grass blades which are given in Table 3.

Table 3: Experimental data regarding blades of grass

Characteristic/ Box code	S1	S2
Surface (cm^2)	290	290
Blades of grass number/unit surface	381	331
Density (blades of grass/cm^2)	1.32	1.13
Average length (cm)	13.33	12.88
Length coefficient of variation (%)	21.3	24.9

Table 3 shows an increasing of 13.1% regarding blades of grass number in the experiment coded S1 compared to S2. Also, blades of grass average length and uniformity increased by 3.4% and 14.5%, respectively, when watering with wastewater compared to watering with clean water.

4. CONCLUSIONS

Wool washing can be done ecologically, without large investments, by using the ash resulting from the burning of the wood and water.Three final alkaline solutions with different percentage of lye and pH, respectively has been used to wash raw wool contamined with impurities.

The higher the pH alkaline solution, the more impurities were removed.

Microscopic images of washed wool fibers revealed the fact that fibers are not damage during washing regarding surface structure and are cleaner then raw wool.

In order to protect the environment, the wastewater resulting from the wool washing can be reused in the agricultural or household field for watering the pastures and lawn, respectively. In addition, the soil (sludge) in the washing solution and dried naturally can be used as a mineral fertilizer.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

TEXTILE SOLID WASTE MANAGEMENT: ADDING VALUE AND UNIQUENESS THROUGH DESIGN

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Abstract: *The global fashion industry is highly energy-consuming, polluting, and wasteful: both production and consumption. The industry is mainly spurred by small and medium enterprises (SME) which have the competitive advantage of recovering textile solid waste, thus contribute to the slow/eco/sustainable fashion discourse. Fashion design university graduates particularly join the SME sector, either as employees or entrepreneurs. Hence, their engagement in sustainable fashion through course projects positions them as potential change agents in the industry. Upcycling is one of the most sustainable circular solutions in the waste hierarchy. Upcycling requires little energy input and can eliminate the need for a new product. Upcycling involves a substantial amount of creativity and vision, based on a fundamental environmental consciousness. The end result is typically a product/item that is unique and sustainable. This paper presents a project undertaken by the author and undergraduate fashion design and textile technology students aligned with the International Federation for Home Economics (IFHE) commemoration of the World Home Economics Day held on 21st March. This year's theme was 'Waste Reduction Literacy'. The students and the author interpreted the theme and created apparel, apparel accessories, soft furnishings, and interior accessories from textile solid waste. The effort provided the students with a business opportunity, alternative source of cheaper materials, enriched creativity, and fun. It is critical for higher education institutions offering fashion design programmes to incorporate sustainability in all courses and prepare students to tackle emerging issues in the industry. The faculty too need to keep abreast with sustainable fashion discourse.*

Key words: *disposal, fashion consumption, fashion industry, fashion production, slow fashion, upcycle*

1. INTRODUCTION

The current consumption cycle is that people extract natural resources from the environment, design valued products, sell them, and after using them for some time, they are disposed of as trash [1]. The fashion industry's Small and Medium Enterprises (SMEs) contribute significantly to any country's sustainable economic development, innovation, and competitiveness. However, the industry's unsustainable production processes immensely result in environmental degradation, especially from large quantities of biodegradable and non-biodegradable solid waste [2]. The global fashion industry is highly energy-consuming, polluting, and wasteful. Nonetheless, even a minor extension of the use phase of clothing can significantly reduce the carbon, water, and waste footprint [3]. Although most textile solid waste originates from household sources, waste textiles also arise during garment manufacture: cut pieces of fabrics, rejected apparel, fasteners, threads, used plastic packets, broken cloth hangers, and empty bobbins [4]. The cloth cutting phase is responsible for 20% of waste fabric from the industry. The solid waste may be landfilled (impacting land use), incinerated, with or without energy recovery or recycled (impacting resource depletion and climate change) [5].

2. SUSTAINABLE FASHION

Synonyms for sustainable fashion include eco/green/slow fashion, among others. The latter term was coined by Dr. Kate Fletcher, creating an international movement in fashion from "quantity to quality" [6] or garments produced for extended use, thus postpone their disposal [3]. Further, ‘slow’ is simply an approach in which designers, buyers, retailers, and consumers are more aware of the impacts of products on workers, communities, and ecosystems [6]. This paradigm shift has spurned global designers to investigate alternative materials and link pleasure and fashion with awareness and responsibility. Unwanted clothing recirculates by gifting to friends and family, donating to charity, swapping informally or formally, and selling to resale boutiques or peers via online platforms [3]. Upcycling is disrupting fashion’s unsustainable cycle as it offers a mix between upgrading and recycling. Upcycling is taking disposable items and transforming them into products of added value [1]. The products created through upcycling are better than the original ones, unique, and sustainable and they tell sustainability stories such as 'production with zero waste', 'small is beautiful', and 'start local, but think global' [1; 7; 8]. Upcycling is one of the most sustainable circular solutions in the waste hierarchy, since it typically requires little energy input and can eliminate the need for a new product. The process of upcyling involves a substantial amount of creativity and vision, based on a fundamental environmental consciousness [8]. Upcycling also involves the reuse of pieces of an existing article. The opportunity to recycle materials opens up new business horizons for SMEs as well as companies already established in the labour market, enriching their production. Collaborations must be established between large-series producers and the small business environment, comprising small workshops, various non-profit organisations, or school organisations, which have the capacity to reuse them [9].

3. DESIGN FOR SUSTAINABILITY IN HIGHER EDUCATION INSTITUTIONS

Design is crucial for sustainability. It is paramount to educate the next generation of designers in the first years of design education, in all sustainability fields: environmental, social, and economic, and in subjects such as upcycling, zero-waste design, and disassembly, so that they can grow with the idea of designing not just one generation of products [5]. It is paramount to teach not only sustainability and the impact of the fashion sector, but also instill skills, which enable the students to pursue fashion design as sustainable practice [10]. The interaction between student/teacher becomes an obvious source of learning, a way of cooperation, where the teacher becomes an observer and facilitator in the work [11]**.** Sustainable design should be explicitly incorporated in various undergraduate fashion design course contents. The recommendation is achievable because the faculty understand sustainable fashion and are knowledgeable about its benefits. Consequently, the students employ sustainable design in course projects mainly through the lecturers' encouragement [12]. In concurrence, while teaching Sustainable Fashion Design at California College of the Arts, the students’ positive learning outcomes are recognized in their ability to assemble disparate information and to provide discursive argument for relevant sustainable design strategies. As their understanding of sustainability deepens and broadens beyond materiality and processing considerations, so do the directions and opportunities for sustainability practice also open up, including in other studio classes. The students have developed ‘critical’ skills to reassess their role as fashion designers [10]. Most of Ghana’s senior high school visual arts students use leather scraps to make small- to medium-sized items for non-commercial purposes. Patchwork, thonging, and applique were the most prominently used techniques. The size and extent of defects also determined the usefulness of leather scraps. Leather scraps can be used either as a supporting or dominating material for making leather articles. Joining is a prerequisite for the latter [13].

The objective of this project was to inculcate in the Kirinyaga University undergraduate students pursuing Fashion design and textile technology degree, the role of designers in promoting sustainable/slow/eco fashion. That students can practice sustainable fashion while undertaking their studio projects. Thereby, create a pool of responsive fashion designers. Further, it was aimed at coaching students to interpret fashion themes and produce themed creations.

The author is a member of the International Federation for Home Economics (IFHE). The IFHE celebrates World Home Economics Day annually on 21st March. This year's theme was Waste Reduction Literacy. The author shared the information with the students. Brainstorming sessions were held with the students about fashion's unsustainable consumption and production practices, and how to address the IFHE theme. The students and author created various items at their own time.

4. RESULTS

The creations included apparel, apparel accessories (bags), soft furnishings (floor mat and organizer), and interior accessories (flower vase, storage basket and bag, and paintings). The apparel comprise a dress constructed from upcycled second-hand blouses and organza pre-consumer waste (Fig. 1); dress from second-hand curtain (Fig. 2); trouser from bandana and white cotton fabric scraps (Fig. 3); culotte and blouse fashioned from second-hand curtain and bow from second-hand silk pillowcase (Fig. 4); and denim flared trouser from old ripped denim trouser and used chiffon dress (Fig. 5). The fashion accessories consist of bags constructed from second-hand bedsheets (Fig. 6 and 7), and new *Maasai* cloth scraps (Fig. 8). Soft furnishings include a woven rug made from yarns constructed from a second-hand bedsheet and embellished with waste knitting yarns (Fig. 9) and an organizer fashioned from pre-consumer fabric waste (Fig. 10). The interior accessories comprise a crocheted basket for storing sewing equipment and notions constructed from braided yarns made from old clothes (Fig. 11) and a storage bag for the same purpose constructed from pre-consumer scrap fabrics (Fig. 12); a flower vase made with pre-consumer fabric scraps and decorated with bottle caps covered with fabric from used pillowcases (Fig. 13); paintings fashioned from a torn *Maasai* cloth mounted on a wooden frame, treated and painted (Fig. 14 and 15); and wall hangings from waste paper and aluminium foil (Fig. 16) and bottle caps covered with fabric from old pillowcases (Fig. 17). The students were able to express their creativity in the projects and foster sustainable design. The students' opinion about the project was positive: "Designers can make great things out of waste fabrics from their studio projects. Those small scraps of fabrics when given a thought will not disappoint in making whatever kind of garment a designer wants. Upcycling is cheap and profitable. My model loved the patchwork and went an extra mile of buying it to wear for a modelling competition as street wear". "Recreating new outfits from old clothes is a good and easy way of reducing waste in the fashion industry. One can make bags, jewellery, headwraps, crop tops, shorts, and many other items from old outfits that one is not using instead of disposing them". "I greatly enjoyed taking part in this project and it gave me a cheaper alternative material to draw my paintings on since the canvas fabric that is used for painting is a bit expensive and that can be limiting at times". "This project can help to reduce the textile product waste that is disposed to the environment".

5. CONCLUSION

The projects demonstrate the participants’ creativity, application of apparel construction techniques such as patchwork and quilting. The finding resonates with [13], that patchwork was one of the most prominently used technique. The size, defect, quality of pre- and post-consumer waste influenced the final product. Upcycling offers unlimited design ideas from apparel, accessories, soft furnishings, to interior accessories, as well as cheaper alternative raw materials. In addition, it opens up new business for designers. One student sold the trouser (Fig. 3). The result concurs with [9], especially for fashion SMEs, to which most graduates venture as employees or entrepreneurs. Capacity building on sustainable fashion be conducted for faculty instructing fashion design undergraduate degree programmes to enable them impart the same to the students. For instance, a training manual to be developed and shared in an open access format.

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APPENDIX

Apparel

Fig. 1: Author's

Fig. 2: Student's

Fig. 3: Student's

Fig. 4: Student's

Fig. 5: Student's

Fashion accessories

Fig. 6: Student's

Fig. 7: Author's

Fig. 8: Author's

Soft furnishings


Fig. 9: Student's


Fig. 10: Student's

Interior accessories


Fig. 11: Student's


Fig. 12: Student's


Fig. 13: Student's


Fig. 14: Student's


Fig. 15: Student's


Fig. 16: Student's


Fig. 17: Student's

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INFLUENCE OF YARN TYPES ON SINGLE-JERSEY KNITTED FABRIC PERFORMANCE

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Abstract: *Poliester and cotton fibres are the most utilized fibres by the textile and clothing sector, where ring spinning and open-end rotor spinning systems are the most widely used technologies to manufacture yarn by the sector. Also, with the increment in sustainable awareness in the sector, new approaches like use of recycled raw materials have been improved. The yarns converted from recycled fibres have been started to be intensively used in apparel and household textiles. However, recycled yarns are considered as mechanically weak. In the present study, it is aimed to how yarn type and fabric tightness affect the pilling tendency, mechanical characteristic, and vertical liquid transfer behaviour of knitted fabrics. For this purpose, six different knitted fabrics with different loop lengths were manufactured in single jersey construction using different yarn types. The selected yarns are 100% poliester (PES) ring carded, 100% cotton (Co) ring carded, and recycled polyester/cotton open-end rotor yarns in 35/65 proportion. In this direction, pilling resistance, bursting strength, and wicking tests were performed. It was observed that the knitted fabrics using PES ring carded yarns have medium to light pilling tendency, while the knitted fabrics using PES/Co blended open-end yarns show serious to medium pilling tendency. In addition, loose fabrics with higher loop length have no pilling tendency. Tight fabrics have the highest strength, whereas the fabrics from recycled open-end rotor yarns have poor strength. In both wale and course direction, the fabrics knitted using PES ring carded yarns displayed better wicking behaviour.*

Key words: *Ring carded yarns, open-end rotor yarns, recycled yarns, bursting strength, pilling resistance, wicking*

1. INTRODUCTION

Today, poliester, cotton, and poliester/cotton blended fibres are those that the textile and clothing sector relies on. It is reported that textile fibre production exceeds 113 million metric tons by 2021, 88.2 million of which is accounted for chemical fibres including synthetic fibres and cellulose-based fibres, where 25.4 million metric tons of which were reached by natural fibres such as cotton and wool [1]. In total fibre manufacturing volume, the ratio of recycled fibre was reported as ~7.6% recycled bottles, ~0.5% recycled pre- or post-consumer textiles and other non-bottle feedstock. In the case of cotton and poliester fibres, the recycled fibre ratio was reported~ 0.96% and ~15% respectively [2]. These fibres are mostly handled by ring spinning and open-end rotor spinning systems, which are the most commonly accepted yarn spinning systems. Besides, open-end rotor system has been widely used to convert recycled fibres to yarn with the increment of awareness of sustainability concept in the sector. The systems have unique economical and feasible strengths. High production rate recycled raw material usage, commercial production of coarse yarns, and low-end breaks are the advantages of rotor spinning systems. Flexibility in yarn count and low maintenance cost advantage are the strengths of ring spinning systems [3-8]. Nonetheless, ring and open-end rotor spinning systems are the most utilized systems, the advancements in both spinning systems keep carrying on. The recent developments in ring systems concentrate on high efficiency, high-speed winding operation efficiency, removing yarn residual torque, reduced ring-traveller friction, low twist systems, controlling spinning triangle, and modifications for reduced hairiness [9-12]. On the other hand, reduction in capital cost, reduced rotor diameter, low power consumption, magnetic bearing, quality monitoring system, and cooling systems are the concepts that are focused on advancements in rotor system [9].

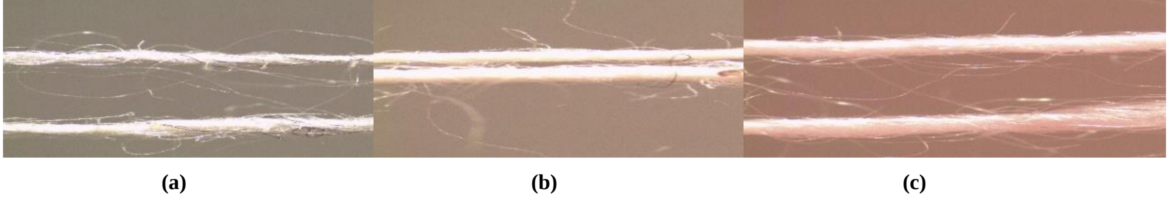
Besides the economical distinctions of spinning systems, characteristics of ring spun yarn and rotor spun yarns differ as well. Ring spun yarns are well known for high strength and denser structure, where rotor spun yarns stand out including less irregularities, better evenness, low count variations, and less hairiness [4, 8, 10, 13]. It is reported that fibre and yarn type impact the physical, mechanical, thermal, and comfort behaviour of the fabrics [14]. Hailemariam and Muhammed (2022) investigated and compared tensile and tear strengths, abrasion resistance, pilling resistance, and air permeability properties of 3/1 twill fabrics manufactured from ring spun yarns or rotor spun yarns [3]. Akhtar et al. (2020) investigated tensile and tear characteristics and pilling behaviour of woven fabrics manufactured from ring spun, ring compact spun, rotor spun, and air-vortex spun poliester and cotton yarns [8]. Gedilu et al. (2022) analysed the physical and comfort properties of single jersey, rib, and interlock knitted fabrics manufactured from ring-spun and rotor-spun yarns [15]. Kathirvelu (2018) examined bursting strength, abrasion resistance and pilling characteristic of single jersey fabrics manufactured from ring-spun and rotor-spun yarns [16]. Keskin et al. (2014) investigated and compared absorbency properties of two group fabrics, one of which included plain, twill (2/1 Z), peshtamal fabrics, and the other one of which included different terry towels [17].

In this study, it is aimed to investigate the effect of yarn type and fabric tightness on pilling tendency, mechanical characteristic, and vertical liquid transfer behaviour of knitted fabrics. For this motive, six different knitted fabrics having different loop lengths were manufactured in single jersey construction. In this direction, pilling resistance, bursting strength, and wicking tests were performed.

2. MATERIAL - METHOD

2.1 Material

In the study, 100% poliester (PES) ring carded yarns, 100% cotton (Co) ring carded yarns, and recycled poliester/cotton open-end rotor yarns in 35/65 proportion were used. All yarn counts are Ne 20. Figure 1 displays differences of fibre alignment in yarn structure.



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

Fig. 1: Close vieew of the yarns (a) PES/Co open-end rotor yarns (b) 100% Co ring carded yarns (c) 100% PES ring carded yarns

A laboratuary-sized circular knitting machine was utilized to manufacture single jersey fabrics with different tightness. The tightness of the fabrics was adjusted by manipulating the loop length. Technical properties of the knitted fabrics used in the study are given in Table 1.

Table 1: Technical properties of the fabrics

Fabric code	Fibre/yarn type	Wale density	Course density	Areal density (gr/m^2)	Loop length (mm)
F1	PES-Co/Open-end rotor	12	11	140	3.46
F2	100% Co/Ring carded	12	13	154.5	2.9
F3	100% PES/Ring carded	11	12	138	2.7
F4	PES-Co/Open-end rotor	7	9	90.5	5.24
F5	100% Co/Ring carded	7	11	112.5	4.45
F6	100% PES/Ring carded	7	10	115.5	4.24

2.2 Method

In the experimental works of the study, to evaluate the pilling tendency of the fabrics, Martindale abrasion and pilling tester was performed in 2000 and 4000 cycles. The test was carried out according to ISO 12945-2 standard and evaluated according to pilling grade scale of the Martindale standard test (Figure 2).

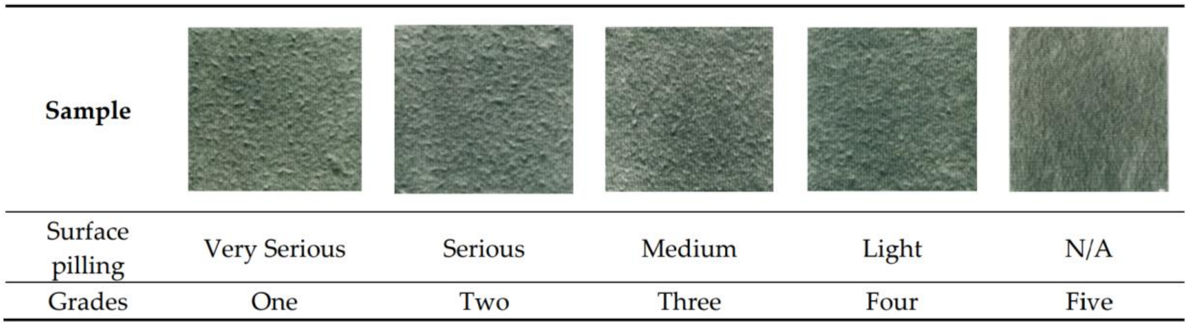


Fig. 2: Five grades of pilling detection

According to ISO 13938-1 standard, bursting strength test was carried out on SDLATLAS M229P PnuBurst Tester to determine mechanical characteristic of the fabrics. To assess the vertical liquid transfer behaviour of the fabrics, in-house wicking test was achieved.

3. FINDINGS

3.1 Pilling Properties

Concerning the number of abrasion cycles on Martindale measurement device, any pilling propensity was observed in all six fabrics by the end of 2000 cycles, whereas pillings are observed by the end of 4000 cycles depending on yarn type and loop length. It was seen that loose fabrics with higher loop length do not show high pilling tendency. As compared yarn types, F3 and F6 fabrics made of 100% PES ring carded yarns have medium to light pilling grades of 3 and 4 respectively. F1 and F4 fabrics made of PES-Co open-end rotor yarns have serious to medium pilling grades of 2 and 3 respectively. Pilling propensity of the fabrics manufactured from rotor yarns could be attributed to weak initial fibre orientation. Another possible reason is that short fibres are used in rotor yarn spinning and hence short fibres are protruded on the fabric surface. These migrated fibres could be considered as a contributor for the pilling in the fabrics. Also, high pilling tendency in PES-Co blended fabrics can be attributed to the presence of PES fibres in the yarn content. In such a situation, PES fibres with high strength and long length prevent the breaking of pillings that are built up by recycled short lengthed cotton fibres.

3.2 Bursting Strength

The bursting strength values of the fabrics are displayed in Table 2. As seen in the table, F1 and F4 fabrics made of recycled open-end rotor yarns have the weakest bursting strength. It can be ascribed that fibres expose the mechanical forces during the mechanically recycling process and thus converted yarns from recycled raw materials lose their strength. Another possible reason for poor strength is that the fabrics manufactured from open-end rotor yarns that have a high content of short fibre.

Table 2: Bursting strength values of the fabrics

Fabric code	Bursting strength (KN/m^2)	Fabric code	Bursting strength (KN/m^2)
F1	576.46	**F4**	430.46
F2	665.16	**F5**	577.56
F3	1017.06	**F6**	858.13

In terms of fibre type, high strength of poliester fibre, is reflected in the fabric and thus poliester fabrics of F3 and F6 displayed the best performance among all fabric types.

Also, it can be seen in Table 2, the loose fabrics with the high loop length resist the lower pressure as compared to the tight fabrics with the low loop length, which can be attributed that loose fabrics have less number of yarn intersections, low wale and course density in unit area, and inherently low areal weight.

3.3 Wicking Properties

The wicking test results in wale and course direction are displayed in Table 3. In wale direction, F3 fabrics manufactured from PES fibres have the strongest wicking ability, where F2 fabrics manufactured from cotton yarns have the poorest wicking ability. In course direction, F3 fabrics have the best wicking ability, where F5 fabrics have the weakest wicking ability. In terms of tightness or looseness of the fabrics, tight fabrics having short loop length were observed to absorb more liquid in both wale and course direction.

Table 3: Wicking test results of the fabrics

Fabric code	Time (minute)	Wicking height (cm)	
		Wale direction	Course direction
F1	5	11.66	17.00
	10	25.33	37.00
	15	39.33	48.66
F2	5	3.00	0.00
	10	5.00	2.33

	15	10.00	9.66
F3	5	45.33	44.33
	10	67.33	62.00
	15	83.66	77.33
F4	5	6.33	6.33
	10	11.66	13.00
	15	22.00	19.66
F5	5	1.00	0.00
	10	2.66	0.66
	15	4.66	5.00
F6	5	9.66	12.00
	10	24.33	20.33
	15	39.00	30.33

4. CONCLUSION

In this study, pilling tendency, mechanical characteristic, and vertical liquid transfer behaviour of single jersey knitted fabrics manufactured using ring spun and open-end rotor spun yarns were investigated and compared. Three types of fibre including poliester, cotton, and poliester/cotton blend were selected. In addition, the fabrics were designed in tight or loose construction manipulating their loop length. In the frame of the experimental work, the extracted conclusions are followed as:

- The fabrics from poliester ring carded yarns have medium to light pilling tendency, while the fabrics from poliester/cotton open-end rotor yarns show serious to medium pilling tendency. High pilling tendency in PES-Co blended fabrics can be explained with the presence of PES fibres in the yarn content. PES fibres with high strength and long length prevent the breaking of pillings that are built up by recycled short lengthed cotton fibres. From the view of fabric tightness, loose fabrics with higher loop length do not have pilling tendency.
- Among the fibre types, poliester fabrics displayed the best performance. On the other hand, since blended yarn is recycled yarn, bursting strength of the poliester/cotton fabric yarn show poor bursting strength level. The tight fabrics have higher bursting strength than loose fabrics, since tight fabrics have higher number of yarn intersections.
- In both wale and course direction, the fabrics knitted from poliester ring carded yarns displayed better wicking behaviour.

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METHODS OF QUALITY ASSURANCE FOR FORMALDEHYDE DETERMINATION FROM TEXTILE MATERIALS

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Abstract: *Formaldehyde (CH_2O) is a colorless, highly toxic, and flammable gas at room temperature. Exposure to formaldehyde can irritate the skin, throat, lungs, and eyes, and repeated exposure to formaldehyde can lead to cancer. Formaldehyde resin products used in the textile industry include printing inks, dyes and textile finishing products. These formaldehyde-based materials help bind dyes and pigments to fabrics, prevent colours from running, improve a fabric's resistance to wrinkles, ease clothing care and maintenance and prevent mildew. This study described two analytical methods for detecting formaldehyde in textile materials: high performance liquid chromatography and spectrophotometric. The textile materials containing formaldehyde were extracted in water at 40 degrees C, filtrated and complexed with a coloring reagent – Nash, that contains acetylacetone, acetic acid, ammonium acetate and water. The solutions were comparatively analyzed by spectrophotometry and liquid chromatography coupled with a multiwavelength detector (HPLC-MWD). The spectrophotometric method was validated for precise and reliable results, proving it fits the intented use. The method is linear from the limit of quantification of 4 mg/kg ppm up to 600 mg/kg levels of formaldehyde. This method is intended for formaldehyde analyses in textile samples with excellent recovery, good sample stability, accurate results and good sensibility.*

Keywords: *formaldehyde, method validation, liquid chromatography, spectrophotometry, textiles.*

1. INTRODUCTION

Formaldehyde (Figure 1) is a colorless, flammable, strong-smelling chemical used in building materials to produce many household products. It is used in pressed-wood products, such as particleboard, plywood, and fiberboard; glues and adhesives; permanent-press fabrics; paper product coatings; and certain insulation materials. In addition, formaldehyde is commonly used as an industrial fungicide, germicide, and disinfectant, and as a preservative in mortuaries and medical laboratories. Formaldehyde also occurs naturally in the environment. Most living organisms produce it in small amounts as part of normal metabolic processes.

Consumers are increasingly exposed to hundreds of potentially hazardous chemicals daily. These compounds can come into contact with their bodies through three different pathways: inhalation, ingestion and dermal absorption. Formaldehyde is commonly used in several textile production processes; for example, after treatment of substantive dyeing and hardening of casein fibres, as a wool protection agent, anti-mould, and cross-linking agent in resin finishing.

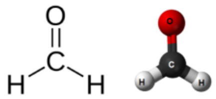

Fig. 1: Chemical structure of formaldehyde.

In 1987, the U.S. Environmental Protection Agency (EPA) classified formaldehyde as a probable human carcinogen under unusually high or prolonged exposure [1]. Since then, some studies of humans have suggested that formaldehyde exposure is associated with certain types of cancer. The International Agency for Research on Cancer (IARC) classifies formaldehyde as a human carcinogen [2]. In 2011, the National Toxicology Program, an interagency program of the Department of Health and Human Services, named formaldehyde a known human carcinogen in its 12th Report on Carcinogens [3].

Formaldehyde mediates its toxic effects by chemically modifying vital cell components, including DNA and proteins, leading to cellular dysfunction. Formaldehyde-mediated genotoxicity is caused by the formation of DNA-DNA and DNA-protein cross-links, as well as covalent DNA mono adducts [4,5,6,7].

In Europe, no legal restrictions are presently applicable to the content of formaldehyde in textiles. In contrast, limitations have been in place in other countries, such as Japan, for over thirty years. However, two voluntary labelling schemes are available: the European Ecolabel, introduced with a Commission Decision [8] and focusing more on ecological criteria, and the private Oeko-Tex Standard 100 [9], which also focuses on consumer protection. Both Ecolabel and Oeko-Tex Standard 100 foresee limits for formaldehyde that vary depending on textile categories. In particular, Ecolabel established the limits of 30 mg/kg for formaldehyde released from textiles in direct contact with the skin (75 mg/kg for Oeko-Tex Standard 100) and 150 mg/kg for textiles which have no direct contact with the skin (the same limit for Oeko-Tex Standard 100). In addition, Oeko-Tex Standard 100 established that textiles for babies up to two years old should release less than 16 mg/kg.

The standard test method for free formaldehyde determination is Japan Law 112 (Oeko-Tex Standard 100), and the accuracy of this method depends on the formaldehyde content in the sample. This method cannot determine the formaldehyde contents under 16 mg/kg. Results obtained below 16 mg/kg are reported as non-detectable. The detection of low formaldehyde contents is important, particularly in some fields, like children's clothing. Thus a more specific and sensitive analysis method was used: high-performance liquid chromatography. Textile substrates finished with different crosslinking reagents were extracted with water to detect free formaldehyde by the acetylacetone method (Nash reagent). The results obtained by the standard test method, Japan Law 112, in which UV/VIS spectrometer was used, were compared with those obtained by the HPLC method, where separation was performed on RP C18 Zorbax Eclipse XDB column with water: ACN as a mobile phase and the result were very close.

2. MATERIALS AND METHODS

2.1. Chemicals and Materials.

All chemicals and reagents were of HPLC or analytical grade. Ultrapure water used throughout the determinations was obtained from TKA GenPure system. Acetonitrile was with assay > 99%.
A standard of formaldehyde (37% methanol stabilized solution) was purchased from Sigma Aldrich.
All performance parameters and statistical experiments were applied to finished textile samples.

2.2 Samples.

4 textile samples (2 knitted materials and two compression garments) collected from various textile producers in Romania were analized both by spectrometry and liquid chromatography, and the quantitative results were compared.

2.3. Spectrophotometric methods validation.

Spectrophotometric methods for formaldehyde determination in textiles were performed according to Romanian Standard SR EN ISO 14184-1:2012, and the method was validated. Method Validation (Fit for Intended Use) includes all of the parameters that demonstrate that a method used for quantitative measurement of analytes is reliable and reproducible for the intended use. Eurachem guideline [10] was followed for checking the method validation performance parameters: selectivity, limit of detection (LOD) and quantification (LOQ), sensibility, linearity, trueness, bias, the precision of repeatability and reproducibility, and robustness.

2.4. Calibration Preparation.

A calibration curve was used for both spectrophotometric and chromatographic methods to quantify the amount of formaldehyde in the textile samples. Calibration levels were: 0.15, 0.3, 0.75, 1.5, 2.25, 4.5, and 6 mg/L.

2.5. UV-VIS Analysis. For UV-VIS spectrophotometric determinations Perkin Elmer UV-VIS spectrometer was used, with a maximum absorption peak of formaldehyde at 412 nm.

2.6. HPLC Analysis. The high-performance liquid chromatography instrument used was model Agilent 1100 series from the USA equipped with a quaternary pump (G1311A), vacuum degasser (G1379B), autosampler (G1313A), MWD Agilent detector (G1365B), and analytical column: Agilent Zorbax Eclipse XDB C18 3.5 µm 4.6 × 150 mm. The sofware used was Chemstation for LC, Rev. B. 01.03. The HPLC pump flow rate was 0.8 mL/min. The formaldehyde mobile phase was acetonitrile 50: water 50 (v/v), with an analysis time of 10 minutes. The multiwavelength detector parameter was selected at 412 nm, with a 0 nm reference wavelength.

3. RESULTS AND DISCUSSION

3.1. Optimization of HPLC Analysis. The described test method was developed and optimized to provide confident results. After scanning a broad spectrum (200 -750 nm), the HPLC analysis wavelength was selected, and the maximum absorption peak was observed as 412 nm. The optimum mobile phase mixture was water: acetonitrile (50: 50 v/v), which gives high peak intensity, good resolution factor (>2), good symmetry (>0.80), and convenient run time (Figure 2).

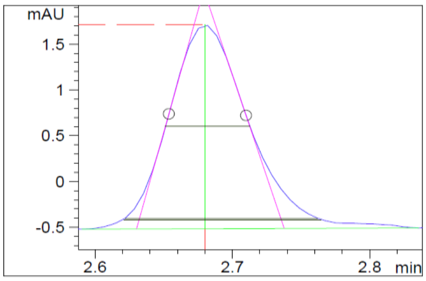

Fig. 2: Peak of formaldehyde 0.75 mg/L, with a symmetry of 0.801

3.2. Method Validation (Fit for Intended Use)

The spectrophotometric method was validated to demonstrate that this method used for quantitative measurement of formaldehyde is reliable and reproducible.

3.2.1. Selectivity

Analytical selectivity shows the method's ability to measure the analyte's response in the presence of all other impurities and compounds in the sample.

Spectrophotometric analysis was performed for the following substances: acetic anhydride 6 mL/L, formaldehyde 0.15 mg/L, formaldehyde 6 mg/L, acetaldehyde 6 mL/L, ethanol 6 mL/L, acetone 2 mL/L, ammonium acetate 150 g/L, acetic acid 3 mL/L, but also for the Nash reagent. It can be observed that the Nash reagent and its components do not spectrally interfere with formaldehyde, the spectrophotometric method being selective for the determination of formaldehyde. All readings were taken in the 350 – 500 nm range. The superimposed spectra of all substances are shown in Figure 3.

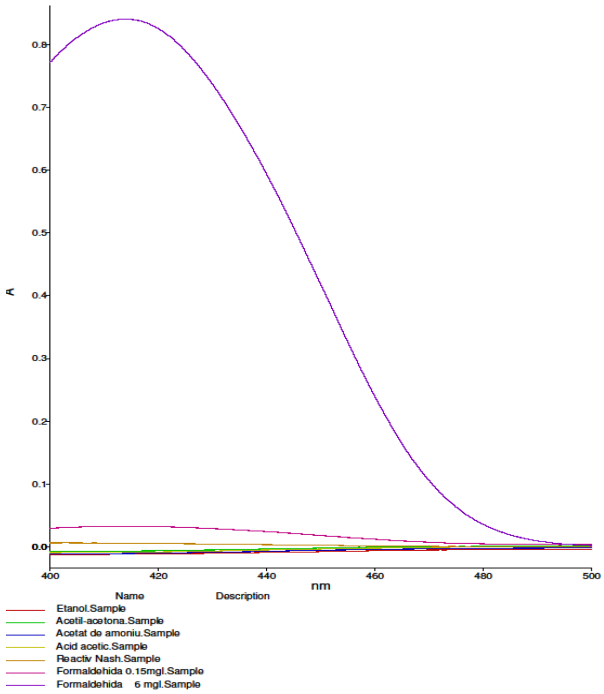

Fig. 3. Superimposed UV-VIS absorption spectra of compounds that can interfere in the determination of formaldehyde

3.2.2. Linearity

The linearity of a quantitative analytical method represents its ability to obtain results proportional to the concentration (quantity) of the analyte in the sample. The linearity was demonstrated by making an 8-point calibration curve in a concentration range of 0.1500 - 6.000 mg/L for the following concentrations: 0.15 mg/L, 0.3 mg/L, 0.75 mg/L, 1.5 mg/L, 2.25 mg/L, 3 mg/L, 4.5 mg/L, 6 mg/L.

The regression curve of corrected absorbance vs concentration was generated (Figure 4). The obtained correlation coefficient (0.999640) demonstrates excellent linearity over the 0.15 mg/L - 6 mg/L concentration range.

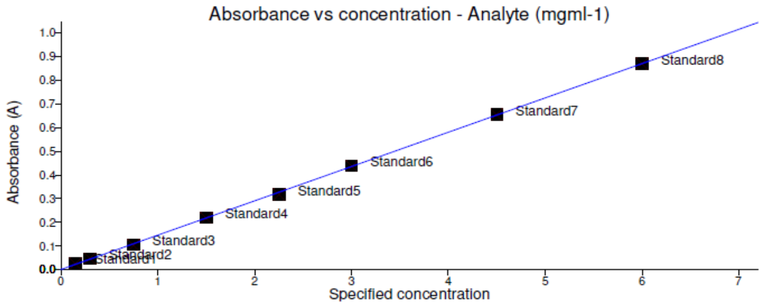

Fig. 4. 8 points - calibration curve

3.2.3. Limit of detection and limit of quantification

The limit of detection (LOD) represents the lowest analyte concentration in a sample that can be detected with reasonable statistical certainty but not necessarily quantified as an exact value under the established test conditions. The limit of quantification (LOQ) is the lowest concentration or amount of analyte that can be quantitatively determined with acceptable repeatability and accuracy. 10 independent blind samples were passed through the entire work procedure and had their absorbance measured. In the second step, 10 independent blank samples fortified at 6 concentration levels were prepared: 0.11 mg/L, 0.12 mg/L, 0.13 mg/L, 0.14 mg/L, 0.15 mg/L, 0.16 mg/L and had their absorbance measured (Table 1).

Table 1. The experimental results obtained for 6 concentration levels, standard deviation and RSD%

n (no. det.)	0.11 mg/L	0.12 mg/L	0.13 mg/L	0.14 mg/L	*0.15 mg/L*	0.16 mg/L
1	0.1052	0.1145	0.1158	0.1377	0.1485	0.1647
2	0.1056	0.1142	0.1164	0.1384	0.1453	0.1568
3	0.1059	0.1143	0.1156	0.1386	0.1509	0.1595
4	0.1062	0.1142	0.1164	0.14	0.1556	0.1618
5	0.1062	0.1145	0.1164	0.1401	0.1505	0.1643
6	0.1065	0.1148	0.1166	0.1407	0.1571	0.1667
7	0.1067	0.1143	0.1165	0.1406	0.1420	0.1689
8	0.1071	0.1148	0.1168	0.1408	0.1445	0.1712
9	0.1066	0.1142	0.1168	0.1412	0.1470	0.1739
10	0.1065	0.1151	0.1171	0.1412	0.1502	0.1762
$x_{m(sample)}$	**0.1063**	**0.11449**	**0.11644**	**0.13993**	**0.1492**	**0.1664**
σ_{sample}	**0.0006**	**0.00031**	**0.00045**	**0.00125**	**0.00475**	**0.00624**
RSD%	**0.5273**	**0.27451**	**0.38874**	**0.89579**	**3.1872**	**3.74712**

LOD = 0 + 3* 0.00475 = **0.01425 mg/L (1.425 mg/kg CH_2O)**
LOQ = 0 + 10* 0.00475 = **0.0475 mg/L (4.75 mg/kg CH_2O)**

The results obtained for the detection and quantification limit allows establishing the lower limit of the working concentration range at the value of 0.15 mg/L but especially allows the detection and quantification of formaldehyde at lower levels of concentrations. \

3.3. Quantitative results

Results obtained for the quantitative determination of formaldehyde in textile samples by spectrometry and liquid chromatography are very close (Table 2). Therefore, HPLC-MWD technique can be easily and precisely used as a more modern and efficient alternative to the spectrophotometric method.

Table 2. The result obtained for CH_2O determination in textile samples

Analysis technique	**Formaldehyde concentration (mg/kg)**			
	Sample 1 (Knitted material)	Sample 2 (Knitted material)	Sample 3 (compression garment)	Sample 4 (compression garment)
UV-VIS Spectrometry	4.89	12.35	6.12	12.35
HPLC-MWD	4.74	13.27	5.72	14.05

4. CONCLUSION

Detection and monitoring of formaldehyde in textile materials is a serious concern, considering the toxic effect of this substance on human health. This study presented two reliable methods for the simple and fast quantitative determination of formaldehyde in textile samples. The spectrophotometric method was validated for reliability and precision in routine analysis, confirming that this method is fit for purpose. The chromatographic method was optimized and gave very close quantitative results compared to the spectrophotometric method. HPLC-MWD equipment can thus be safely used for a more rapid, precise and modern determination.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

EXTRACTION OF ANTHOCYANINS FROM ARONIA MELANOCARPA, AS A POTENTIAL NATURAL TEXTILE DYE

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Abstract: *Gaining sustainability in the textile finishing industry deals among others with the replacement of synthetic dyes with non-toxic and biodegradable natural dyes. Lately, increasing preoccupation has been noticed with the reassessment of the North America and Europe flora, as potential resources for extraction of natural colorants. Within the wide range of natural colorants, anthocyanins - found in fruits and vegetables, dye natural fibers in beautiful pink and purple shades. Chokeberry (*Aronia melanocarpa*) fruit, ordinarily used as a nutraceutical, has one of the highest contents of anthocyanins in the plant kingdom. This paper deals with the extraction of anthocyanins from dried chokeberry fruits and pomace, using a conventional solvent extraction with acidulated acetone-water mixture and a non-conventional aqueous two-phase extraction based on salt-alcohol mixtures. The anthocyanins extraction yield from chokeberry fruits was very low and had comparable values for both extractants, of around 70 mg/100 g dried fruit. Pomace had a much higher anthocyanins content, namely 876.37 mg/100 g dry pomace for the acetone extractant and 1287.2 mg/100 g dry pomace for the two-phase extractant. Anthocyanins' color and stability showed an expected variation when the solution pH shifted from acidic to alkaline. Aronia juice extraction leftovers can be turned from a potential waste into a valuable and easily available source of natural dyes.*

Key words: *vegetable dye, plant pigments, two-phase extraction, solvent extraction, eco-dyeing, chokeberry*

1. INTRODUCTION

Chemical finishing is a critical stage of the textile value chain, in terms of environmental impact derived from water and toxic chemicals, extensively used in the manufacturing processes; synthetic dyes raise the main pollution issues, due to toxicity and low biodegradability. In recent years, the textile industry's duty to comply with sustainability commandments revived the interest in natural dyeing and in finding new renewable resources for the extraction of natural dyes [1, 2].

Natural dyes with feasible applications in textile finishing cover a wide range of chemical structures: anthraquinone, indigoid, carotenoid, flavonoid, dihydropyran, etc. [3]. Anthocyanins (ANs) are considered the main water-soluble plant pigments from the flavonoid/polyphenolic class, which render vivid red, purple, or blue colors to different fruits, seeds, and vegetables [4]. Dyeing of cotton, wool, and silk with ANs extracted from vegetal sources has been reported in literature [5, 6].

Anthocyanins are conveniently extracted with methanol, ethanol, or acetone aqueous solutions [7], preferably slightly acidulated to avoid degradation. Extraction with aqueous two-phase systems (ATPSs) made up of a lower alcohol and a highly soluble salt has lately attracted attention due to several advantages over organic solvent extraction – no use of toxic solvents, convenient recycling of extraction agents, low sugar content of the anthocyanin-rich phase [8,9].

Aronia is a species of shrub native to Eastern North America, but it was brought to Europe, including Romania, where it is cultivated in several plantations and traded as a nutraceutical, due to its antioxidant properties. Amongst berries in general, chokeberry has the highest total anthocyanin concentration, with a maximum of about 1480 mg/100 g of fresh fruit weight (FW) [10].

In this paper, conventional solvent and ATPS extraction are assessed as possible techniques for the extraction of anthocyanins from chokeberry fruits and pomace, in terms of extraction yield and optimal plant material: solvent ratio. Color change and stability of the aqueous extracts as a function of pH were also evaluated.

2. MATERIALS AND METHODS

The dehydrated whole fruits and powdered pomace of *Aronia melanocarpa* were purchased from SC Aronia Charlottenburg SRL, Romania. Grounded fruits and pomace were sieved at 100 mesh and stored hermetically at room temperature. All reagents: acetone, ethanol (EtOH), citric acid, ammonium sulfate, monosodium phosphate, and chemicals for buffers preparation, were of analytical grade.

The water content of the vegetal materials was determined gravimetrically by air-drying at 105°C till constant weight.

Conventional ANs extraction was performed with acidified acetone solution (acetone:water 70:30 v/v, and 0.2% citric acid w/w), at a solvent:solid ratio of 40:1 v/w. Extraction proceeded in 4 stages 30 min each, at 40°C, under magnetic stirring at 200 rpm. Acetone was removed from the crude extract by vacuum rotary evaporation at 30°C, and fine solid particles were separated by centrifugation at 1600 RCP for 20 min. The supernatant was collected and kept at 4°C till characterization.

Two-phase extraction was performed with two ATPSs, namely $(NH_4)_2SO_4$- EtOH, and NaH_2PO_4- EtOH, with identical salt:alcohol:water ratio, equal to 20:30:50 w/w/w. ATP extraction experiments were performed with batches of 20 mL ATP and plant matter mass of 0,2 to 0.7 g. First, salt was dissolved in water, then the plant solid, fruit or pomace, was dispersed in the salt solution. After ethanol addition, extraction was performed for 15 min at 40°C under magnetic stirring at 600 rpm. The mixture was left still for phase separation at 30°C for 2 h. The upper ethanol-rich phase with higher ANs content and the lower salt-rich phase were separated, and the solid was discarded.

Anthocyanin content in extracts was determined by the pH differential method, as described in [11]. Briefly, two standard buffer solutions were prepared: a KCl/HCl buffer solution of pH 1.0 and a CH_3COONa/HCl buffer solution of pH 4.5 Equal volumes of Aronia extract were introduced in two test tubes and completed to 10 mL with solutions of each buffer. The solutions were left still at dark for 6 h. The absorbance of each solution was measured at 500 nm and 700 nm against distilled water, on a HACH DR/2010 spectrophotometer. The estimate of the anthocyanin content was expressed as cyanidin-3-O-glucoside (Cy-3-glc) equivalents and calculated by eq (1):

$$ANC\,(mg\,/\,L) = \frac{A \times MW \times DF}{\varepsilon \times L} \times 1000 \qquad \textbf{(1)}$$

where: $A = (A_{500} - A_{700})_{pH1.0} - (A_{500} - A_{700})_{pH4.5}$ is the turbidity corrected absorption; MW = 449,2 g/mol is the Cy-3-glc molar weight, DF – the dilution factor; ε – extinction coefficient (ε = 26,900 L/cm×mol), and L – optical path (L = 1.36 cm).

Color change and stability of pomace extracts were assessed at pH values of 2, 4, 6, 8, and 10, in appropriate buffer solutions.

3. RESULTS AND DISCUSSION

3.1. Influence of ATPS content and plant material dosage on the extraction efficiency

Different ATPSs are used for anthocyanin extraction, of which the $(NH_4)_2SO_4$- EtOH is the most popular; optimal ranges of salt and alcohol concentrations have been established for several plant sources [10]. The NaH_2PO_4- EtOH ATP also works well in anthocyanin extraction, even with a superior yield to that of the $(NH_4)_2SO_4$- EtOH ATP for certain plant sources [9].

Anthocyanin concentration in the upper phase resulted from $(NH_4)_2SO_4$-EtOH and NaH_2PO_4- EtOH extraction from Aronia fruits and pomace at different plant solid dosages are given in **Fig. 1** and **Fig. 2**.

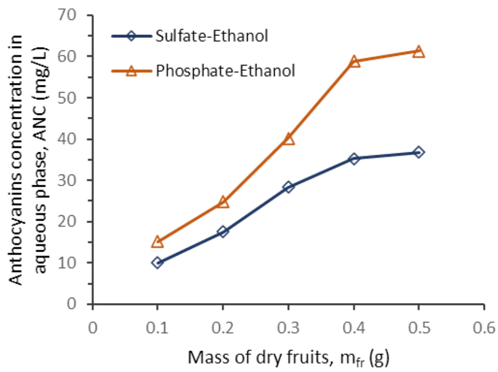


Fig. 1: Anthocyanin concentration in the ethanol-rich phase from ATP extraction from chokeberry fruit, as a function of vegetal material dosage per 20 mL ATPS.

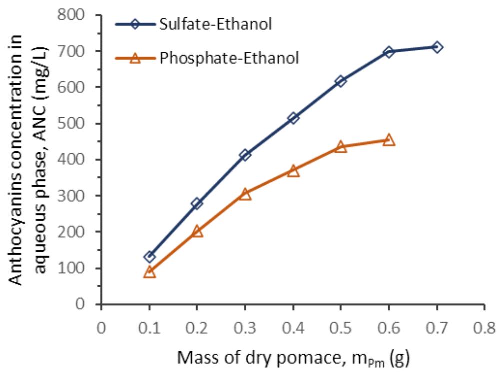


Fig. 2: Anthocyanin concentration in the ethanol-rich phase from ATP extraction from chokeberry pomace, as a function of vegetal material dosage per 20 mL ATPS.

No matter the ATPS composition, the extraction yield of ANs from dried fruits, given as anthocyanin concentration in liquid extracts (ANC), is significantly lower than that corresponding to pomace powder: for the sulfate-EtOH ATPS, the pomace yield: fruit yield ratio is about 17, while for the phosphate-EtOH system, the pomace yield: fruit yield ratio is about 7. This behavior can be related to the ANs sensitivity to water and processing temperature. The highest anthocyanin content is found in fresh fruits and is lowered by temperature and humidity [12]. Fresh chokeberry fruits have a high water content, of about 75 – 83% [13] while the pomace resulting from juice extraction has a much lower humidity content. In the fabrication process, both fruits and pomace are air-dried in mild conditions at 40°C, but the drying time for pomace is lower, due to the lower water content and comminuted physical state. For whole fruits, dehydration time is longer, enough to produce severe anthocyanin degradation. Moreover, it is stated that ANs are found mostly in the pulp and peels remained in pomace after juice extraction [9], which can explain the experimental findings. When fruits were used as extraction materials, the phosphate-EtOH provided a higher extraction yield than the sulphate-EtOH system.

For fruits, the extraction yield increased linearly with dosage increase, up to a maximum of 0.4 g, and then recorded a negligible raise. Identical evolution was recorded for pomace in sulfate-EtOH up to 0.6 g, but, at this dosage, the phase separation was hindered by the high volume of the solid phase. In the phosphate-EtOH, a maximum dosage of 0.5 g was recorded. Anyway, the amount of ANs dissolved in the upper ethanol-rich phase (ATP technique) gets to a saturation point, beyond which the increase of the solid mass dosage becomes non-feasible. Further extraction experiments were performed on samples with a dosage of 0.5 g plant material for 20 mL ATPS. which are very convenient to manipulate in the extraction experiments and correspond to a solvent:solid ratio of 40:1 v/w, identical to that used in acetone extraction.

3.2. Influence of the extraction agent on the extraction yield

Comparative studies of ANs extraction using acetone, methanol, and water, showed that acetone renders efficient and more reproducible extraction, avoids problems with pectins, and requires a much lower temperature for concentration [14].

The values of ANs extraction yield from the acetone: water and the sulfate-EtOH extractants, given in mg/L extract and in mg/100 g dry vegetal matter, are given in **Fig. 3**. As with the $(NH_4)_2SO_4$-EtOH ATP, extraction yield in acetone was very low for fruits and significantly higher for pomace. The AN extracted from pomace, reported to the dry matter, was about 13 times higher than that extracted from fruits:876.37 mg/g DW for pomace vs 66.32 mg/g DW for fruit.

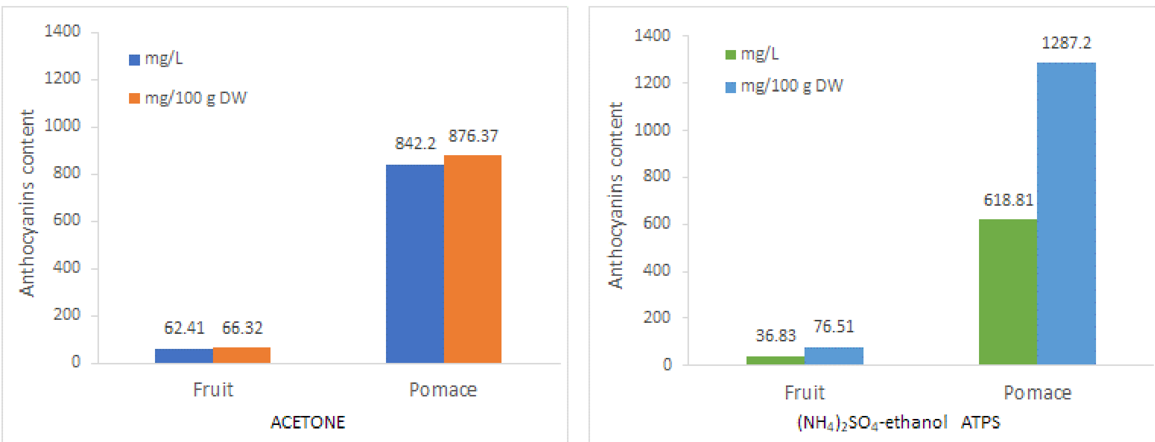


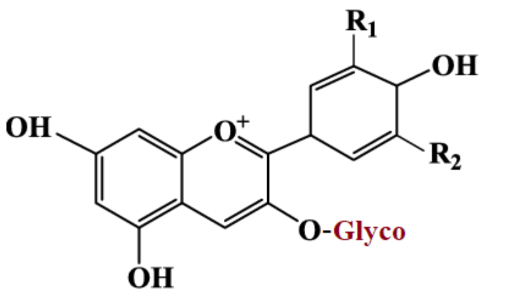
Fig. 3: Dependence of anthocyanins extraction yield on the extraction agent.

The concentration of ANs extracted in the ethanol-rich phase of the $(NH_4)_2SO_4$-EtOH ATP was lower than that obtained with acetone, both for fruit and pomace, because the volume of the upper phase was higher than the extract resulted from acetone extraction, but the AN yield reported to the dry plant was superior. For fruit, yield values were quite comparable: (66.32 mg/100 g fruit and 76.51 mg/100 g fruit) due to the low AN content in the chokeberry fruits, and this may be the maximum attainable concentration. The AN extracted from fruits are close to the actual AN content in the dry chokeberry fruits. As regards the pomace, the yield of the two-phase extraction is about 1.5 higher than that of acetone extraction. Taking into account that the air-dried pomace suffered inevitable ANs degradation, an extraction yield of 1287.2 g AN/100 g dry pomace can be considered satisfactory.

3.3. Dependence of anthocyanins color and stability on solution pH

When pH varies from acidic to alkaline, structural transformations of AN pigments occur, which result in obvious color changes. It is generally admitted that in acidic medium, anthocyanins appear red, have a purple hue in neutral pH, and the color changes to blue in alkaline conditions.

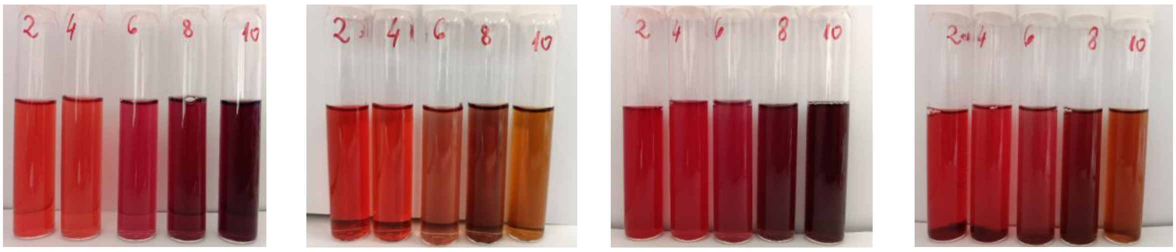
There are six main types of anthocyanins that commonly occur in nature, namely Cyanidin, Delphinidin, Malvidin, Pelargonidin, Peonidin, and Petunidin. They derive from a common polyphenol skeleton and differentiate themselves by the substituent groups (see **Fig. 4**) In nature, they derive from anthocyanidins - the sugar-free counterparts of anthocyanins, after their combination with different glycosides, such as glucoside, arabinoside, rutinoside, etc. Anthocyanins from Chokeberries mainly consist of cyanidin (up to 98%), followed by delphinidin, and the other types in very small amounts [15].



Anthocyanidin	R_1	R_2
Cyanidin	OH	H
Delphinidin	OH	OH
Malvidin	OCH_3	OCH_3
Peonidin	OCH_3	H
Pelargonidin	H	H
Petunidin	OCH_3	OH

Fig. 4: Chemical structures of main naturally occurring anthocyanins, named after their sugar-free anthocyanidin counterparts

Colors of extracted ANs at different pH values and at identical concentration, of 56 mg/L in the buffer solutions, are given in **Fig. 5.** Antocyanins color ranges from red at acidic pH, light magenta at pH 6 and reddish purple at alkaline pH, with higher intensity at pH 10 than at pH 8. Acetone extracts are transparent, while the ATPS extracts are slightly turbid at acidic pH and show darker shades.



(a) (b) (c) (d)

Fig. 5: Anthocyanins color at different values of pH, from acidic to alkaline: a) acetone; b) acetone after 24 h; c) $(NH_4)_2SO_4$-ethanol; d) $(NH_4)_2SO_4$-ethanol after 24 h

It is accepted that in plants, cyanidin pigment has a reddish-purple (magenta) hue, while delphinidin appears as a blue-reddish pigment. In acidic aqueous media pH (pH <4) cyanidin has a red color, which shifts to purple at pH 6-7 and turns to blue at higher pH values (pH =8-9). The blue color can persist even at higher pH values. Changes in the chemical structure of cyanidin along with pH, which accounts for its color variation, are depicted in **Fig. 6**. In strongly acidic solutions (pH < 2), the flavylium cation predominates in the structures of anthocyanin, conferring them bright, stable red hues and high solubility in water [16]. With pH increase over 4, the quinoidal species start to emerge and determine an apparent color change starting with pH 6.

Delphinidin turns from purple to blue only in higher pH conditions. [16]. Due to its low concentration in Aronia ANs, delphinidin's influence on color change is very weak. The experimental findings on color change of Aronia ANs as a function of pH are consistent with previous literature data [6].

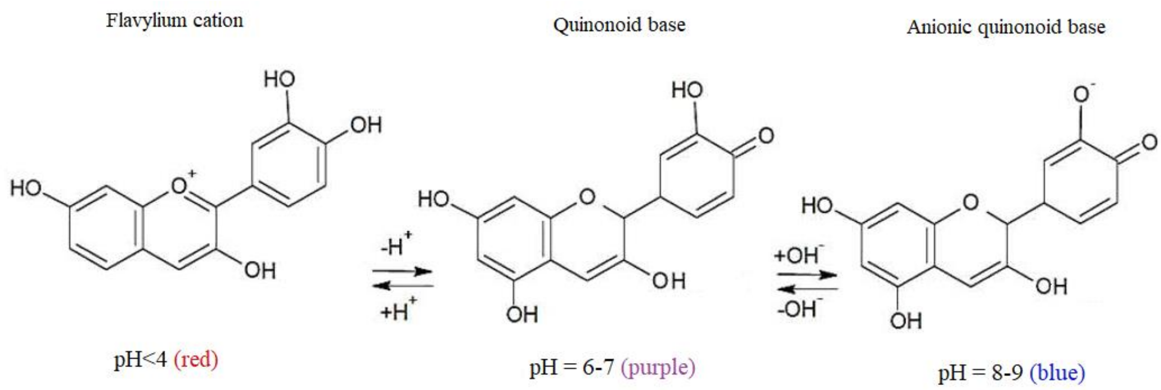


Fig. 6: Structural and color changes of cyanidin with pH

Color stability in time at acidic pH values of 2 and 4 is easily noticeable. At pH 6, ANs extracted with acetone showed a color shift to reddish-brown, while ANs extracted in ATPS were still red-pink. In alkaline pH, both AN extracts underwent an obvious color fading and shifting to brown shades after 24 h, due to the instability of quinoidal molecular structures of cyanidin. Exposure of alkaline samples to daylight may be also responsible for color alteration [17].

5. CONCLUSION

Acetone extraction of anthocyanins from Aronia provided a good extraction yield and a straightforward extract concentration process.

The aqueous two-phase extraction with $(NH_4)_2SO_4$-EtOH rendered a superior extraction yield than the acetone extraction and worked well with the plant material in solid form.

Anthocyanins concentration in dried fruits was considerably lower than that in pomace, which proves that the water content and the physical state of the vegetal material, together with the parameters of the drying process have a major influence on anthocyanins stability.

Anthocyanins extracted from Aronia exhibited high stability at acidic pH and rapid degradation at alkaline pH, which is common for this flavonoid class.

Aronia pomace, a potential waste coming from an indigenous plantation, can be turned into a valuable source for anthocyanin colorant extraction.

Further studies on anthocyanins extracted from chokeberry are needed, to assess their tinctorial properties and use for textile dyeing.

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BIOMATERIALS FOR THE FASHION INDUSTRY

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Abstract: *The textile industry is estimated to be the second most polluting industry in the world. Carbon emissions exceed the amount of simultaneous emissions from the aviation and shipping industries, which are also responsible for 20% of the total amount of polluted water. Biomaterials are a sustainable alternative to traditional materials used in the fashion industry. The actuality of the theme is determined by the increased interest of researchers in the field of the fashion industry to find a sustainable alternative for traditional textiles. The aim of the paper is to find sustainable alternatives in the textile industry. The paper includes not only theoretical studies on the current state of availability and areas of usage of biomaterials in the fashion industry but also practical applications for obtaining biomaterials and studying their characteristics. For this purpose, I created 3 samples of biomaterial according to the same recipe, following the same process. The samples had been researched in different environmental conditions. Environmental conditions were simulated under laboratory conditions. For the manufactured biomaterial sample were detetermined characteristics such as thickness, mass and surface. The obtained results are summarized in the form of graphs. The obtained data allow to evaluate the samples of the tested biomaterial and determine the conditions, areas of use. Further research directions will include the determination of mechanical, hygienic-functional, and appearance properties for manufactured biomaterial samples.*

Key words: *bioplastic, characteristics, assessment, environmental conditions, manufacture.*

1. INTRODUCTION

The textile industry is estimated to be the second most polluting industry in the world, responsible for 10% of global carbon emissions. Chemical paints and substances used in the textile finishing process pollute 20% of all waste water globally [1,2]. Global textile fiber production has doubled over the past 20 years, reaching an all-time high of 111 million tons in 2019, and growth forecasts remain for 2030 [1]. The recycling rate of textile waste is very low, with only 13% of it being recycled [1].

The impact of the textile industry on environmental pollution is one of the problems that requires finding sustainable alternatives in the field of fashion. A circular economy is a solution that reduces environmental impact. Biomaterials are a future trend in fashion and sustainability, but also contributing to a circular economy. Although, biomaterials are implemented in the fashion industry, they are not fully studied. In the fashion industry, biomaterials can be obtained in different ways: by contain “biomass”, from biological ingredients, made by using biological processes, biodegradable, or all of the above. For their wider use in fashion, theoretical and experimental research is needed to establish the theoretical and practical aspects necessary for finding sustainable solutions to traditional textiles.

2. EXAMPLES OF BIOMATERIALS FOR THE FASHION INDUSTRY

Due to the growing concern about sustainability and the negative impact of the textile industry on the environment, in recent years, interest in biomaterials has increased significantly. Evidence of the concerns about the use of biomaterials in the field of fashion are the works of fashion designers who work with biomaterials, or create new biomaterials (table 1) [3].

Table 1: Biomaterials for fashion

Name	Creator	Brief description
Sequins made from algae	Carolyn Raff	Biodegradable sequins created from bioplastic made from algae.
Increased crystals from sweat	Alice Potts	Athletic clothing covered with crystals grown from sweat
Glass-like dress	Scarlett Yang	Glass-like dress, grows over time and can decompose in water in 24 hours. Made from algae extract and silk cocoon protein.
BioMarble	Hannah Elisabeth Jones	Made from paper's wasting, it has a unique texture and surface pattern.
Fabric from bacteria	Jen Keane	He created a process of "microbial weaving" by manipulating bacteria found in kombucha, also known as K. Rhaeticus. This synthetic fibre is stronger than steel and more durable than Kevlar.

Biomaterials are a promising research topic, being also actively used by commercial companies (table 2) [4,5].

Table 2: Biomaterial manufacturing companies

Biomaterial name	Manufacturing company	Brief description
Sorona Fiber	DuPont	Made of 37% plant materials.
Piñatex	Piñatex	Obtained from the fibres of pineapple leaves. It is characterized by strength and durability. It is used for making some products of clothing, bags, shoes and accessories.
Mycelium	MycoWorks	Bioleather made from mushrooms grown in the laboratory and then processed to obtain a flexible and durable textile material. It is used for making some products of clothing, bags, shoes and accessories.
Desserto	Desserto	Bioleather made from cactus-natural material that has properties similar to those of animal skin. It is used for making bags, belts, shoes and clothing.
Zoa	Modern Meadow	Made from the collagen of animal cells. It is used to create a variety of leather products, from clothing to leather goods.
Spider Silk	Bolt Threads	Obtained by cultivating a species of spider in the laboratory and extracting the silk thread. A strong and flexible material, used in high-quality clothing and fashion accessories.
MycoFlex	Ecovative	This is a flexible, durable material, mainly used to create shoes and fashion accessories.

3. EXPERIMENTAL PART

3.1. Material and method

The study includes the manufacture of bioplastic samples with the following composition: agar-agar, glycerine, and water. The process and recipe are described in table 3.

Table 3: Bioplastic with agar-agar

Recipe	Process
• 2 gr agar-agar; • 1.25 ml glycerine; • 200 ml of water; • 1 gr denim yarn.	• Heat the water to a temperature of 60 degrees; • Add the plasticizer- glycerine; • Add agar-agar; • Stir until smooth and cook until a thick liquid is obtained; • Pour on the chosen surface and leave it to dry in a dry room.

For the manufactured samples, the following characteristics were determined: thickness, surface area, weight (table 4).

Table 4: The characteristics of manufactured bioplastic

Characteristics	Appearance		
	sample 1	sample 2	sample 3
			
thickness, mm	0,3	0,3	0,3
surface area, mm^2	132,7	132,7	132,7
weight, gr	5	5	5

3.2. Results and discussion

For studying how the characteristics of the manufactured biomaterial change in different environmental conditions, I did some researches. The environments were: high humidity (sample 1), temperature < 0^0C (sample 2), and high temperature (sample 3). Environmental conditions were simulated under laboratory conditions. Observations were recorded for different time periods: 3 hours, 8 hours, and 24 hours (table 4).

Table 4: Results

Environmental conditions	Characteristics	Results		
		3 hours	8 hours	24 hours
High humidity – 80…90%	thickness, mm	0,3	0,3	0,2
	surface area, mm^2	132,7	130,6	124,6
	weight, gr	5	4	2
Temperature < 0^0C	thickness, mm	0,3	0,3	0,3
	surface area, mm^2	132,7	132,7	132,7
	weight, gr	5	5	5
High temperature – 34…37^0C	thickness, mm	0,3	0,3	0,3
	surface area, mm^2	132,7	132,7	132,7
	weight, gr	5	5	5

Based on the recorded results, I made some graphs that represent the changes of the sample biomaterials in different environments and their changes over a period of time (fig. 1).

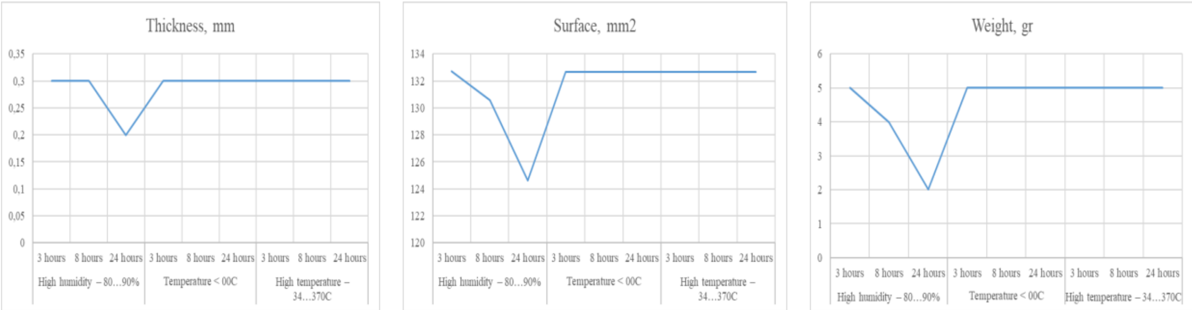

Fig. 1: The changes of the biomaterials characteristics in different environmental conditions

The obtained data allow for determining the resistance of the tested biomaterial in various environmental conditions and, subsequently, establishing concrete areas of use.

5. CONCLUSIONS

The samples of the manufactured biomaterial were tested in 3 different environments: increased humidity, temperatures below 0^0C and high temperatures:

- in the environment of increased humidity (80 ... 90%), the sample changed its characteristics of thickness, surface, and mass, being obvious a degradation of it;
- in environments below 0^0C and high temperatures (34...37^0C), the characteristics of the tested samples did not change.

The recorded data allow to determine the conditions and areas of use, as well as estimating the conditions of their biodegradation in a short period of time.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

THE RENDERING OF A DRESS USING THE ASSYST ® 3D VIDYA SOFTWARE

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Abstract: *This papers' main aim is to present the rendering method for a dress within the 3D Vidya module of the Assyst design program. Rendering is one of the major topics of 3D computer graphics, and in practice it is always connected to the other topics. It is the last important step in the graphics pipeline, giving models and animation their final look. With the increasing sophistication of computer graphics since the 1970s, it has become a more distinct subject. Assyst has the largest 3D dimensioning and fitting portal in the world. It enables the integration of customer sizing and fitting directly into the used processes and systems, with a multitude of functions ranging from market and target group studies to 3D and CAD integration and avatar creation. The computer-aided design program Assyst is in the top 3 of the profile programs used on the European market, the latest development is the 3D Vidya design module. Assyst 3D Vidya combines both the design process, the product, the 2D designed model and its subsequent simulation in 3D. The texture of materials is displayed in the highest photo quality, and the simulation of the use of accessories such as zipper, snaps is very realistic. Using the 3D Vidya module can save the sample execution process and increase the quality and efficiency of the supply chain.*

Key words: *Assyst Vidya, V-Ray, 3D modelling, apparel, rendering.*

1. INTRODUCTION

The ease of use and the multitude of tools, commands and functions that serve the drawing, modeling and styling process have made graphic programs increasingly used and beloved in the textile industry [1], [2], [3]. Rendering is the process of generating a photorealistic or non-photorealistic image from a 2D or 3D model by means of a computer program. The resulting image is called a rendering [4]. Multiple models can be defined in a file containing objects in a strictly defined language or data structure. The file contains geometry, viewing angle, texture, lighting, and shading information that describe the virtual image. The data contained in the file is then passed to a rendering program to be processed and translated into a digital image or raster graphic image file. The term "rendering" is also used to describe the process of calculating effects in a video editing program to produce the final video output [4]. The computer-aided design program Assyst is in the top 3 of the profile programs used on the European market, the latest development is the 3D Vidya design module. Assyst 3D Vidya combines both the design process, the product, the 2D designed model and its subsequent simulation in 3D [5], [6].

2. RENDERING OF A DRESS

The emphasis here is on transparency, roughness, color and opacity. Opening the desired file in our case being the DRESS, we are changing the working mode to "material texture editing" from the top menu bar, clicking on a piece and then selecting a wool/elasthane composition for the main material from the left menu **Fig. 1**.

Fig. 1: Rendering a dress, with the material being wool elasthane composition

2.1. Transparency

To reduce the transparency, depending on the density of the garment, select the desired value from the menu on the right, the default value is always 100%, the lower the value, the more transparent the texture [4], **Fig. 2**.

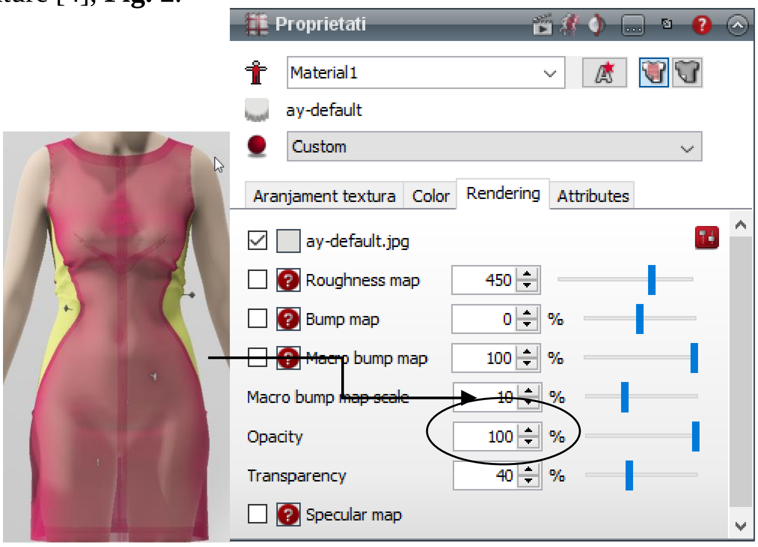

Fig. 2: Setting the desired trasparency value

2.2. Roughness

Roughness determines how much light is reflected from the materials surface. The higher the value, the less light is reflected. Therefore the texture is rougher [4] **Fig. 3**.

Roughness value 0 Roughness value 100 Roughness value 5000

Fig. 3: Examples of applied roughness values and the effect on the material surface

The roughness map determines where the texture reflects more or less light. The map consists of a grayscale image. White or lighter spots reflect less light than darker or black ones. Thus, the texture on the brighter/white areas of the map looks rougher. Roughness is diffused and nuanced by the map [4].

Roughness map and roughness values work together:

- The roughness value 0 (=black) always results in a lacquer-like texture, whether with or without a map file.
- Conversely, the black spots on the map retain the lacquer effect, regardless of the roughness value
- The white spots on the map behave according to the roughness value: The higher the value the rougher.
- Gray tones of the roughness map weaken the effect. [4] **Fig. 4**.

Black *Anthracite* *Grey* *White*

Fig. 4: Examples of roughness 0 for black, dark grey, grey and white

2.3. Rendering lace surface for the side inserts of the dress

In order to be able to highlight various pieces by using other materials than the main one, in our case we select the lace for the side inserts of the dress, the "*material texture editing*" mode is active and from the este activ and in the "*fabrics and accessories*" menu on the left we select from the database the picture of the material we want to insert as shown in **Fig. 5**.

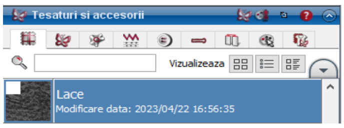

Fig. 5: Selecting lace for the side inserts

Left-click on the side inserts of the dress and from the "*fabrics and accessories*" menu by "drag & drop" we insert the new material, as shown in **Fig. 6**.

Fig. 6: Final appearance of the dress

3. CONCLUSIONS

With the 3D Vidya module, the efficiency is given by the multiple options in terms of converting the designed pattern in Assyst CAD by means of only a few steps in the 3D simulation process. The program also offers the possibility of selecting fabrics with real parameters such as: density, thread thickness, color, structure or effects. At the same time, flexibility is found in the ease of implementing changes, which within a company significantly reduces the decision making reaction time and the costs needed to produce more samples.

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ANNALS OF THE UNIVERSITY OF ORADEA
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ACTUATORS USED FOR ARTIFICIAL MUSCLES

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Abstract: *This work presents aspects regarding the actuators used to create artificial muscles and their operating principles. Actuators perform an action (movement, brightness increase, colour change) based on a stimulus (electrical, mechanical, magnetic or chemical). Actuators can be used to create artificial muscles, stimulating or replacing the functions of human muscles, for robots or medical devices such as prostheses. They can be used to create linear or rotary motion and can be controlled via electrical or hydraulic systems. In terms of artificial muscles, actuators are used to produce the movement or force required to mimic the action of human muscles. In general, the actuators used in artificial muscles must present good precision and be easily controlled. In addition, they must be reliable and able to be integrated into a wide range of devices. While electric motors are the most popular actuator-based systems, hydraulic, pneumatic and piezoelectric actuators are frequently used to create artificial muscles.*

Key words: *actuators, artificial muscles, energy, medical devices*

1. INTRODUCTION

Actuators are essential for complex systems that require the production of motion. They can be defined as controllable execution systems that transform input energy of various origins, electrical, magnetic, thermal, optical or chemical, into mechanical work (a displacement, rotation, force or moment).

Integrating actuators in textiles is a new approach with an incredible potential for developing the textile industry, opening new perspectives for using smart textiles. In general, most actuator-based actuation systems are rigid, heavy, and noisy, features that make them unsuitable for integration into smart textiles, and in addition, they need heavy power supplies that are rarely flexible and lightweight, which affects wearability, it is necessary to create flexible actuators, with reduced mass and dimensions and silent [1, 2].

Based on the characteristics, stimuli-sensitive materials represent an emerging class of materials responding to temperature, pH, light, magnetic fields and can manifest by changing the dimensions, shape, appearance, permeability, electrical conductivity, and mechanical or optical properties [1].

Polymers are among the most used materials for making textile actuators (actuators based on polymers), due to their many advantages compared to actuators based on ceramic or metal materials [2].

To realise artificial muscles, materials or devices (actuators) are used that imitate natural muscles by changing the stiffness, contraction, elongation or reversible rotation under the action of an external stimulus (pressure, electric voltage, temperature) [3]. To create artificial muscles, pneumatic actuators use pressure generated with compressed air to generate mechanical movement, and thermal or piezoelectric actuators use electrical energy to generate movement.

2. ARTIFICIAL MUSCLES

2.1. Artificial pneumatic muscles

Pneumatic artificial muscles (PAMs) are actuated by air pressure and contract when air pressure increases. These actuators are made of membrane covered with a structure made by interlacing some filaments. As the soft membrane is pressurized, the volume increases, expanding in the radial direction and contracting in the axial direction [4].

The working mechanism of PAMs can be described in two categories which are:

- under a constant load and with variable pressure;
- with constant pressure and a variable load.

Soft pneumatic actuators define the field of robotics that deals with intrinsically soft or extensible materials used to construct robot bodies and actuators, as a possibility to create robots with new capabilities.

Unlike common actuators used in industry, which are based on rigid materials and perform one or several operations efficiently, soft pneumatic actuators are flexible.

These actuators are particularly interesting in narrow spaces, as they can adapt their shapes accordingly.

The first pneumatic muscle patented by A.H. Morin in 1953 was made of textile threads integrated into a cylindrical rubber tube [5]. The most common muscles of this kind are known as McKibben [6].

The McKibben's muscle is a simple structure consisting of an internal elastic tube surrounded by a braided sleeve. The tube provides gas-tightness during the deformation that occurs when the muscle is supplied with compressed air introduced into the tube, while the braid controls the expansion of the tube, allowing the radius to increase and thus produce an axial contraction to the actuator.

Figure 1 shows the McKibben muscle in a relaxed state (figure 1.a. the diameter of the elastic tube is minimum) and in a tense-deformed state by introducing compressed air (figure 1.b. the diameter of the elastic tube is maximum). The braided wire structure in which the elastic tube is wrapped exerts control over its expansion.

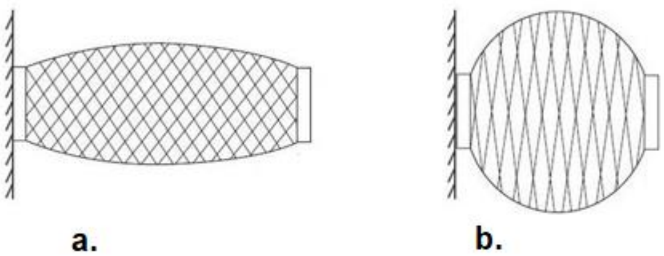

Fig. 1: Deformation depending on the pitch angle of the wires and their density [7]

Since the first pneumatic muscles were developed, medical rehabilitation equipment based on artificial muscles is considered an important application. Essentially, the pneumatic actuator-based artificial muscle can produce force and perform the movement as it contracts, with an action similar to that of natural muscles. Consequently, these pneumatic actuators can be effectively used as substitutes for natural muscles or for actuating robots.

In the field of medical recovery, pneumatic actuators have the following applications:

- External devices applied to the upper and lower limbs (active exoskeletons);
- Active clothing operated by pneumatic devices;
- Inflatable massage balloons.

Soft actuators can be integrated into rehabilitation equipment, having the following applications:

- Artificial muscles made of elastic, gas-tight tubes and fabric or braid to limit the degree of expansion of the elastic tube;
- Interwoven fluidic muscles, based on the use of high resistance placed sheaths. They can produce medium/high forces;
- Actuators with large deformation, which present a particular geometry and are used when large movements are required;
- Soft pressure actuators consist of several chambers side by side and are used to transmit pressure forces that differ from area to area.

2.2. Other types of actuators used for artificial muscles

The pleated pneumatic artificial muscle developed by Daerden [7] is a membrane rearrangement actuator, meaning that the membrane surface is rearranged as it is inflated and no material tension is involved. The membrane of this actuator has a number of longitudinal folds that unfold when the muscle is inflated, allowing the membrane to expand and the actuator to contract. The performance of this actuator depends on the muscle length-to-radius ratio [7].

The Yarlott muscle is an elastomeric balloon reinforced with a series of cables running axially and connected to end fittings. When fully inflated, the muscle takes on a spherical shape.

The Kukolj muscle is similar to the McKibben's muscle, except that in the unloaded one the condition is that there is a space between the inner and outer membrane. For this actuator, the initial working condition is that when the load is applied, the inner membrane is fully extended and contraction occurs when the muscle is inflated. The advantage of this design over the McKibben's muscle is that it prevents the membrane from buckling near its ends [7].

Straight fiber muscle. Many types of pneumatic muscles have longitudinal fibers that connect end fittings. The fittings move towards each other when a deformable interior element is inflated. Through insertion, unilobed or multilobed muscles can be produced with circumferential stiffening rings at certain sections [7].

Paynter hyperboloid muscle. Another variation of the fiber arrangement is used by Paynter, who constructed an actuator whose membrane is shaped like a hyperboloid of revolution. The membrane is closed by a sleeve of inextensible, flexible wires that, in the initial state of the actuator, run in straight lines but form an angle to the axial direction. At full contraction, the actuator expands into an almost spherical shape [7].

3. CONCLUSIONS

The integration of materials with an acting role in textiles is a new approach with incredible potential for the development of the textile industry, bringing significant improvements in the performance of textiles. However, the downside is that most actuation technologies are hard, non-compliant, have robust operating systems, are heavy and make noise, characteristics that make them unsuitable for assembly into smart textiles. In addition, actuators require heavy power supplies that are rarely flexible and lightweight, severely affecting the usability. With the advancement of wearable devices, there is a need for soft, compliant, lightweight and quiet actuators. Moreover, polymer-based coatings and textile materials can be used as actuation materials. Many actuator models with different actuation mechanisms contain or are made of distinct textile elements. Most types of artificial muscles are based on pneumatic actuators or soft actuators. Developing materials for preparing actuation materials is an important step that enables their application, especially in smart textiles.

Although the recent development of smart textiles appears extremely promising, challenges still remain to improve their properties and performance to become suitable for practical and commercial applications.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ADDITIVE MANUFACTURED FLEXIBLE TEXTILE-BASED SENSORS: A BRIEF OVERVIEW

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Abstract: *Additive manufacturing technologies have a great potential for use in the manufacture of flexible sensors and in recent years, rapid research advances have been achieved in this field. Moreover, by combining textiles with printing technologies, novel sensing structures can be developed, eliminating the disadvantages of rigid sensors. These sensors are in great demand in various applications from the field of wearable e-textiles, such as sports, rehabilitation, and in medical tasks like vital sign monitoring. Printing makes possible to design patterns with complicated structures that could not be possible with the traditional weaving techniques, for example, because of the lack of precision. This also allows the use of a wide range of materials with advanced properties. Flexible sensors require flexible materials that can withstand the mechanical demands of bending, twisting or compression, provide comfort and most importantly withstand repeated washing cycles.*

In this document, we briefly overview the flexible sensors manufactured via different printing approaches and the flexible materials developed by recent studies in this area. Moreover, we discuss a hot topic in current research: self-powered flexible sensors. These sensors eliminate the need for an external power source, enabling fully portability and lightweight wearable devices. On the other hand, we present some challenges encountered in the field of flexible printed sensors.

Key words: *sensorised textiles, wearables, printing, flexibility, comfort, durability*

1. INTRODUCTION

Active smart textiles are fabrics with incorporated electronic components such as sensors, actuators and batteries that can provide added value to the wearer. Apart from conventional fabrics, they can monitor, transform, communicate, or generating/storing energy, giving wearer remarkable benefits that can enhance efficiency and provide a more comfortable and health-focused experience. The growth in the wearable electronics industry, the miniaturization of electronics and developments across flexible electronics are some of the key factors driving the growth of the smart fabric market [1].

Flexible sensors are going to be in tremendous demand owing to their significant potential for wearable electronics and Internet of Things (IoT) applications. Flexible sensors are extensively required in health diagnosis, motion monitorin and human-computer interaction. The healthcare industry is a big user of flexible sensors, ranging from glucose and pH sensors to pressure and strain sensors, and other devices such as wearable patches [2]. The term "flexible sensor" refers to a sensor constructed of flexible materials or structures that can be bent, stretched or folded freely during use and still maintain their electrical and mechanical properties. They are preferred over rigid sensors because the rigid ones often lose their sensitivity when subject to bending. Moreover, they could allow miniaturization of products as they can be packed conformally with the device [3].

Additive manufacturing is a technology that could enable the successful manufacture and expansion of the flexible sensors market. Moreover, by combining textile materials and the various printing technologies, new possibilities could be opened in this sector. Printing technology offers unparalleled flexibility and simplicity in the fabrication of highly complex objects [4] and textiles also, could be the next-generation sensing platform because of their many advantages, like good breathability, softness, and structural elasticity [5].

According to Allied Market Research the global market for printed and flexible sensors is projected to reach $8.6 billion by 2031, growing at a compound annual growth rate (CAGR) of 8.3% from 2022 to 2031. Yet, it is worth mentioning that some important drawbacks in this market are the high manufacturing cost, the increased price of the materials and end-use products and the early stage of manufacturing technologies [2].

2. FUNCTIONAL SENSING MATERIALS FOR FLEXIBLE SENSORS

Important ways that could permit the obtaining of flexible sensors with improved performances are the developing of new functional materials and building special device structures [6].

Is expected that flexible and wearable sensors to provide an accurate and reliable sensing function, and also ensure that the natural movements and comfort of the users are enabled. Therefore, their skin-like conformability and stretchability represent very important characteristics that define these sensors [7]. To achieve these properties, different kinds of materials can be used. There are two basic components, the flexible substrates and the most important, the active sensing element (Figure 1). Research on flexible sensors mainly focuses on enhancing the flexibility and conductivity of the materials utilised in their structure, with electrical conductivity being one of the main properties that makes sensing materials work.

Different printing technologies require different materials to print. Three main types of flexible materials are used in the additive manufacturing area and available on the mass market with different print quality: thermoplastic polyurethane (TPU) materials, CLIP resins (continuous liquid interface production) and silicone rubbers. Among them, TPU is being the most popular material for 3D printing applications, because of its range of benefits, including flexibility, durability, ease of processing, abrasion/scratch resistance, resistance to ultraviolet light and low cost [8].

Other important and long studied and applied materials in the field of printed sensors are also conductive inks. In fact, conductive ink is the core of printing technology and also one of the fastest growing sectors among all ink industries. Metal nanoparticle ink formulations or low-cost inks composed only of graphite flakes and silicone were applied in the field of printed sensors. Graphene-based inks are especially recognized as very promising for future fabrication of devices because of their low cost, unique properties, and compatibility with various platforms such as plastics, textiles, and paper [9].

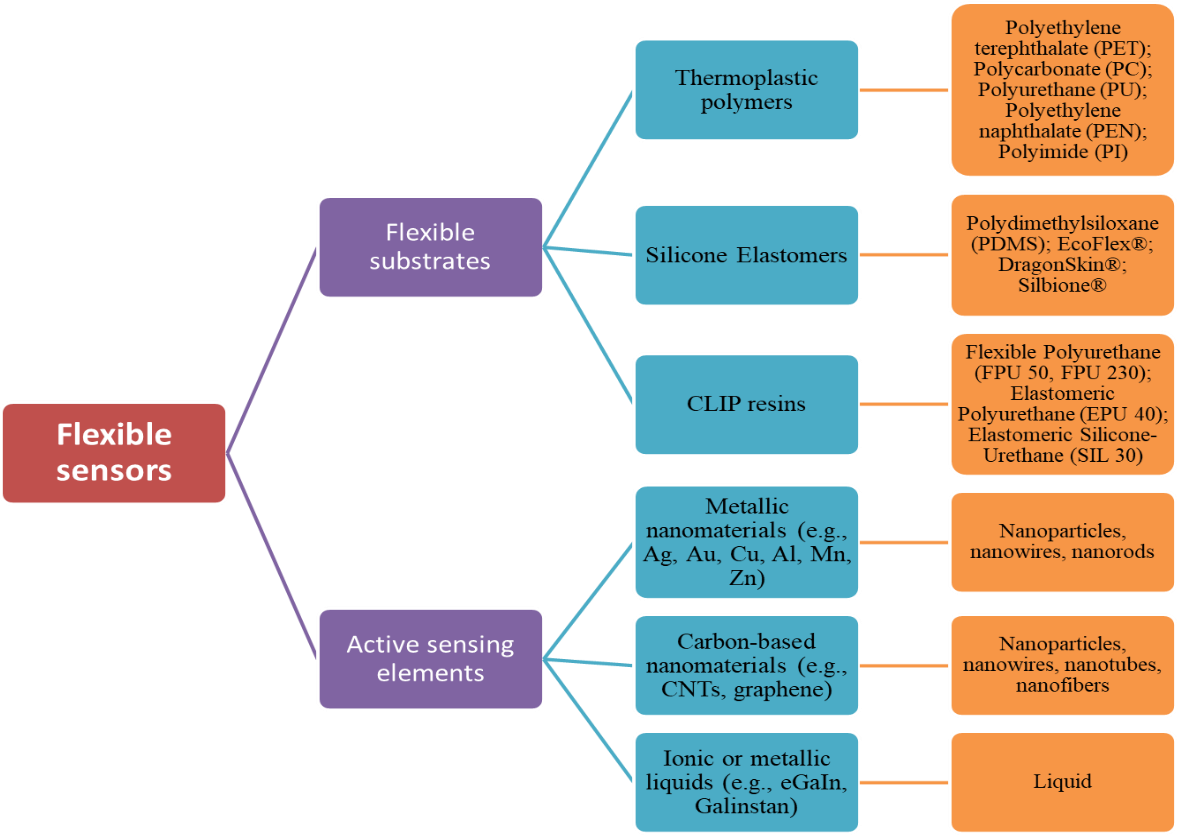

Fig. 1: Basic materials for making flexible sensors

The sensing materials can be divided into the following groups: photo-responsive materials, mechanical-responsive materials, chemo-responsive materials, thermo-responsive materials and humidity-responsive materials based on the response properties of the flexible sensing materials to different stimuli [7].

The selection of materials to be used in printing technology directly affects the characteristics of the object to be printed, namely durability, mechanical properties, and applications [10].

3. FABRICATION TECHNIQUES FOR FLEXIBLE PRINTED SENSORS

Combining textile materials and printing technologies could lead to an impressive development potential for the textile industry.

Different technological approaches were followed over the last years for the manufacture of printed flexible textile sensors:

- Print directly on textiles (using inks or conductive polymeric filaments), the most common method that can add new functions to the existing textiles (Table 1).

Depositing conductive polymeric filaments onto a textile substrate represents an easy and low-cost method to create textile sensors, but the adhesion between the printed material and the textile substrate represents a sensible parameter.

Among the most studied printing technologies with specialized inks are screen-printing, ink-jet printing and direct-ink-writing. Furthermore, the typology of the inks, their deposition and circuit design, as well as the complexities posed by their properties of flexibility and elasticity, raise an issue in their use [11]. Also, because of the inherent fabric properties like porousness and roughness of surface, the formation of electrical materials directly on fabric substrates still represents an obstacle to overcome [12]. Additional barriers to the development of printed sensors are the washing resistance and durability over time.

Table 1: Fexible sensors printed directly on textile substrates

Printing Technology	Sensing Mechanism	Printable Materials	Machine Type	Potential Application	Ref.
FDM (fused deposition modeling)	-	Rubber-like TPU with a carbon black filler (PI-ETPU)	Lulzbot Taz PRO	Biopotentials detection (e.g. electrocardiography (ECG), electromyography (EMG))	[10]
FDM	Strain sensing	TPU	Prusa i3 MK3	Measurement of the breath rate	[13]
Direct-ink-writing	Strain, pressure and EMG sensing	Polydimethylsiloxane (PDMS) mixed with graphite flakes	RegenHu 3D Discovery	Home based monitoring of hand function (neurological and musculoskeletal conditions)	[14]
Screen printing	Strain sensing	Polyurethane (PU) mixed with carbon black nanoparticles and PDMS microbeads	-	User-interface device monitoring respiration and arm motion signals in real time	[15]
Modified extruder	Strain and bending sensing	Sheath-core fibre: styrene–ethylene–butylene–styrene (SEBS) shell and a Ga–In–Sn alloy liquid metal core	Anycubic Chiron printer	Wearable devices in soft robotics, environment sensing, and healthcare monitoring	[16]
Direct-ink-writing	Strain, temperature, ECG sensing	SEBS with carbon black (CB) or Ag flakes and SEBS/PEDOT/CB	RegenHu 3D Discovery printer	Monitoring markers such as physiological temperature, strain, and ECGs	[17]

- Print different textile structures with intelligent functions by using flexible conductive materials.

Due to their flexibility and wearability potential, fibre-shaped materials have received considerable attention in the development of flexible sensors (Table 2).

The most important characteristic of fiber-based sensors is their ability to avoid film-based structure sensors' catastrophic collapse or wrinkling during stretching. Nanoparticles (NPs) are extensively used to enable conductivity in these fibrous shaped printed structures. However, they pose some major concerns, such as the possibility of clogging the printhead and complicating the process of printing [18] or more importantly, the biocompatibility and the risks associated with human health, especially in the field of printed medical sensors, as they can cross cell membranes [19].

Table 2: Fiber-shaped printed flexible sensors

Printing Technology	Sensing Mechanism	Printable Materials	Machine type	Application	Ref.
FDM	Strain sensing	TPU fibrous textile coated with AG NPs	PMAX 3D printer	Wearable electronic component to monitor human motions and facial expressions	[20]
Extrusion	Capacitive strain sensing	Multicore–shell fiber: silicone elastomer (Dragonskin 10) and ionically conductive fluid	Custom built 3D printer (ABG 10000, Aerotech Inc.)	Wearable electronics, human/machine interfaces, soft exosuits, and soft robotics	[21]
FDM	Strain sensor	Mesh-like structures from conductive polylactic acid (PLA)	Flash Forge Creator Pro 2	Soft and wearable robotics	[22, 23]
Direct-ink-writing	Tactile sensing	Coaxial core-sheath fibre: PDMS and graphene and polytetrafluoroethylene (PTFE) particles	Home-made 3D printer	E-skin	[24]
Extrusion	Strain sensing	MXene-Reinforced Cellulose Nanofibril Inks	JDX01 printer from Changsha Nayi Co., Ltd	Monitoring finger and wrist bending, swallow of the throat and speaking	[25]
FDM	Piezoelectric sensing	Polyvinylidene fluoride (PVDF) matrix with barium titanate NPs and a silver ink	-	Wearble sensor for knee joint and respiration monitoring	[26]

4. SELF-POWERED PRINTED SENSORS

Self-powered sensors have been in great demand recently in wearable applications. Current wearable sensors require additional bulky batteries that need to be often recharged or replaced so the system could function normally. Therefore, self-powered sensors represent a promising alternative in this field. Two types of sensors are included in this category, piezoelectric and triboelectric sensors. Their sensitivity is a change in the output current or voltage under pressure [27].

Printing technology was used in various studies to create such types of sensors. Huang et al. have made a hyper-stretchable self-powered sensor based on nano/microfibers using a helix electrohydrodynamically printing method, which demonstrated ultra-high mechanical stretchability (>300%), ultra-low detection limit (<1 mg), and excellent durability. The printed fibers were obtained from PVDF which were sandwiched between Ecoflex substrates and a PDMS interlayer [28].

Also, Cao et al. fabricated a self-powered touch/gesture tribo-sensor that showed very good performances by using CNTs (carbon nanotubes)/PU ink screen-printed on a nylon fabric and a silk fabric layer serving as frictional material. The sensor exhibited high sensitivity and flexibility, fast response time and excellent performance under harsh mechanical deformation (e.g. washing) with great potential in multi-functionalities wearable devices and human machine interface systems [29]. Screen-printing was also chosen by Islam et al. to fabricate graphene-based conductive pattern on textile substrates that served as a highly conductive, flexible, and machine-washable e-textile platform to store energy and monitor physiological conditions including bio-signals [30].

5. CONCLUSIONS

Printing methods have advanced recently, resulting in time and cost savings, and becoming more easier and environmentally friendly. Various flexible additive manufactured textile-based sensors have been developed, but there is still room for improvement in the process and performance of printed sensors. These sensors need to fulfill many characteristics such as precision, reliability, repeatability, and the resistance to mechanical deformation, so they could be used successfully and determine the widespread of wearable e-textiles.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

RAPID DEVELOPMENT OF PRESSER FOOT BASE PRODUCTS: A REVERSE ENGINEERING APPROACH

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Abstract: *The worn-out of different components of textile machines can conduct to deterioration or even failure, which may have a negative impact on their effectiveness. If such spare parts can not be found on the market, a possibility of their redesign and manufacture is the use of a reverse engineering approach. In order to apply reverse engineering, the points cloud that defines the physical part must be first obtained. The points cloud of the real part is then transferred to a dedicated redesign program to redesign the 3D model of the piece. Finally, the redesigned part is manufactured using rapid prototyping techniques. The aim of this paper is to present the application of a reverse engineering approach for the redesign and manufacture of the presser foot base for sewing machines. The Shining 3D Scanner was used to scan the part, and the redesign of the part was achieved using the ShiningForm XOR software. The part was manufactured using the Inspire 200 3D printer, and the quality inspection of the manufactured part was carried out using the ShiningForm XOV software. The use of the reverse engineering approach allows the rapid development of parts with complex geometry, acceptable quality and relatively lower manufacturing costs.*

Key words: *reverse engineering, textile machines components, digitization, rapid prototyping, quality inspection*

1. INTRODUCTION

Different components of textile machines operate under dynamic and vibration conditions that may conduct to their worn-out. As a result, the state of these parts can deteriorate or even fail, which may have a negative impact on their effectiveness. If such spare components are not available on the market, a reverse engineering approach can be used for their replacement [1], which is based on digitization and rapid prototyping processes [2].

The digitization process is employed to transfer the physical part to digital form by using specific equipment such as coordinate measuring machine (CMM) or 3D scanners to acquire the points cloud that defines the real part [3]. Then, the points cloud is transferred to a dedicated redesign software where these points are cleaned, connected, and converted into the 3D model of the part [3, 4]. The behavior of the resulting part under different working conditions can also be studied through finite element analysis and if necessary, the part can be modified [5]. Finally, the redesigned part is manufactured using rapid prototyping processes [2]. The quality inspection can be achieved by comparing the 3D model of the redesigned part with the scanned data of the manufactured part using dedicated software [5].

Within the above-described framework, this paper aims to present the employment of a reverse engineering approach to redesign and manufacture the presser foot base for sewing machines.

2. MATERIALS AND METHODS

The study was conducted using the reverse engineering system depicted in figure 1 [6]. This system includes the Shining3D Scaner, the products redesign software ShiningForm XOR, the Inspire 200 3D printing and the ShiningForm XOV software for quality inspection. The ABS material is used for the manufacturing of products by Inspire 200 3D printing.

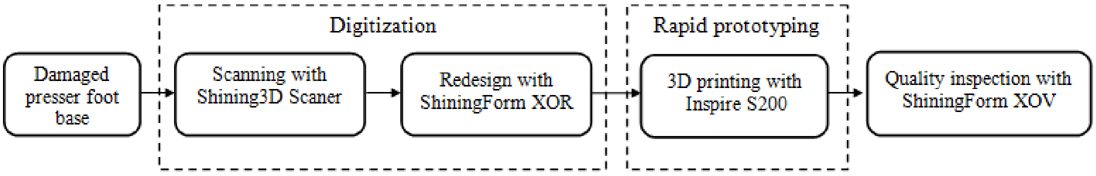

Fig. 1:The reverse engineering system [6]

3. RESULTS

The automatically scanning option of the Shining3D Scaner was used to scan the presser foot base part, which was placed on turntable of the reverse engineering system. The resulting points cloud is illustrated in figure 2. In order to be transferred to the redesign software, the points cloud was exported into a “.rge” format.

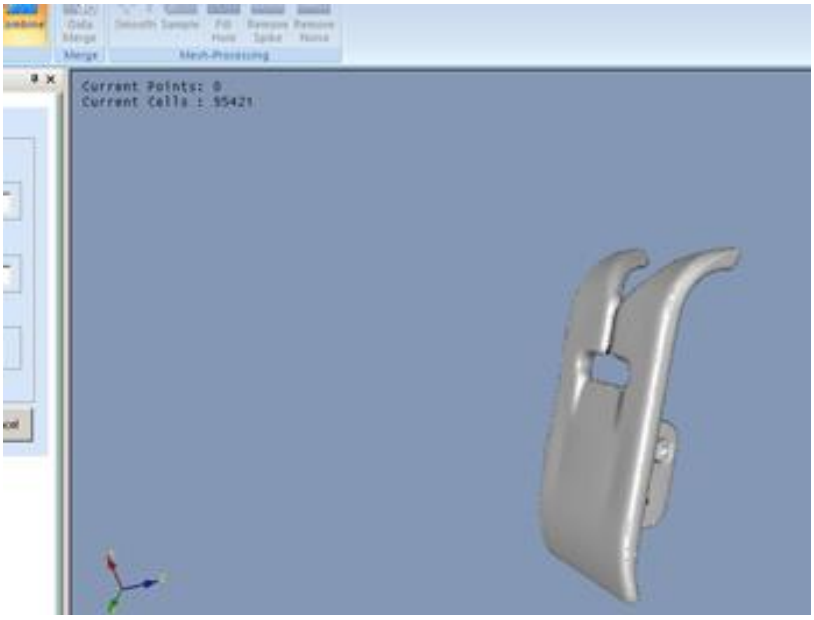

Fig. 2: The points cloud of the scanned part

The redesign of the part was performed through the ShiningForm XOR software, which allows the import of the “.rge” format of the points cloud. Finally, the 3D model of the redesigned part was obtained (figure 3).

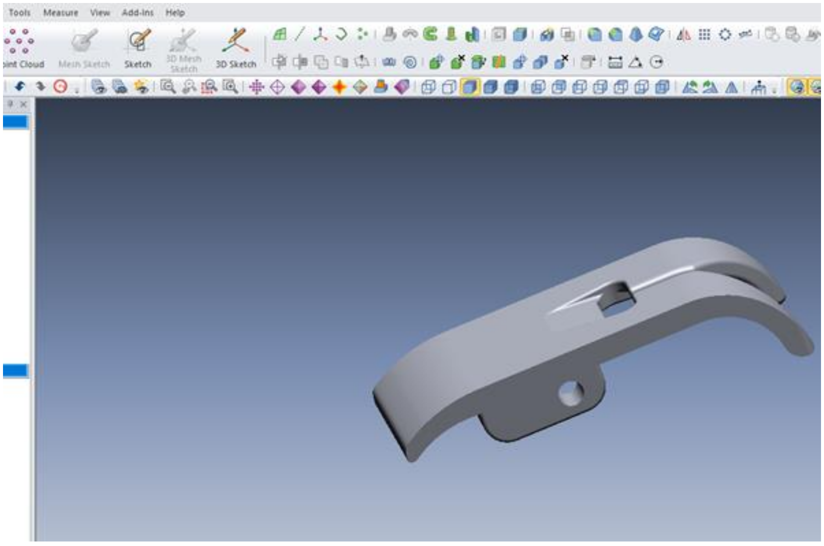

Fig. 3: The 3D model of the redesigned part with ShiningForm XOR software

The ShiningForm XOR does not provide the possibility to save the 3D model of the redesigned part in a ".stl" format to be manufactured with the Inspire 200 3D printer. For this reason, the 3D model of the part was exported from ShiningForm XOR in a ".stp" format, which was then converted in a ".stl" format using Solid Edge software. Figure 4 depicts the result of the 3D printing of the redesigned part.

Fig. 4: The redesigned product manufactured with Inspire 200 3D printing

The ShiningForm XOV software was employed for quality inspection of the manufactured part by comparing its scanned data with the 3D model of the redesigned part. Figure 5 presents the result of this process.

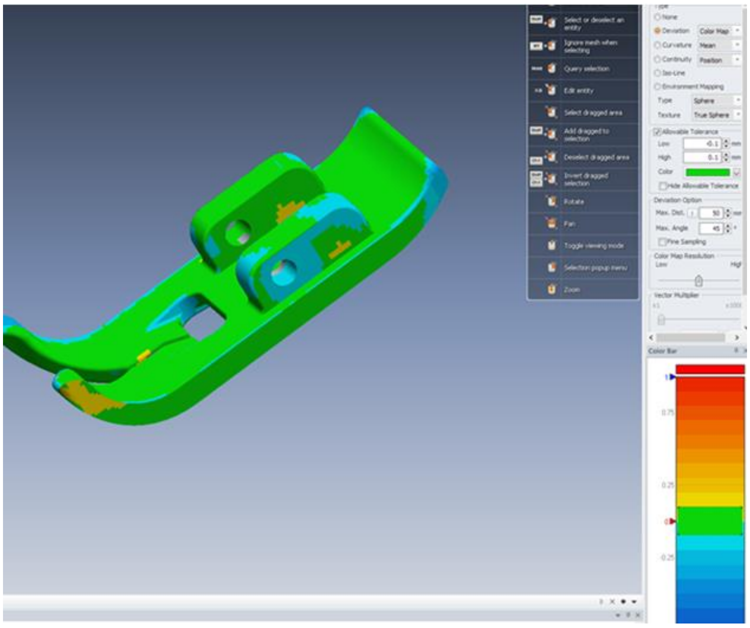

Fig. 5: The quality inspection with ShiningForm XOV software

4. CONCLUSIONS

In this paper, a reverse engineering approach was employed for the rapid development of presser foot base products. The use of such approach allows the rapid development of textile machines components with complex geometry, acceptable quality and relatively lower manufacturing costs.

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