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ANNALS OF THE UNIVERSITY OF ORADEA
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EXPLORING THE USE OF BUFFING DUST FOR SCULPTING IN GHANA

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Abstract: *Waste is an inevitable part of life and this is the case for the leather industry. Despite this, very few studies have focused on understanding how leather waste like buffing dust can be managed by harnessing its potential to serve as a resource to the benefit of society. This study experiments with buffing dust for recycled art through sculpting. Through modelling and casting techniques, the study leverages experimental arts to extend the possibilities of buffing dust. The study sought to find answers to questions like effective binders, ideal proportions and material properties like water resistance among others. Three artworks were executed and data collected during the production process through reflective journaling and analysed thematically. The study concludes that bonded glue is an effective binder for using buffing dust in modelling. However, buffing dust can be used for modelling with limitations. Additionally, the study concludes that buffing dust is a suitable material for casting and resin is an effective binder. The study recommends that art professionals and art student practitioners explore the use of buffing dust for their sculpture practice and evaluate clients' acceptability of the new material.*

Key words: *Leather Industry, Waste as Resource, Up-cycled Art, Modelling, Casting*

1. INTRODUCTION

Generation of waste is inevitable in any human community. Human activities in prehistoric times involved using materials for domestic activities which led to the generation of waste [1]. Wastes were usually small in quantity and very little effort was put into creating a management system to ensure their safe disposal. Over time, increasing populations led to high quantities of waste that nature could not absorb some of which were toxic, hazardous, and non-biodegradable. Currently stakeholders including [2] have been experimenting with recycled art to manage solid leather wastes. Buffing dust (BD) is one of the solid waste types that has received little attention in the literature. BD is usually associated with soles that require smoothening as part of the leather products manufacturing process. BD may pose greater health risks, in comparison to other waste types in leather product manufacturing due to the ease of inhalation. In contrast, few research [3, 4] have discovered benefits from BD. This study experiments with buffing dust as an alternative material for sculpting. Using modelling and casting techniques, the research produces sculpture artworks with buffing dust to answer questions about effective binders, ideal binder-BD proportion among others. The study also investigates the water resistance and enzymatic properties of buffing dust.

2. LITERATURE REVIEW

Traditionally, materials such as stone, marble, bronze, wood, clay, metal, and plaster have been preferred for sculpting. Stone and wood are preferred for carving due to their ability to withstand chipping without breaking. Clay is also popular for modelling due to its malleability and non-drying attributes [5]. Thus, clay can remain workable for a long time when wet as well as achieve good cohesion, adhesion, and plasticity when dry. Plaster is also a good material for casting due to its fluidity, quick setting ability, and resistance to shrinkage upon hardening. Over the years, contemporary materials such as glass, plastic, and paper have emerged and artists need to consider the availability of these materials locally when making decisions. Clay, wood, plaster, and cement are core materials for sculpting in Ghana [6]. Ghanaian researchers have experimented with waste materials such as bones, drinking straw, plastic bottle, and eggshell for sculpture work [6] due to their cost-effective benefits. Notwithstanding, practitioners face challenges in getting to these materials in the right quantity [6]. Further, it possible, but challenging, to combine different materials in each sculpture work [6]. Considering that materials can behave differently under different conditions; there is a need to experiment with even more materials to understand their suitability for sculpting.

3. RESEARCH METHOD

This study used an experimental art design where buffing dust was used to create different artworks for the purpose of learning about a material. This study used practice as a data collection instrument to discover a new material from waste in leather footwear production [7]. During the experimentation process, data was collected using reflective journaling and analysed thematically in an iterative and reflexive process [7]. Three artworks were produced: a miniature human foot, a miniature rabbit and an abstracted crab-shaped flower vase (Fig. 1). The foot was selected for its simplicity while the rabbit created room to experiment with intricate designs. The flower vase facilitated experimentation for a sculpture in-a-round artifact. Bonded glue was selected as binder for modelling based on findings from a study that experimented with groundnut shell powder [8]. Resin was chosen as a binder for casting following a preliminary experiment with bonded glue, contact glue and resin. Below is a description of the production process for the different artworks. Once the artifacts were ready, the study conducted a water resistance and enzymatic test to better understand the new material using established guidelines as reference [9, 10].

Fig. 1*. Exhibit of final artworks produced*

4. RESULTS AND DISCUSSION

Modelling with buffing dust

Findings showed that BD mixed well with bonded glue with good cohesion. Further, BD emerged as workable due to its ability to withstand handling for a long time before hardening. The bonded glue- BD mixture was easy to manipulate for 10 to 15 minutes in the modelling process. After manipulation, the mixture dried at a very slow pace with the first application taking an average of 3 hours to obtain a reasonably dry surface. The second and third applications also took 72 and 24 hours respectively to dry completely. Results from the study also showed that BD had limited malleability properties. BD could not be pressed easily into shape without breaking. To make modelling possible, the bonded glue-BD mixture had to be applied in thin layers on the armature. Each layer needed to surface dry before the next layer of mixture could be applied. Ease of spread of the mixture varied based on texture. While the very coarse BD sample used for the foot was difficult to spread, the fine BD particles used for the rabbit was easy to manipulate.

Limited malleability made it problematic to cut through the partially dry bonded glue-BD mixture to create intricate designs. For example, lines that portrayed the toes of the foot could not be deepened to make the toes stand out properly. Initially, the researcher assumed that this difficulty may be a result of the hard nature of the Styrofoam used for the armature of the foot. Therefore, the modelling of the rabbit adopted a slightly different approach where clay was used first to model the rabbit; after which the mixture was applied. Despite this, there were still challenges with making details on parts of the rabbit distinct (Fig 2). Findings revealed that the bonded glue-BD mixture did not adhere properly to Styrofoam when freshly mixed. This was evidenced by the dripping of the mixture at one side of the miniature foot in the early stages of the application. BD on the other hand proved capable of adhering easily to clay without support. Fidings revealed that BD gave a unique texture that made the artifact look real.

Fig. 2. *Depiction of intricate details in clay vs BD sculture (see groove of the eye)*

Casting with buffing dust

Findings from the preliminary BD binder experiment indicated that contact glue and bonded glue were not effective for casting with buffing dust. They produced buffing dust composite with very slow setting times and poor adhesion. Resin showed potential for casting, hence its use in the main artwork construction. To understand the fluidity property of BD, the researcher experimented with different proportions of resin for casting. The first mixture used a proportion of 500ml of resin to 0.17kg bottles of buffing dust for the first coat of the resin-buffing dust cast work. This ratio of resin to BD was less fluid so the mixture was unable to enter some of the corners leading to defects (Fig. 3). For the second and third applications, the proportion of 250 ml of resin to 0.17 kg of buffing dust worked well because, the mixture were meant to fill the space in the mould rather than pick intricate designs.

The casting process was repeated a second time using a resin to buffing dust ratio of 500ml of resin to 0.086 kg of buffing dust for the first application. This revised ratio led to an improvement in the fluidity of the mixture. This formulation was light enough to penetrate all the corners of the mould with no defects on the final output. A total of seven 0.6 kg of BD and 1000mls of resin was used to produce the entire work. Setting time for the resin- BD sculpture was fast. Overall, production time stood at one hour twenty-five minutes. The use of an accelerator and a hardener, in line with practices established in casting with plaster helped to speed up the setting time. The cast work showed no evidence of contraction upon cooling.

Fig. 3. Defects in work cast with resin-buffing dust mixture of 500mls to 0.17kg

To allow for a comparison of the features of BD with plaster of Paris (PoP), the researcher repeated the casting process for the abstracted crab using a resin-PoP mixture. Findings from this study showed that a resin-PoP ratio of 250mls of resin to 0.0867kg of PoP worked well for the first application. A total production time for resin-PoP sculpture was one hour twenty-two minutes. Thus, although the chemical composition of BD varied from PoP, the setting time was the same for both artworks because of the equal quantity of accelerator and hardener was used. Findings also showed that although the same quantity of resin (i.e., 1000 mls) was used, more PoP (0.95 kg) was needed to produce the same artwork as opposed to 0.6kg used in the BD case. Regarding portability, findings indicated a difference in favour of BD. While the cast BD sculpture weighed 1.5 kg, the PoP sculpture weighed 3.2 kg. Findings also showed that finishing with lacquer was an effective approach in preserving the glossiness of the resin-fibre buffing dust composite.

Findings from observing the modelled work revealed no change in aesthetic appearance after subjection to humid conditions over the one-month period. There was no evidence of microbial action and effect on the modelled work. Regarding the cast work, findings showed no evidence of mould generation in the first three weeks of subjection to humid conditions. Nevertheless, the cast work revealed changes in the appearance of the artefact like small white spots and reduction in the glossy effect of the artefact (see Fig. 4) in the fourth week. Suggesting some reactions that need further investigation.

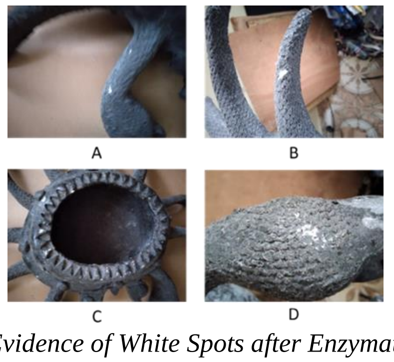

Fig. 4. Evidence of White Spots after Enzymatic Test

The researcher anticipated that bonded glue- buffing dust composite will absorb water due to the water-soluble nature of the glue. Therefore, experimentation with the modelled work without finishing involved the pouring of drops of water on the artifact. This suspicion was confirmed as the drops of water mixed with the glue and gave a whitish look (Fig 5). Therefore, the researcher experimented further to see if lacquering could improve its water-resistant features. The bonded glue-BD composite improved in its water-resistant ability as drops of water poured on the lacquered artefact suspended (Fig. 5). Regarding the cast work, findings showed that the resin- BD composite had water resistant features irrespective of the use of a finish or not. The resin-BD cast sculpture weighed 0.8kg before and after exposure to water leading to a porosity rate of 0.071%.

A B

Fig. 5. *Effect of water on lacquered and on-lacquered modelled work*

5. CONCLUSIONS

The study experimented with buffing dust as alternative material for sculpturing. Findings from the study showed that bonded glue worked well as a binder in using BD for modelling. However, key features such as malleability and adhesion strength were inadequately present with limited degree of workability. Resin on the other hand worked well as a binder in using BD for casting. BD possessed all of the characteristic features of materials that are suitable for casting. The feature of portability was an additional benefit of BD in comparison to other traditional sculpting materials. Based on the above findings, it can be concluded that bonded glue is an effective binder for using buffing dust in modelling. However, buffing dust can be used for modelling with limitations. Additionally, the study concludes that resin is an effective binder for using buffing dust in casting. Additionally, buffing dust is a suitable material for casting.

It is recommended that art professionals and art student practitioners explore using buffing dust for their sculpture practice and evaluate their clients' acceptability of the new material for artworks. The evaluation should capture how much clients would pay for the artworks to enable a cost price analysis. The bulky nature of the work limited the researcher's ability to undertake several tests to understand the properties of the buffing dust. Although the study has established that buffing dust can be used for sculpting, there is need to conduct more tests on the material composition and properties of the new material to determine its suitability for different functional items.

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ANNALS OF THE UNIVERSITY OF ORADEA
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SUSTAINABILITY AND INNOVATION TRANSFORMING FASHION OPERATIONS MANAGEMENT

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Abstract: *The fashion industry is currently in a state of flux, driven by growing consumer awareness and increasing regulatory pressure for sustainability and, above all, transparency. This paper examines the intersection of operations management, innovation, and socio-environmental responsibility within the fashion and apparel sector. Using qualitative methods, including an in-depth literature review and semi-structured interviews with leaders of responsible fashion companies, the study identifies key practices, tools and challenges related to the transition to sustainable operations. Findings emphasize the integration of advanced technologies, such as ERP systems and supply chain digitization, to optimize resource utilization and improve traceability. The adoption of circular economy principles, including material recycling and small-scale localized production, appears to be a promising but complex strategy. Persistent obstacles, such as high implementation costs, systemic opacity and technical constraints, remain particularly significant for small and medium-sized enterprises. To address these challenges, the paper recommends systemic collaboration, policy incentives, and investment in education to empower both businesses and consumers. This preliminary study provides actionable insights for practitioners and policymakers, while also identifying opportunities for future research to support the sustainable transformation of the fashion industry.*

Key words: *Sustainable Practices, Circular Economy, Supply Chain Innovation, Ethical Production, Digital Transformation, Socio-Environmental Accountability, Economic Priorities, Ecosilence.*

1. INTRODUCTION

In recent years, the fashion industry has undergone a profound transformation, driven by the rise of the accelerated production model, more commonly known as fast fashion. This model, based on extremely short production cycles, allows brands to frequently update their collections and respond to trends with unprecedented agility. However, this speed comes at a price: it puts increasing pressure on natural resources, working conditions and the environment. The over-exploitation of raw materials, the growing precariousness of workers in the supply chain, and the significant environmental impact of production and distribution are now major challenges. In light of these issues, it has become imperative to rethink operations management in the fashion manufacturing industry by integrating more innovative and responsible approaches. In this context, operations management in this sector is strategic because it encompasses the entire process from sourcing raw materials to delivering the final product. Yet the dominant model remains largely linear (i.e.,"*make–use–throw*," where products are manufactured, consumed, and then discarded without reuse or recycling). It also relies on a globally fragmented supply chain (where different stages of production occur in different countries), making transparency (knowing what happens at each step) and traceability (tracking the origin and movement of materials) much more difficult.

For companies seeking to adopt more sustainable practices, these constraints present significant hurdles. In addition, while technological advances and digital tools promise more efficient management of production and logistics flows, their implementation still faces financial, technical, and structural barriers. At the same time, growing pressure from consumers, investors, and regulators is pushing more companies to integrate responsible practices. What was once considered a differentiator has become a strategic imperative. However, balancing profitability (generating economic returns), speed (responding quickly to market demand), and environmental commitment (reducing ecological harm) remains a delicate exercise. Many companies face tensions between economic performance and the transition to more ethical models, requiring deep organizational and cultural changes. This article explores how fashion companies strive to combine operational efficiency with sustainable commitments. Using a qualitative approach that blends literature review and interviews, the study reveals both the progress driven by innovation and the structural barriers that remain. It highlights the tools companies are using, the strategies they are pursuing, and the challenges they face in moving towards more responsible models.

2. LITERATURE REVIEW

Operations management plays a key role in coordinating product creation and delivery in the fashion industry, balancing quality, cost, and speed. As global competition intensifies, these functions are increasingly linked to sustainability and ethical responsibilities. Raw material sourcing, in particular, is challenging, as it determines not only product quality but also environmental and social impact. Companies are under pressure to select textiles, dyes, and components that comply with both regulatory standards and consumer demands for ethical production. According to Fletcher [1], traceability and environmental impact assessments have become crucial in differentiating brands in a market leaning toward sustainability. Yet, sourcing remains only the first step in a complex manufacturing chain involving tightly coordinated processes across geographically dispersed suppliers. Payne [2] emphasizes that while lean management helps reduce waste and improve efficiency, the fast pace of fashion cycles hinders the implementation of sustainable practices. This reveals a tension between speed-driven models and the systemic alignment needed for responsible supply chain decisions. As Colombage et al. [3] observe, innovations in materials and production methods offer promising solutions, but their high costs limit accessibility, especially for SMEs, creating disparities in the adoption of sustainable standards across the industry. As products move into distribution, logistics becomes a decisive factor. Rising consumer expectations for rapid delivery, particularly in the digital retail landscape, compel companies to rethink their logistics strategies. Naderi et al. [4] emphasise the importance of omnichannel models, combining central warehouses with physical points of sale, to maintain efficiency and manage costs. However, such models remain out of reach for many smaller companies facing financial and technological limitations. Fletcher [1] further critiques the sector’s industry's intensive use of high-emission transport like air freight and advocates for localized production as a strategy where regional know-how, short supply chains and a strong sense of place can model systemic change and drive global sustainability shifts. Though some businesses explore sustainable logistics and shared networks, these remain exceptions rather than the rule. Efforts to optimise resources, whether materials, labour, or energy, are increasingly prioritised, as Burman [5] explains through a framework highlighting the benefits of data analytics and digitalisation. Nevertheless, fragmented global supply chains complicate coordination and standardisation, diluting the impact of sustainability initiatives. While larger companies can invest in advanced systems such as ERP and IoT, smaller companies, while representing a significant portion of the industry, are often precariously positioned with limited access to such technologies and must rely on local resources and tight partnerships as an uncertain means to optimize operations and resource utilization. Additionally, current research overlooks crucial areas such as employee training and change management, both vital for successful transitions toward responsible practices. As technologies like automation and blockchain offer new efficiencies, they simultaneously introduce challenges of affordability and energy consumption [5]. Environmental and social priorities are reshaping the industry's agenda, with the circular economy and ethics gaining prominence. Yet, as Payne [2] points out, without supportive public policies and accessible certification processes, many firms struggle to scale their sustainable ambitions. Despite the breadth of existing research, gaps remain in understanding how businesses can manage global complexity, improve technology adoption, and integrate the human dimension into sustainable transformations [6].

3. METHODOLOGY

This study uses a qualitative approach to explore the practices and challenges faced by fashion companies as they strive for sustainability. It aims to understand the strategies they use to integrate socio-environmental principles, while identifying the structural barriers that make this shift difficult. To build a solid foundation, an extensive literature review was conducted, drawing on academic research, industry analysis, and examples of best practices in responsible fashion. These findings guided the design of semi-structured interviews conducted with three key actors in the field: specifically, one founder and two senior managers of companies committed to sustainable approaches. The selection criteria focused on small- to medium-sized companies in markets where sustainable practices were already established. The data collected were analyzed thematically, combining deductive coding based on existing literature with inductive coding that revealed new and unexpected findings. This combination allowed for a rich and nuanced understanding of the realities faced by these companies. A qualitative method was essential to capture the internal dynamics of their operations and the often complex gap between their ambitions and the practical constraints of implementation. By adopting this perspective, the study offers deeper insights into both the opportunities and obstacles that shape the journey towards more sustainable practices in the fashion industry.

4. OVERVIEW OF THE STUDY AND ITS PRELIMINARY RESULTS

The fashion industry is undergoing a profound transformation now, driven by increasing environmental concerns and growing consumer expectations for greater transparency and ethical practices. This study examines the operational strategies of companies committed to sustainability and the balance they seek between technological innovation and economic constraints. Many companies still oscillate between traditional models of mass production and emerging sustainable approaches that emphasize careful planning, better resource management, and eco-innovation. The rise of integrated systems such as ERP underscores the desire to better predict demand and minimize overproduction, which helps reduce waste and environmental impact. However, access to these technologies remains uneven, creating a gap between large corporations with ample resources and smaller companies that often lack the means to implement such solutions. Beyond resource optimization, production methods themselves are beginning to evolve. Practices such as made-to-order manufacturing, closer collaboration with certified suppliers, and strategies to reduce unsold inventory reflect a genuine commitment to more responsible models. These changes are not isolated gestures, but part of a broader shift in industry dynamics. But despite this progress, significant challenges remain. Competitive pressures and the relentless pursuit of profitability continue to slow the adoption of sustainable practices across the board. Small and medium-sized companies, in particular, face the burden of high upfront costs associated with sustainable materials and certification processes, making the transition even more complex for those with limited financial capacity. The opacity of the supply chain adds another layer of difficulty. The fragmented and globalized nature of sourcing makes it difficult to track raw materials and verify supplier working conditions. Without transparency, companies' commitments to sustainability risk being perceived as superficial. This could undermine consumer confidence and encourage what is becoming known as “ecosilence”. In other words, a strategic silence that companies adopt by avoiding disclosing their environmental performance or procurement practices. Unlike greenwashing, which involves making exaggerated or misleading claims about sustainability, eco-silence is characterized by silence or statements of little substance. It is often adopted to avoid scrutiny, regulation or reputational risk. In response, some forward-thinking brands are investing in advanced tracking technologies, such as blockchain and IoT, to improve visibility across their logistics networks. But despite their potential, these solutions require stronger regulatory frameworks and standardized protocols not yet fully in place, leaving companies to navigate this transition largely on their own. Ultimately, the transition to a sustainable fashion model cannot rely solely on the initiatives of individual companies. A collective effort involving companies, institutions and consumers is essential to structurally embed these changes. Access to targeted financing, shared infrastructure, and harmonized standards will help level the playing field and enable wider adoption of responsible practices. Without systemic support, sustainable fashion risks remaining a niche movement rather than the new industry standard. By aligning innovation with socio-environmental responsibility and fostering collaboration among all stakeholders, the sector can lay the groundwork for a more resilient and ethical future.

5. DISCUSSION AND CONTRIBUTIONS

The results of this study illustrate how the transformation of the fashion industry depends on the gradual integration of sustainability principles into operations. As shown in Figure 1, the sustainable value chain emerges at the intersection of environmental, social and economic dimensions, supported by internal and external factors and driven by innovation in fashion operations. Companies are increasingly turning to sustainable materials, digitalization of production flows and smart logistics as levers for progress, reflecting a genuine effort to reconcile economic efficiency with socio-environmental responsibility. These initiatives are not merely symbolic: they represent real progress in reducing the sector's environmental footprint and improving labor practices, while responding to growing consumer demand for transparency and accountability. However, the study reveals persistent barriers slowing widespread adoption. The high initial investment required for sustainable materials, advanced technologies and certification continues to disproportionately affect small and medium-sized enterprises (SMEs), which often lack sufficient resources. Supply chains, which are fragmented and opaque, remain a major challenge for traceability and alignment of standards among stakeholders. While large companies have the capacity to implement ERP systems and smart manufacturing tools, smaller structures struggle to follow suit, perpetuating inequalities within the sector. Moreover, despite the momentum of public opinion and regulatory pressure, the tension between profitability and sustainability remains unresolved. Responsible practices are increasingly valued in the marketplace, but their implementation collides with economic realities that are difficult to overcome. The analysis highlights the importance of structured external support to enable systemic change. The convergence of stakeholders (governments, investors, NGOs, etc.) is important to reduce barriers and promote shared responsibility. Policies supporting circular economy initiatives, incentives for eco-innovation and shared infrastructure could significantly reduce the gap between large corporations and SMEs.

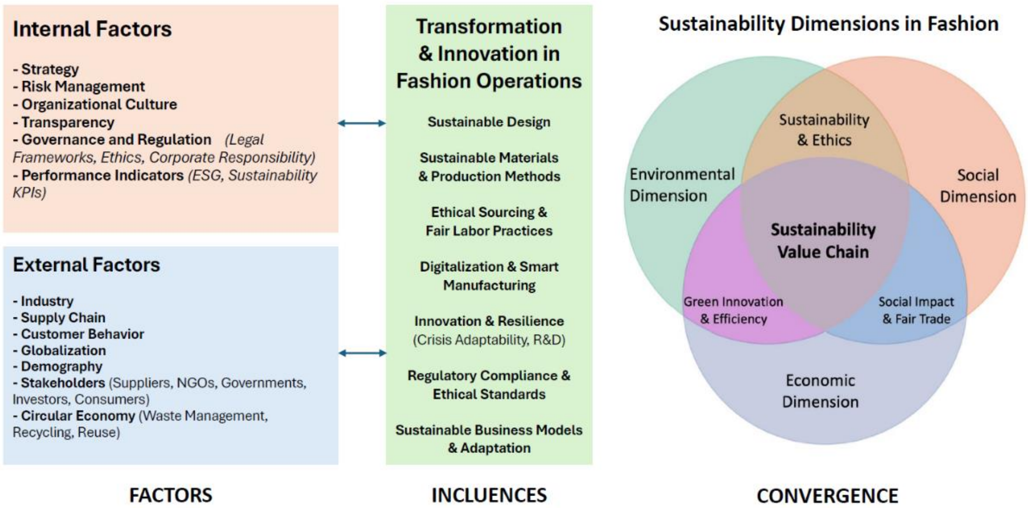

Fig. 1*: Interactions of Factors and Dimensions in the Transition to a Sustainable Fashion Value Chain*

Figure 1 illustrates how internal governance, regulations, and resilient innovation must align with external forces such as stakeholder engagement and circular practices to drive change. Without coordination, sustainable fashion risks remaining a niche rather than an industry standard. This study advances academic and professional discourse by proposing an integrated framework that captures the complexities of the fashion supply chain and pathways to embed sustainability at its core. It highlights the urgency of collective mobilization and targeted investment to accelerate the transition to a truly sustainable fashion ecosystem.

6. CONCLUSIONS

The sustainable transformation of the fashion industry relies on the adoption of advanced technologies, supply chain optimization, and the application of circular economy principles. However, small-medium-sized enterprises (SMEs), continue to face significant challenges such as high costs, limited visibility into supply networks, and technical constraints. Balancing profitability with social and environmental responsibility remains a major concern. To move forward, it is important to rely on collaborative initiatives, supportive public policies, and targeted investments in innovation and consumer education. As the sector reaches a tipping point, the collective commitment of all stakeholders, including companies, institutions and consumers, is essential to establish a more ethical and sustainable model. The digitization of logistics flows, and the use of integrated ERP systems strengthen traceability and improve operational efficiency. At the same time, practices such as material recycling and local production open up new opportunities but require significant structural adjustments. By combining innovation with accountability, the fashion industry can move towards more resilient management practices. It can also meet growing expectations for sustainability and transparency while building a more sustainable business model. As Payne [2] points out, the definition of sustainability in fashion remains fluid and contextual, particularly across business scales in terms of production volume and capacity to act. This calls for a more integrated view, where resource efficiency and streamlined operations are important, but must be aligned with life cycle thinking and mindful communication as key elements to drive circularity and address consumer perception biases. Their alignment across scales and functions is essential to foster more coherent and transformative practices.

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TREATMENTS APPLIED TO THE MATERIALS IN THE COMPOSITION OF MATTRESS COVERS

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Abstract: *The chemical treatments applied to the materials used in the manufacture of mattress covers can significantly influence their quality, strength and durability. The present work has demonstrated that these treatments are important for achieving the desired performance, adapting to the different uses of the covers, whether it is for domestic use or use in the hotel sector. Addressing consumer education on the use of chemicals in textiles is key to promoting informed choices and a healthy and sustainable lifestyle. The comparative analysis of the finishing treatments of natural materials used in mattress covers highlights the fact that each treatment has specific applicability depending on the field of use. Manufacturers must consider balancing the needs of comfort, durability and aesthetics, without compromising sustainability. Thus, consumers can benefit from quality products, adapted to their specific requirements. In the present work, a detailed analysis of the materials used for the manufacture of two types of mattress covers was carried out: one intended for domestic use and the other oriented to the hotel regime. This research aimed to obtain essential information about the chemical treatment process of the fibres in the new covers and to assess the impact of these treatments on the performance and safety of the product. Future studies should focus on examining these covers and the chemical compounds they contain.*

Keywords: *chemical treatments, fibers, hotel regimen, household use.*

1. INTRODUCTION

Compliance with safety standards in the treatment of fibers for mattress covers is very important for the health protection of users [1]. Mattress manufacturers, by adopting responsible and transparent practices, contribute to a safer environment, and consumers, by informing them and making informed product choices, can positively influence the textile industry [1]. The mattress cover is in constant contact with the body, and any irresponsible chemical treatment can cause allergic reactions, irritation or even respiratory problems [2], [3], [4].

Importantly, the industry continues to improve testing standards and regulations related to consumer product safety. Awareness and education are key to helping consumers make informed choices regarding mattresses and their covers [5], [6]. Consumers can benefit from assurances of product safety through certifications such as CertiPUR-US, but there is insufficient awareness about mattress covers and additives used in these materials [7], [8]. CertiPUR-US certification guides consumers in choosing high-quality polyurethane foams without harmful compounds [7].

Collaborations between regulators, certification organisations and researchers will contribute to the development of safer and more efficient solutions for consumers [9]. Consumers may believe that certified mattresses have undergone rigorous testing and do not contain hazardous substances [6]. The finishing treatments applied to knitted materials for mattress covers play an essential role in improving the functionality, appearance and durability of the final product. The choice of the right treatment depends on the client's requirements and the intended use of the mattress. Textile finishes not only improve the performance of knitted materials, but can customize covers according to the type of customer and market. It is always recommended to choose treatments according to the analysis of the final requirements

2. GENERAL INFORMATION

The choice between natural and synthetic fibres, or the use of a blend of fibres, depends on the user's priorities in terms of comfort, durability and maintenance [10]. Mattress covers made of natural fibers offer superior comfort and are skin-friendly, while synthetic ones bring strength and functionality [10]. Fiber blends are a very effective solution, bringing together the best features of both types of fibers, which allows obtaining textile products with excellent performance, adapted to the requirements of modern consumers.

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

Fig. 2*: Motic microscope* [4]

Table 1: *Household cover (mattress) treatment*

Treatment	LIKROLL
Recipe	Citric Acid 0.2% Elastofin STO501 1.4%, Temp:150^{0}C
Request width	229-231 cm
Request weight	558-581 gr/m^2
Composition	20% Tencel, 2%Elastane, 78% Pes
Color	Opera, Black, Basalt, Black

Table 2: *Cover (mattress) treatment for hotel use*

Treatment	PADDER
Recipe	AbioFlame 14% Temp:130^{0}C
Request width	239-241 cm
Request weight	369-384 gr/m^2
Composition	85% Organic Cotton (Bio), 15%Hemp
Color	Natural, Natural

In the present work, the materials used to make two mattress covers (one mattress cover for domestic **Fig. 3** use and one for hotel use **Fig. 4**) were treated (on the Squeezing Pader Machine **Fig. 1**) in order to obtain basic information about the chemical treatment of the fibers in the new mattress covers.

The 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 two mattress covers.

The analysis of the mattress cover and the constituent materials is an essential step in evaluating the quality and characteristics of these products. In the study, the constituent components of the two mattress covers were collected and analyzed in detail to highlight the differences in the finishing treatments applied to them, considering the various fields of use [7].

For the analysis of the mattress cover samples, a Motic **Fig. 2** microscope was used, which has technical characteristics and superior optical quality, which allows for obtaining clear and detailed images of the structures of the analyzed materials.

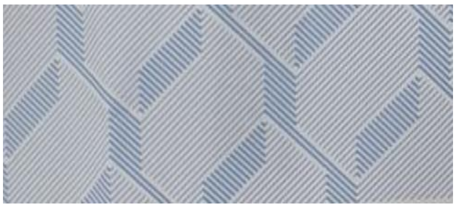

***Fig. 3**: Treated material for household cover (mattress)*

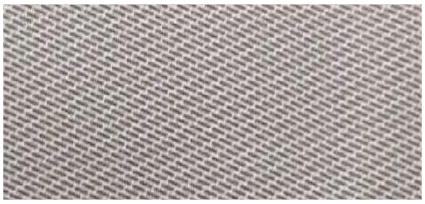

***Fig. 4**: Treated material for hotel cover (mattress)*

The main components of each mattress cover tested and their observed compositions are summarized in Tables 1 and 2. The different components of the mattress cover, for home use, were mixtures of Citric Acid 0.2% Elastofin STO501 1.4%,/pick-up 100% control weight/weight controls, Temp:1500C, compared to the cover intended for hospital use, which has in its component AbioFlame JASMIN 14%, Temp:1300C, are different and require an immersion treatment, to obtain that charge with 100% to 150% solution. Being a knit made of cotton yarn (85%) mixed with hemp (15%), it requires an increased flame retardant treatment.

The analysis carried out in this paper highlights the importance of chemical treatments in creating functional and durable mattress covers, suitable for both domestic use and the hospitality industry. The results obtained demonstrate that, in most cases, chemically treated materials offer significant advantages, thus contributing to a better user experience.

The authors' recommendations include continuing studies on the long-term impact of using these treatments and exploring environmentally friendly alternatives that can improve the performance of materials without compromising consumer health or environmental integrity. These steps are essential for innovation in the textile field and for the development of sustainable and safe products.

5. CONCLUSIONS

This paper highlights the analysis of the differences between the finishing treatments applied to knitted materials, especially those intended for mattress covers made of natural yarns.

The choice of treatments applied to mattress covers depends on individual preferences and the specific needs of the user. Each treatment has its advantages and disadvantages, and the final decision should consider not only the short-term effects but also the long-term impact on health and comfort.

The chemical treatment of the materials used for mattress covers can significantly contribute to improving the quality, comfort and durability of products.

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VALIDATION OF EDUCATIONAL STRATEGIES FOR FORMING SOCIOCULTURAL VALUES IN STUDENTS OF ENGINEERING STUDY PROGRAMS

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Abstract: *The application of educational strategies in the field of engineering, a field often considered technical and objective, may seem less related to the promotion of sociocultural values, but there is a growing interest in their integration into professional training. In this regard, innovative educational approaches, which include interactive and participatory methods, such as project-based learning, case studies and discovery learning, have been recognized as essential for facilitating the understanding and application of sociocultural values in the daily lives of students.*
Therefore, the research is oriented not only towards identifying the most effective educational strategies, but also towards exploring their impact on the formation of sociocultural values in young people in the field of engineering, thus contributing to the consolidation of a society that values cultural diversity and social responsibility.
As an objective in the paper, we propose to capitalize on the results of the application of the Pedagogical Model for the formation of sociocultural values of students in engineering study programs.
The development of sociocultural values in subjects in university education in engineering study programs aims not only to train the student as a specialist in a field that acts guided by narrow professional concerns, but also as a professional, anchored in a universal culture, endowed with a system of values such as: discipline, self-discipline capacity, dignity, respect for oneself and others, responsibility, honesty, kindness, empathy, tolerance, etc.

Key words: *strategies, educational process, values, culture, heritage, variables*

1. INTRODUCTION

The study of the specialized literature on the dimension of educational strategies in promoting sociocultural values has highlighted the interest of some researchers in various aspects such as educational strategies, widely reflected in national historiography. A special place belongs to research in the field of sociocultural values, cultural heritage, education through and for heritage, current at the beginning of the 21st century. The human need to face social challenges, directed us towards choosing the research topic regarding the formation of sociocultural values in engineering students through the use of educational strategies.

In this context, recent studies highlight the importance of integrating sociocultural values into the educational curriculum, not only for the formation of strong character and cultural identities, but also for the development of intercultural competences that meet the demands of a globalized environment. Research also suggests that education, when oriented towards the understanding and appreciation of cultural heritage, contributes significantly to the formation of a responsible and conscious attitude towards the social and cultural past and present.

The documentation of sociocultural values defined by elements of heritage and culture in the study of specialized literature has highlighted several defining findings and conclusions, which have generated the exploitation of these values in an experimental plan. The qualities of the modern student are connected to the requirement of today's society, increasing the need to work independently and creatively. In this sense, university studies represent a solid support in the development of the values necessary for professional integration through the ability to adapt to change, critical and analytical thinking, contributing to the formation of a solid base of knowledge and skills that allow graduates to face the challenges of a professional environment in continuous transformation. Moreover, university studies facilitate access to a diversified academic environment, where students can learn through the exchange of ideas and experiences. Interaction with professors, colleagues and specialists from various fields stimulates the development of a global perspective and essential interpersonal skills.

Generating theoretical-methodological concerns, we will be able to answer the question: What are the theoretical benchmarks of educational strategies and how can they be capitalized on in the process of forming sociocultural values in engineering students?

2. MATERIALS AND METHODS

The experimental research methodology, in the sense of the system of applied and interpreted methods, was developed for the purpose of assessing the level of sociocultural values in the groups of students included in the research sample, concretized by the variables identified and proposed for measurement based on the criteria developed for this purpose. For these reasons, the research methodology was developed based on the research instruments developed for the identification of sociocultural values in the experimental and working groups within the higher education institutions Technical University of Moldova and The International Free University of Moldova.

The established sociocultural values were subjected to experimental research within five university courses designed in the curricula of undergraduate higher education programs for engineering students (table 1.).

Table 1. *Engineering study programs / University courses established for experimental research of sociocultural values*

University Courses	Sociocultural Values
Computer-Aided Design (ULIM) Computer Graphics Programming (ULIM) History of Design (UTM) Textiles in Interiors (UTM) Contemporary Design. Theory and Concept (UTM)	Innovative Cooperation Self-Development/Progressive Autonomy Ethical/Moral Responsibility Reflective/Equidistant/Non-Offensive Tolerance Self-Development/Autonomy Cognitive Flexibility Professional Integrity Respect/Cultural Attitude

The variables measured in the research refer to the sociocultural values identified in the researched literature and correlated with the labor market integration needs of university graduates: cooperation, self-development/autonomy, responsibility, tolerance, flexibility, integrity, respect/attitude.

3. RESULTS AND DISCUSSION

The study was focused on the following experimental objectives:

- analyzing the degree of formation of sociocultural values of students of engineering study programs during the professional training process;
- implementing the methodology for evaluating sociocultural values;
- interpreting the experimental results obtained by using the tools developed to identify sociocultural values.

The experimental research was based on the results of theoretical research conducted through the three classical stages during the years 2022-2024, including an investigation toolkit in order to test the level of formation of sociocultural values at the stages of ascertainment and control of the pedagogical experiment, the development and implementation of actions to apply educational strategies to students within the framework of higher education programs in engineering. To achieve the research objectives, two educational institutions (table 1) with accredited bachelor's degree programs in the field 07 Engineering, processing technologies, architecture and construction (Technical University of Moldova and Free International University of Moldova) were selected and 198 students were trained.

The research groups were made up of students from the Information Technologies and Interior Design undergraduate programs within the Faculty of Informatics, Engineering and Design (ULIM) and the Faculties of Informatics, Engineering and Design and Interior Design (UTM):

a) experimental group (LE) - 44 students from ULIM, Faculty of Informatics, Engineering and Design, Informatics (Inf) study program, Information Technologies (TI) study program and 60 students from UTM, Faculty of Urbanism and Architecture, Interior Design (DIN) study program;

b) control group (LC) - 43 students from ULIM, Faculty of Informatics, Engineering and Design, Information Technologies study program and 51 students from UTM, Faculty of Urbanism and Architecture, Interior Design study program.

The development of the values matrix based on the theoretical study from established sources, such as D. Antoci [1], C. Cucoș [2], C. Enăchescu [3], P. Iluț [4], V. Pâslaru [5], N. Silistraru [6] which formed the system of research variables (innovative cooperation; progressive self-development/autonomy; ethical/moral responsibility; reflective/equidistant/harmless tolerance; cognitive flexibility; professional integrity; respect/cultural attitude) facilitated the identification of the context for collecting empirical data and the initiation of experimental research by measuring the action of independent variables on dependent ones.

Table 2. *Sociocultural values research design*

Group	Academic year	Group/ specialty	No. of subjects	Discipline/ University course
Experimental (LE)	**ULIM, Faculty of Informatics, Engineering and Design, Department of Information Technologies**			
	2022/2023	TI-211, anul II (ro, F)	13	Computer Aided Design
		Inf-213 anul II (ro, F)	14	

		TI-211-21 anul II (ro, FR)	10	Computer Graphics Programming
		TI-32, anul III (ru, F)	7	
	UTM, Faculty of Urban Planning and Architecture, Interior Design department			
	2022/2023	DIN-201 anul III (ro, F)	20	History of design
		DIN-201 anul III (ro, F)	20	Textiles in the interior
	2023/2024	DIN-201 anul IV (ro, F)	20	Contemporary design. Theory and concept
	Total:		**104**	
Ccontrol (LC)	**ULIM, Faculty of Informatics, Engineering and Design, Department of Information Technologies**			
	2022/2023	Inf – 201 anul II (ro, F)	29	Computer Aided Design
		TI -36 anul III (ro, FR)	14	Computer graphics programming
	UTM, Faculty of Urban Planning and Architecture, Interior Design department			
	2022/2023	DIN-201 anul III (ro, F)	17	History of design
		DIN-201 anul III (ro, F)	17	Textiles in the interior
	2023/2024	DIN-201 anul IV (ro, F)	17	Contemporary design. Theory and concept
	Total:		**94**	

The starting point in designing the research variables was the analysis of the socio-humanistic component in the curricula of the engineering study programs Computer-aided design, Computer graphics programming, History of design, Textiles in the interior, Contemporary design. Theory and concept. The objectivity of the recorded results is demonstrated by the introduction of research variables into the educational reality at the level of the educational process regarding the evaluation of the degree of formation of sociocultural values of students in engineering study programs, conditioning the transposition into a university didactic context on the participation of research subjects in courses set for this purpose.

At the observation stage of the pedagogical experiment, two research methods were established to measure the level of formation of sociocultural values: observation and interview. The instrument that facilitated data collection through the observation method was the observation sheet, developed based on the items established for each value and named based on the abbreviations of the 7 variables: CARTFIR Sheet (C=Innovative Cooperation; A=Self-development/Progressive Autonomy; R=Ethical/Moral Responsibility; T=Reflexive/Equidistant/Inoffensive Tolerance; F=Cognitive Flexibility; I=Professional Integrity; R=Respect (Cultural Attitude). The specialized literature consulted on sociocultural values does not offer the possibility of evaluating values according to certain pre-established criteria.

The instrument that facilitated data collection was developed based on the items specific to the field and curricular area taught, included in the Observation Sheet, CARTFIR, based on the abbreviations of the 7 variables identified. Their selection was preceded by an analysis of the curriculum for the discipline taught within the university education institution selected for the research experimental, which served as a starting point for designing the research variables. The CARTFIR form is built to assess the level of development of sociocultural values of engineering students on a three-level interval (minimum, medium, high). Each variable was subjected to measurements depending on the context of manifestation of the value (team activity, teacher-student relationship, presentation of work tasks in accordance with the norms of the cultural context, etc.) and measured on a three-level interval (minimum, medium, high).

The research method was observation. The observation process took place within the university courses mentioned in Table 1., and the items that were included in the observation sheet subjected the students' behavior to observational analysis. At the observation stage, it is observed that both research groups, experimental and control, register approximately the same close percentage results regarding the level of development of sociocultural values (figures 1.).

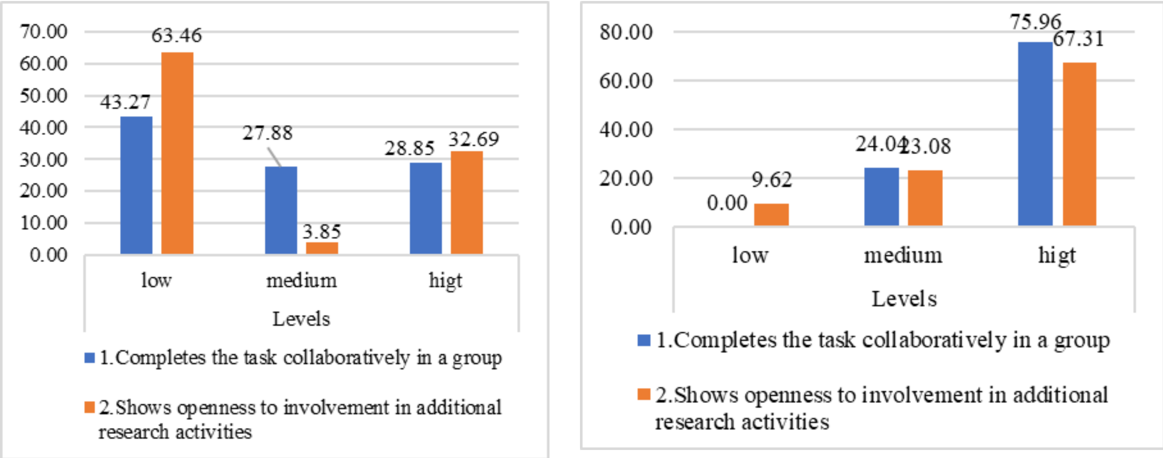

Fig. 1. *The level of innovative cooperation of engineering students in the experimental group in the comparative plan of the stages of the pedagogical experiment (observation-control)*

The data from the experimental group in the comparative plan of the stages of the observation-control pedagogical experiment (figure 1.) represent a high level in both criteria analysed after the experiment.

4. CONCLUSIONS

The observation of the large number of students in the experimental group with a low level of knowledge and integration of sociocultural values demonstrates that at this stage the effects of a deficient development are present for all established indicators, an argument for the application of experimental pedagogical intervention through a program to capitalize on educational strategies for the formation of sociocultural values in students of engineering study programs.

Therefore, the application of innovative educational methods (for example, P2P collaborative learning, interdisciplinary projects, role-playing games, etc.) can support and significantly contribute to the formation of sociocultural values in university education, thus students will be able to respond to the challenges of today's society. The conclusions reached after synthesizing the students' responses are the following:

- sociocultural values contribute significantly to the way of communicating with colleagues and teachers;
- students are open to new challenges;
- students are much more involved in solving real cases related to the activity in society;
- students show appropriate emotional reactions, are much more receptive and tolerant;
- students show a tendency to self-develop, integrate and cooperate with colleagues;
- students show flexibility and socio-cultural responsibility.

ACKNOWLEDGEMENTS

Thanks to the colleagues and teachers who contributed to this study.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

ECO-TEXTILES FOR A SUSTAINABLE FUTURE IN THE PRODUCTION OF SPORTS SHOES

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Abstract: *The adoption of eco-friendly textiles plays an important role in transforming the fashion industry into a more sustainable sector. Despite the challenges faced, such as higher upfront costs and underdeveloped recycling infrastructure, it is essential to recognise the long-term benefits that can appeal not only to the well-being of the environment, but also to the health of consumers and the economic viability of producers. Recycled polyester yarn used in the textile industry, especially in the knitting process of a sports shoe, is a significant innovation that brings multiple environmental benefits. Sports shoe uppers made of such materials are not only an environmentally friendly choice, but also a viable option in terms of performance, providing comfort, durability and aesthetics. In addition, the use of recycled polyester contributes to the creation of a circular economy, in which products have a longer lifespan and are re-entered into the economic circuit. This not only fosters innovation in footwear design and production, but also improves the image of brands that adopt such sustainable solutions. In this context, consumers become more aware of the impact of their choices and can opt for products that reflect their ecological values.*

In conclusion, the recycled polyester yarn used to make sports shoe uppers is not only a sustainable alternative, but also an opportunity to redefine industry standards and promote more responsible practices that protect the environment and contribute to the development of a more sustainable society.

Keywords: *uppers for sports shoes, fashion industry, design program STOLL M1+.*

1. INTRODUCTION

The textile industry, renowned for its comfort-providing role, is undergoing a significant transformation to address its environmental impact [1].

It has been observed that textile waste generation has increased due to fast-changing fashion, rises in population, and an increased consumption of clothes per person in wealthier families. The escalating environmental impact of the textile industry demands urgent attention. It has also been noted that 90% of post-consumer textile waste is reusable [2].

Plastics have surpassed most man-made materials and have long been subject to environmental analysis. However, robust global information is lacking, in particular on their fate at the end of their life cycle [3]. The rapid growth in plastics production is extraordinary, outpacing most other man-made materials [3]. Despite the widespread use and benefits of plastics, environmental challenges remain acute. These issues require not only technological innovation, but also global cooperation to improve data collection and waste management so that we can navigate to a more sustainable future [3].

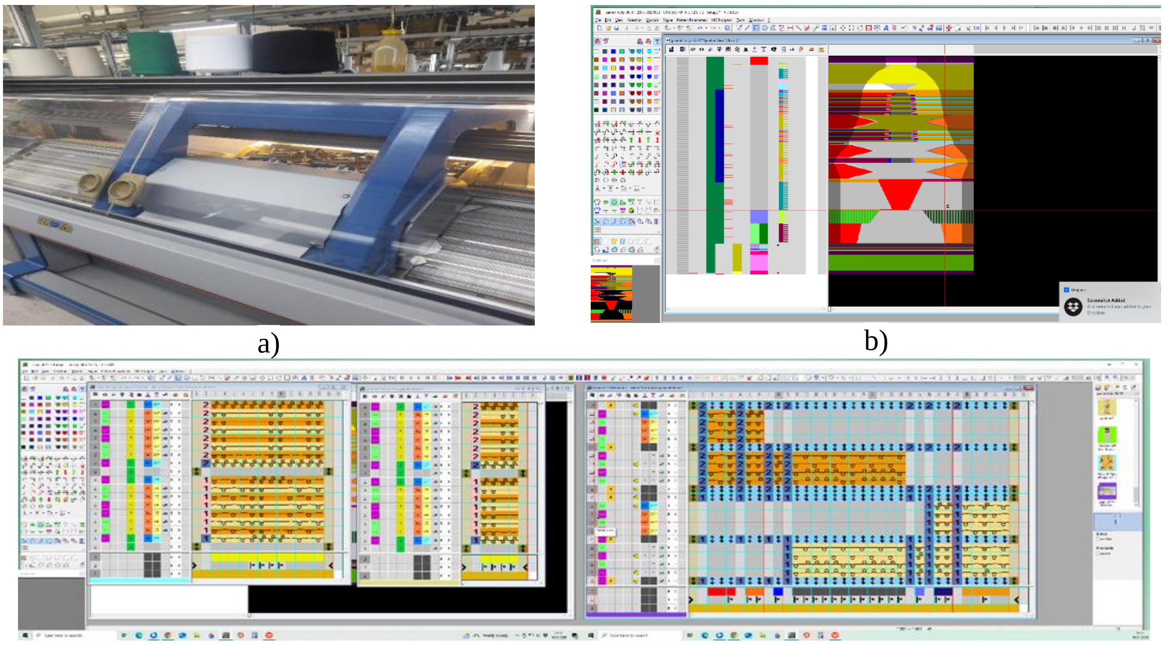
2. GENERAL INFORMATION

Advanced research in the field of materials has led to the development of significant innovations in the industry, including in the field of sports shoes [4], [5]. Tricotate sneaker uppears are a perfect example of how modern technology improves performance, comfort, and sustainability [6].

Knitted shoe girls [4], [5], also known as "knitted shoe uppers", are a recent innovation in the footwear industry, combining modern production technology with a comfortable and attractive design. These shoe uppers are made of yarns of different materials, including recycled polyester, cotton, wool or other synthetic and natural fibers, thus allowing for a wide range of options.

Knitted shoes [4], [5] are used not only for sports shoes, but also for sandals, boots or casual shoes. Many well-known brands are adopting these technologies to appeal to consumers who are looking for sustainable and comfortable products. The footwear industry continues to evolve, and knitted girls are just one of the innovative solutions that emphasize the commitment to sustainability and the response to changing consumer demands. This trend is in line with the global movement towards more responsible and eco-friendly fashion.

A concrete example of the use of rPET [7] in the production of eco-friendly sports shoes is the sneaker model developed by various renowned brands, which have integrated recycled materials into the design and manufacture of their products [7]. For example, a pair of sneakers can contain the equivalent of 6 recycled 2-litre PET bottles,[8] thus helping to reduce plastic waste [7]. In addition, companies in the textile industry are adopting this technology to create sustainable collections, with an emphasis on environmental responsibility.



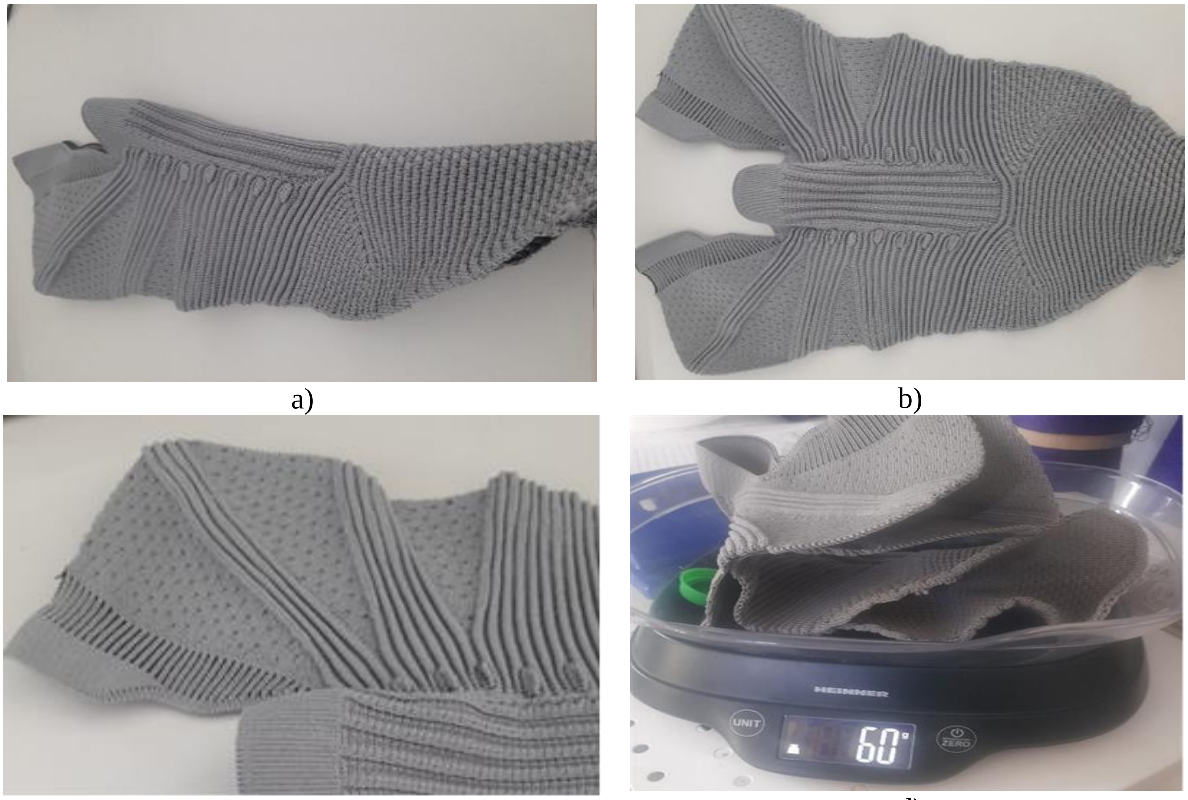
a) b)

c)

Fig. 1*: Rectilinear knitting machine CSM STOLL 530 HP (a) with the design software M1+ (b) and details from the knitting program (c)* [9]

The uppers for sports shoes as shown in **Fig. 2** were made of 100% recycled polyester yarn, with a fineness Nm 1/118, 100% recycled. A quantity of threads of 60 grams was used for manufacturing one face. These faces were knitted on the CSM STOLL 530 HP rectilinear knitting machine, multiguage fineness 7.2/ 14 [9]. For the realization of the knitting program of this product, the STOLL M1+ design program was used, as shown in **Fig. 1** [9].

The contoured panels as shown in **Fig. 2** are made in the Rex structure with ajur designs combined with knitted mesh retained on the entire back font, to obtain the 3D wave effect.



a) b)
c) d)

Fig. 2*: Uppers for sports shoes (a), (b), made by knitting (c) and the weight of yarn used (d) to make an upper for footwear*

To move towards a sustainable future, it is essential that both producers and consumers change their paradigm. The promotion of textile eco-materials involves not only the development of innovative materials, but also their integration into production and consumption practices that prioritize sustainability. Through education and innovation, the textile industry can be transformed into a source of sustainable solutions to today's environmental challenges.

3. CONCLUSIONS

In conclusion, this paper emphasizes the importance of adopting sustainable and innovative practices in the textile industry, aiming to reduce resource consumption and to reduce the negative impact on the environment.

Recycled polyester yarn used in the textile industry, especially in knitting a sports shoe, is a sustainable solution that contributes to reducing waste and conserving natural resources. It offers significant advantages such as durability, strength and flexibility, essential characteristics for products intended for intensive consumption.

Also, the use of these types of yarns helps to reduce the carbon footprint associated with the production process, having a positive impact on the environment. In addition, recycled polyester yarn can be efficiently integrated into modern production processes without compromising the performance and comfort of the final product. Thus, it is an important step towards a greener and more responsible future of the textile industry.

Eco-textiles represent the future of a responsible industry, the development and adoption of these materials, along with sustainable policies and consumer education, are essential for the transition to a sustainable future in fashion and textiles.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

FUNCTIONALISATION OF TEXTILE MATERIALS WITH VOLATILE COMPOUNDS

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Abstract: *The aim of this research work was the determination of volatile oils components of textile materials treated with essential oils extracted from Eucalyptus globulus and Pine. Two types of textile materials (Variant 1 - 80% cotton / 20% Elastane and Variant 2 - 45% cotton / 55% Polyester) were prepared and treated with the solutions of essential oils in the concentration of 0,002%. Initially, a 1% gum Arabic solution was made to which the corresponding amount of essential oil dissolved in ethyl alcohol was added by dripping. Textile materials were treated by exhaustion with the two solutions obtained for 30 min at 40°C. The Ugolini apparatus with a 1:10 hydromodulus (500 mL float) was used. After completion of the treatment, the samples were dried freely at room temperature for 24 hours. The Gas Chromatography-Mass Spectrometry (GC-MS) method was applied to obtain the chromatograms of the essential oils and the constituent chemical compounds. The following compounds were identified in eucalyptus essential oil: Caryophyllene oxide, m-cymene, Eucalyptol, Spathulenol, and in pine essential oil: 1R-alpha-Pinene, Aromadendrene oxide-(2), Caryophyllene. In the textile samples treated with eucalyptus/pine essential oil, the compound 17-Pentatriacontene, belonging to the terpenoid class, recognized for its antibacterial properties, was identified.*

Key words: *essential oil, textile, chemical compounds, chromatograph, functionalization*

1. INTRODUCTION

According to *European Pharmacopoeia,* essential oils are defined as an "odorous product, usually of complex composition, obtained from a botanically defined plant raw material by steam distillation, dry distillation, or a suitable mechanical process without heating. Essential oils are usually separated from the aqueous phase by a physical process that does not significantly affect their composition" [1].

Essential oil is a secondary metabolite synthesized by medicinal and aromatic plants. They represent less the 5% of the total composition of the plants and consist of mixtures of hydrocarbons (terpenes, aldehydes, alcohols, esters, and phenols) and are extracted from plants by conventional methods (hydro distillation, organic solvent extraction, and cold pressing) and innovative methods (supercritical fluid extraction, ultrasound-assisted extraction, solvent-free microwave extraction [2,3], etc.). They can be derived from one or more plant parts, such as flowers (rose, jasmine, clove, lavender), leaves (mint, lemongrass, jamrosa), stems (geranium, verbena, cinnamon), or seeds (fennel, coriander, nutmeg). Essential oils are widely used in various domains due to their beneficial properties such as fragrance, flavors, and medical properties [4]. Essential oils such as eucalyptus, rosemary, tea tree, lemongrass, etc. possess natural antibacterial properties, being a natural alternative to the use of antibiotics and chemical additives [5]. Textile functionalization with essential oils can help inhibit the growth of bacteria and fungi, enhancing the hygiene of fabric-based products. Microencapsulation of essential oils and embedding into clothing fibers assure the resilience and durability of treatment and allow the fragrance and beneficial effect to be released gradually over time [6,7].

2. MATERIALS AND METHOD

2.1 Sample preparation

Textile materials: Sample 1 – 80 % Cotton / 20% Elastane, Sample 2 – 45 % Cotton / 55 % Polyester, were treated with 2 types of essential oils: pine essential oil and eucalyptus essential oil of 0.002% concentration. The textiles were washed for 30 minutes at 30°C with Kemapon PC/LF solution. Subsequently, they were rinsed twice with warm water (30°C) and once with cold water (20°C) and dried freely at room temperature.

Two treatment solutions with essential oils (pine essential oil and eucalyptus essential oil) of 0.002% concentration were obtained. Initially, a 1% gum Arabic solution was made to which the corresponding quantity of essential oil dissolved in ethyl alcohol was added by dripping. The three textile samples were treated by exhaustion with the two solutions obtained for 30 min at 40°C. The Ugolini apparatus was used with a 1:10 hydromodulus (500 mL float). After the treatment, the samples were dried freely at room temperature for 24 hours.

2.2 Method and equipment

Main constituents of essential oil of pine, eucalypt from textile materials were determined by Gas Chromatography-Mass Spectrometry (GC-MS) on an Agilent 6890N Gas Chromatograph System, 5973N MS detector (70 eV), Agilent ChemStation software, ZB-5MSi (5%, 95% dimethylpolysiloxane), 0.25 µm x 30 m x 0.25 mm column. The GC operating conditions were as follows: 100 to 310ºC at a heating rate of 5 ºC/min and then isothermally held for 2 min, injector temperature of 260ºC, injected volume was of 1µL of the volatile oil, split less, with flow rate of 1.0 mL/min, He gas used as carrier gas. MS detector parameters were as follows: ionization voltage: 70 eV; ion source temperature 280 ºC, mass range: 35-500, and scan time 0.32s. The identification of each oil constituent was made by matching unknown peaks with an MS data bank (Wiley 6, NIST02, Mass Finder 2.3 Software).

3. RESULTS AND DISCUSSIONS

3.1. Chromatographic analysis

Chemical compounds were identified for eucalyptus essential oil and pine essential oil. **Fig. 1** presents the GS-MS chromatogram for eucalyptus essential oil. The following compounds were identified in eucalyptus essential oil: a) Caryophyllene oxide, b) m-cymene, c) Eucalyptol, and d) Spathulenol (**Fig. 2**).

Fig. 3 presents the GS-MS chromatogram for pine essential oil. In pine essential oil the following compounds were identified: a) 1R-alpha-Pinene, b) Aromadendrene oxide-(2), c) Caryophyllene (**Fig. 4**).

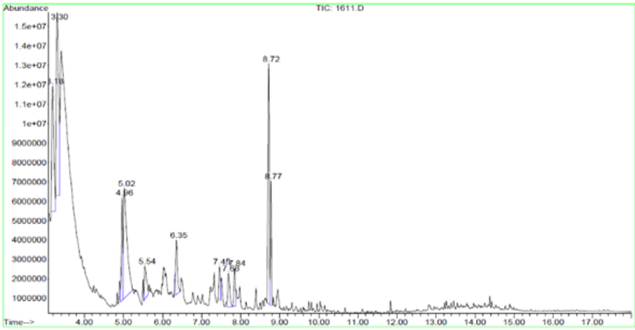
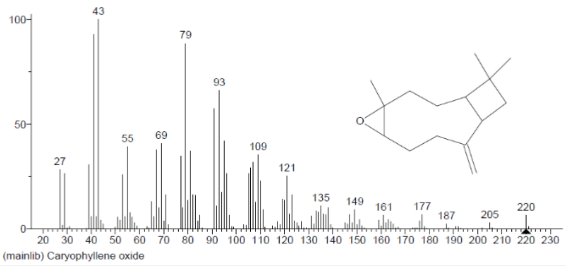
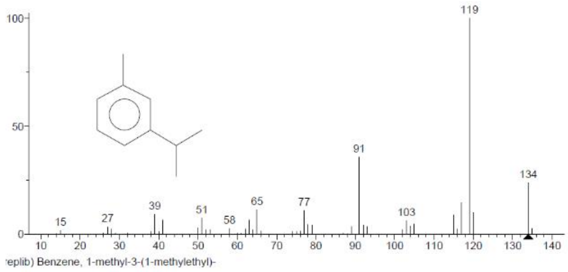


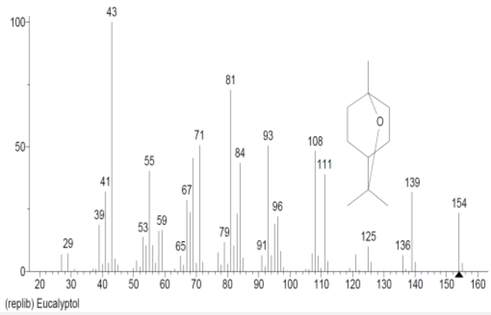
Fig. 1. *Chromatogram of eucalyptus essential oil*



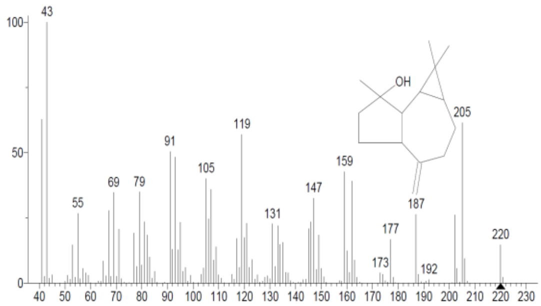
a) caryophyllene oxide



b) m-cymene



c) eucalyptol



d) spathulenol

Fig. 2. *Compounds identified in eucalyptus essential oil*

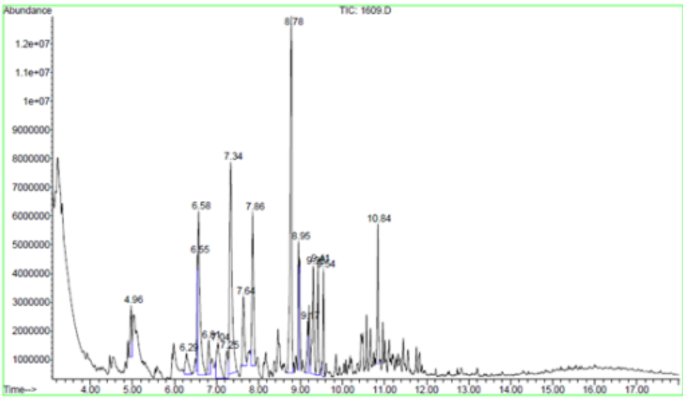
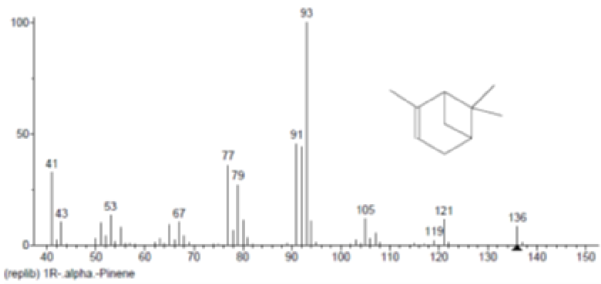
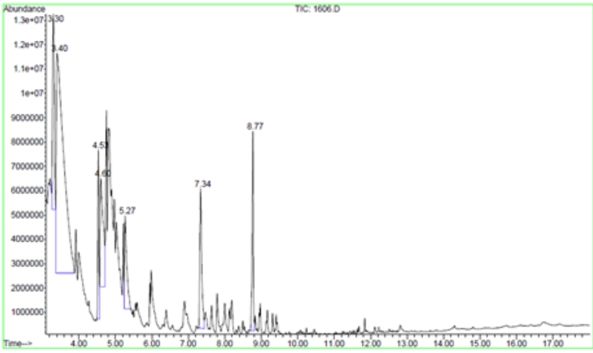


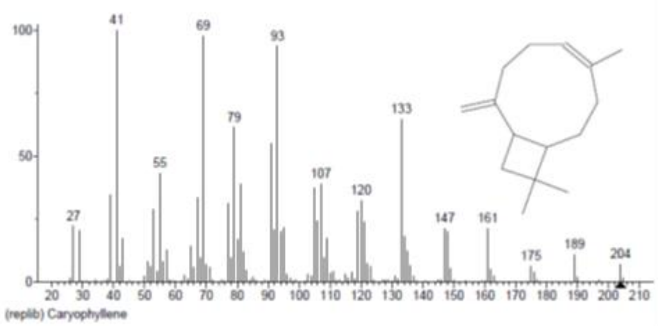
Fig. 3. *Chromatogram of pine essential oil*



1R-.alpha.-Pinene



Aromadendrene oxide-(2)



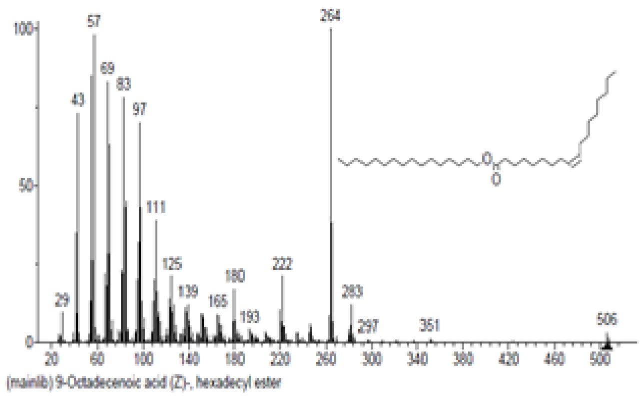
Caryophyllene

***Fig. 4**. Compounds identified in pine essential oil*

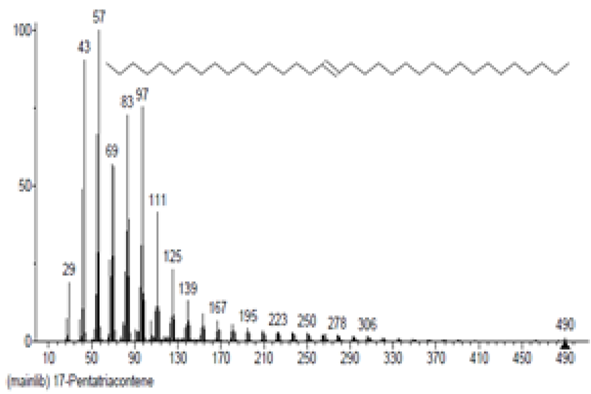
Identification of the chemical compounds of the treated textile structures revealed:

Variant 1- treated with eucalyptus essential oil

For this variant the following chemical compounds were identified: Palmityl oleate, 17-Pentatriacontene, and 1-Tridecene (**Fig. 5 a, b, c**).



a) Palmityl oleate

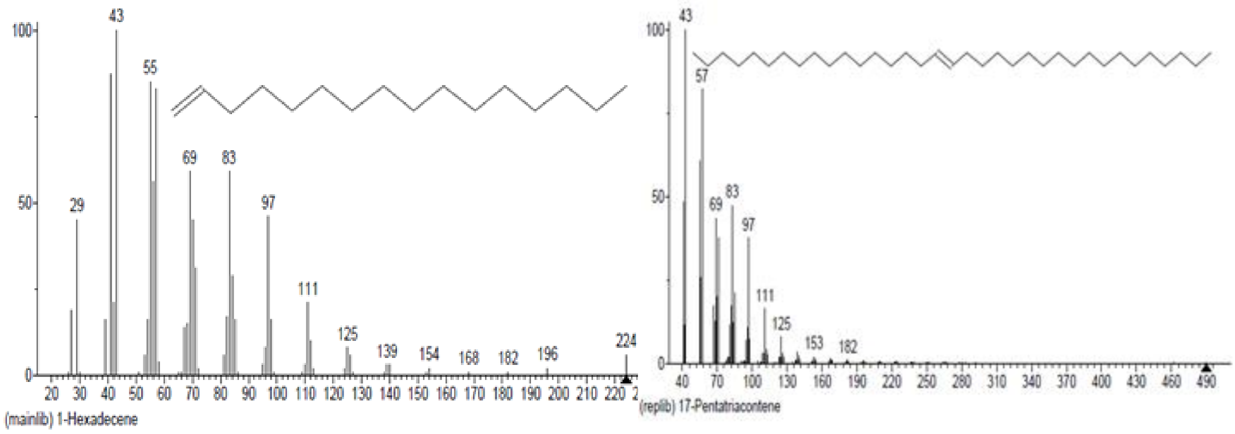


b) 17-Pentatriacontene

***Fig. 5.** Chromatograms of chemical compounds variant 1-treated with eucalyptus oil*

Variant 2- treated with eucalyptus essential oil

For this variant the following chemical compounds were identified: 1-Hexadecene, 17-Pentatriacontene (**Fig. 6 a, b**).

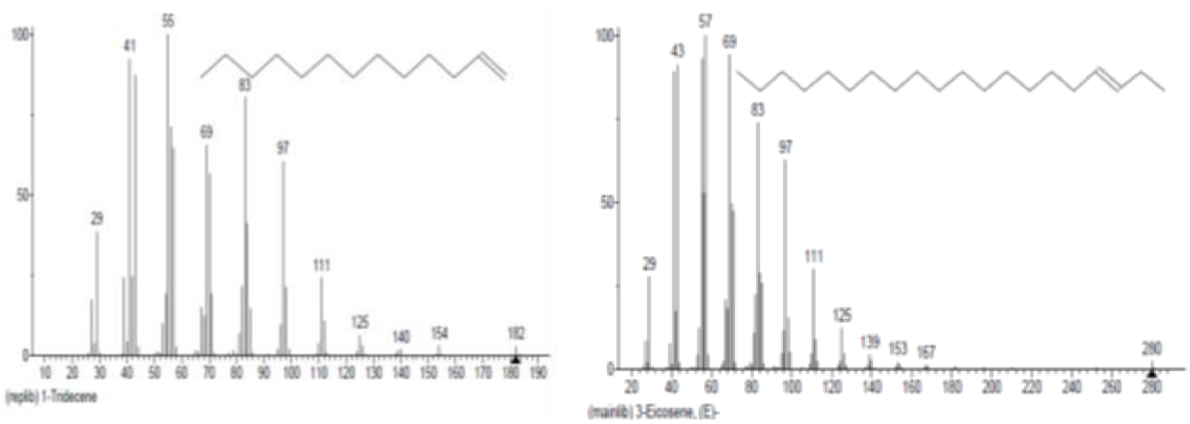


a) 1-Hexadecene *b) 17-Pentatriacontene*

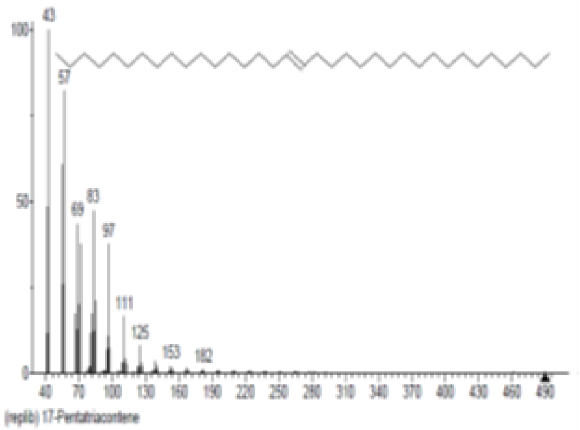
***Fig. 6**. Chromatograms of chemical compounds variant 1-treated with eucalyptus oil*

Variant 1- treated with pine essential oil

For this variant the following chemical compounds were identified: 3-Eicosenes, 1-Tridecenes, and 17-Pentatriacontenes (**Fig. 7 a, b, c**).



a) 3-Eicosenes *b) 1-Tridecenes*

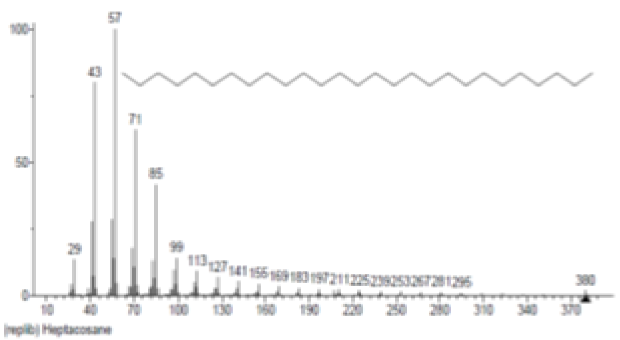


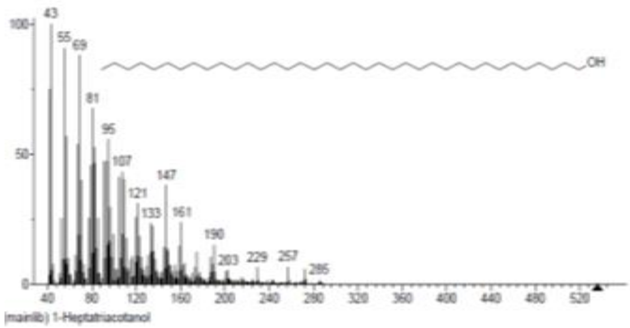
c) 17-Pentatriacontenes

***Fig. 7**. Chromatograms of chemical compounds variant 1, treated with pine oil*

Variant 2- treated with pine essential oil

For this variant the following chemical compounds were identified: 1-Heptatriacotanol, 17-Pentatriacontene (**Fig. 8 a, b**).





a) 1-Heptatriacotanol *b) 17-Pentatriacontene*

***Fig. 8**- Chromatograms chemical compounds variant 2 - treated with pine oil*

Antibacterial activity

The antibacterial activity was evaluated based on SR EN ISO 20645/2005 Textile fabrics - Agar diffusion plate test. The principle of the method is that the specimens are placed on agar plates with two layers. The lower layer consists of a bacteria-free culture medium while the upper layer is seeded with selected bacteria. The level of antibacterial activity is assessed by examining the bacterial growth surface in the contact zone between the agar and the test specimen, and if appropriate the surface of the inhibition zone around the test specimen. The evaluation is based on the absence or presence of bacterial growth in the contact zone between the agar and the specimen and on the appearance of an inhibition zone around the specimen, if any. The tests were performed using the bacteria Staphylococcus aureus ATCC 6538 (gram-positive) and Escherichia coli ATCC10536 (gram-negative) for untreated textiles treated with essential oils of pine, and eucalyptus.The textile structures treated by exhaustion with pine and eucalyptus oil in a concentration of 0.002% and gum Arabic (1%) showed an antibacterial effect on Escherichia coli and Staphylococcus aureus of *satisfactory* level compared to untreated samples *(unsatisfactory*) (**Fig. 9**).

a1) a2) b1) b2)

***Fig. 9**. a) untreated sample; b) treated sample – Escheria coli (1); Staphylococcus aureus (2)*

The evaluation is based on the absence or presence of bacterial growth in the contact area between the agar and the sample, and on the possible appearance of an inhibition zone around the samples.

The width of the inhibition zone—that is, the area without bacteria near the edge of the test tube—is calculated using the following formula (1):

$$H = (D - d) / 2 \tag{1}$$

Where:

H = inhibition zone, in millimeters;
D=total diameter of the test tube and the inhibition zone, in millimeters;
d = diameter of the test tube, in millimeters.

A zone of inhibition greater than 1 mm, without any multiplication, means a *satisfactory effect***.** For the initial samples, the H values were between 2.5-11 and after washing, between 1-1.5.

CONCLUSION

Analysis of the volatile oils by GC-MS revealed the following phyto compounds: mono/sesqiterpenoids: 17-pentatriacontene, tridecen, hexadecen, heptacosan, eicosene, and pentatriacotanol, identified by NIST mass spectra library [8]. In all 4 samples treated with eucalyptus/pin essential oil, the compound 17-Pentatriacontene, belonging to the terpenoid class, was identified. This compound is a decomposition radical resulting from ionisation specific to the GC-MS method of analysis and is commonly found in the chromatographic analysis of essential oils, as specified in the literature [9]. The textile structures treated by exhaustion with pine and eucalyptus oil in a concentration of 0.002% and gum Arabic 1% showed an antibacterial effect on Escherichia coli and Staphylococcus aureus of a *satisfactory* level compared to untreated samples *(unsatisfactory*). For the initial samples, the H values were between 2.5-11 and after washing, between 1-1.5. The durability of the treatment is being studied further.

ACKNOWLEDGEMENTS

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DIGITAL FASHION – A SUSTAINABLE ALTERNATIVE FOR THE FUTURE

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Abstract: *Digital fashion is becoming a viable and sustainable solution to the ecological challenges faced by the clothing industry. This article explores how 3D technologies can serve as a sustainable means of design and production, helping to reduce environmental impact through the lowering of carbon emissions, water consumption, and textile waste. By replacing physical prototypes with virtual simulations, digital fashion enables an efficient, flexible, and waste-free creative process. The article presents arguments supporting the transition from traditional to virtual fashion: optimizing production costs, shortening the development time of collections, enabling design personalization, and increasing brand competitiveness in the digital market. Moreover, this transition allows for rapid adaptation to market demands and encourages responsible consumption. Special attention is given to the evolution of digital fashion in the Republic of Moldova, highlighting its integration into university curricula, particularly at the Faculty of Design of the Technical University of Moldova, as well as the first local industry initiatives in this direction. Concrete examples are provided regarding the use of CLO 3D, Style3D and CAD solutions, which contribute to developing students' digital skills and improving production efficiency. Although the digital transition faces challenges related to technological access and professional training, the article argues tha, through strategic investment and educational innovation, digital fashion can become a key pillar of sustainability in the fashion field.*

Key words: *digital fashion, sustainability, 3D design, virtual prototyping, CAD systems*

1. INTRODUCTION

Digital fashion represents a revolution in the fashion industry, offering innovative solutions that reduce the negative environmental impact. Through the use of 3D technologies, clothing design can be created and tested virtually, eliminating the need for physical prototypes and significantly reducing resource consumption. In a global context where the fashion industry is responsible for approximately 10% of carbon emissions and generates millions of tons of textile waste annually [1], the adoption of digital fashion becomes a necessity for a sustainable future.

The concept of digital fashion has evolved alongside advances in graphic technologies and artificial intelligence, driven by the need to optimize design and production processes. A relevant example is the use of 3D prototyping software, which enables the creation of virtual garments with realistic details, thus reducing material waste and the need for physical testing [2]. These tools allow designers to experiment with shapes, colors, and textures without generating waste, leading to increased efficiency and a reduced ecological footprint. Beyond environmental benefits, digital fashion also redefines the traditional economic model of the apparel industry. Platforms for selling virtual garments, such as The Fabricant and DressX [3, 4], demonstrate the emergence of a market for digital clothing, intended for both virtual environments and augmented reality [5]. This trend reduces demand for fast fashion, thereby helping to decrease pollution caused by mass production.

However, the transition to digital fashion also presents challenges. Access to technology and the skills required to use 3D software remain obstacles for many traditional designers and manufacturers. Moreover, the energy sustainability of the servers running these technologies is a topic of ongoing debate. Nevertheless, the development of more energy-efficient practices and the increased accessibility of digital tools can contribute to the widespread adoption of this alternative.

2. ENVIRONMENTAL BENEFITS OF DIGITAL FASHION

The fashion industry has a significant impact on the environment, being responsible for approximately 10% of global carbon emissions and for the considerable consumption of natural resources such as water and energy. However, the integration of digital technologies—particularly 3D design—can address these ecological issues by optimizing production processes, reducing material waste, and lowering the carbon footprint. Figure 1 illustrates the problems generated by traditional fashion under current conditions.

Traditional fashion / Digital fashion

Problem:	Excessive consumption of material resources	Significant generation of textile waste	Significant carbon emissions	Intensive water consumption	Global transport for distribution
	↓	↓	↓	↓	↓
Ways to solve the Problem:	The use of 3D virtual prototypes allows for testing and optimizing designs before physical production, thus reducing the need for materials for physical samples and minimizing material waste.	3D digital design enables the creation of precise models, adjusting to production requirements and thereby reducing errors and material losses in the cutting and manufacturing processes.	Virtual simulations enable the optimization of production processes, reducing the need for repeated transport of physical prototypes and minimizing the carbon emissions associated with transportation and manufacturing.	3D technologies can help reduce water consumption by optimizing production processes, such as cutting and dyeing materials, which can be simulated to reduce water usage in factories.	By using 3D technologies for virtual prototypes and digital models of products, physical sample transportation can be minimized, thus reducing distances and resources involved in the global delivery of products.

Fig. 1: *Problems caused by traditional fashion*

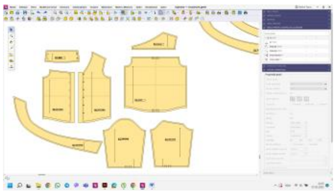
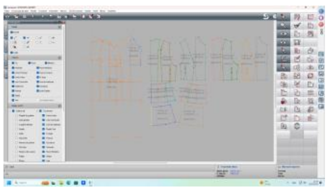
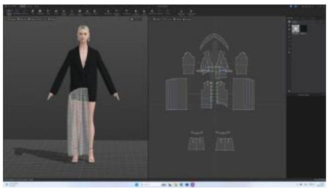
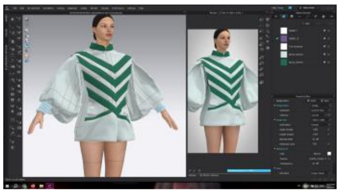
An important aspect is that digital models can have a significant impact on production costs. According to a report by McKinsey & Company (2025), the digital design process can reduce production costs by up to 30%, thereby saving considerable financial resources for brands and companies of all sizes. [6] This is due to the elimination of many physical production stages, thus reducing the need for physical samples.

3. DIGITAL FASHION IN THE REPUBLIC OF MOLDOVA

In the Republic of Moldova, digital fashion is beginning to make its presence felt, highlighted by innovative initiatives and collaborations. When analyzing the fashion sector, two main directions for the use of digital fashion can be observed.

The first direction is higher education in the fashion field, where digital fashion is gradually being integrated into study programs. Specialized universities are starting to include courses focused on computer-aided design (CAD) and 3D simulations for clothing for personalized avatars. [7] These tools not only develop students' digital skills, but also provide a sustainable framework for creative experimentation without the physical consumption of resources. Digital fashion thus becomes an essential element in the training of future professionals. In this context, I would like to emphasize that at the Faculty of Design of the Technical University of Moldova, there is an increasing openness to integrating digital technologies into the curriculum. Students are introduced to specialized software, such as CLO 3D and Style3D, which enables them to design collections in a virtual environment, visualize patterns on 3D avatars, and experiment with textures and volumes in a sustainable way (Table 1).

Table 1: *Results of using 2D and 3D software at the Faculty of Design*

Type	Examples
CAD Systems (GeminiCAD, AssystCAD)	 
3D Prototyping Software (Style3D, CLO3D)	 

The second direction is the integration of digital fashion into the manufacturing industry, where the focus is on streamlining design, prototyping, and promotion processes. Local brands and workshops are beginning to use 3D technology to reduce the time required for collection development, eliminate the need for physical samples in the early stages and create realistic visual content for digital marketing. In this context, digital fashion directly contributes to cost optimization and increased market competitiveness. Some brands and creative workshops in the Republic of Moldova have started adopting digital technology in the processes of designing and developing products. With the support of ZIPHOUSE Fashion Innovation Hub, [8] they are experimenting with the application of digital solutions in the creation of innovative garments. The results of these initiatives were showcased at the Moldovan Brands Runway SS24 event, which highlighted the integration of digital art into fashion shows, setting a new standard for future editions and demonstrating the creative potential of Moldovan fashion on the international stage. [8]

However, at the level of production within local enterprises, digital technologies are predominantly used in the stages of pattern making, construction verification, and frame creation, which helps optimize material consumption and reduce execution errors.

4. CONCLUSIONS

Digital fashion brings a range of significant benefits to the apparel industry, particularly through its ability to reduce ecological impact, streamline production processes, and stimulate creative innovation. The use of 3D technologies and computer-aided design software allows for the elimination of physical prototypes, conserving resources and shortening the time required for collection launches. Moreover, the integration of digital fashion into education and industry contributes to the development of professionals who are better equipped to meet the demands of the contemporary market. Additionally, it serves as a sustainable solution that reduces waste, supports the circular economy, and fosters more responsible production practices. However, the transition to digital is not without difficulties. Limited access to advanced technology, a lack of technical skills among industry professionals and the need for significant initial investment present tangible barriers. Furthermore, many companies remain hesitant to adopt new technologies, either due to fear of failure or a lack of understanding regarding the long-term benefits. This reluctance slows down the innovation process and keeps the industry entrenched in traditional, less efficient models of production.

Therefore, for digital fashion to become a fundamental component of sustainability in the fashion industry, technological development alone is not enough. A shift in mindset is equally necessary, both within companies and educational institutions. This shift must encourage experimentation, embrace innovation, and promote the adoption of sustainable practices. Only by fostering a culture of openness to digital transformation can the fashion industry fully realize the potential of digital fashion, ensuring it becomes a key player in shaping a more sustainable and efficient future.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

PERSONALIZED PATTERNS FOR PEOPLE WITH DISABILITIES USING 3D MODELING

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Abstract: *The garment industry is faced with challenges related to achieving a proper fit for diverse body types, especially for individuals with physical disabilities. Standardized sizing often fails to accommodate variations such as asymmetries, differing limb lengths, and other anatomical differences. This issue is particularly significant for people with neurological body modifications, such as those caused by Multiple Sclerosis, Parkinson's disease, spinal cord injuries, or stroke. The lack of well-fitting, functional clothing options for these individuals has led to an increasing demand for personalized and functional garments.*

This study explores the potential of digital fashion technologies, such as 3D body scanning and virtual prototyping, to create customized clothing solutions. Using the CLO3D simulation system, two virtual body models were created to represent an adult woman with specific body measurements. One model represented a standard body, while the second model incorporated modifications focused on the upper torso area. The study investigates the development of functional garment patterns, highlighting differences between standard and modified body shapes, particularly in the shoulder and neck regions. By comparing these patterns and overlapping the two designs, the research aims to explore how digital tools can contribute to the development of more inclusive, comfortable, and well-fitting clothing for individuals with disabilities.

Key words: *Personalized clothing, 3d body modelling, disability fashion, virtual prototyping, functional garments, adaptive fashion*

1. INTRODUCTION

The garment industry is one of the largest and most influential sectors worldwide, playing a crucial role in the global economy. However, despite advancements in production and technology, significant inefficiencies remain. Recent studies indicate that approximately 25% of all garments produced annually remain unsold, contributing to substantial waste and financial loss [1]. One of the key factors behind this issue is the challenge of achieving a proper fit for diverse body types. Standardized sizing systems, while widely used, often fail to accommodate individual differences such as varying limb lengths, asymmetries, or body proportions that fall outside the commercially available size range.

This challenge is even more pronounced for individuals with physical disabilities. In addition to difficulties in finding well-fitting clothing, they often require functional adaptations that enhance comfort, mobility, and independence in daily activities. Traditional mass production methods are not designed to address these unique needs, leading to limited options for inclusive and adaptive fashion.

As a response to these issues, the demand for individualized and customized clothing has gained increasing attention in both research and industry. Advances in digital fashion technologies, such as 3D body scanning, virtual prototyping, and AI-driven pattern adjustments, offer new opportunities to improve garment fit and functionality. The growing interest in personalized fashion not only aims to enhance comfort and wearability but also contributes to sustainability efforts by reducing waste associated with ill-fitting and unsold garments [2].

This study explores the potential of digital tools and innovative design approaches in creating functional clothing solutions tailored to diverse body types, with a particular focus on individuals with disabilities. By addressing both fit and functional requirements, the research aims to contribute to the ongoing development of inclusive and adaptive fashion solutions.

2. GENERAL INFORMATION

Designing personalized garments for individuals with neurological body modifications such as those caused by Multiple Sclerosis, Parkinson’s disease, spinal cord injuries, or stroke requires a comprehensive understanding of their unique needs. These garments must integrate functionality, comfort, adaptability, and aesthetics while incorporating assistive and therapeutic features to improve the wearer's daily life [3].

Functional clothing is specifically developed to address the challenges faced by individuals with disabilities, providing solutions for self-dressing difficulties, health-related concerns, ergonomic comfort, fit, style, and fashion. While many mainstream fashion brands have introduced some degree of mass customization, their solutions are typically limited to modular design approaches. This means that consumers can personalize garments using predefined design elements within a co-design framework. Although this customization enhances consumer engagement and personal branding, it does not fully resolve the critical issue of tailoring garments to individual body shapes and measurements [4,5].

A key technological advancement in the field of functional fashion is the implementation of 3D garment modeling on virtual body representations. This approach is particularly beneficial for designing both technical and functional clothing for individuals with disabilities. Traditionally, garment design involves manual draping techniques on mannequins, requiring expert craftsmanship and numerous precise adjustments. Alternatively, 2D pattern-making methods are widely practiced, particularly in digital environments, offering greater efficiency in the design process. The integration of these techniques into a 3D digital workflow not only accelerates the development cycle to meet increasing demand but also presents a cost-effective solution for creating customized, well-fitting garments [1,2].

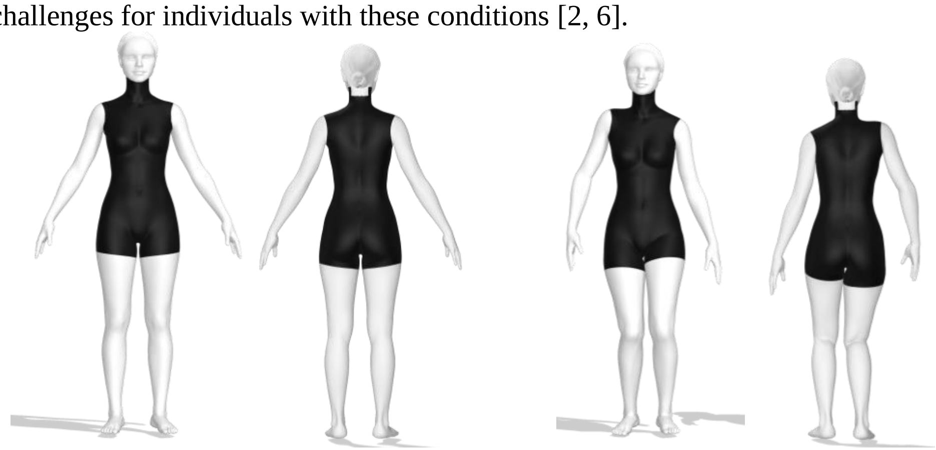
3. METHOD APPLIED

3.1. Description

To better understand the needs and relevance of the selected topic, a simulation was conducted using two body models representing an adult woman with a height of 170 cm and a bust circumference of 81 cm. The remaining body measurements were automatically adjusted by the CLO3D simulation system to ensure as much similarity as possible between the body models and the patterns generated, with minimal error in the results. This simulation approach allows for the precise generation of body shapes and patterns, offering a better understanding of how digital tools can be used to enhance garment design [2, 6].

The first avatar *a)* from ***Fig 1*** shows a 3D simulation of a normal body, adjusted according to the parameters described above.

For the second avatar *b)* from ***Fig 1***, specific modifications were applied, focusing on the upper torso area. These modifications were based on publicly available images and publications of body modifications resulting from medical conditions with a neurological impairment. The torso was adjusted to reflect variations in shoulder width, neck circumference, and upper body asymmetry, common challenges for individuals with these conditions [2, 6].



a) b)

Fig. 1*: 3D avatar of normal and modified body*
a) front and back view of the healthy body; b) front and back view of the modified body

3.2. Method

Utilizing the dimensional characteristics obtained from the CLO3D system after the applied modifications (as illustrated in ***Fig. 1 a and b***), the upper body structure was mapped and unfolded into a 2D representation. This process creates a highly accurate model of the human body, allowing for a detailed analysis of anatomical shape variations. These variations—such as changes in the shoulder width, torso asymmetries, and neck area modifications—are crucial in understanding how to best design clothing that accommodates these specific features [2, 6].

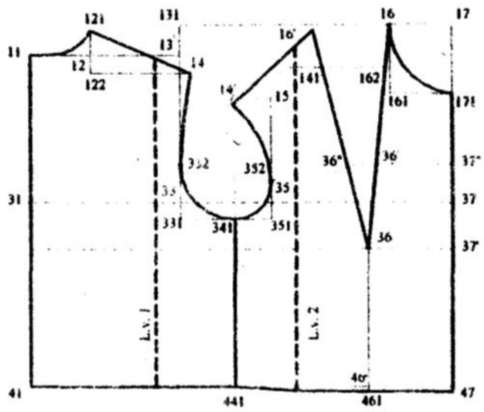
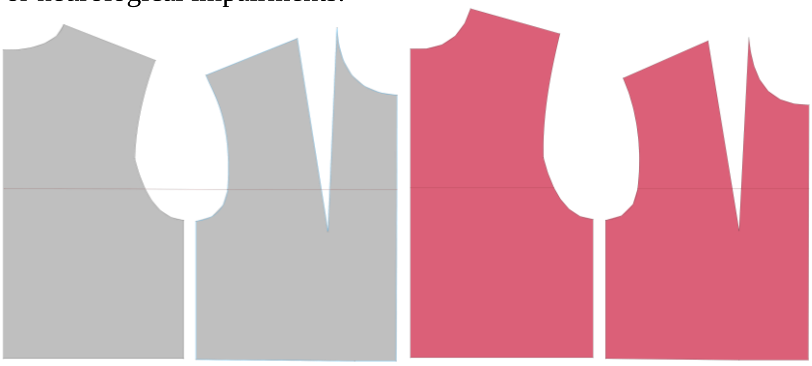


Fig. 2*: Scheme of the upper body pattern making [7]*

The unfolded 3D model was then analyzed to determine how the body's structure would influence the garment construction process. Adjustments were made in the garment's pattern to accommodate these body features and ensure better fit, comfort, and functionality. This process enabled the identification of design solutions that align with the body's anatomical needs.

Based on the scheme from ***Fig 2***, two distinct patterns were developed: one corresponding to a standard body (*Avatar a*), and another adapted for the modified body (**Avatar b**). These patterns were carefully designed to reflect the structural differences identified during the simulation process. The patterns represent the unique needs of individuals who have different body shapes, such as those with disabilities or neurological impairments.



a) b)

Fig. 3*: Normal body pattern and modified body pattern*
a) Normal avatar pattern; b) Modified avatar pattern

In this comparison presented in ***Fig 3*** the normal body pattern (representing *Avatar a*) and the modified body pattern (representing *Avatar b*) are shown side by side. This visual representation allows for a clear comparison of how the two patterns differ. Notably, the shoulder and neck areas exhibit significant differences, as these regions are often where body modifications due to neurological conditions have the most impact. This comparison underscores the necessity for garment designers to consider these variations when creating functional and comfortable clothing for individuals with special needs.

To further analyze the impact of the modifications, the two patterns—standard and modified—were overlapped. This overlap helps to visually represent the specific adjustments made to the garment patterns to accommodate the anatomical variations of the modified body.

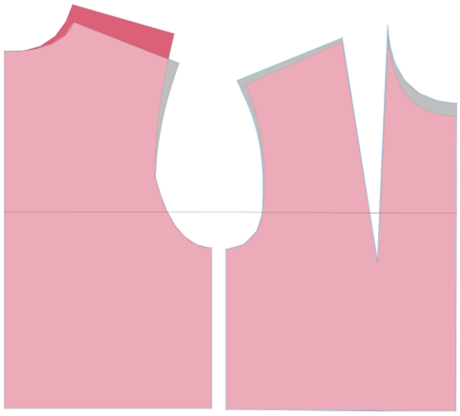
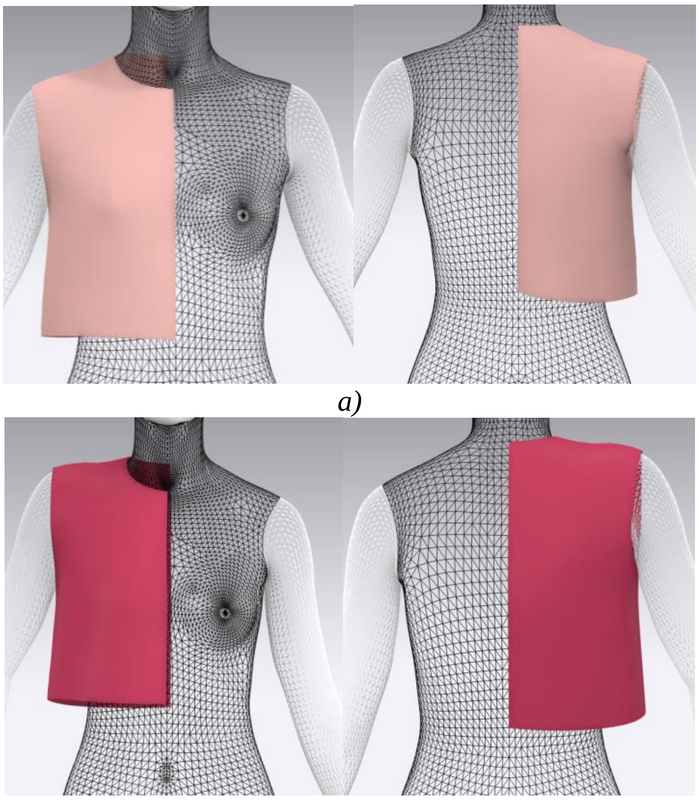


Fig. 4*: Patters overlap*

Fig 4 illustrates how the standard body pattern and the modified body pattern align when overlapped. The core framework of the patterns is kept as similar as possible to ensure that the garment's overall size remains consistent. However, visible differences in the shoulder and neck areas highlight the adjustments necessary to accommodate the anatomical differences of the modified body. The overlap emphasizes how digital modeling tools, such as CLO3D, can be used to identify and address these variations precisely, offering a tailored solution that would be difficult to achieve using traditional manual pattern-making techniques.



a)

b)

Fig. 5*: Pattern and garment simulation – front and back views.*
a) Standard body; b) Modified body.

By analyzing the overlap in ***Fig 4*** and the pattern fit in ***Fig 5***, we can see that it shows that the garments visually fit well on both body types, thanks to specific adaptations made to the pattern.

The ability to visualize and adjust body shapes digitally is a valuable tool for designers working to create functional clothing that fits diverse body types and meets the specific needs of people with disabilities or physical impairments. This process showcases how digital tools can significantly enhance the development of adaptive and inclusive fashion.

4. CONCLUSIONS

The integration of digital technologies such as 3D body modeling offers significant potential for creating personalized garments, particularly for individuals with physical disabilities or neurological body modifications. The findings of this study demonstrate the effectiveness of the CLO3D system in adjusting garment patterns to accommodate unique body shapes, with a focus on functional adaptations for improved mobility and comfort. By comparing standard and modified body patterns, it is evident that digital tools allow for precise adjustments that would be difficult to achieve using traditional garment design methods.

The research highlights the need for further development in the field of adaptive fashion and emphasizes the importance of personalized garment solutions. The ability to tailor garments to individual body shapes not only enhances the comfort and functionality for people with disabilities but also contributes to sustainability by reducing waste associated with ill-fitting and unsold garments. Moving forward, digital fashion technologies can play a key role in addressing the diverse needs of consumers, creating a more inclusive and adaptable fashion industry.

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ANNALS OF THE UNIVERSITY OF ORADEA
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THE INTEGRATION OF 3D DESIGN AND BIOCOLORING IN SUSTAINABLE FASHION DESIGN

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Abstract: *The contemporary fashion industry is undergoing a transition toward sustainable practices due to the negative environmental impact of conventional textiles. This article explores the integration of sustainability in fashion design through the use of 3D design and natural biocoloring, highlighting the benefits of these technologies in reducing waste and utilizing eco-friendly resources. 3D design is revolutionizing the creative process by eliminating the need for multiple physical prototypes, thereby reducing material and energy consumption. Digital technologies enable the optimization of models and design testing before final production, significantly minimizing textile waste. Biocoloring, as an alternative to conventional dyeing methods, uses natural pigments extracted from renewable sources, offering a non-toxic and environmentally friendly process. This technique promotes the aesthetic uniqueness of fabrics and enhances product durability. Studies on bio-dyes demonstrate color stability and a reduced impact on ecosystems. The combination of 3D design and natural biocoloring provides an innovative solution for the development of sustainable collections, contributing to pollution reduction and the advancement of a more responsible fashion industry. This article analyzes the potential for integrating these technologies and their impact on the future of fashion design.*

Key words: *sustainability, 3D design, biocoloring, fashion design*

1. INTRODUCTION

The fashion industry is facing major challenges regarding its environmental impact, being one of the most polluting industries globally. Traditional textile production processes involve intensive water consumption, the use of toxic chemicals, and the generation of significant amounts of waste. Against this backdrop, sustainability in fashion has become a critical goal, leading researchers and designers to explore innovative solutions to reduce the ecological footprint.

One fundamental direction is the use of eco-friendly and biodegradable materials. The choice of sustainable natural fibers such as organic cotton, linen, hemp, or bamboo is becoming increasingly popular, replacing polluting synthetic materials. Innovative textiles are also being developed, such as biomaterials, vegan leather made from mushroom mycelium, or silk created through biological synthesis. These alternatives offer environmentally friendly solutions, reducing pollution and excessive resource consumption. [1] Another essential aspect is the integration of digital technologies into the design process. 3D design is revolutionizing the way fashion collections are created, allowing for material optimization and waste elimination. Additionally, zero-waste patterns and modular clothing contribute to waste reduction, offering adaptable and sustainable products. [2, 3]

Biocoloring and eco-dyeing represent innovative alternatives to conventional textile coloring methods. Replacing toxic chemicals with natural pigments derived from plants, fungi, and bacteria enables the creation of vibrant colors without harmful environmental effects. Moreover, modern dyeing technologies reduce water usage and eliminate toxic emissions [4].

The circular economy plays a key role in the transition to sustainability. The concept of circular fashion involves reusing, repairing, and recycling garments, thereby extending product lifespans. Increasingly, brands are adopting initiatives to collect used clothing, transforming old materials into new fabrics and promoting responsible consumption [5].

At the same time, there is a growing focus on ethical and transparent production. Respecting the rights of textile industry workers and increasing supply chain transparency are key elements of a fair production system. Blockchain technologies allow material traceability, giving consumers clear information about the origin and impact of the clothes they purchase. In contrast to the fast fashion phenomenon, which encourages excessive consumption and mass production, the slow fashion movement promotes the creation of durable collections with timeless design. Garments made from high-quality materials, produced in limited quantities, offer a sustainable alternative, reducing textile waste and encouraging a conscious lifestyle [6].

The purpose of this article is to present the results of a research study on the creation of a fashion product using a combination of 3D design and biocoloring. Additionally, it analyzes the benefits of combining these two technologies and highlights their potential in redefining standards within the fashion industry. The study proposes an interdisciplinary approach, exploring how 3D design and biocoloring can transform the clothing production process both ecologically and aesthetically. By integrating these practices, the fashion industry can become more responsible, reducing pollution and promoting sustainable solutions for the future.

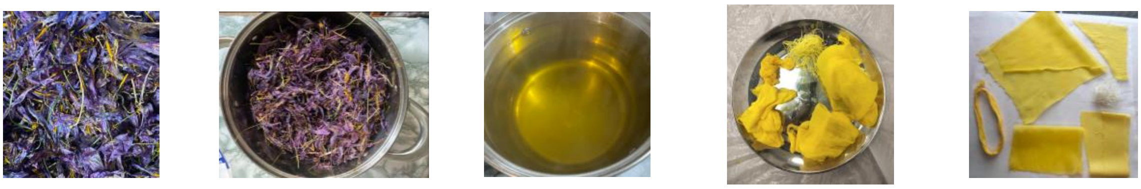
2. 3D DESIGN AND BIOCOLORING IN FASHION DESIGN

Among the most promising directions are the adoption of 3D design and the use of natural biocoloring. 3D design allows for the optimization of the creative process by eliminating the need for multiple physical prototypes, thus reducing material consumption. This technology facilitates the virtual development of models, giving designers the opportunity to test and adjust garments in a digital environment before production. Through this method, textile waste is minimized, production time is shortened, and resource usage is optimized.

In parallel, biocoloring represents a sustainable alternative to conventional textile dyeing, which is responsible for polluting numerous aquatic ecosystems. Traditional dyeing techniques involve harsh chemicals and excessive water usage. In contrast, biocoloring uses natural pigments extracted from plants, fungi, and microorganisms, offering an ecological and non-toxic solution. These methods not only reduce environmental impact but also add aesthetic and cultural value to fashion products. The combination of 3D design and biocoloring opens new perspectives for sustainability in the fashion industry. This integration enables the creation of innovative, functional, and aesthetically appealing collections with a reduced environmental footprint. Digital design reduces resource consumption in the prototyping phase, while biocoloring ensures an environmentally friendly dyeing process.

3. PRACTICAL RESULTS REGARDING THE COMBINATION OF 3D DESIGN AND BIOCOLORING

The experimental research focused on testing and validating the combination of 3D design and natural biocoloring, with the aim of demonstrating their applicability in creating a sustainable fashion product. Initially, a natural dye was selected to be used for coloring the fabric intended for the product model. Saffron was chosen due to its unique properties, offering vibrant shades of yellow and orange associated with elegance and refinement. Moreover, saffron is a sustainable dye, extracted from a renewable resource, aligning with the principles of zero-waste design and sustainability. Figure 1 presents images from the saffron collection and preparation process for dyeing, including the solution obtained and used for this purpose. Also shown are the fabric samples dyed with saffron, including the final ones.



a b c d e

Fig. 1: *a,b,c - preparation of the saffron and the saffron solution; c,d - results of saffron dyeing*

The dyed fabric was manually embellished using techniques characteristic of traditional Romanian folk costumes (fig.2).

Fig. 2: *Handcrafting the ornamentation on the textile material*

Using 3D prototyping technologies, the construction of the garment was developed without generating waste, optimizing both its shape and capacity through a precise digital process. Then, the scanned images of the colored and hand-decorated elements, the final model of the garment was defined, integrating the aesthetic details directly into the digital design, without requiring additional physical samples. This allowed the testing and adjustment of visual elements before actual production, eliminating material waste and reducing the impact on the environment. Thus, the result reflects the balance between innovation and ecological responsibility, combining technological precision with the authenticity of sustainable materials (fig. 3).

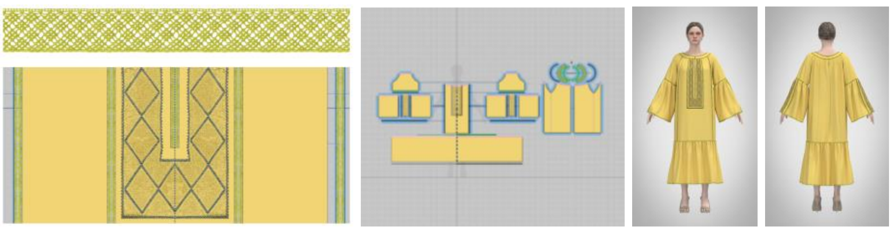


Fig. 3: *Use of 3D prototyping software*

4. CONCLUSIONS

The integration of 3D design and biocoloring in the fashion industry brings significant benefits, both ecologically and technologically, namely:

- Reduction of textile waste – 3D design eliminates the need for multiple physical samples, allowing for the digital testing and adjustment of products before production. This minimizes material waste and optimizes resource consumption.
- Efficiency in the design process – 3D technology accelerates the development of fashion products, enabling designers to quickly experiment with shapes, textures, and colors. This contributes to reducing production time and associated costs.
- Eco-friendly dyeing without toxic chemicals – Biocoloring uses natural pigments from plants and microorganisms, eliminating the use of synthetic, polluting dyes. This method reduces water consumption and the negative impact on ecosystems.
- Creation of unique and authentic products – The use of natural pigments not only protects the environment but also gives each fashion piece a distinct aesthetic and cultural value. Thus, biocoloring adds originality to fashion collections.
- Promotion of a sustainable production model – By combining these technologies, the fashion industry can adopt a circular production system based on waste reduction and the use of renewable resources. This contributes to the development of responsible fashion.

Thus, 3D design and biocoloring not only optimize the creative process but also set a new standard in the fashion industry. The adoption of these technologies represents an essential step toward sustainable, efficient, and innovative fashion production.

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INVESTIGATION INTO IMPROVING LOOP LENGTH PREDICTION IN WEFT-KNITTED FABRICS USING EXPERIMENTAL AND GEOMETRICAL APPROACHES

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Abstract: *Geometrical models of weft-knitted fabrics aim to capture the spatial geometry of yarn loops by utilising structural and material parameters. This study investigates the accuracy of various geometrical models in predicting loop length (LL) using theoretically and experimentally adjusted yarn diameters. The geometrical models proposed by Chamberlain (1926), Pierce (1947), Leaf and Glaskin (1955), Munden (1960) and Kawabata (1970) were investigated. These models use course and wale spacing and yarn diameter as predictors. The yarn diameter, initially calculated using yarn linear density, was experimentally validated through microscopy-based image analysis. An adjustment factor was introduced by comparing measured yarn diameters to theoretical values to refine model predictions. Results revealed that predictions using adjusted yarn diameters significantly outperformed those using theoretical diameters, with Pierce's model demonstrating the highest accuracy among the tested models.*
Experimental validations were conducted on diverse fabric samples, incorporating wale and course spacing, yarn count, and other structural parameters. Comparisons between theoretical and experimental loop lengths illustrate the efficacy of the adjustment factor in enhancing prediction reliability. Additionally, this study establishes a foundation for future work in automated loop length determination using image analysis of fabric structure, enabling more efficient and accurate predictions in textile engineering. The findings contribute to improved geometrical modeling of weft-knitted fabrics and offer practical applications for the textile industry, particularly in quality control and product design optimisation. Further studies are recommended to expand the scope to other fabric types and modeling techniques.

Keywords*: geometrical modelling, yarn diameter, image analysis, loop length prediction, quality control, product design*

1. INTRODUCTION

Geometrical models of weft knitted fabrics

Geometric modelling is the computer-generated representation of an object's geometry by the extensive use of curves to construct surfaces [1]. The curves can be formed by:

- A set of points;
- Analytical functions;
- Other curves.

Geometrical models of weft-knitted fabrics attempt to obtain the geometric features of the spatial shape of loops in the fabric based on the yarn and knitting parameters. These features define and add value to the textile product [2-3]. Most models are validated by accurately predicting the yarn loop length, *l* (mm), from other structural parameters of the fabric [4-5]. Table 1 summarises the models investigated in this work.

Table 1: *Summary of selected geometrical models of weft-knitted fabrics (Vassiliadis, 2007)*

MODEL	LOOP GEOMETRY	ASSUMPTIONS	LOOP LENGTH EQUATION	PARAMETERS
Chamberlain	-Circular arcs and straight lines	Two-dimensional loop	$l = w(3\pi + \sqrt[2]{13})$	w – wale spacing
Pierce	-Yarn forming course lies on a circular cylindrical surface -Arc tangentially connected to two-line segments	-Wales spacing is four times the yarn diameter -Course spacing is $\sqrt[2]{3}$ times the yarn diameter	$l = \frac{2}{c} + \frac{1}{W} + 5.94D$	C – Courses/mm W – Wales/mm D – Yarn diameter(mm)
Leaf and Glaskin	-Yarn forming course lies on a series of circular cylindrical surfaces -Projection of the loop comprised of tangentially connected arcs	- Wales spacing is four times the yarn diameter - Course spacing is $\sqrt[2]{3}$ times the yarn diameter	$L = 4a\varphi D$ $\varphi = \pi + \sin^{-1}\left\{\frac{C^2D}{\sqrt{C^2 + W^2(1 - C^2D^2)}}\right\}$ $a = \frac{1}{(4WD\sin\varphi)}$	L- Loop length (inch) C- Courses/inch W – Wales/inch D- Diameter(inch)
Munden	-Based on forces resulting from pressure of one loop on another	-Direction of forces considered parallel to the course direction of fabric	$\frac{l}{c} = 1.088\frac{c}{D} + 2\left\{1 + \frac{9}{16}\left(\frac{D}{c}\right)^2\right\}$	c- course spacing (mm) D- Yarn diameter(mm)
Kawabata	-Unit cell structure of quarter loop composed of circular arc and a straight line	-No deformation of unit cell	$\frac{l}{2} = \frac{w}{2} + \frac{3\pi D}{\sqrt[3]{2}} + \sqrt{\left(c - \frac{\pi D}{\sqrt[3]{2}}\right)^2 + \left(\frac{\pi D}{\sqrt[3]{2}}\right)^2}$	w- wale spacing(mm) c- course spacing(mm) D- Yarn diameter(mm)

This paper aimed to evaluate the loop length prediction accuracy of the different models summarised in Table 1 using measured values of loop length (LL), number of courses and wales per cm, and yarn diameter for fine gauge weft knitted fabrics made of 100% combed cotton yarn. The measured yarn diameters were compared to theoretical yarn diameters computed from cotton fibre density and yarn linear densities. This comparison enabled the formulation of an adjustment factor to theoretical values to obtain more realistic estimates of yarn diameter from the yarn's linear density.

2. MATERIALS AND METHODS

For this investigation, 19 cotton weft knitted fabric samples of various area densities and yarn counts corresponding to different loop lengths were selected. The fabrics included 10 single jerseys, 4 single piques, 2 double piques, and 3 multi-tuck piques. The loop lengths recorded for the tuck-containing fabrics were those corresponding to the all-knit courses.

2.1 Measurement of fabric constructional parameters

The fabric samples were conditioned under standard conditions. Courses and wales per cm were measured using a 3x3 cm pick glass according to ISO 14971. The course and wale spacing were obtained by taking the reciprocal of courses per cm and wales per cm, respectively. The loop length was measured using a Shirley crimp tester according to ISO 4915.

2.2 Yarn diameter measurement

The procedure used for measuring the yarn diameter was as follows:

1. Unravel five courses of known YC from a 10cm-by-10cm fabric sample;
2. Place a decrimped segment of one course on the glass slide;
3. View the image on the Motic® microscope video screen;
4. Adjust the clarity of the image such that the edges of the yarn core can be clearly identified;
5. Use the image analysis tool to measure the diameter at five different places along the length of the yarn segment;
6. Repeat steps 2-5 for the other four courses;
7. Compute the average actual yarn diameter, $D_{ac,}$ for the 25 readings obtained.

2.3 Computation of theoretical yarn diameter

The theoretical diameter, D_{th}, in cm, was derived from the yarn linear density as follows:

$$\rho = {}^{m}/_{v} = {}^{m}/_{A\,x\,l} \quad \textbf{(1)}$$

$$A = \frac{\pi D^2}{4} \quad \textbf{(2)}$$

$$\rho = \frac{4m}{\pi d^2} = \frac{4}{\pi \cdot 10^5} \cdot \frac{tex}{d^2} \quad \textbf{(3)}$$

$$d = \sqrt{\frac{4}{\pi \cdot 10^5 \cdot 1.54}} \cdot \sqrt{tex} \quad \textbf{(4)}$$

$$d = 9.1 \cdot 10^3 \cdot \sqrt{tex} \quad \textbf{(5)}$$

Where,

ρ = density of cotton= 1.54 g/cm^3
m= mass of yarn, g
v= volume of yarn, cm^3
A= area of cross-section, cm^2
l = length of yarn, cm

d = diameter of yarn, cm

3. RESULTS AND DISCUSSIONS

Table 2 gives the theoretical and measured diameters of yarns of different counts. Their ratios were computed in order to establish an adjustment factor for the theoretical diameter.

Table 2: Adjustment factor for average different yarn count

Yarn count (Ne)	**12**	**16**	**20**	**24**	**30**	**40**
D_{th} (mm)	0.638	0. 553	0. 494	0. 451	0. 403	0. 349
D_{ac} (mm)	0.341	0.271	0.237	0.208	0.1817	0.175
D_{th}/D_{ac}	1.9	2.0	2.1	2.2	2.2	2.0

Based on the ratios obtained, it was decided to set the adjustment factor to a fixed value of 2.0. The adjusted diameter of a yarn of any count was thus obtained from its theoretical diameter as follows:

$$D_{ad} = \frac{D_{th}}{2.0} \tag{6}$$

Tables 3 and 4 show the values of LL obtained from different theoretical models using the theoretical yarn diameter (corresponding to loop length, LL_{th}) and the adjusted yarn diameter (corresponding to loop length, LL_{ad}), respectively.

Table 3: *Geometrical model predictions of LL using theoretical yarn diameter*

Fabric Code	**Tex**	**LL (cm)**	**Theoretical diameter (cm)**	**Chamberlain model (cm)**	**Pierce model (cm)**	**Leaf and Glaskin model (cm)**	**Munden model (cm)**	**Kawabata model (cm)**
SP4	19.7	0.33	0.040	1.36	0.39	-	0.85	0.87
SP3	19.7	0.25	0.040	1.05	0.38	-	0.59	0.83
SP2	24.6	0.26	0.045	1.09	0.42	-	0.67	0.92
SP1	29.5	0.30	0.049	1.25	0.46	-	0.74	1.02
SJ9	36.9	0.33	0.055	1.05	0.53	0.38	0.59	1.09
SJ8	29.5	0.31	0.049	0.99	0.47	0.35	0.55	0.98
SJ7	24.6	0.28	0.045	0.84	0.43	0.32	0.46	0.89
SJ6	24.6	0.28	0.045	0.93	0.43	0.33	0.51	0.90
SJ5	19.7	0.25	0.040	0.76	0.38	0.27	0.44	0.80
SJ4	19.7	0.26	0.040	0.84	0.40	0.35	0.38	0.80
SJ3	19.7	0.24	0.040	0.79	0.39	0.30	0.42	0.80
SJ2	19.7	0.26	0.040	0.81	0.40	0.34	0.38	0.80
SJ10	39.4	0.35	0.057	1.16	0.54	0.41	0.64	1.14
SJ1	14.8	0.24	0.035	0.78	0.36	0.35	0.30	0.69
MT3	19.7	0.25	0.040	1.12	0.42	0.44	0.39	0.82
MT2	29.5	0.29	0.049	1.05	0.49	0.39	0.51	0.98
MT1	14.8	0.25	0.035	0.86	0.38	0.44	0.27	0.69
DP2	49.2	0.40	0.064	1.71	0.59	-	1.18	1.33
DP1	19.7	0.26	0.040	1.12	0.38	-	0.14	0.84

Figures 2 and 3 show the predictive capabilities of the different models using theoretical and adjusted yarn diameters, respectively. Accordingly, Pierce's model with adjusted yarn diameter gives the highest prediction accuracy.

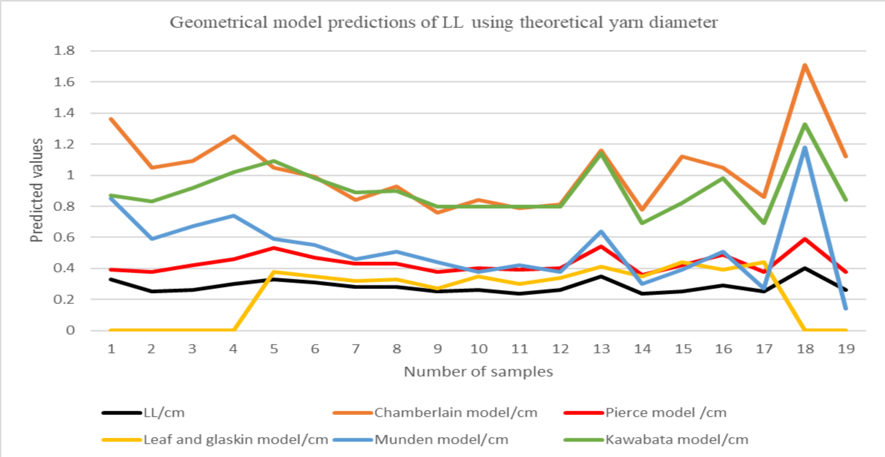

Fig. 2: *Geometrical model predictions of LL using theoretical yarn diameter*

Table 4: *Geometrical model predictions of LL using adjusted yarn diameter*

Fabric Code	**Tex**	**LL (cm)**	**Adjusted diameter (cm)**	**Chamberlain model (cm)**	**Pierce model (cm)**	**Leaf and Glaskin model (cm)**	**Munden model (cm)**	**Kawabata model (cm)**
SP4	19.7	0.33	**0.020**	1.36	0.27	0.48	0.85	0.74
SP3	19.7	0.25	**0.020**	1.05	0.26	0.48	0.59	0.71
SP2	24.6	0.26	**0.023**	1.09	0.29	0.50	0.67	0.79
SP1	29.5	0.30	**0.025**	1.25	0.32	0.56	0.74	0.87
SJ9	36.9	0.33	**0.028**	1.05	0.36	0.71	0.59	0.94
SJ8	29.5	0.31	**0.025**	0.99	0.32	0.63	0.55	0.84
SJ7	24.6	0.28	**0.023**	0.84	0.30	0.60	0.46	0.77
SJ6	24.6	0.28	**0.023**	0.93	0.30	0.57	0.51	0.77
SJ5	19.7	0.25	**0.020**	0.76	0.26	0.50	0.44	0.69
SJ4	19.7	0.26	**0.020**	0.84	0.28	0.66	0.38	0.69
SJ3	19.7	0.24	**0.020**	0.79	0.27	0.55	0.42	0.69
SJ2	19.7	0.26	**0.020**	0.81	0.28	0.65	0.38	0.69
SJ10	39.4	0.35	**0.029**	1.16	0.38	0.72	0.64	0.98
SJ1	14.8	0.24	**0.017**	0.78	0.26	0.67	0.30	0.60
MT3	19.7	0.25	**0.020**	1.12	0.30	0.80	0.39	0.71
MT2	29.5	0.29	**0.025**	1.05	0.34	0.73	0.51	0.85
MT1	14.8	0.25	**0.017**	0.86	0.28	0.84	0.27	0.61
DP2	49.2	0.40	**0.032**	1.71	0.40	0.65	1.18	1.14
DP1	19.7	0.26	**0.020**	1.12	0.26	0.49	0.14	0.72

By comparing the results in Table 3 with those of Table 4, it is found that the models give better predictions when using the adjusted yarn diameter. Pierce's model could predict LL with the highest accuracy among all the geometrical models considered.

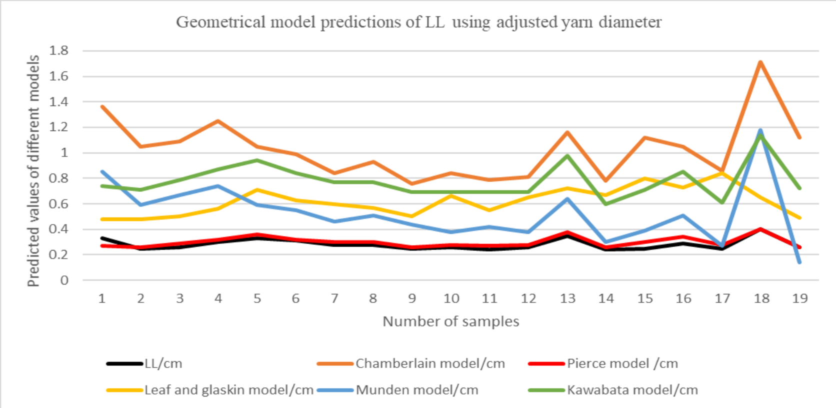

Fig. 3: *Geometrical model predictions of LL using adjusted yarn diameter*

4. CONCLUSIONS

Experimental data were used to verify the prediction accuracy of various theoretical loop length models. Pierce's model was found to be the most accurate one. All the models gave improved prediction values when an adjustment factor was applied to the theoretical yarn diameter. These findings will be used in future works to obtain the LL from fabric images by counting the number of courses and wales per cm using image analysis methods and deriving the adjusted yarn diameter for the fabric from the input of its YC.

5. ACKNOWLEDGMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

DEVELOPMENT OF A FIBRE GLASS/SISAL FIBRE HYBRID COMPOSITE FOR USE AS A CROSSARM IN ELECTRICITY DISTRIBUTION NETWORK

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Abstract: *Crossarms are one of the most important components in the electricity distribution sector. These are beams mounted on a utility pole which takes up load from the transmission wires and transfers it to the pole. Wooden crossarms which are mainly used but are prone to insect attacks and are susceptible to bio-deterioration. This study is focused on the development of a composite for potential use in the electricity distribution sector as a crossarm. The composite was fabricated using hand lay-up technique. The mechanical and electrical properties of the hybrid fiberglass/sisal fiber reinforced polyester were investigated. The results showed the highest tensile strength of 171.16 MPa. For flexural strength, the highest strength was 281.32 MPa. The highest compressive strength of 189.4 MPa was recorded. The insulation resistance was found to increase with the increase in fiberglass content. The study concludes that the hybrid sisal/fiberglass reinforced polyester composite crossarm has the potential to offer significant advantages over traditional crossarms in terms of performance, cost, and environmental impact. Futher studies are needed on aging performance of the composite and full-scale testing before commercial applications.*

Key words: *composite, electrical properties, fibreglass, mechanical properties, sisal fibre*

1. INTRODUCTION

Electric power is distributed through transmission lines that are supported by pylons and utility poles [1]. The supporting structures used for overhead transmission line conductors, such as poles and towers, are called the transmission line supports as shown in Fig 1. The line supports used for the distribution of electrical power can be made from wood, steel or composites [2]. The type of supporting structure used depends on factors such as the location of the line, importance of the line, desired lifetime of the line, money available for initial investment, cost of maintenance, and availability of material [3]. Wooden supporting systems have been used favorably for the support of electricity catenary wires because of their availability, low cost, insulating properties and ease of production [4]. The cross arms are mounted on a utility pole which takes up load from the transmission wires and transfers it to the pole. The cross arms also help to protect the conductors by providing support and security [5]. Wooden crossarms are prone to be attacked by insects which will eventually lead to their failure. Failure of crossarms in transmission network tends to disrupt electrical supply to end-users, and additional maintenance cost [6]. The wooden poles are treated with preservatives to help them last longer and keep bugs away.

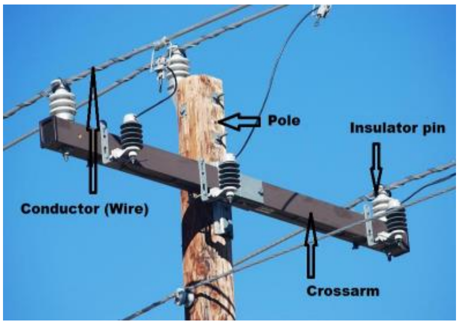

Fig. 1*: Showing components of the support system[7]*

Unfortunately, these preservatives contain dangerous chemicals such as pentachlorophenol that is harmful to humans, animals and the environment [8]. Furthermore, when wooden cross arms become compromised, there is small and sustained current flow leakage along the surface of the insulator and thereafter into the wood itself [9]. This may eventually lead to pole top fires. The fire can easily spread since many of the transmission lines traverse vast rural land and if this fire is not discovered timeously, it can cause breakage of the relevant cross arm or the pole itself. Therefore, there is a need to engineer a resistant and durable alternative. This study seeks to develop cross arms that will be able to last longer and have sufficient mechanical and resistance to electrical conductivity as required in the usage.

2. RESEARCH METHODOLOGY

2.1 Raw Materials

The study made use of glass fibre and sisal as the reinforcement materials in the composite and polyester resin NC901.The sisal fibres were treated with a 2% solution of NaOH for 1 hr. The fibers were then washed thoroughly with water to remove the excess of NaOH sticking to the fibers.

2.3 Fabrication of the composite material

The composite was fabricated using hand lay up technique. The experimental design followed in the study is as shown in table 1.

2.4 Characterization of the developed composite

Mechanical and electrical tests were carried out on the composite as outlined in the subsequent sections.

Table 1 – *Composite Experimental Design*

Number	Sisal fiber (%)	Fiberglass (%)
1[S20/G10]	20	10
2 [S18/G12]	18	12
3 [S16/G14]	16	14
4 [S14/G16]	14	16
5 [S12/G18]	12	18

2.4.1 Tensile Strength

A Universal testing machine (Testometric 500) was used to ascertain tensile strength as well as elongation at break. The specimens were prepared according to ASTM D3039. The tensile strength was determined at 2 mm/min crosshead-speed.

2.4.2 Compressive strength

The compressive strength was tested using a Universal testing machine (UTM) according to ASTM D3410.

2.4.3 Flexural strength

The flexural strength was tested according to ASTM D790 using a UTM machine. A three-point flexural test was carried out to find the flexural strength of the composite.

2.4.4 Insulation resistance

Insulation resistance testing was done to measure the resistance of the composite crossarm to the flow of electrical current. This test was conducted according to ASTM D257. The specimens were subjected to a voltage of 5 KV on a High Voltage Insulation Tester for a minute and the resistance was recorded.

3. RESULTS AND DISCUSSIONS

3.1 Tensile test results

Fig 3 shows the tensile properties of the developed composites.

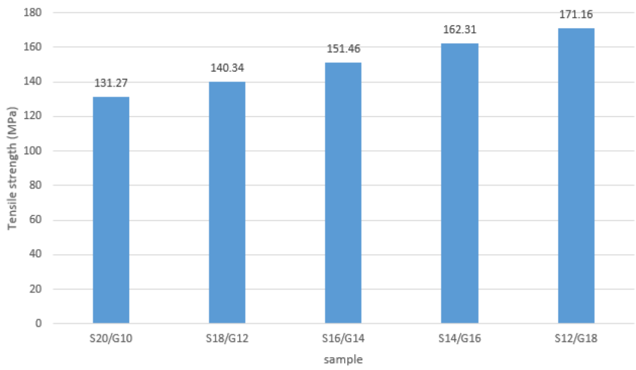

Fig. 3: *Showing the variation in tensile strength for different samples*

Sample S12/G18 with the least amount of sisal fibers had the highest tensile strength of 171.16 MPa. Addition of 2% fiberglass for sample 2 while maintaining the fiber volume fraction increased the tensile strength by 5%. It is seen from fig 3 that increase in fiberglass content considerably increases the tensile strength of the composite. This observation is consistent with study by [10] who showed a similar trend for green hybrid sisal and glass fiber composites. This may be attributed to the fact that sisal fibers carry less load when compared to glass fibers. Sample S20/G10 with a higher percentage of sisal fibers compared to fiberglass had the least tensile strength of 131.27 MPa. Another reason for higher tensile properties of hybrid composites may be due to higher percentage elongation of glass fibers as compared to sisal fibers as also observed by [10].

3.2 Compressive test results

Fig 4 shows the compressive strength of the composites according to the experimental design.

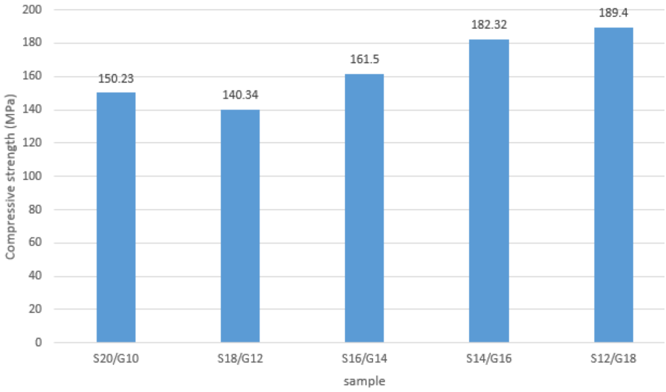

***Fig.** Error! No text of specified style in document.: Showing composite compressive strength*

A linear slight in compressive strength is observed with the increase in fiberglass content except for S18/G12. This agrees with the study done by [11] on the mechanical characterization of glass/sisal fiber reinforced composite. Sample S18/G12 has the least compressive strength. This could be due to the greater likelihood of fiber–fiber contact occurring which reduces the stress transfer ability of the composite. The maximum compressive strength of 189.4 MPa was obtained with sample S12/G18 which had higher fiberglass content due to the higher stiffness and strength of the glass fibers.

3.3 Flexural test results

Figure 5 shows the composite flexural strength.

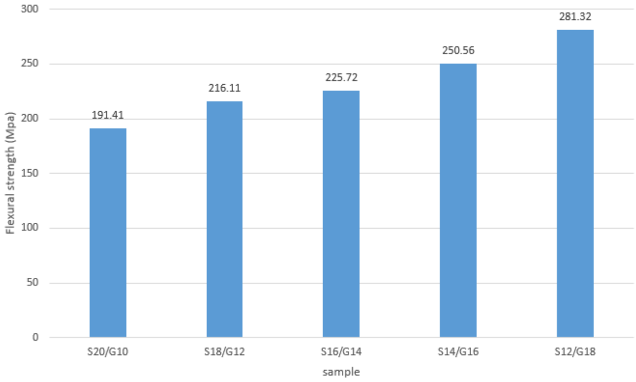

Fig. 5: *Showing the variation in flexural strength for the different samples*

Fig 5 shows an increase in flexural strength with increasing fiberglass content with sample S12/G18 having a maximum flexural strength of 281.2 MPa. This is an expected consequence of the better glass adhesion to polyester in comparison to the sisal adhesion and a consequently higher allowable degree of stress transfer to the fibers during loading. Sample S20/G10 has the least flexural strength of 191.41 MPa because it has the highest sisal fiber content. The results obtained are consistent with study by [12].

3.4 Insulation resistance test results

The results from the insulation resistance test are as shown in Fig 5.

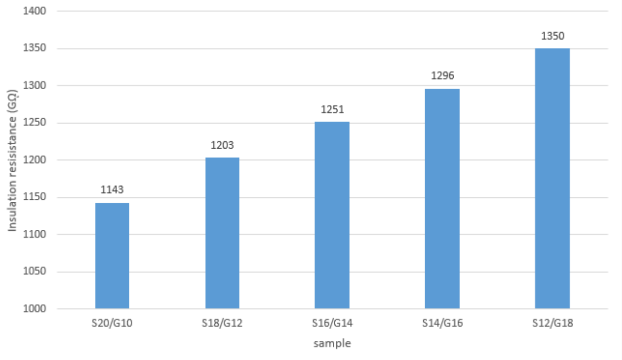

Fig 6: *Showing the variation in insulation resistance*

Fig 6 shows a linear increase in insulation resistance with an increase in fiberglass content. S12/G18 which has 18% fiberglass content had the highest resistance of 1350 GΩ and S20/G10 had the least resistance of 1143 GΩ. Addition of glass fibers improved resistivity of the composites. This is because the network of insulating fiberglass becomes denser, making it more difficult for electrical current to flow through the material. This is consistent with [13] who observed higher insulation resistance values of fiberglass reinforced crossarms. The higher insulation resistance values can also be attributed to the alkali treatment of the sisal fibers. The least resistance of S20/G10 can be due to higher sisal fiber content. As the proportion of sisal fibers increases, the orientation and alignment of the fibers can become more random, reducing the overall electrical strength of the composite. This can lead to a decrease in insulation resistance, as the material becomes more susceptible to electrical breakdown. The same effect was also reported by [14]. However, the developed composites showed higher insulation resistance values when compared to wood which was reported to be around 1400 KΩ by [15] which makes them a better alternative in the electricity distribution sector.

5. CONCLUSIONS

The main conclusions reached during this study are:

- Sisal/fiberglass reinforced polyester composites show potential as a sustainable alternative material for electrical crossarms due to their good mechanical properties, low cost and environmental friendliness.
- Hybridizing sisal and fiberglass fibers in the composite utilized the benefits of both while overcoming their individual limitations. The reinforcement formed a synergistic reinforcement system.
- The composites showed very high insulation resistance with S12/G18 which has 18% fiberglass content having the highest resistance of 1350 GΩ. When compared to wood the resistance makes them a better alternative in the electricity distribution sector.

ACKNOWLEDGEMENTS

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

SPORTWEAR PREFERENCES AND SATISFACTION OF KENYAN FEMALE SITTING VOLLEYBALL ATHLETES WITH PHYSICAL DISABILITIES

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Abstract: *Sitting volleyball is one of the most inclusive and empowering sports among athletes with physical disabilities, particularly those with amputations, spinal cord injuries, and limb weakness. Despite its popularity, sportswear needs of sitting volleyball athletes with physical disabilities has received less attention in research, particularly in Sub-Saharan Africa. This study explored the functional, expressive and aesthetic sportswear preferences and satisfaction of female sitting volleyball athletes with physical disabilities in Kenya. Structured questionnaires were used to collect data from 67 female sitting volleyball players, aged 20–65 years, and actively playing sitting volleyball. Descriptive statistics was used to summarize the level of satisfaction with the sportswear attributes. Inferential statistics were used to examine the significant differences in sportswear preferences and athletes' satisfaction, as well as assessing the associations among various sportswear attributes. Findings reveal that while the sitting volleyball athletes are more satisfied with the aesthetic (M=3.85) and expressive (M=3.31) sportswear attributes than functional attributes (M=3.31). The study concludes that although satisfaction with the functional attributes was lower compared to other attributes, it has a significant relationship with both expressive and aesthetic satisfaction. This indicates that functional aspects should be more emphasized in the design of sitting volleyball uniforms to enhance satisfaction.*

Key words: *Sitting volleyball, functional, expressive, and aesthetic attributes, athltes' satisfaction*

1. INTRODUCTION

Sportswear needs and preferences of athletes have been reported in several studies. These studies indicate that functional attributes, particularly fit and comfort, are the most significant factors influencing athletes' satisfaction, followed by aesthetic attributes such as style, color, and pattern [1]. The fabrics used in sportswear play a crucial role in affecting the thermo-physiological comfort and performance of athletes through properties such as breathability, stretchability, moisture vapor transport, and protection [2]. Although expressive attributes are considered the least important for influencing sports performance, female athletes have been documented to desire sportswear that is not only functional and attractive but also satisfies their psychological needs for identity, values, and status [3]. Similarly, Athletes with Physical Disabilities (AWPD) consider functional attributes such as comfort, fit, mobility and fabric characteristics in addition to fashionable uniforms as important to their performance enhancement. However, adaptive sportswear should camouflage the disability to make it difficult for observers to recognize it, while at the same time ensuring efficient performance [4]. Athletes with Physical Disabilities (AWPD) often experience challenges in accessing suitable sportswear that are relevant to their specific sport [4], [5]. This often results in barriers to their sports' participation, hence isolating them from the community. For instance, wheelchair rugby players in the UK reported challenges with fit and the inability to regulate body temperature [5]. The study proposed design recommendations to meet the athletes' needs for fit, thermal comfort and safety while also stressing the need for inclusive design approaches. Similarly, a study of wheelchair-bound tennis players in India revealed challenges related to ease of movement, poor fit, excessive sweating and heat generation [4].

The sportswear preferences of junior AWPD revealed great dissatisfaction with attributes such as fit, mobility and weight [6]. However, the study was confined to one region, and included only two sitting volleyball players. Moreover, the study examined sportswear needs for various sports, including football, netball, chess, and scrabble which vary significantly in movement and levels of physical activities compared to sitting volleyball. In all the databases of Kenya, there is a dearth of information and data addressing the specific sportswear needs of sitting volleyball AWPD. This study aimed to address these gaps by examining the functional, expressive and aesthetic sportswear preferences of sitting volleyball AWPD in Kenya to guide in the development of more suitable sportswear solutions.

2. METHOD

2.1 Sample and Data Collection

A cross-sectional survey was conducted to examine the sportswear preferences and satisfaction of 67 female sitting volleyball AWPD aged 20-65 years (M=36.5) in Kenya. Participants were identified through snowball sampling, drawn from 8 county sitting volleyball teams at selected sports grounds, including Kasarani and Nyayo National Stadium, during training and competitions. Ethical clearance and permission were obtained from the relevant bodies (Research Permit No. NCST/RCD/14/013/487) before data collection. Data was collected using structured questionnaires, physically administered by the researcher to athletes who had played sitting volleyball for at least 1 year. The items in the questionnaire were measured using a 5-point Likert scale ranging from 1=Strongly Disagree, to 5=Strongly Agree.

2.2 Data analysis

The data was analyzed using descriptive statistics to identify the sportswear preferences and satisfaction of female sitting volleyball athletes with physical disabilities. Pearson's correlation coefficients was used to identify the most preferred sportswear attributes in shaping athletes' preferences and satisfaction. ANOVA was used to measure the statistical significance of the sportswear preferences and satisfaction among the athletes. Fishers Least Significant Difference (LSD) post hoc test was performed to identify the specific sportswear attributes that differed significantly. Pearson's correlation coefficient was then used to compare the relationships among three sportswear attributes. All the statistical tests were conducted at 95% level of confidence, with significance determined at $p < 0.05$.

3. RESULTS AND DISCUSSION

3.1 Instrument Reliability

Cronbach's alpha was used to assess the internal reliability of the questionnaire items measuring the three sportswear attributes: the functional, expressive and aesthetic aspects. This revealed a reliability coefficient of 0.8477, indicating a strong internal consistency across the three items measured in the study (Table 1). This suggests that all the FEA attributes are reliable for assessing the sportswear preferences of AWPD. The average inter-item covariance of 0.2749 further suggests that the individual FEA items used to measure sportswear satisfaction are adequately correlated, but not so highly correlated to be redundant. This result confirms that combining these three attributes into a single measurement framework yields consistent and interpretable findings.

Table 1: *cronbach's alfa reliability test*

Test scale	mean (unstandardized items)
Average interitem covariance	0.2749165
Number of items in the scale:	3
Scale reliability coefficient:	0.8477

3.2 Pairwise correlations between the functional, expressive and aesthetic sportswear attributes

The study found that all the correlation coefficients among the three sportswear attributes are statistically significant at $p < 0.01$(see Table 2):

Functional–Aesthetic (r=0.785): The strong positive relationship between satisfaction with functional and aesthetic sportswear attributes implies that athletes who prioritize functional attributes of their sportswear, such as fit, comfort and mobility, also tend to have a high regard for aesthetic attributes such as color, and style [1]. These findings also support a study of female golf players who considered the most significant influence on their sportswear satisfaction with team uniforms was whether their team uniforms were comfortable and attractive [7]. However, the findings contradict a study of female inline skaters who placed somewhat greater importance on comfort than fashion for skating sportswear [8].

Functional-expressive (r=0.616): the study also found a moderate positive correlation between functional and expressive attribures. This suggests that functional satisfaction is associated with expressive elements such as self-esteem, gender roles, athletic status and identity, although the link was weaker than the correlation between fuctnional and aesthetic sportswear attributes. These findings support studies that associated good fit with positive body image, self esteem and confidence [7].

Aesthetic–Expressive (r=0.672): The correlation between satisfaction with aesthetic and expressive sportswear attributes support the view that athletes who desire to wear sportswear that look good, with fashionable style are likely to derive psychological or symbolic benefits from it as well. These findings support existing studies indicating that while functionality, expressiveness, and aesthetics are distinct facets of sportswear satisfaction, they remain interrelated in shaping the overall user experience [3]. However, the findings contradict most sportswear studies on AWPD that tend to prioritize incorporating only functional and aesthetic aspects in sportswear [1], [4], [5].

Table 2: *Pairwise correlations between the functional, expressive and aesthetic sportswear attributes*

Variables	Functional	Aesthetic	Expressive
Functional	1.000		
Aesthetic	0.785* (0.000)	1.000	
Expressive	0.616* (0.000)	0.672* (0.000)	1.000

**** p<0.01, ** p<0.05, * p<0.1*

3.3 Comparing the relationship between satisfaction with the Functional, Expressive, Aesthetic, and satisfaction for sportswear

The study performed a One-Way Analysis of Variance (ANOVA) to determine the significant differences among the mean sportswear preference scores for the functional, expressive, and aesthetic attributes among the sitting volleyball AWPD. Table 3 reveals that there is a high significant difference (p = 0.000) among the mean scores for Expressive, Aesthetic, and Functional (FEA) preferences. This suggests that the variation in the sportswear preferences across the FEA attributes does not result from random chance. The high F-value (14.76) further emphasizes that at least one of these means is substantially different from the others; therefore, random chance is an unlikely explanation.

Table 3: *Analysis of Variance*

Source	DF	Adj SS	Adj MS	f-value	p-value
Factor	2	12.49	6.2455	14.76	0.000
Error	198	83.78	0.4231		
Total	200	96.27			

The study also conducted post hoc analysis using the Fisher Least Significant Difference (LSD) test to identify the specific sportswear satisfaction attributes that differed significantly (see Table 4). The results revealed that the sitting volleyball AWPD were more satisfied with both aesthetic (M=3.21) and expressive (M=3.37) sportswear attributes than functional attributes (M=2.78). However, the differences between the sitting volleyball AWPD's satisfaction with the aesthetic and expressive attributes were not statistically significant (p=0.462). Therefore, to improve the overall satisfaction of sitting volleyball AWPD regarding all sportswear attributes, designers need to pay greater attention to enhancing the functional performance of their sportswear.

Table 4: *Homogenous grouping using Fisher LSD Method and 95% Confidence*

Preferences	N	Mean ± SEM
Expressive	67	3.3716 ± 0.0781^{a}
Aesthetic	67	3.2172 ± 0.0976^{a}
Functional	67	2.7828 ± 0.0576^{b}

Means that do not share a letter are significantly different.
NB: *1 = Very dissatisfied, 2 = Dissatisfied, 3 = Sometimes satisfied, 4 = Satisfied, 5 = Very satisfied*

Tables 3 and 4 show that ANOVA and Fisher's LSD pinpoint that functional aspects lag behind the other two dimensions in terms of sportswear satisfaction. This gap indicates an opportunity for designers and manufacturers to focus on improving performance-related attributes such as comfort, durability, protection, stretchability and fit, without neglecting aesthetic or expressive benefits that many sitting volleyball AWPD also strongly value.

From the interval plot in Figure 1, the mean scores for FEA preferences each have 95% confidence intervals shown. This plot indicates that the mean of the Functional attribute (2.8) is lower than the mean of the other two sportswear attributes, and its confidence interval does not overlap with those of Aesthetic or Expressive. Meanwhile, the intervals for Aesthetic (3.2) and Expressive (3.4) overlap, indicating no statistically significant difference between them. This plot corroborates the ANOVA and post hoc findings indicating that female sitting volleyball AWPD express lower satisfaction with functional aspects of their sportswear, while aesthetic and expressive considerations are rated higher and roughly at par with each other. These results indicate that improving the comfort, protection, and mobility in sportswear can help in raising the functional satisfaction to the level that athletes already perceive in the aesthetic and expressive domains.

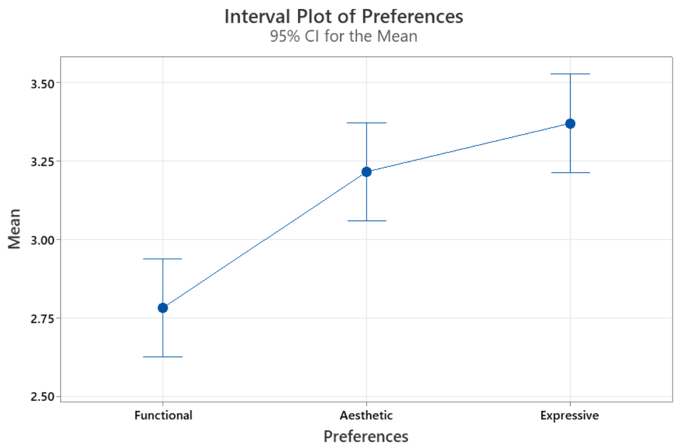

Fig. 1: *Interval Plot*

3.4 The most important aspect of sitting volleyball athletes' sportswear

According to Table 5, participants identified multiple aspects of sportswear as important, but the highest mean scores revolved around feeling beautiful (3.836), ease of movement (3.791), and overall comfort (3.716). These three elements all fell within the "Satisfied" range, indicating that, on average, the athletes view these features as well-met by their current sportswear. Furthermore, the idea of "feeling good about the body" scored a mean of 3.567, suggesting that apparel that foster positive self-esteem are also significant [7], [8].

Table 5: *The most important aspect of the sportswear*

The most important aspect of my sportswear is that:	Mean	Interpretation
It makes me feel beautiful	3.836	Satisfied
It allows me to move freely	3.791	Satisfied
It feels comfortable when worn	3.716	Satisfied
It makes me feel good about my body	3.567	Satisfied
It fits me well	3.433	Sometimes satisfied
It protects me from injury	2.343	Dissatisfied
Overall mean	3.424	Sometimes satisfied

NB: *1 = Very dissatisfied, 2 = Dissatisfied, 3 = Sometimes satisfied, 4 = Satisfied, 5 = Very satisfied*

4. CONCLUSIONS

Although functional needs are considered the most important aspect of most sportswear, this study found that female sitting volleyball AWPD in Kenya expressed more satisfaction with expressive and aesthetic attributes of their uniforms than with the functional aspects. This reveals a critical need to improve the functional aspects of their sportswear by incorporating features such as fit, comfort, and mobility. Unlike previous studies, which mainly focused on the general sportswear needs of AWPD or able-bodied athletes, this research provides sport-specific insights to guide the development of inclusive sportswear that enhances performance.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

CONDUCTIVE TEXTILE TRANSMISSION LINES FOR MICROWAVE FREQUENCY FILTERS

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Abstract: *Smart textiles require transmission of the vital signs towards a central unit, via embedded antennas. Impedance matching is required in order to maximize the power transmitted by the antenna. This paper presents the design and manufacturing of a low pass filter, including a series inductor and a parallel capacitor, manufactured by screen printing on a flexible textile substrate. The filter reflection factor S11 was firstly simulated in the frequency range 5-2000 MHz, then the filter was manufactured by screen printing of silver paste on a Polyamide-imide-Viscose substrate and afterwards measured via a network analyser. The S11 reflection measurement results show a good relation to the simulated values.*

Key words: *silver, smart textiles, reflection factor S11, simulation, measurement*

1. INTRODUCTION

Printed flexible electronics finds nowadays numerous applications in emergent fields, such as wearables, personal protection equipment (PPE) and smart textile materials [1]. Such applications include both the conventional textile functionalities, such as thermos-physiological comfort, mechanical and weathering protection, style etc. as well as various additional functionalities, such as signal transmission via conductive paths, signal transmission via antennas, energy harvesting and storage via e.g. supercapacitors etc. [2]. These smart textiles applications envisage monitoring of vital signs for health and sports [3]. Main aim of the research in this domain is to integrate textile and electronics and to ensure the autonomous functioning of the textronic (textile+electronic) system [4]. Flexible conductive paths are required to transmit high frequency signals within textronic systems. The scientific literature in this field reports various solutions [5-10].

The various additive manufacturing methods for flexible electronics and their advantages are presented in [5]. Some advanced solutions to manufacture microwave passive components and filters on cellulose flexible substrates were accomplished by [6].

A deep analysis of microstrip textile antennas and the environmental factors affecting their performance was accomplished by [7]. The study of high frequency transmission lines with an impedance of 50 Ohm was also done in [8]. The design of a flexible microstrip antenna, including simulation of reflection S11 response both for the strait and bended antenna are presented in [9]. Another type of antenna, namely a flexible dielectric resonator antenna for monitoring vital signs was developed in [10].

The coplanar waveguide (CPW) is a specific transmission line in additive manufacturing, presented numerous advantages, such as single side printing, easy mounting of passive devices and reduced radiation loss [11]. Such CPW transmission lines and the related distributed elements were extensively studied [12], however, the scientific literature of applying CPW lines on flexible substrates is rather scarce.

This paper presents a CPW transmission line, printed on a flexible textile substrate, preliminary designed as low pass filter and subsequently measured via a network analyser for validation of the simulation design.

2. EXPERIMENTAL

2.1 Physical-mechanical properties of the textile substrate

The textile substrate used for additive manufacturing of the silver paste transmission line has the composition of 70% Kermel (Polyamide-Imide) and 30% Viscose, with fireproof properties and a high surface evenness character. The physical-mechanical properties of the textile substrate are presented in table 1.

Table 1: *Physical-mechanical properties of the textile substrate*

No.	Physical mechanical property		UM	Values	Standard
1	Specific mass		g/m^2	268	SR EN 12127
2	Thickness		mm	0,59	SR EN ISO 5084:2001
3	Tensile strength	Warp	N	1389	SR EN ISO 13934-1
		Weft		905	
4	Elongation at break	Warp	%	24,6	
		Weft		14,0	
5	Tear resistance	Warp	N	66,0	SR EN ISO 13937-3
		Weft		70,2	
6	Dimensional change at washing	Warp	%	-1,72	SR EN ISO 6330
		Weft		-1,0	
7	Abrasion resistance		no. abrasion cycles	28.015	SR EN ISO 12947-2
8	Air permeability		l/m^{2}s (mm/s)	212	SR EN ISO 9237

2.2 Determination of relative permittivity and loss tangent of the textile substrate

A test bench was designed to measure the complex relative permittivity of solid dielectric materials. The system comprises the Agilent E4991A RF Impedance/Material Analyser, the Agilent 16453A dielectric material test fixture, and a solid dielectric material sample for measurement. Utilizing this analyser, the complex relative permittivity of dielectric materials can be measured over a frequency range of 1 MHz to 1 GHz. The Agilent E4991A materials analyser determines the impedance (or admittance) of an equivalent capacitor, which is physically formed by the upper and lower electrodes of the Agilent 16453A test fixture, with the dielectric material under test positioned between them. The relative permittivity of the solid dielectric material is then computed based on the measured impedance (or admittance), given the known thickness of the dielectric material between the capacitor plates. The real part of the complex relative permittivity is calculated using the equation:

$\varepsilon_r' = \frac{gC_e}{\varepsilon_0 S}$, where S represents the surface area of the lower electrode, g is the thickness of the dielectric material sample, and C_e denotes the capacitance of the equivalent capacitor. The imaginary part of the complex relative permittivity is given by: $\varepsilon_r'' = \frac{g}{\omega \varepsilon_0 S R_e}$, where R_e is the equivalent resistance or loss resistance. The loss tangent of the dielectric material is determined as the ratio of these two components. The measured values for the relative permittivity and tangent delta are presented in figures 1 and 2. The relative permittivity and the tangent delta of the textile substrate are mandatory parameters in computing scattering values of microwave transmission lines.

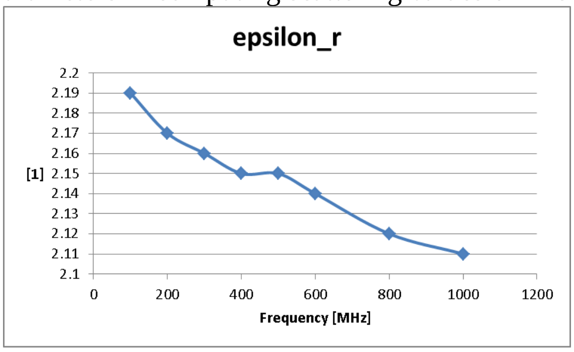

Fig. 1: Relative permittivity

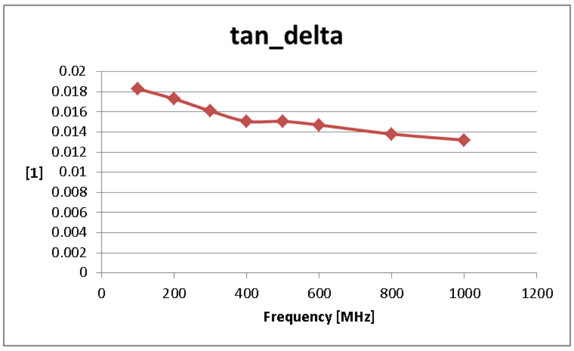

Fig. 2: Tangent delta

Figures 1 and 2 present the frequency evolution of the relative permittivity and of tangent delta for the Polyamide-imide-Viscose textile substrate, used for screen printing of the transmission lines.

2.3 Determination of the thickness of the silver trace

The thickness of the silver trace was determined via the Scanning Electron Microscope (SEM), by averaging the various thicknesses measured crossover the trace. These measurements are shown in figure 3 and detailed in figure 4.

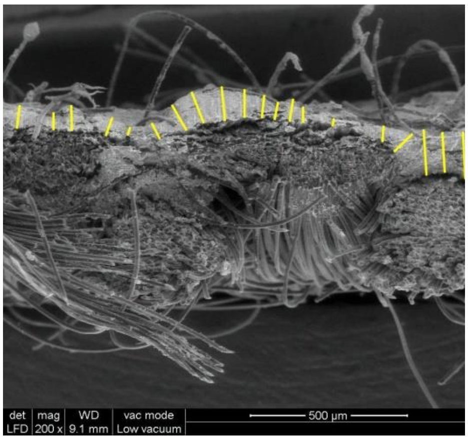

Fig. 3: SEM image of the silver trace average thickness

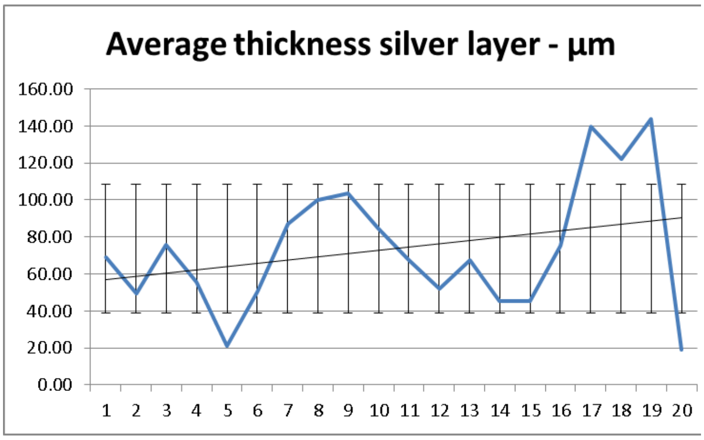

Fig. 4: Average thickness with standard deviation of the measured values

It is recommended for a good CPW transmission line, that the average thickness of the silver trace should be smaller than the skin depth of the silver trace. In our case, the skin depth at 2 GHz is 0.083 mm, while the average thickness is 0.074 mm. Figure 5 shows the skin depth and the average thickness depending on frequency. Up the frequency of 2 GHz, the average thickness is smaller than the skin depth.

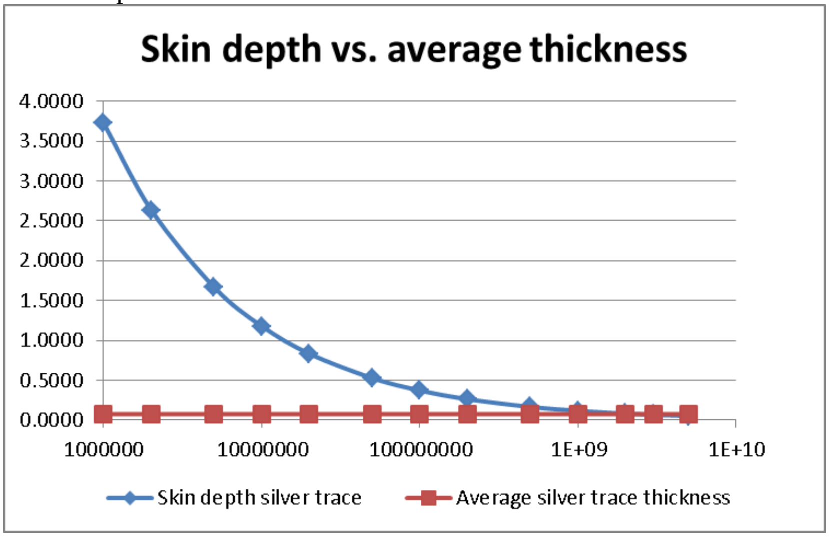

Fig. 4: The skin depth in relation to the average thickness of the silver trace

The skin depth relation is given by

$$\delta[m] = \sqrt{\frac{2}{\omega\mu\sigma}}$$

Were σ [S/m] – electric conductivity was determined via ohmmeter from the linear electrical resistance

μ - [H/m] magnetic permeability of the silver trace

ω – [rad/s] angular velocity in relation to the frequency of the signal

2.4 Determination of the silver trace morphology

The SEM image (Fig. 6) acquired at 3000X magnification show a porous morphology with large number of pores having the sizes in a range of 2.4 µm, average of 1.0 µm and STD of 0.6 µm. Therefore, the pores are enough small to have a high total boundary area, providing a good electrical contact between the conductive coating and an adhesive layer used to fix the circuit elements on the electric tracks.

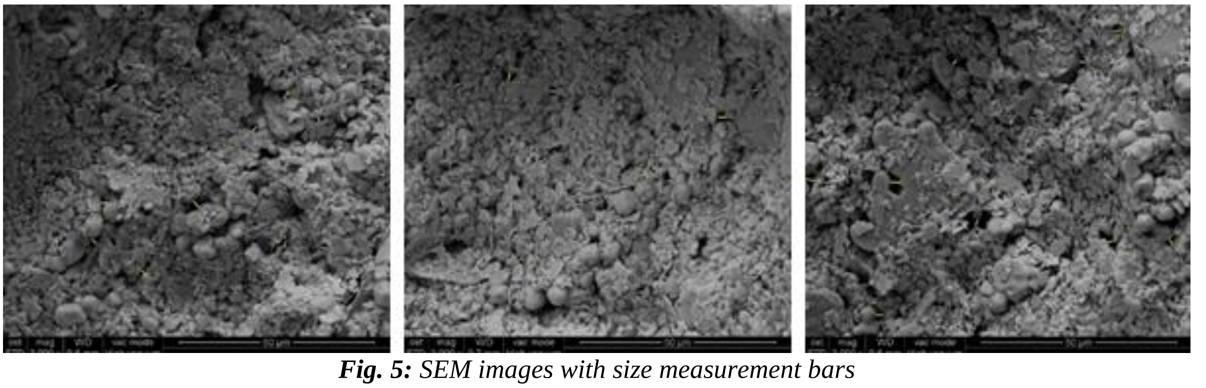

Fig. 5: SEM images with size measurement bars

The EDAX analysis (Fig. 6, Table 2) reveals that the Ag is the most prevalent element from conductive ink which forms the active ingredient in chemical bonding with Cl. The other elements are in very small concentrations, excepting the carbon and oxygen which come from the textile substrate.

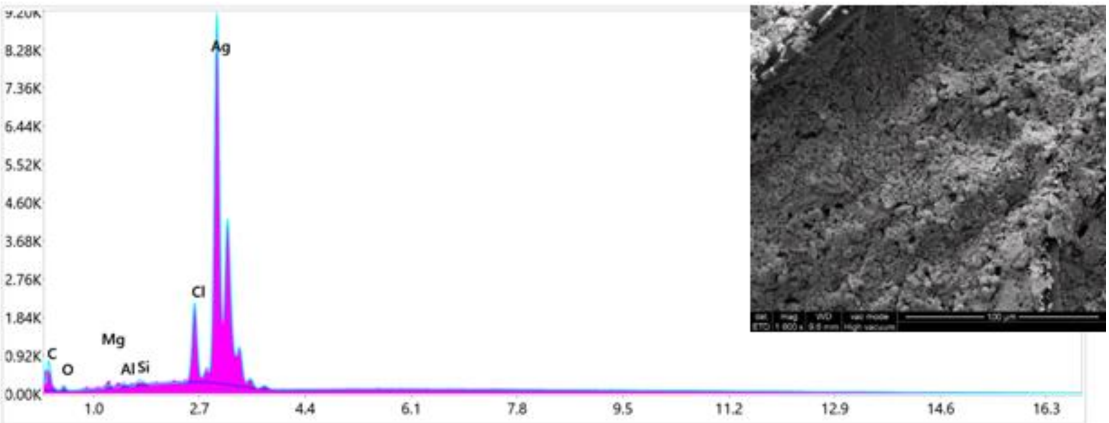

Fig.6: *EDAX spectrum and scan zone at 3000X magnification*

Table 2: *Weight and atomic concentration of elements*

Element	Weight concentration [%]	Atomic concentration [%]
C	9.9	40.5
O	3.8	11.6
Mg	0.6	1.3
Al	0.6	1
Si	0.6	1.1
Cl	6.2	8.7
Ag	78.4	35.9

3. DESIGN, MANUFACTURING AND VALIDATION OF THE CPW LOW PASS FILTER

The CPW transmission line was designed as low pass filter with an inductor in series and a capacitor in parallel. The CPW series inductor has according to the scientific literature a smaller width than the transmission line, while the parallel capacitor has a thicker width than the transmission line. The filter was designed according to the following scheme (Figure 7) and simulated in Sonnet Lite as Coplanar Waveguide (Figure 8).

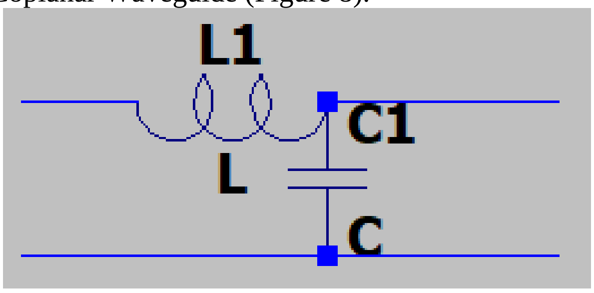

Fig.7: *Design concept of the Low-pass filter*

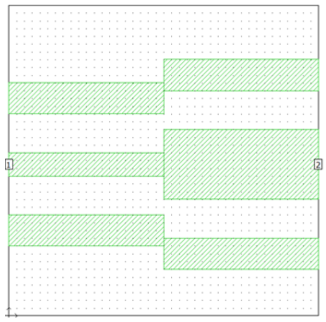

Fig.8: *Simulation of the Coplanar Waveguide including series inductor and parallel capacitor in Sonnet Lite*

The following simulated S11 scatter diagram applies for the CPW Low-pass filter in Sonnet Lite (Figure 9).

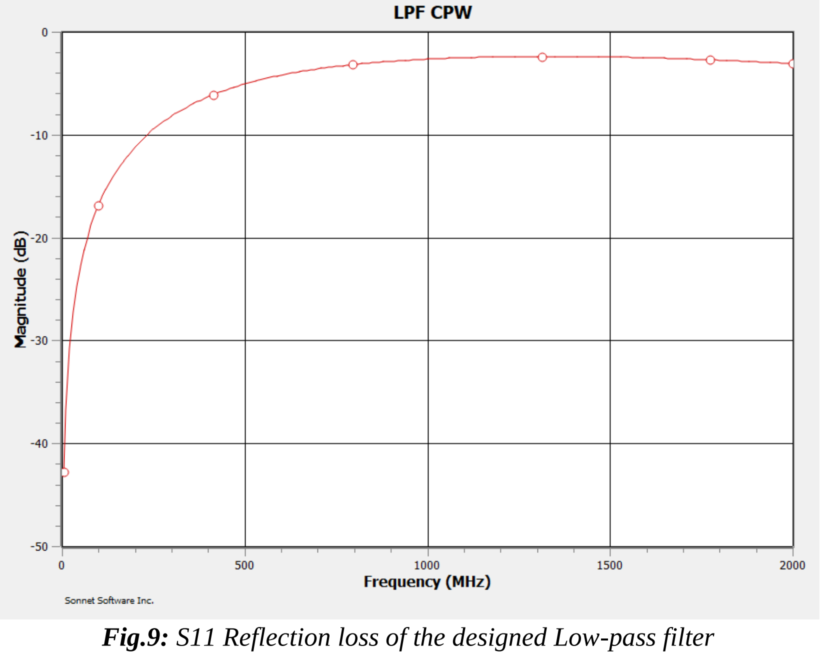

Fig.9: *S11 Reflection loss of the designed Low-pass filter*

After design and simulation the filter was manufactured by screen printing on the textile substrate. Figure 10 and 11 show the manufacturing method of the filter by screen printing with silver paste.

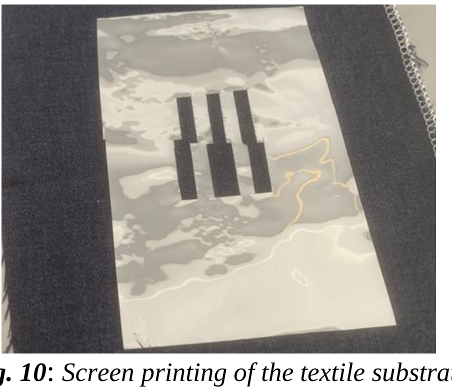

Fig. 10: *Screen printing of the textile substrate*

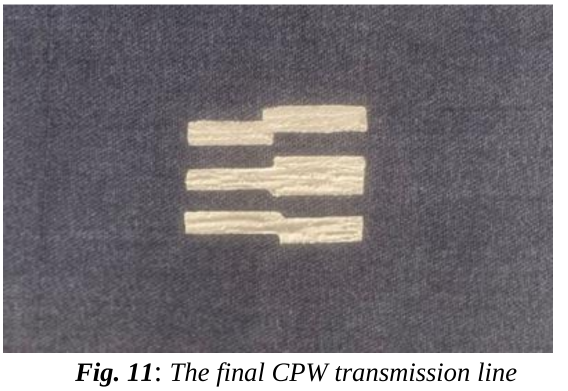

Fig. 11: *The final CPW transmission line*

Figure 12 and 13 present the measurement of the CPW LPF via network analyser in both straight and bended position. The deviation of the S11 signal in bended position had a non-significant deviation to the straight position.

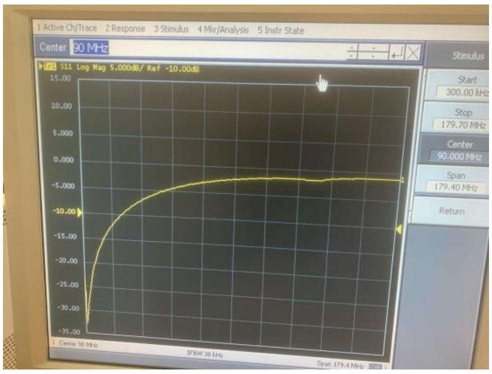

Fig. 12: *Measurement via network analyser*

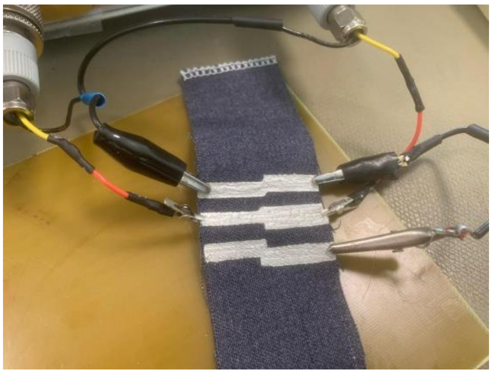

Fig. 13: *Fixture of the flexible CPW LPF for measurement*

Figure 14 present the simulation values of the S11 – Reflection factor in dB, for the frequency range 5-2000 MHz, as well as the measurement of the reflected signal via a network analyser.

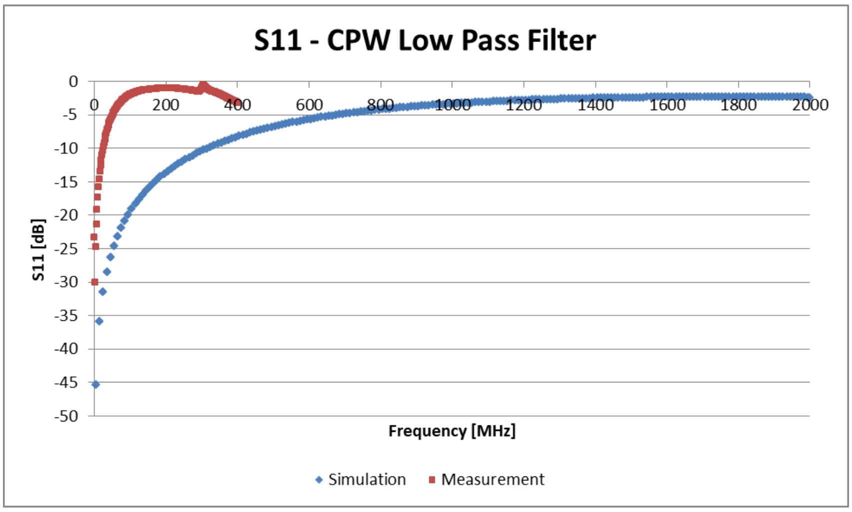

Fig. 14: *Simulation and measurement of the CPW transmission line as low pass filter*

The measurement results show a good relation to the initial simulation for the design of the CPW low pass filter.

4. CONCLUSIONS

The design and manufacturing of lumped components R-L-C on flexible textile substrates via screen printing, opens a promising solution for creation of load matching circuits, destined for embedded antennas in smart textiles. The paper successfully validated a Coplanar Waveguide low pass filter by measurement with a network analyser, after its design and manufacturing by screen printing of silver paste on a flexible textile substrate.

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THE INVOLVEMENT OF ARTIFICIAL INTELLIGENCE IN THE PATTERN-MAKING AND DESIGN PROCESS

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Abstract: *In this paper, the authors propose a brief presentation of the effect of involving artificial intelligence in the process of collection development, design and fashion design. Artificial intelligence (AI) is a generic term that comprises a wider area of branches and systems, such as: machine learning, deep learning and generative artificial intelligence. Most of fashion software have included artificial intelligence, especially generative artificial intelligence, in the pattern-making and design process, making the design process shorter and easier. Artificial Intelligence (AI) plays an increasingly important role in the fashion industry, bringing significant changes in the way clothing is designed and produced. Whether it is used to generate a print or to generate a more complex model, as presented in this paper, the result is obtained based on a text description entered by the user. Platforms that use (AI) to generate designs are often equipped with user-friendly interfaces that allow users to enter textual descriptions effortlessly. This new feature in the design process, is making it accessible even to users without fashion experience. AI not only accelerates the design process, but also expands the horizons of creativity, offering new opportunities for innovation in the fashion industry.*

Key words: *ChatGPT, Illustrator, Adobe Firefly, design, AI in fashion*

1. INTRODUCTION

Artificial intelligence is a generic term that comprises various computational algorithms capable of performing tasks that typically require human intelligence, such as understanding natural language, pattern recognition, decision making and learning from experience. Early *AI* systems, such as expert systems and knowledge bases, were rule-based and intended to assist users in making decisions [1].

Thereby, *artificial intelligence* represented by expert systems and knowledge bases, includes the following branches: *machine learning* e.g. SVM support vector machines, decision trees; *deep learning* e.g. neural networks, CNN convolutional neural networks; *generative artificial intelligence* e.g. LLM large language models, GAN generative adversarial networks, variational autoencoders, latent diffusion models [1].

The fashion industry is undergoing a transformation initiated and driven by technological innovations centered around *artificial intelligence*. Specifically, artificial intelligence-based clothing development technology, including the design process of a human designer and fashion knowledge, can reduce the workload of designers and product designers, thereby increasing work efficiency [2].

Fashion brands like Tommy Hilfiger, Nike and The Fabricant are already using *artificial intelligence* in their creation and design process. Specifically, Tommy Hilfiger relies on an *AI*-assisted design, IBM Watson, which, based on predicted trends, suggests various designs [3].

In order to have a clearer picture of the extent of the use of artificial intelligence and its tools in the fashion industry, it is enough to use ChatGPT to receive an answer to the following question: *AI tools used in fashion*?

1. Fashion design and trend forecasting [4]
   - *Heuritech* – Uses computer vision and deep learning to analyze social media images and predict fashion trends.
   - *Stylumia* – AI-driven trend forecasting and demand prediction for fashion brands.
   - *Google's DeepDream & Runway ML* – AI-powered tools for creative design and generating fashion patterns.
   - *PatternMaker Pro* – AI-assisted tool for creating custom garment patterns.

2. Virtual try-on and personalization [4]
   - *Zalando's AI Stylist* – Provides personalized outfit recommendations based on customer preferences.
   - *Vue.ai* – AI-powered styling assistant offering virtual outfit recommendations.
   - *Fit Analytics & True Fit* – AI-based virtual fitting tools that suggest the best size and fit.
   - *Revery AI* – AI-driven virtual try-on and garment simulation.

3. AI in Manufacturing and Supply Chain [4]
   - *Sustainaibl.ai* – AI for optimizing sustainable fashion supply chains.
   - *Sewbo* – Uses AI-powered robots to automate sewing and garment manufacturing.
   - *Lectra* – AI-powered cutting and fabric optimization software.

4. AI in Fashion Retail and E-commerce [4]
   - *Shopify's AI* (Sidekick & Shopify Magic) – AI-driven product recommendations and content creation.
   - *Vue.ai* – AI for automated product tagging, description generation, and visual search.
   - *Syte.ai* – AI-powered image search and product discovery for fashion e-commerce.
   - *Lily AI* – AI-driven retail intelligence to improve product descriptions and customer engagement.

5. AI in Marketing and Consumer Insights [4]
   - *Phrasee* – AI-generated marketing copy for fashion brands.
   - *ChatGPT* și *Jasper AI* – AI-powered content generation for fashion marketing.
   - *Vidora* - AI-driven customer behavior prediction and targeted marketing.

2. GENERATIVE ARTIFICIAL INTELLIGENCE (*GenAI*) AND ITS USE IN SOME ADOBE CREATIVE CLOUD APPS

Since the emergence of *ChatGPT*, *GenAI* has become the center of attention and numerous such models are now available, which are capable of generating various types of content, from texts to video sequences by way of images. The so-called generativity of these tools stands at the origin of many discussions, and the number of uses and users is increasing [5].

In fashion, the design development process has experienced considerable changes over time, influenced by the emergence of innovative technologies that have introduced new design tools. In recent years, we have witnessed an increase in the interest of using *AI* in design, which is changing the approach to textile design. The use of *AI* technology supports the designer’s creative process by providing deep learning systems that mimic the commonly used manual design [6].

2.1. Adobe Firefly — the AI art generator

Adobe Firefly is a family of generative AI models for driving creativity and accelerating workflows in Adobe products, providing a creative copilot to accelerate ideation, exploration, and production. It is also designed for safe commercial use [7].

Generate images, edit existing photos, apply artistic styles, create social media content, flyers, and more using text descriptions [8].

The following image show the steps of generating images using *Adobe Firefly*, by means of text to image conversion, the image will be generated based on a text cue in English: Pencil skirt with black, white and yellow floral print, as shown in **Fig. 1**, the image generation will include 4 options the user is able to choose the model that best suits the text cue.

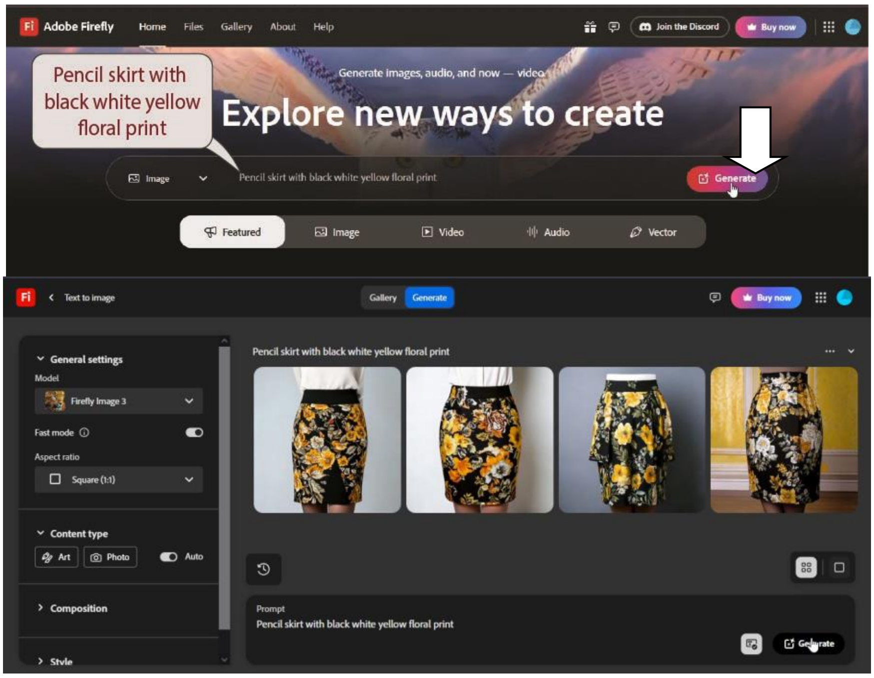

Fig. 1*: Generating model options using Adobe Firefly*

2.2. Adobe Illustrator – Generating vector graphics

Text-to-vector graphics conversion, powered by *Adobe Firefly*, allows you to create realistic vector graphics, such as scenes, objects, and icons, in a short amount of time and with minimal effort [9].

Based on a brief description of the desired graphic, *Illustrator* [10], [11], [12] quickly generates 3 variants as a result. Once the variant that best aligns with the artistic vision is chosen, it can be saved and edited.

The following is an example of generating a vector graphic, [10], [11], [12] therefore the rectangle tool is selected from the toolbar and a rectangle is drawn in the work area, the size of the rectangle will represent the size of the graphics. Subsequently the shape is selected by using the selection tool. , **Fig. 2.**

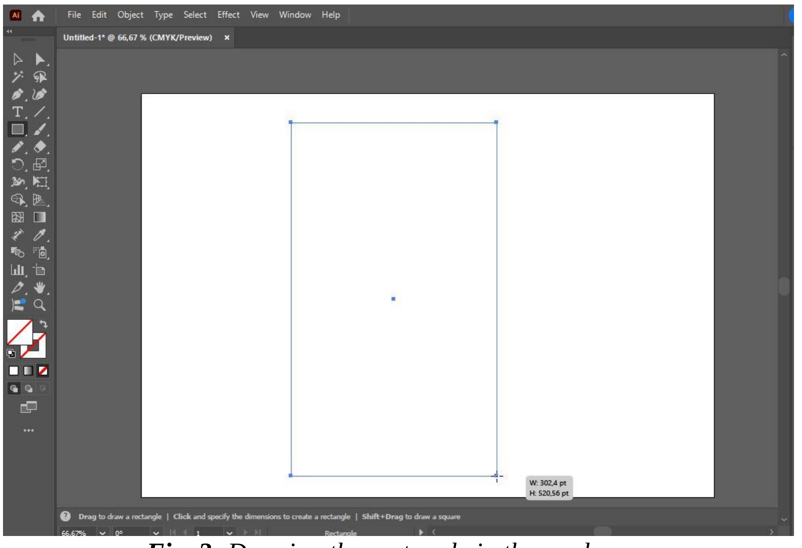

Fig. 2*: Drawing the rectangle in the work area*

For the next step, select *Generate vectors* from the contextual bar that appears after drawing the rectangle, **Fig. 3.**

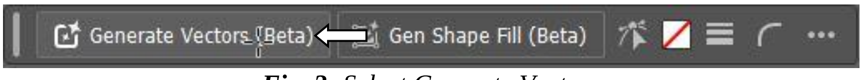

Fig. 3*: Select Generate Vectors*

In the text input field, write the description of the graphic or scene which is to be generated, **Fig. 4a**, for more options about content type and detail please click on to choose between generating a scene, subject or icon **Fig. 4b**, please click on to adjust the style reference, **Fig. 4c**.

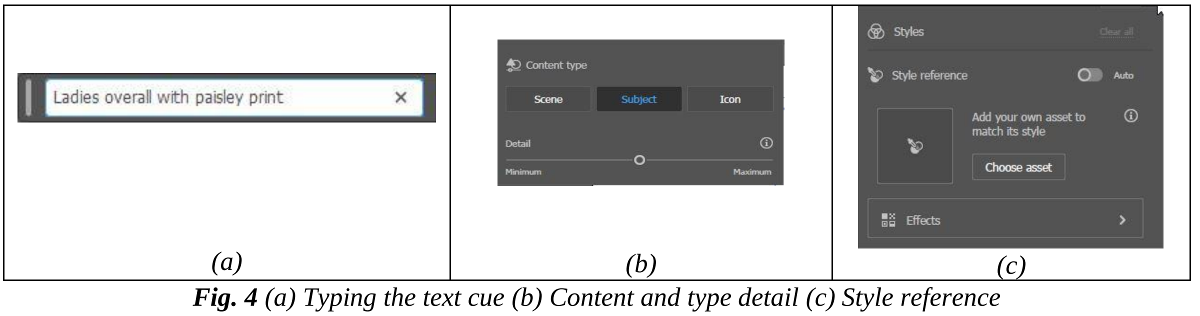

Fig. 4 *(a) Typing the text cue (b) Content and type detail (c) Style reference*

To view and access all desired settings before generating the vector graphics, access the view all settings button, this window also includes the color or number of colors setting **Fig. 5**.

For the vector graphics to be generated, the settings remain standard, the text cue for generating the graphics being: Women's overall with paisley print. Illustrator first generates 3 options that can be evaluated, the generating process can be continued or if the result is satisfactory, the chosen option can be saved. The selected and saved option can still be modified, as it is a vector graphic, changes are unlimited, starting with changing of the fill color or background, changing the shape and changing the print, everything is possible, **Fig. 6**.

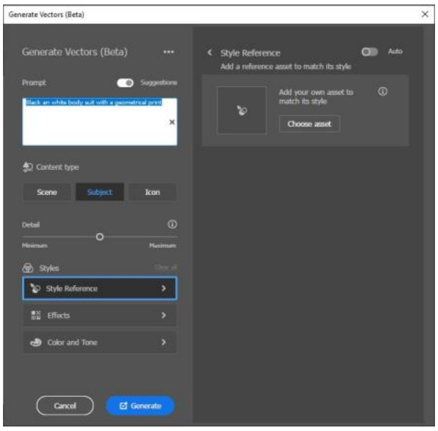

Fig. 5 *: All setting window*

Fig. 6 *: The three vector graohics generated by a text cue*

3. CONCLUSIONS

Artificial intelligence is already revolutionizing the fashion industry, with its involvement entire collections can be created based on the analysis of trends and user preferences. It also offers the possibility of completing the entire design process in a much shorter time and with reduced effort. The complexity of its use is found in important stages within the entire production flow: trend forecasts, customization, design and creativity, sustainability, accuracy in tailoring, production and automation. To assure all previously mentioned stages, the textile industry has available apps that include *artificial intelligence* and are used for design, 3D conversion of the model, virtual fitting. All these stages, which are now easier to complete, increase efficiency and reduce the effort and time required for the entire process, starting with the design concept and ending with the production stage.

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ANNALS OF THE UNIVERSITY OF ORADEA
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HIGH-EFFICIENCY CHROME TANNING: REDUCING WATER INPUT IN LEATHER PROCESSING

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Abstract: *In today's industrial landscape, minimizing environmental impact is a growing priority, particularly in water and chemical-intensive sectors like leather production. One of the main challenges in chrome tanning is the low chromium uptake, with only 40–60% of the tanning agent binding to collagen fibers resulting in significant chromium discharge. This study focuses on improving chrome exhaustion by optimizing water usage in the tanning process. Experimental tanning trials were conducted with reduced water ratios. Following the tanning process, chromium oxide concentration and conductivity were measured in the wastewater. Additionally, the chromium content and shrinkage temperature of the tanned leathers were analyzed to evaluate tanning efficiency and thermal stability. The results were compared to those from conventional chrome tanning processes. Findings revealed that decreasing the water ratio can significantly enhance chromium uptake, reduce environmental impact, and maintain or improve the performance of the final leather product, supporting the development of more sustainable tanning technologies.*

Key words: Chrome tanning, chromium exhaustion, leather wastewater, sustainable leather processing, water ratio optimization

1. INTRODUCTION

The leather industry heavily relies on large volumes of water and various chemical agents to convert raw hides into finished leather through complex chemical modifications of collagen. This transformation involves multiple stages, including liming, pickling, tanning, and post-tanning operations, each of which consumes considerable amounts of water and contributes to the generation of polluted effluents. However, this conventional production approach generates a substantial amount of highly polluted wastewater, posing significant environmental threats. The presence of organic matter, sulfides, ammonium compounds, and heavy metals like chromium in these effluents has raised concerns over their discharge into natural water bodies. Therefore, reducing the use of both water and chemicals during leather processing is vital for environmental protection, resource conservation, and the sustainability of leather manufacturing [1].

In response to the increasing awareness of environmental and human health concerns, stricter regulations and limitations on the use of hazardous substances in leather production have been introduced [2]. Particularly in developed countries, initiatives have been taken to evaluate the environmental impact of chemicals, develop predictive models, establish chemical databases, and implement process designs aligned with the principles of sustainable production. The REACH regulation is one such effort, aimed at improving chemical safety, enhancing risk management, and promoting alternative assessment methods. These regulatory frameworks encourage manufacturers to shift toward greener formulations and safer process routes. Despite these efforts, both the presence of hazardous residues in finished leather products and the discharge of chemical-laden wastewater remain pressing issues that hinder sustainable leather production [3].

Achieving zero-waste production is essential to advancing a cleaner and healthier environment. Accordingly, the adoption of cleaner production strategies centered around the principles of "reduce, reuse, and recycle" has become increasingly important. Cleaner production not only aims to minimize pollutant generation at the source but also promotes the reuse of process streams and by-products within the production cycle. International organizations are also promoting the transition to green and low-carbon economies, supporting innovations in closed-loop processing and energy-efficient technologies [4]. Reports on water use in the leather industry indicate that producing 1 ton of leather consumes approximately 35–50 tons of water, leading to an estimated annual wastewater output of 1.0×10^8 tons [5]. This figure has recently increased to about 1.6×10^8 tons [6], reinforcing the urgent need to develop water-saving solutions across all stages of leather manufacturing.

A critical aspect of the tanning process is the effective penetration and fixation of the tanning agent within the collagen fiber matrix of the hide. However, studies have consistently shown that the uptake of tanning agents under conventional aqueous processing conditions remains inefficient. Typically, only 50–60% of the chromium offered is fixed within the leather, while the remainder is discharged into wastewater, representing both an environmental burden and a financial loss. Significant portions of the tanning agents, particularly chromium salts, remain in the process bath, contributing to pollution loads [7]. Research indicates that exhaustion rates in conventional tanning are relatively low, resulting in high volumes of wastewater contaminated with unconsumed tanning agents. With chrome tanning still accounting for approximately 90% of global leather production, the environmental implications are substantial [8].

Globally, the leather industry uses nearly 500,000 tons of chromium (III) salts annually. With a tanning efficiency of just 55–65% under current methods, nearly half of the chromium applied ends up in wastewater [9]. This inefficient use of chrome not only results in economic loss but also contributes to chromium-related environmental concerns. Despite various studies focusing on alternative tanning agents [10], these substitutes have generally failed to match the hydrothermal stability and physical performance of chrome-tanned leather [11-12]. For this reason, chrome tanning remains indispensable to large-scale leather production. Consequently, approaches that retain chrome use while minimizing environmental risks particularly by improving fixation efficiency and reducing chemical load in wastewater—may be more viable and practical for widespread industry adoption.

Although numerous efforts have focused on post-process wastewater treatment [13], relatively little research has addressed the reduction of water usage during the process itself. Most wastewater solutions have concentrated on end-of-pipe treatments, which, although helpful, are energy-intensive and do not address the root cause of pollution. While suggestions have been made to lower water consumption for sustainability, few practical strategies have been developed to ensure sufficient chemical penetration under reduced water conditions [13]. Therefore, developing efficient in-process solutions that reduce float volume without compromising leather quality is an emerging necessity. As such, previous efforts have been limited in both scope and effectiveness, and have not been widely implemented in commercial practice.

In light of these challenges, the present study aims to address the inefficiencies of conventional chrome tanning by designing novel tanning recipes that significantly reduce both water and chromium tanning agent consumption. By developing high exhaustion chrome tanning systems, this research seeks to evaluate the resulting leather properties and wastewater characteristics, and to identify the most effective formulations through optimization studies. Ultimately, the study aims to support the transition to more sustainable tanning processes that maintain leather quality while minimizing environmental impact. These efforts align with the global push toward circular resource use, cleaner industrial practices, and compliance with future environmental legislation.

2. EXPERIMENTAL

2.1. Materials

Pickled sheepskins obtained from the commercial domestic market were used as the raw material for tanning experiments in the conventional process.

2.2. Recipes for experiments

Prior to the tanning process, a depickling process was carried out. The formulation used for depickling is presented in Table 1.

Table 1: *Depickling recipe*

Process	%	Substances	Temperature (ºC)	Time (min.)	**Remarks**
Depickling	150	Water	25	20	**7-8 Bé**
	1.5	HCOONa		40	**pH: 4.0**
	0.6	$NaHCO_3$		45	**pH 5.5, drain**
Bating	100	Water			
	1.5	Acidic bating agent	35	60	**Drain**
Washing	200	Water	30	10	**Drain**
Degreasing	6	Degreasing agent	28	60	
	50	Water (3 Bé)	28	90	**Automatic for night, drain**
Washing x 3	200	Water	30	30	**Drain**

Following the depickling process, conventional chromium tanning was applied to the skins. The tanning formulation is provided in Table 2.

Table 2*: Conventional chromium tanning process*

Process	**%**	**Substances**	**Temperature (ºC)**	**Time (min.)**	**Remarks**
Pickling	100	Water	30	20	6-7 Bé
	1.5	H_2SO_4		Run overnight	pH 3.0
	0.1	Fungicide		20	
Chrome tanning	4	Chromium salt		60	
	1	Synthetic fatliquoring agent			
	4	Chromium salt		600	10 hours
	1	HCOONa		45	
	0.8	$NaHCO_3$		90	pH 4.2, drain
Washing x 2	100	Water	30	20	Drain

In the high-exhaustion tanning system, the chromium application level was reduced from 8% to 5% to improve efficiency. To optimise water usage, experiments were conducted using water levels of 80%, 60%, and 40%. The recipe employed in these trials is presented in Table 3, where the water usage levels are denoted by the variable X.

Table 3. *High chrome exhaustion tanning recipe*

Process	**%**	**Substances**	**Temperature(ºC)**	**Time(min.)**	**Remarks**
Tanning	**X**	**Water**			**X:80-60-40**
	0.25x2	HCOOH		60	**pH: 5.0-5.2**
	5	Chromium salt			
	0.25	Masking agent		60	
	1	Electrolyte stable fatliquor		30	
Next morning			50	60	**pH 5.2**
Washing x 2	100	Water	30	20	**Drain**

2.3. Shrinkage temperature analyses

Shrinkage temperature was determined in accordance with TS 4120 EN ISO 3380. Rectangular samples (50 mm × 3 mm) were prepared, and a 1:3 glycerol–water mixture at 65°C was used as the test medium. The temperature was increased at a controlled rate of 2°C per minute, and the shrinkage point was identified as the temperature at which significant contraction occurred. Readings were taken every 30 seconds, and the shrinkage temperature was defined based on the movement of the indicator needle.

2.4. Chrome oxide (Cr_2O_3) analyses

The chromium oxide content in leather was determined in accordance with TS EN ISO 5398-1, while its concentration in wastewater was analysed following the SLC 208 procedure.

2.5. Conductivity and salinity analyses

Conductivity and salinity analyses of the waste float water following the tanning process were performed using a YSI Incorporated (Yellow Springs Instrument) device. In cases where the conductivity and salinity values exceeded the instrument's measurement range, the floats were diluted at predefined ratios to allow accurate readings, and final values were calculated by accounting for the dilution factor. Conductivity was expressed in millisiemens per centimeter (mS/cm), and salinity in parts per thousand (ppt).

2.6. Statistical evaluations

For all experimental trials, two sheepskins were placed into the same drum to ensure uniform processing conditions, and each tanning formulation was repeated in three independent production cycles to achieve replication. As a result, a total of six leather samples (2 skins × 3 replicates) and three corresponding residual float samples were obtained for each test condition. All analytical measurements including chromium oxide content, shrinkage temperature, conductivity, and salinity were performed on these replicated samples to ensure statistical reliability. The mean values and standard deviations of the data sets were calculated using the SPSS 15.0 statistical software package to assess the consistency and reproducibility of the results.

3. RESULTS AND DISCUSSION

The increasing global focus on sustainable production has underscored the importance of scientific studies aimed at saving water and energy, and ensuring the efficient use of raw materials and natural resources. Within the scope of environmentally friendly leather processing, many studies emphasize the development of technologies that reduce water and chemical consumption. Nevertheless, research efforts targeting water saving in leather production have often fallen short of providing sufficiently effective outcomes or translating laboratory findings into industrial applications [14].

In this study, rather than completely eliminating water from the tanning process, a high exhaustion chrome tanning system was developed with the goal of minimizing water use without compromising leather quality. Preliminary trials revealed that eliminating water entirely caused undesirable effects like heating on fiber structure and leather integrity due to inadequate lubrication and tanning agent mobility. Based on these observations, the experimental focus shifted toward identifying the lowest possible water usage levels that still allow effective tanning reactions and maintain leather performance characteristics. The results obtained from the conventional chrome tanning method were compiled and are presented in Table 4, serving as a baseline reference to evaluate the efficiency and environmental advantages of the high exhaustion system tested at different reduced water ratios, as given in Table 5.

Table 4: *Characteristics of leather and wastewater after conventional chrome tanning*

Analyses	**Conventional tanning results**
Cr_2O_3%	2.91 ± 0.88
Shrinkage temperature (ºC)	103 ± 1.50
Cr_2O_3 (residual float) (g/L)	4.4 ± 0.56
Conductivity (mS/cm)	121.6 ± 14.25
Salinity (ppt)	98.2 ± 9.24

As can be seen from Table 4, the shrinkage temperature of the leathers produced by the conventional chrome tanning system was determined to be 103 ± 1.50 °C. This result reflects that the leather structure has been adequately stabilized by the chrome tanning agent and shows typical thermal behavior for chrome-tanned leathers.

The Cr_2O_3 content in the leather was found to be 2.91 ± 0.88%, which is slightly lower. This moderate Cr_2O_3 content suggests that although tanning occurred, the level of chromium uptake into the leather matrix was not maximized. This could be attributed to relatively low float exhaustion levels typical of conventional tanning, where chromium penetration and fixation are limited by bath concentration and diffusion gradients. Supporting this point, the residual chromium oxide concentration in the float after tanning was measured as 4.4 ± 0.56 g/L, which indicates significant unutilized chromium remaining in the bath. This relatively high residual content is a critical drawback of conventional chrome tanning, highlighting inefficient chemical uptake and environmental concerns due to higher chromium loads in the effluent.

In addition, the conductivity of the residual float was recorded as 121.6 ± 14.25 mS/cm, and salinity as 98.2 ± 9.24 ppt. These high values reflect the substantial presence of dissolved salts and electrolytes in the spent float, which can arise from salt additives used during pickling. High conductivity and salinity levels are important indicators of environmental impact, especially in terms of wastewater treatment challenges. Altogether, the data in Table 4 confirms that conventional chrome tanning results in acceptable leather quality in terms of shrinkage temperature but suffers from inefficiencies in chrome fixation and significant environmental burden due to high residual chromium, conductivity, and salinity in wastewater.

Table 5: *High exhausted tanning processes at different water ratios*

Analysis	**80% water**	**60% water**	**40% water**
Cr_2O_3% (leather)	4.13 ± 0.14	4.27 ± 0.19	3.68 ± 0.46
Shrinkage temperature (ºC)	102.5 ± 1.25	102 ± 0.71	102 ± 1.23
Cr_2O_3 (residual float) (g/L)	0.88 ± 0.15	0.65 ± 0.12	0.61 ± 0.44
Conductivity (mS/cm)	54.2 ± 2.3	45.7 ± 3.5	44.8 ± 1.6
Salinity (ppt)	38.4 ± 2.5	40.2 ± 1.7	40.7 ± 2.3

Table 5 illustrates the results of high exhaustion chrome tanning processes carried out at different water use levels (80%, 60%, and 40%), and the findings clearly demonstrate the effectiveness of high pH based exhaustion system with water reduction strategies in increasing chrome uptake and reducing effluent pollution.

At 80% water usage, the Cr_2O_3 content in leather was determined as 4.13 ± 0.14%, which is substantially higher than that achieved in the conventional system (2.91%). The shrinkage temperature was 102.5 ± 1.25 °C, which is very close to the conventional system and confirms that the leather achieved comparable thermal stability despite using less water and a different process approach.

The residual chromium oxide in the float was found to be 0.88 ± 0.15 g/L, significantly lower than the value observed in the conventional system (4.4 g/L). This indicates a highly efficient exhaustion process with improved chromium fixation and a corresponding reduction in environmental load. When the water usage was decreased to 60%, the Cr_2O_3 content in leather increased slightly to 4.27 ± 0.19%, representing the highest chromium uptake among all conditions tested. This value strongly suggests that moderate reduction in water can enhance chromium diffusion and fixation due to more concentrated reaction conditions. The shrinkage temperature remained high at 102 ± 0.71 °C, indicating that structural stabilization was effectively achieved. The chromium content in the residual float decreased further to 0.65 ± 0.12 g/L, supporting the conclusion that 60% water usage provided optimal exhaustion performance in terms of both leather quality and environmental output.

At the lowest water usage level of 40%, the Cr_2O_3 content in the leather decreased to 3.68 ± 0.46%, although it still exceeded the conventional system's chromium content. The shrinkage temperature remained stable at 102 ± 1.23 °C, indicating that tanning was still effective. The chromium oxide remaining in the float was 0.61 ± 0.44 g/L, the lowest among all conditions, which may reflect better exhaustion in low-moisture environments. While the exhaustion appears very efficient, the slightly lower Cr_2O_3 in leather suggests that under extreme water reduction, the diffusion of chromium into the hide matrix becomes more difficult, possibly due to limitations in mobility within the reduced aqueous phase. Conductivity values in the residual float showed a clear downward trend with decreasing water: from 54.2 ± 2.3 mS/cm at 80% to 45.7 ± 3.5 mS/cm at 60% and 44.8 ± 1.6 mS/cm at 40%. These results indicate a lower ionic concentration in the wastewater, which aligns with the more efficient utilization of tanning chemicals. However, salinity values remained relatively stable across all trials, ranging between 38.4–40.7 ppt, possibly due to retained salt residues from previous processing stages.

The data in Table 5 highlights that the high exhaustion system is capable of achieving better chromium fixation, lower chromium waste, and comparable leather quality even when the float volume is significantly reduced. Among the tested conditions, 60% water usage appears to be the most favorable, delivering the highest chromium uptake in leather, low residual chromium in the float, and high shrinkage temperature, thereby offering an optimal balance between performance and sustainability. While 40% water usage also showed excellent exhaustion efficiency, a slight decrease in chromium uptake into the leather suggests that diffusion limitations may arise at very low water levels. Therefore, it can be concluded that high exhaustion tanning systems operating with 60% float offer a promising pathway toward water-saving leather production without sacrificing quality or environmental performance.

4. CONCLUSIONS

This study demonstrates that substantial environmental and technical benefits can be achieved in chrome tanning through the implementation of a high exhaustion tanning system with reduced water usage. By lowering the float ratio to 60% and optimizing process conditions, it was possible to not only increase chromium uptake in leather but also significantly reduce residual chromium concentration in wastewater without compromising shrinkage temperature or overall leather quality. Compared to the conventional system, the high exhaustion approach resulted in up to 46% higher Cr_2O_3 fixation in leather and a drastic reduction in effluent chromium levels, conductivity, and salinity. These improvements contribute directly to mitigating the ecological impact of tanning operations, particularly in terms of chromium discharge and salt pollution, which are among the industry's most pressing sustainability challenges. The findings confirm that reducing water usage does not inherently diminish tanning efficiency; rather, when appropriately engineered, it enhances exhaustion performance. Among the tested float levels, the 60% water ratio emerged as the optimal condition, offering the best balance between environmental performance and leather properties.

In conclusion, this study offers a viable and practical solution for the leather industry to advance toward cleaner production practices. The proposed high exhaustion tanning methodology enables significant reductions in both water consumption and chemical discharge, paving the way for more sustainable chrome tanning without sacrificing product performance thus making it suitable for broader industrial application.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

FOOTWEAR UNDER THE IMPACT OF DIGITAL TECHNOLOGIES: A REVIEW

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Abstract: *Digital technologies have had a major impact on the footwear industry, transforming both the design and manufacturing processes. The advanced use of 3D scanning and computer modelling allows the creation of customised footwear that is precisely tailored to the specific dimensions, shape and needs of each user. In production, vibration sensors integrated into machines and connected via IoT platforms enable real-time monitoring, enabling rapid detection of problems and predictive maintenance to minimise downtime and repair costs. In addition, analysis of the data collected helps to optimise production parameters, ensuring greater operational efficiency. IoT technologies also play a crucial role in intelligent supply chain management, facilitating real-time tracking of raw materials, inventory and deliveries, leading to reduced losses and improved logistical coordination. Throughout the use of footwear, digital technologies offer significant improvements in comfort, performance and monitoring of the user's health. Sensors integrated into the structure of footwear allow gait analysis, monitoring pressure on the sole and detecting potential postural or medical problems. In addition, digital technologies contribute to user safety by being used to develop smart shoes for people with visual impairments or to prevent accidents in the workplace. By integrating these innovations, the footwear industry is moving towards more sustainable and efficient production, offering more comfortable and safer products that are tailored to the individual needs of each user.*

Key words: *footwear, design, production, innovation, digital technologies*

1. INTRODUCTION

Digital technologies have revolutionised the footwear industry in many ways. The most notable applications include CAD system, 3D printing, process automation and the use of robots, Internet of Things (IoT), the integration of sensors and smart devices, the use of augmented reality (AR) and virtual reality (VR).

Digital technologies have had a profound impact on the industry, changing the way footwear products are designed and manufactured. They have also had a significant impact on the way footwear is used, bringing improvements in comfort, performance and monitoring.

Digital technologies such as 3D scanning and computer modelling make it possible to create customised footwear that perfectly fits the shape and needs of each user. These technologies help to improve comfort and prevent injuries. 3D scanning allows the foot shape to be accurately captured, while computer modelling facilitates pattern adjustments for a perfect fit.

The integration of sensors and smart devices makes it possible to monitor user performance by collecting data on steps, distance travelled, speed and running form. This information is transmitted to mobile applications, allowing athletes to analyse their performance and adjust their training. Sensors can also detect and analyse foot movements, providing real-time feedback to improve recovery techniques for various conditions.

Digital technologies are used at all stages of the footwear lifecycle, from design to use.

The main objective of this paper is to analyse and highlight the impact of digital technologies on the footwear industry. The study examines how various digital technologies have revolutionised the design, production and use of footwear products.

The methods of scientific research used in the paper are scientific analysis and literature review. The use of digital technologies in the footwear industry is presented separately for each stage that the product goes through, from design to use.

2. USE OF DIGITAL TECHNOLOGIES IN FOOTWEAR

2.1. The use of digital technologies in footwear product design

Computer-aided design (CAD) has transformed the footwear design process by offering advanced tools that enable designers to create, visualize, and perfect their footwear concepts with greater efficiency and precision.

Various researchers have introduced innovative methods and software to improve various aspects of footwear design. For example, Davia-Aracil et al. developed a methodology for the design and validation of shoe soles focusing on structural and functional aspects to meet international safety standards [1]. Luximon and Luximon developed shoe last design software that allows real-time modifications based on foot shape measurements, improving design efficiency and user comfort [2]. Leshchyshyn et al. introduced a method for designing shoe soles with an artistic approach, improving design efficiency and simplifying manufacturing [3] and Luo et al. improved the foot-leg relationship through an integrated design system using database technology for precise fitting [4]. All of these innovations streamline design and manufacturing processes, improve product quality and enhance user comfort and sustainability.

Currently, AI has revolutionised footwear design through automated design assistance. Generative design software enables AI algorithms to rapidly create multiple design prototypes, optimising various parameters of footwear products. This approach simplifies the design phase and ensures that the final products are tailored to the specific needs and preferences of consumers.

An example of this is Adidas, which has applied AI to footwear design by developing the Futurecraft 4D programme. By using Carbon's Digital Light Synthesis (DLS) technology to create high-performance shoe soles, Adidas has created customised soles that are tailored to each athlete's needs in terms of movement, cushioning, stability and comfort. DLS technology enables the production of high-performance footwear at scale and speed, eliminating the need for traditional prototypes or moulds [5].

Another example is Nike, which leverages computer vision, machine learning, data science, and augmented reality to scan customers' feet using a smartphone camera. This process generates a precise 3D model of the foot, enabling accurate shoe size recommendations that enhance customer satisfaction and significantly reduce return rates [6].

Kim et al. have proposed the use of Digital Twins for customized footwear design. Their research shows how Digital Twins can be used to create virtual models of customers' feet, enabling accurate measurements and personalised shoe designs. This approach not only improves fit and comfort, but also reduces the need for physical prototypes, speeding up the design process [7].

3D printing is another example of how digital technologies are being applied to footwear design. Under Armour has used this technology to create the ArchiTech Futurist, an innovative athletic shoe. This model features a 3D printed midsole that forms a lattice structure to provide optimal cushioning and support [8].

The choice of materials is also crucial in the design phase. Innovations in footwear materials, such as Adidas' Boost technology, offer high-performance cushioning and lightweight, breathable fabrics. These technologies improve the comfort and performance of footwear, making it suitable for a range of sports from running to basketball [9].

In addition, the incorporation of sensors into various parts of the shoe is considered at the design stage. For example, the Nike HyperAdapt 1.0 features pressure sensors embedded in the soles that detect the insertion of the foot and trigger an algorithm to automatically tighten the laces. The shoe also has built-in LEDs that alert the user to low battery levels or a tight fit [10].

New applications of AI will continue to revolutionise the footwear industry by enabling fully customised shoe design through automated assistance. Design software will allow AI algorithms to quickly generate multiple design prototypes, simplifying the design phase and ensuring that the final products are tailored to consumers' specific needs and preferences [11].

2. 2. The use of digital technologies in the footwear production chain

The traditional shoe manufacturing process is labour intensive and involves many manual operations. Therefore, many studies have been conducted on automation in the footwear industry, focusing on robot-based automation. Various methods have been proposed to automate different operations in the shoe manufacturing process. Kim et al. proposed a new robot-based shoe manufacturing system for the upper manufacturing and sole application processes [12]. Oliver et al. propose a robotic cell to automate operations such as sole digitisation, glue application and sole manipulation at different locations in the factory [13]. Molinari-Tosatti and Fassi presented an industrial prototype with roughing and cementing tools [14]. Pedrocchi et al. took a different approach to roughing uppers by designing a fuzzy logic controller [15]. Nemec et al. developed a shoe polishing cell using an industrial robot [16]. Castelli et al. showed how to automate the gluing process and Kim J.Y. proposed an automated glue spraying system [17,18]. Gracia et al. have proposed the automation of the shoe packaging process using a robot [19].

Another directive for using digital technologies in footwear production refers to incorporating vibration sensors into production equipment and interconnecting them through Internet of Things (IoT) platforms, allowing continuous real-time monitoring.

This integration facilitates comprehensive data collection, enhancing predictive maintenance capabilities. IoT platforms enable remote monitoring and data analysis, providing insights into the health and performance of equipment. These platforms are also particularly useful for the optimisation of production activities and efficient supply chain management.

Modern sensors have been developed to be more sensitive and reliable, with the capacity to detect even the most subtle vibrations. These advancements have enhanced the accuracy of the data and the efficiency of fault diagnosis, leading to more effective vibration analysis [20].

Innovations such as wireless sensors have been introduced, eliminating the need for extensive wiring and simplifying installation and maintenance. The utilisation of these sensors within the context of footwear production facilitates enhanced product quality by facilitating the detection of mechanical issues in manufacturing equipment and the resolution of these issues prior to their impact on production. This, in turn, ensures consistent product quality.

Furthermore, the implementation of continuous vibration monitoring has been shown to reduce downtime, thereby ensuring the maintenance of a steady production flow and averting delays in product delivery [21].

It is widely acknowledged that vibration analysis facilitates the implementation of predictive maintenance, optimising resource utilisation and reducing costs associated with reactive or preventive maintenance. The maintenance of equipment in optimal working condition has also been demonstrated to contribute to a reduction in energy consumption and associated costs.

Furthermore, the identification and resolution of mechanical issues prior to their escalation, as facilitated by vibration analysis, results in the prolongation of production equipment lifespan, thereby diminishing the necessity for recurrent investments in new machinery. The early detection of mechanical failures has been shown to reduce the risk of accidents and to ensure a safer work environment for employees, as properly functioning equipment is less likely to cause hazardous incidents [22].

The employment of sophisticated algorithms facilitates the identification of vibration patterns and trends. Comparisons of this data with established standards can facilitate the identification of anomalies and potential issues. The utilisation of advanced data analytics tools facilitates the rapid processing of substantial data volumes, thereby providing real-time insights into the health status of equipment [23]. AI algorithms can analyse large datasets to identify subtle patterns that indicate potential problems. Machine learning models can predict equipment failures by learning from historical vibration data. This enables more accurate maintenance predictions and recommendations, facilitating proactive interventions. AI-driven analytics can also optimize maintenance schedules, reducing downtime and maintenance costs.

A notable proponent of integrating AI and IoT to enhance various operational facets, including customer experience and supply chain management, is Nike. The integration of IoT sensors and AI algorithms has enabled the company to predict product demand, optimise inventory, and enhance the accuracy of shoe fitting recommendations through AI-powered applications. This holistic approach has resulted in enhanced service quality and operational efficiency [24].

In addition, Nike employs predictive analytics and machine learning algorithms to analyse extensive datasets pertaining to consumer behaviour and market trends. This enables the company to dynamically adjust its supply chain, thereby maintaining optimal stock levels, reducing overproduction, and minimising unsold inventory. This real-time responsiveness facilitates more efficient delivery of products to retailers and consumers [6].

Allbirds, a footwear company, successfully transformed a complex, multi-store, multi-country supply chain into a globally connected supply chain by partnering with ChannelApe. This was achieved by managing the supply chain through a single unified fulfilment platform. This integration enabled Allbirds to manage order fulfilment across multiple facilities more efficiently, saving time and resources that could then be redirected towards brand growth [25].

A study by Casais and Caldas on the digital transformation of the Portuguese footwear industry highlights how small and medium-sized enterprises (SMEs) have adopted the IoT and other digital technologies. These innovations have enabled SMEs to transition from traditional production to a more export-driven and innovative industry. The integration of the IoT has been identified as playing a pivotal role in the enhancement of production processes and supply chain management [26].

Research has also explored how Digital Twins can simulate and optimize manufacturing processes, from material selection to final assembly. By creating virtual replicas of production lines, companies can identify bottlenecks, predict maintenance needs, and improve overall efficiency. The shift from traditional sketches to digital prototypes not only streamlines the design process but also contributes to building a more sustainable fashion ecosystem [27].

The utilisation of Edge computing in the domain of footwear manufacturing has the potential to enhance the process of production by facilitating real-time monitoring and quality control. Specifically, sensors integrated within manufacturing equipment can collect data on parameters such as temperature, pressure, and vibrations. These data are then processed to detect any anomalies and ensure that the manufacturing process meets the relevant quality standards. A study on edge computing in manufacturing highlights how this approach can reduce latency and improve decision-making on the production line [28].

2. 3. The use of digital technologies during the footwear usage period

The utilisation of digital technologies during the footwear usage period is chiefly concerned with personalised health monitoring and assistive technologies.

Wireless monitoring systems are utilised for data collection, with the capacity to transmit data to central databases for analysis. This facilitates remote monitoring and diagnosis.

Technologies like Bluetooth facilitate wireless data collection and transmission, incorporating features such as GPS tracking, obstacle detection, and physical activity monitoring. For instance, smart shoes can monitor diabetic foot ulcers, assess rehabilitation progress, and detect falls in elderly individuals [29].

Smart shoes embedded with accelerometers, gyroscopes, and pressure sensors allow for precise gait and posture analysis. These data are essential for the correction of posture and the improvement of gait, benefiting both sports performance and medical rehabilitation [30].

Through gait and mobility analysis, smart shoes can aid in the prevention, diagnosis, and treatment decisions for various conditions, or enable individualized disease monitoring [31].

Duan et al. patented an intelligent monitoring and protection system for individuals at risk of diabetic foot ulcers. This system incorporates smart shoes connected to an intelligent terminal device via a wireless connection. The shoes are equipped with a main control module that continuously monitors temperature and pressure to assess ulcer risk. Alerts are generated for both users and healthcare professionals when the risk is high, facilitating early intervention and personalised patient care [32].

Another patent discloses an integrated smart electronic system in footwear, designed to alert workers to nearby objects at night or in dark environments on construction sites. The system incorporates logic circuits that receive signals from a proximity sensor, thereby generating input signals to a wireless transmitter. The system has been developed to prevent accidents by warning workers about nearby obstacles, thereby improving construction site safety [33].

An innovative safety system for visually impaired individuals has been developed, based on the IoT technology. This system integrates smart shoes equipped with three ultrasonic sensors, a microprocessor, water and flame sensors, and GPS technology to detect obstacles and alert users through sound notifications. The system has been developed to assist visually impaired individuals in navigating construction sites safely, without colliding with objects or other people [34].

Sensors embedded in sports shoes record key metrics for runners, including pace, distance, step count, stride length, and cadence. These data can be wirelessly transmitted, facilitating precise performance evaluation and enhancing the efficacy of training sessions [35].

The utilisation of shoe sensors facilitates the provision of personalised feedback on health, fatigue, posture, steps, speed, distance, calories burned, sleep duration, and even weight. By connecting to a device via Bluetooth or through custom applications, real-time personalised coaching becomes possible. Examples of such technology include Digitsole Smart Shoes and Xiaomi MiJia Smart Shoes [10].

The integration of sensors in footwear has also been successfully used for patient monitoring during rehabilitation treatments. This technology facilitates continuous measurement and recording of ankle movements during physical therapy, thereby enhancing patient care by providing real-time and precise information about foot conditions [36,37].

3. CONCLUSIONS

Digital technologies have had a profound impact on all stages of the footwear industry's product lifecycle, encompassing design, production, usage, and monitoring.

The integration of artificial intelligence, three-dimensional scanning, and three-dimensional printing has profoundly transformed the design process, facilitating the development of personalised and ergonomic products. Technologies such as Digital Twins and augmented reality have optimised shoe fit and comfort, reducing the need for physical prototypes. The integration of innovative materials and sensors within the footwear structure has also been instrumental in enhancing user performance and safety.

Robot-based automation has brought significant improvements to footwear production, reducing intensive manual labour. Various methods have been proposed to automate different operations in the shoe manufacturing process, including packaging.

In the production process, the implementation of IoT sensors and vibration analysis of manufacturing equipment allows for the execution of predictive maintenance. This contributes to cost reduction and enhanced economic efficiency. The application of edge computing and AI has been demonstrated to enhance supply chain management, optimise production processes, and reduce waste.

The integration of embedded sensors into footwear products, along with their wireless connectivity to diverse applications, facilitates the real-time monitoring of user performance and health parameters. Gait analysis applications and parametric monitoring of physical activities provide athletes and patients with real-time feedback, helping to enhance training and rehabilitation processes. Innovations in this field have a significant impact on health, safety and comfort, and are applied in areas such as the prevention of diabetic ulcers and assistance for visually impaired individuals.

Digital technologies are poised to transform the footwear industry, ushering in a new era of sustainable production, enhanced user comfort, and personalised experiences.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

EXPERIMENTS TO ASSESS POLLUTION LEVELS IN THE TEXTILE MATERIALS PROCESSING INDUSTRY

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Abstract: *Concerns about pollution, its extent, and its impact on the health of organisms and biodiversity have increased over the years. Managing and reducing the effects of pollution are critical issues for policymakers, industry stakeholders, the academic community, and researchers. The textile industry is a potential significant contributor to pollution, producing substantial amounts of wastewater, toxic dyes, and microplastics. Furthermore, it significantly contributes to greenhouse gas emissions due to the energy-intensive nature of manufacturing processes. This study presents the results of experiments conducted to assess the concentration of particulate matter in the air within a textile factory that processes synthetic polymers. Factors influencing particulate concentration levels at different times of the day, as well as the distribution of particles based on their chemical composition, are examined. Key findings from the particle measurements indicate that the highest concentration of particles occurs at the end of the shift (FS), with 0.3 µm particles showing the greatest presence across all time points (beginning of shift, end of shift, and after 16 hours). The particle concentrations follow a consistent pattern, with smaller particles (such as 0.3 µm) generally outnumbering larger ones (like 10 µm). The analysis of the particle composition using advanced techniques such as SEM, µRaman and TED-GC/-MS revealed that polyamide particles were consistently present, while polypropylene particles were only identified at the end of the shift due to limitations of the specific techniques. The particle sizes were predominantly smaller than 1.0 µm, with irregularly shaped particles being the most common. The equivalent diameter of the particles is defined and calculated, with their classification based on this parameter. These findings underscore the need for improved air quality management and pollution control measures in textile production environments to mitigate health risks and environmental impacts.*

Key words: *pollution, airborne particle, syntetic polymers,silica filter, quartz filter, µRaman, scanning, equivalent diameter, microplastics*

ANNALS OF THE UNIVERSITY OF ORADEA
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1. INTRODUCTION

Nanoparticles, due to their extremely small size and high reactivity, can penetrate biological barriers and accumulate in human tissues and organs. This raises significant health concerns, especially through inhalation, ingestion, or skin contact. Studies have shown that certain types of nanoparticles can induce oxidative stress, inflammation, and even cellular damage, potentially leading to respiratory, cardiovascular, and neurological issues [1].

The progress made in atmospheric micro- and nanoplastic (MNP) research has seen significant advancements in the last decade. MNPs are released into the atmosphere as a result of an inadequate plastic collection system, resulting in plastic waste in the environment, which breaks down into small fragments through weathering [2]. The accumulation of MNPs in the atmosphere is additionally increased by the operation of wastewater treatment plants, the textile industry processing synthetic fibres, mechanical activities, strong winds, aerosols from the surface of seas, and wave breakage, which frequently transport them [3].

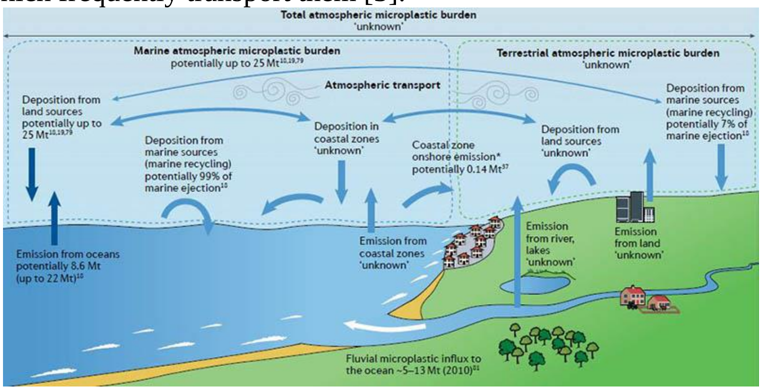


***Fig. 1**: Atmospheric Transport of Micro-Nanoplastics, Annual Potential Flow[2]*

The spraying processes occurring at the sea surface are responsible for approximately 136000 tons of MNPs being blown annually from the water's surface into the air towards the shore (**Fig. 1**). Carried by the wind and waves, microplastics can travel over 1000 kilometres. Atmospheric MNPs are small in size and predominantly under 500 µm. A significant portion of the particles is smaller than or equal to 10 µm, the respirable particle size [4]. These particles fall within the size range that is of the most significant concern for biotic, ecosystem, and human health. Therefore, quantifying the amount of small MNPs that the atmosphere supplies to the ocean and the ocean-atmosphere exchange is important for global health.

Additionally, it is acknowledged that indoor air pollution (including plastic particles) can be up to 100 times greater than outdoor air pollution. Daily, a person inhales up to 130 small plastic particles, and the concentration of MNPs in all environments is continuously increasing [5]. MNPs act as carriers for organic and inorganic toxic substances, releasing organic toxins and accumulating in living organisms, supporting their unprecedented distribution in ecosystems [6]. Environmental organic and inorganic contaminants also interact and react with MNPs, potentially enhancing their transport to environmental compartments. Due to these processes, hydrophobic organic and metal pollutants can accumulate on MNPs, move with them, and interact with them to exacerbate their dangerous effects on biota [7]. Thus, MNPs disproportionately accumulate other environmental contaminants, suggesting that MNPs could function as vectors for harmful microorganisms. According to Zhag [8], the surface of polyethylene terephthalate, a type of microplastic, adsorbs microorganisms that are resistant to multiple antibiotics.

Regarding internal exposure, MNPs interact with the human body through mechanisms of adsorption, distribution, metabolism, and excretion. MNPs have been detected in sputum, lungs, liver, blood, urine, placenta, and breast milk. Elevated MNP levels in arteries correlate with cardiovascular diseases, suggesting links between high MNP exposure and health outcomes. Further research is crucial to elucidate the health effects of acute and chronic exposure to realistic concentrations of MNPs in sensitive and general populations [9].

This study presents results obtained by determining the concentration levels of airborne particles in number/m³ and µg/m³ at three different times during the operations of a textile company processing polypropylene fibre, across three different environments: at the beginning of the work shift, at the end of the work shift, and after 16 hours, measns a 24 h cycle

2. MATERIALS AND METHODS

The study to evaluate the particle concentration levels in the air was conducted for a textile company that processes polypropylene and polyamide yarns with a linear density of 1100-1200 den to create strips with a width of 5-10 cm, intended for reinforcing textile items for packaging/transport. During the weaving process of synthetic yarns, particles or fibres can be produced due to several factors related to the properties of synthetic materials and the mechanics of weaving. Synthetic yarns, such as polypropylene and polyamide, are often smoother and have a higher friction coefficient compared to natural fibres. The friction between the yarns and between the yarn and the weaving machine components (like the loom or shuttle) can cause tiny particles or fibre fragments to break off. Additionally, during weaving, the yarn is subjected to tension and sometimes heat. The combination of these factors can cause a slight degradation of the fibres at the microscopic level, leading to the production of small particles. For example, if the synthetic fibres are not perfectly smooth or have surface imperfections, they may degrade when pulled under pressure or rubbed against other surfaces. Weaving machines often involve high-speed movements and complex mechanical actions, like interlacing the yarns. This can cause fraying, especially if the yarn is not properly processed or is too weak. The mechanical stress on the fibres can result in the release of tiny fibres or particles.

The determination of the particle concentration levels was carried out at three time points: the beginning of the workers' shift (BS), the end of the shift (FS), and after 16 hours (AH) in the proximity of the polypropylene workplace. The production room had natural ventilation. An online procedure was applied to determine the number of particles per cubic meter (particles/m³) in size fractions of 0.3, 0.5, 1.0, 2.5, 5.0, and 10 µm, as well as the concentration (µg/m³) of particles of 2.5 and 10 µm using the TROTEC PC 220 device. The TROTEC device uses laser-based technologies (Class 3R laser, 780 nm) to count airborne particles. The primary principle behind these devices is based on detecting particles suspended in the air and measuring their size and concentration. Thirty determinations were carried out to determine the concentration, expressed in particles/m³ and µg/m³.

A standard operating procedure has been established for collecting airborne particles using the following equipment: an internal capsule made of polyvinyl chloride (PVC) with a diameter of 37 mm, a hydrophobic filter attached to the PVC casing, and support plates within a two-piece filter cassette holder, also 25 mm in diameter; a Gilian Air Plus sampling pump with a flow rate of 1 to 3 L/min, equipped with flexible connection tubes; a microbalance with an accuracy of ±0.001 µg; a static neutralizer (210Po); plastic tweezers; and a climate chamber maintaining a temperature of 20°C ± 1°C and relative humidity of 50% ± 5%. The pump was located about 60 cm away from the working area of the weaving machine, which is located about 90cm from the ground.

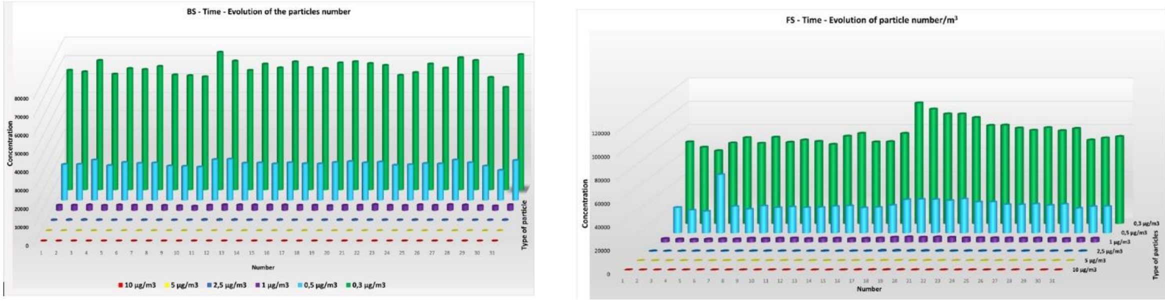
Quartz filters produced by SKC INC (USA), catalogue number 225-1824, were used for the experiments [10]. These 25 mm diameter quartz filters were heated to 800°C to eliminate traces of organics, contain no binders, and have a low metallic background. The filters have a thickness of 280 µm and a pore size of 1.2 µm. The 9 mm silicon wafer membranes are double-sided polished filters and produced by Smartmembranes with a thickness of 0.1 mm and a pore size of 1 or 10 µm. For collection, an adaptation of the GilAirPlus pump holder was made to ensure the concentration of the airflow on the surface of the filter. The collection was carried out in a cascade, selectively for particles of 1 µm and 10 µm. [11].

Particles collected on Si filters were analyzed by scanning electron microscopy (SEM) and µRaman methods. SEM analysis is a powerful technique used in materials science, biology, chemistry, and other fields to study the surface structure, particle size and shape and partly composition of materials (EDX-SEM). It uses a focused beam of electrons to scan the sample and create high-resolution images. Raman analysis, or Raman spectroscopy, is a powerful and non-destructive technique used to study the vibrational, rotational, and other low-frequency modes of molecules. The technique is based on the Raman effect, which is the inelastic scattering of light by molecules, discovered by Indian physicist C.V. Raman in 1928 [12]. This analysis provides molecular-level information about a sample without the need for extensive sample preparation. The "µ" in µRaman refers to the ability of the technique to focus on very small areas (micron-scale) of a sample, allowing for high spatial resolution. This makes µRaman ideal for studying heterogeneous materials, small features, or microscopic regions of interest within a sample. Unpolarized µ-Raman measurements were performed using a triple spectrometer 557 TriVista (S&I Imaging GmbH) in reflection geometry. Excitation was carried out with the 514.5 nm line of the DSS laser, with an output power level of approximately 100 mW. The laser was focused on the sample with a 100x/0.9 microscope objective with a working distance of 0.3 mm, having a spot size smaller than 2 µm. The reflected laser light was rejected by an edge filter. The Raman spectrum was collected with a monochromator with a 1500 g/mm grating and a focal length of 750 mm. Spectrum acquisition was done with a 1024 x 256 Si-CCD cooled with liquid nitrogen.

Particles collected on quartz filters were analyzed by thermal extraction desorbtion-gas chromatography/mass spectrometry (TED-GC/MS). This is a powerful analytical technique combining thermal extraction, gas chromatography, and mass spectrometry to provide detailed and accurate information about the volatile compounds present in a variety of sample types. Its applications range from environmental monitoring to food quality control and forensic investigations. Here, the samples are heated from 25 to 600°C under inert nitrogen atmosphere. The decomposition gases were collected on a solid phase adsorber, desorbted in thermal desorbtion unit and focused by the cold injection system at -100 °C, before the molecules are separated in GC and detected in MS. Further information is given in [13].

3. RESULTS AND DISCUSSIONS

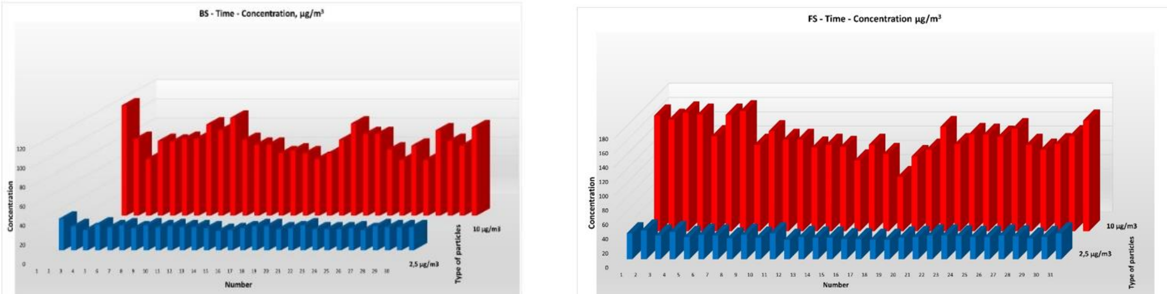
In **Fig. 2a**, **2b**, the evolution of the number of particles/m^3 and the concentration of particles (µg/m^3) at the two selected times is presented.



a b

Fig. 2*: Evolution of the particle number a) BS time b) FS time*

In **Fig. 3a, 3b** the evolution of the particle concentration of 2,5 and 10 µm (µg/m^3) at the tow selected time is presented.



a b

Fig. 3*: Concentration (µg/m^3) a) BS time, b) FS time*

In **Table 1** and **Fig. 4** the evolution of the average, minimum, and maximum values of the number of particles/m³ at the selected times are presented.

Table 1: *The evolution of the average, minimum, and maximum values*

Statistics		**Number of particles/m^3**					
		Particle type, µm					
Time		**0.3**	**0.5**	**1.0**	**2.5**	**5.0**	**10.0**
BS	Min.	55723.0	16170.0	2255.0	352.0	43.0	25.0
	Max	74821.0	22228.0	3104.0	488.0	101.0	56.0
	Mean	66288.06	19894.2	2784.1	413.8	76.5	40.8
	Std	3868.7	1275.4	190.7	35.1	12.1	7.0
FS	Min.	62236.0	18487.0	2524.0	406.0	69.0	38.0
	Max	103000.0	49825.0	4540.0	884.0	228.0	149.0
	Mean	77476.5	24529.9	3503.4	587.4	133.3	82.9
	Std	10.094.4	5535.0	536.0	119.0	41.6	28.9
AH	Min.	56088.0	17343.0	2470.0	366.0	58.0	32.0
	Max	97337.0	29913.0	3700.0	590.0	128.0	77.0
	Mean	66792.9	20472.2	2968.1	452.7	87.4	49.4
	Std	8639.3	2461.4	315.0	49.9	20.3	12.7

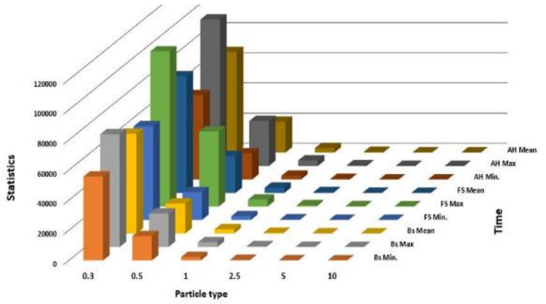


***Fig. 4**: Evolution of the particle average number/m^3*

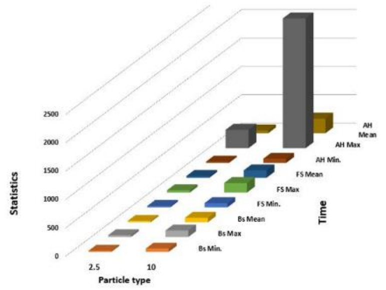


***Fig. 5**: Evolution of the average concentration of the particle(µg/m^3)*

From the analysis of the data presented in the table 1 and figures 4 the following aspects result:

• 0.3 µm Particles: The highest average count is observed at FS time (77,476.5/m³), significantly higher than at BS (66,288.06/m³) and AH (66,792.90/m³). Across all times, 0.3 µm particles consistently have the highest counts, outnumbering the 0.5-10 µm particles.

• 0.5 µm Particles: FS time records the highest count (24,529.9/m³), followed by similar counts at BS (19,894.2/m³) and AH (20,472.2/m³). While still higher than 1.0-10 µm particles, 0.5 µm counts are lower than 0.3 µm particles at all times.

• 1.0 µm Particles: FS time again shows the highest count (3,503.4/m³), with BS (2,784.1/m³) and AH (2,968.1/m³) trailing behind. 1.0 µm particles are consistently fewer than 0.3 µm and 0.5 µm particles but still exceed 2.5-10 µm particles at all times.

• 2.5 µm Particles: The highest count is at FS time (587.4/m³), with BS (413.8/m³) and AH (452.7/m³) showing lower levels. These particles have fewer counts than the smaller sizes (0.3 µm, 0.5 µm, and 1.0 µm) but more than the 5.0-10 µm particles across all times.

• 5.0 µm Particles: FS time shows the highest count for 5.0 µm particles (133.3/m³), with BS (76.5/m³) and AH (87.4/m³) showing lower levels. These counts are always lower than 0.3 µm, 0.5 µm, 1.0 µm, and 2.5 µm particles but consistently higher than the 10 µm particles.

• 10.0 µm Particles: FS time records the highest count (82.9/m³), with BS (40.8/m³) and AH (49.4/m³) values also lower. 10 µm particles have the lowest count across all sizes and times.

The average values for all type of particle are quite similar at the time BS and AH.

In **Table 2** and **Fig**. **5**, the average, minimum, and maximum values of the particle concentrations (µg/m³) at the selected times are presented. The analysis shows that the highest concentration of 2.5 µm and 10 µm particles is found at AH time (51.3 and 258.4 µg/m³, respectively). This increase in particle concentration may be determined by several factors, such as humidity and temperature, which can vary significantly from day to day, influencing particle dispersion. In the morning, when humidity is higher, dust particles may settle more quickly on surrounding surfaces. At 3:00 PM, higher temperatures or lower humidity may have favoured a longer suspension of particles in the air, which explains their higher concentration.

On the first day, at BS time, the environmental parameters were: T: 21.3°C and RH: 55.6%, at FS time T: 30.0°C and RH: 45.0%, and on the second day, at AH time, T: 25.0°C and RH: 45.8%. It is also possible that intensive cleaning of the machines or production area could have released particles that had accumulated over previous days. Additionally, cleaning activities in the morning, with equipment that stirs up more dust, could lead to an increase in the concentration of particles in the air.

Table 2: *The average, minimum, and maximum values*

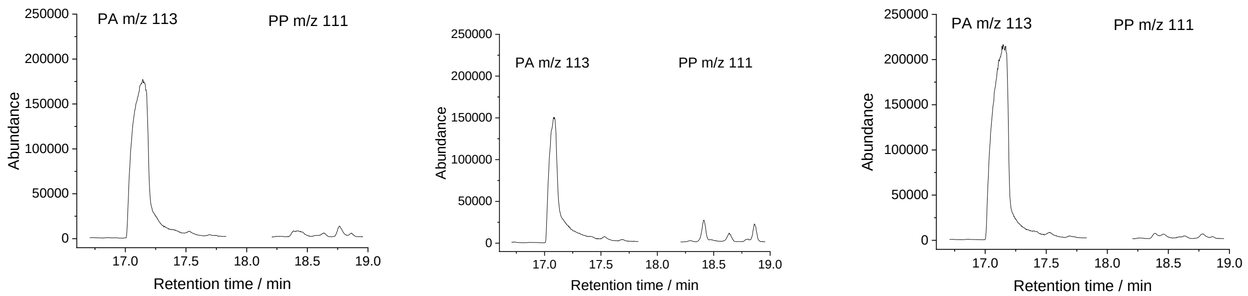
Type of particle/Time		BS	FS	AH
2,5**µm**	Min.	20.0	58.0	23.0
	Max	33.0	115.0	323.0
	Mean	23.9	78.2	51.3
	Std	2.41	13.4	61.1
10**µm**	Min.	58.0	76.0	74.0
	Max	115.0	168.0	2287.0
	Mean	78.2	130.3	258.4
	Std	13.4	21.5	436.4

Mass spectra used for quantification of polypropylene and polyamide are presented in **Fig. 6**, and in **Table 3**, the mass of collected particles obtained by TED-GC/MS.

Table 3: *The mass of collected particles*

Samples	Polypropylene, µg	Polyamide, µg	Sum, µg
BS	Non detected	5,50	5,50
FS	1,53	2,98	4,51
AH	Non detected	7,14	7,14
Blank	Non detected	Non detected	0,0

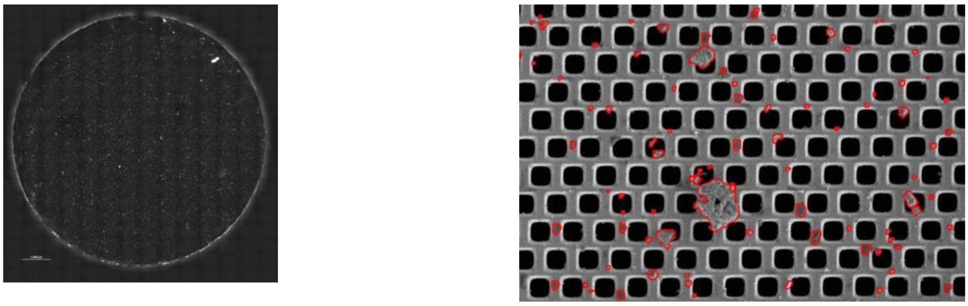
Data analysis highlights the fact that polypropylene particles were identified only at FS time (1.53 µg) and PA at all selected times (BS-5.50 µg, FS-2.98 µg, AH 7.14 µg). Identification occurred via the PA marker caprolactam with m/z 113, 55 and 85. PP was detected by use of 2,4,6,8-tetramethylundec-10-ene (m/z 111, 69, 154, 210). The evolution over time of total amounts follows the same trend outlined above. The particle counting results above show many small particles but only small amounts for particles with 10 µm. Since large particles have much more volume/mass compared to small particles, they contribute much more to the PP and PA mass detected with TED-GC/MS. Obviously, the PA particles reach the limit of detection and quantification of the TED-GC/MS instrument, while at BS and AH the mass of particles is too low for quantification.



BS FS AH

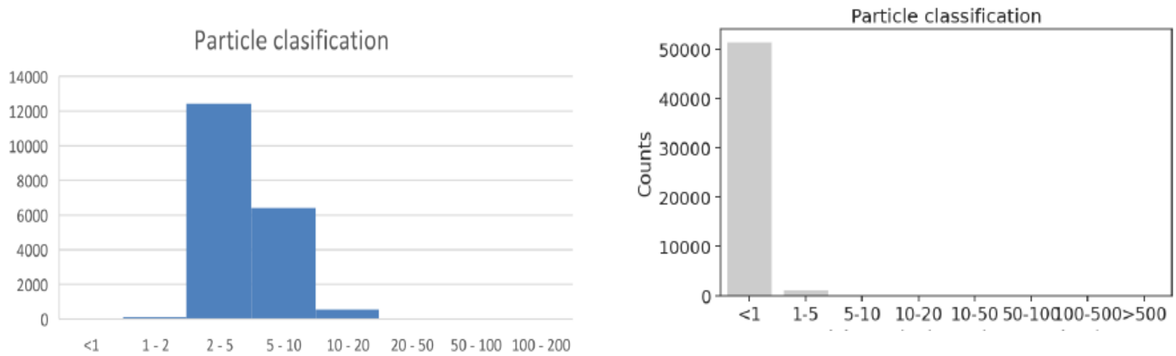
Fig. 6*: Mass spectra for PA (m/z 113) and PP (m/z 111) of particles collected on quartz filters*

In **Fig. 7a** and **7b**, SEM images for 10µm and 1µm particles collected with Si filters at FS time are presented and in **Fig. 8a**, the classification and evolution of equivalent diameter.



a. Si - 10µm b. Si - 1µm

***Fig. 7**: SEM for the particle of 10µm and 1µm*



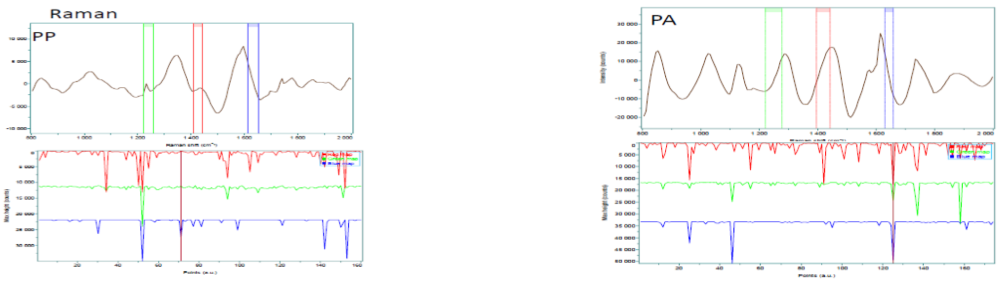
a. b.

***Fig. 8**: a. particle classification; b. Evolution of equivalent diameter*

All the samples indicate a high concentration of particles on Si filters and a lower concentration of fibres. The majority of the particles exhibit an irregular shape.

The particle classification by diameter follows the same trend as mentioned earlier, with a higher proportion of particles having a diameter smaller than <1.0 µm compared to those in the 2.5-10.0 µm range. Since most particles are irregularly shaped, the equivalent diameter was calculated to better represent the distribution of particle sizes. The equivalent diameter is defined as the diameter of a sphere that has the same volume or area as the actual particle, even if the particle is not spherical. This diameter allows for a comparison of the particle's characteristics, such as cross-sectional area or volume, with those of a spherical particle. In all cases, the equivalent diameter of the collected particles is below 1.5 µm.

In **Fig.9** the Raman spectra of 1 and 10 µm polypropylene and polyamide particles are presented. Polypropylene, a polymer with a typical Raman spectrum, exhibits several characteristic peaks. The vibrational modes commonly observed include: CH2 and CH3 groups, with -CH2- and -CH3 stretching and bending modes typically in the range of 1400 cm^{-1} to 3000 cm^{-1}; CH2 wagging/bending around 1000-1300 cm^{-1}; and C-C stretching in the 800-1000 cm^{-1} range. The amide functional group (-CONH-) gives rise to characteristic Raman peaks from its stretching and bending vibrations, with the Raman spectrum of polyamide (Nylon) showing peaks between 400-2900 cm^{1}.



10µm 1µm

***Fig. 9**: Raman spectra*

The Raman spectra (**Fig. 9)** confirm the results obtained with TED-GC/MS regarding the chemical structure of the particles collected at the selected times, specifically identifying polyamide and, to a lesser extent, polypropylene.

This phenomenon may have the following causes:

- Polyamide (such as nylon) has a higher density (1.13 g/cm^2) and a structure that is more difficult to disperse in the air compared to polypropylene (0.9g/cm^2). Although both are plastic materials, polyamide is more hygroscopic (meaning it absorbs more moisture), which can influence the behaviour of the particles in the air. These polyamide particles may remain suspended in the air for a longer period or may be more easily captured by collection systems.
- Polyamide has a higher melting point (220 °C) than polypropylene (160 °C), which may mean that during the processing, polyamide can solidify more quickly and form finer particles. These fine polyamide particles are easier to suspend in the air and can be more readily captured by collection systems.

4. CONCLUSIONS

- The study on particle concentration in the air at a textile company manufacturing polypropylene and polyamide yarns reveals significant insights into the airborne particles generated during the weaving process. Key findings from the particle measurements indicate that the highest concentration of particles occurs at the end of the shift (FS), with 0.3 µm particles showing the greatest presence across all time points (beginning of shift, end of shift, and after 16 hours). The particle concentrations follow a consistent pattern, with smaller particles (such as 0.3 µm) generally outnumbering larger ones (like 10 µm).
- Environmental factors like temperature and humidity appear to influence particle concentration, with higher temperatures and lower humidity at the end of the shift contributing to a greater suspension of particles in the air. The cleaning activities in the morning and the presence of accumulated particles may also contribute to the elevated particle levels.
- Furthermore, the analysis of the particle composition using advanced techniques such as SEM, µRaman and TED-GC/-MS revealed that polyamide particles were consistently present, while polypropylene particles were only identified at the end of the shift due to limitations of the specific techniques. The particle sizes were predominantly smaller than 1.0 µm, with irregularly shaped particles being the most common. The study's findings suggest that polyamide's higher density and hygroscopic nature could make it more prone to remaining suspended in the air compared to polypropylene.
- In conclusion, this study highlights the importance of monitoring and controlling airborne particle concentrations in workplaces involving synthetic yarn processing, as the potential for

respiratory exposure and environmental impact exists. The results also underline the need for further research into the effects of particle size distribution and material properties on air quality.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

SUSTAINABLE DESIGN BY PRESERVING FASHION HERITAGE

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Abstract: *The article addresses the influence of earlier fashion trends – Empire, Romanticism, Victorian and Art Nouveau – on contemporary fashion design. The design models demonstrate how the visual and constructional details of the earlier periods can be brought to the present through the use of new technologies, new materials and creative solutions. The coexistence of nostalgia for the elegance of the past and demands of contemporary life is emphasized. The result of the analysis is that historical fashion knowledge not only enriches modern design, but also offers new opportunities for innovation and creative expression. This dialogue between tradition and modernity is one of the reasons for sustainable and culturally appropriate development of fashion design.*

Keywords: *Fashion Heritage, Historical Styles, Modern Innovation, Sustainable Design, Cultural Aesthetics, Creative Expression*

1. INTRODUCTION

Fashion history is inextricably linked to the cultural, social and artistic processes that have developed for each individual era [1, 2]. During different historical periods, the style of clothing reflects not only the aesthetic demands characteristic of its time, but also, on the other hand, reveals the different ideas about femininity, status and social identity [3, 4]. This article will trace the evolution and interrelationship between four key historical styles of fashion design. Namely, Empire, Romanticism, Victorian style and Art Nouveau style of clothing, through the creation and analysis of contemporary design interpretations borrowed from the esthetics of these historical eras.

Each of the created and examined models presents the characteristic constructive features of the respective style, such as decorative elements and various silhouette solutions, which are refracted through contemporary design concepts, turning the model into a modern and current trend. The historical Empire style is represented through models that emphasize clean lines and classical elegance, which are characteristic of the late 18th and early 19th centuries. Romanticism, in turn, is reflected in the lightness, as well as the volume and pastoral sensitivity that are typical of fashion trends for the first half of the 19th century. The Victorian style, in turn, is represented by complex constructive solutions that emphasize the silhouette, which recreates the rich and strict appearance of clothing, typical of the second half of the century. The Art Nouveau aesthetic is recreated through organic lines, floral motifs and decorative elements that are typical of the late 19th and early 20th centuries [5, 6].

The purpose of this study is to analyze how historical clothing styles can be adapted to contemporary fashion design. This is achieved through the use of new technologies both for the construction of the model construction and for the use of new materials and approaches. By juxtaposing traditional elements that are part of historical clothing and the use of contemporary design practices, this article explores the connection between the past and present development of fashion, demonstrating how traditional cultural heritage in clothing can inspire the creation of new innovative and current design solutions.

2. AMPERE

Figure 1 presents models of contemporary women's clothing inspired by the Empire period. Figure 1a presents a minimalist dress with accents of a men's vest called "Classic Mystery". This model is a modern interpretation of the Empire silhouette, inspired by the gentle elegance of women's clothing from the period 1795–1820, combined with the simple rigor of the men's vest, characteristic of this era. The design of this model is built on the contrast of the smooth Empire lines with the geometric arrangement of the masculine elements, which creates a mysterious and sophisticated vision.

The appropriate materials and texture for the manufacture of this model are light layers of fine silk with a matte texture. This lightness conveys a smooth fall of the skirts, and also follows the movement of the body.

The construction and silhouette of the upper part of the model are clean, with the classic Empire waist, which falls just below the bust. The cut of the upper part is in the form of a classic men's vest, typical of the Empire period, with its V-shaped neckline. The neckline is emphasized with a contrasting black edging. The sleeves of the model are short and slightly gathered in the shoulder area, ending with a clean cuff. These sleeves with the typical balloon effect are characteristic of women's dresses from the early 19th century. The construction of the lower part is represented by a falling, straight skirt without excess volume, which is typical of the Empire style.

The details and ornaments, such as the contrasting black edging on the neckline and around the waist, give a slightly elegant look of sophistication, typical of a men's vest.

The main color palette of the model can vary between cream, ivory or soft champagne. The contrasting black color of the elements is to emphasize the masculine elements.

The model in Figure 1a adapts to contemporary fashion through the lightness and comfort of modern materials, as well as the loose cut. The minimalist approach presented combines the classic esthetics of the Empire style with a new modern interpretation. This model is suitable for both evening events and more informal occasions.

a) Classical mystery b) Imperial sensation c) Ancient militancy

Fig. 1. *Fashion design in Ampere style*

Figure 1b presents an evening dress pattern with men's frock coat elements called "Imperial Sensation". This pattern is a contemporary interpretation of the Empire style, drawing inspiration from historical men's frock coats and empire lines. By combining the classic grace of Empire dresses with modern futuristic elements, the dress has a strict and symmetrical structure that preserves the elegance inherent in the Empire period.

The pattern is made of satin or silk, which gives sophistication and flexibility to the body, as well as lightness. In the upper part, the silhouette and construction are presented in the form of a fitted bodysuit, which emphasizes the empire waist, located just below the bust. The double-breasted fastening with small elegant buttons is inspired by the men's frock coat. The high, tight collar gives a strict, but at the same time elegant look. The geometric seams and embroidery give the dress a modern look. The sleeves are long, fitted to the wrists, with miniature golden buttons at the end, creating contrast and elegance. The shoulders are presented with padding to give volume and a straight, elegant shape. The construction of the lower part of the model is presented by a double skirt. The lower skirt is short and fitted, and the upper skirt is long with deep pleats and gathers, resembling a train.

The details and ornaments in the model are minimalist geometric embroideries in silver or gold, inspired by the Empire period, which emphasize the waist line and hem. Small elegant golden buttons are used to emphasize the construction of the dress. The main color solutions for this model are classic black to emphasize elegance. Silver and gold are used as an accent in the embroidery details to create a contrast with the main color and add dynamics to the look.

The combined elegance and classic femininity of the empire silhouette with futuristic elements make this model suitable for evening events and formal occasions, as the redingote accent adds uniqueness and elegance, and the geometric details create a more current and natural look.

Figure 1c presents an empire dress model with corset and military elements, “Antique Militancy”. This model is a variation of the modern reading of the empire style, in which elegant femininity is skillfully combined with the military rigor of uniforms from the era of the Napoleonic Wars. This dress combines the classic lines of the period with antique references and bold military elements, which create the vision of a strong, confident and independent woman.

The model is made of silk satin with embedded metal elements and embroidered edges at the top, and the skirt is made of fine silk for airiness and freedom of movement. The contrast between the heavy corset and the etherealness of the skirt enhances the dramatic vision.

The construction and silhouette of the top are presented through a corset that is structured to fit the body. The decorative metal buttons on the front, reminiscent of those of men's military uniforms, add additional emphasis. The small stylized epaulets sewn onto the shoulders give a sense of military rigor and strength. The model is sleeveless to emphasize the structure and achieve an antique aesthetic. The lower part is free-falling, made of light silk pleats that create movement and softness, contrasting with the rigor of the top.

The details and ornaments, such as the embroidery of fine gold elements in the corset and epaulet areas, form empire geometric motifs. The main color palette is a deep navy blue, which is a symbol of strength, elegance and aristocracy. The accent gold edges and buttons emphasize the military character of the look.

The model is adapted to modern esthetics through light and breathable fabrics that convey comfort and mobility. The silhouette emphasizes femininity, but through clean lines and bold details. This model is suitable for both formal events and fashion shows and photo shoots of an artistic nature.

3. ROMANTICISM

Figure 2 presents women’s clothing designs inspired by Romanticism. Figure 2a presents a model of an airy dress with dramatic sleeves called “Poetic Grace”. This model reveals a modern adaptation of the feminine and dreamy look of fashion from the Romantic period (1820 – 1850). This dress draws inspiration from the memorable era of “poetic” silhouettes and sophisticated details characteristic of the portraits of elegant ladies of the 19th century. This dress carries the romantic aura of the past, but at the same time is adapted to modern esthetics and comfort.

The dress is made of fine silk muslin for the main part and translucent organza for the sleeves. The materials are selected to provide lightness, airiness and smooth movement. At the bottom of the skirt, delicate cotton lace is used, which is woven into the end of the skirt, which gives a delicate finish.

The upper part of the model follows the principles of romantic fashion, through the clearly emphasized waist, which is a characteristic detail of this period. The fastening of the dress has discreet pearl buttons on the back, which provide stability and an authentic finish. The sleeves, in turn, are borrowed from the “Leg of mutton” type, which are voluminous in their upper part and gradually narrow towards the wrists. The model features voluminous upper arms that narrow in the shoulder area, expanding again into a voluminous shape and ending with a narrowing in the wrist area with padded cuffs. The sleeves are translucent organza. This specific shape conveys a dramatic effect that is typical of a romantic vision. The lower part of the model is represented by a long skirt, which is slightly flared with several soft pleats for additional volume. The lower end ends with a lace trim with floral motifs, which are borrowed from the natural themes of the era.

The small floral motifs around the neckline are fine handmade embroidery. Another detail is the fine pearl buttons on the back, which are decorative, but at the same time functional elements. Another detail of the model is the discreetly placed lace decoration at the bottom of the skirt, which gives a slight vintage flavor.

The main color for this model is soft lavender or "ashes of roses". These are colors typical of the romantic era, which give a feeling of tenderness. The accent tones are tones of the golden-white lace, as well as the pearl details.

Although the model is inspired by the romantic style, the dress is adapted to the modern context through its lightweight construction and modern materials, which replace the heavy historical fabrics and corset straps. The delicate and comfortable inner lining provides additional comfort when wearing. And also the soft and natural line of the skirt, which combines the romantic look with modern elegant esthetics.

a) Poetic grace b) Moon Ballerina c) Gothic Lady

Fig.2. *Fashion design in Romanticism style*

Figure 2b presents a model of an airy dress with ballet notes “Moon Ballerina ”. This model is a modern interpretation of the romantic ideal of lightness, etherealness and aesthetic femininity. The dress is inspired by the silhouette of the ballet costume from the early 19th century and the romantic radiance of the characters from the works of Giselle, La Sylphide and other ballet ballads of the era. This model combines the poetics of dance with elements of romantic fashion, presented through an elegant and modern vision.

The dress is made of soft tulle material in several layers, which are combined with satin silk for the bodice. Decorative additional elements, such as fine brocade and miniature shiny threads, create the illusion of moonlight reflecting on the fabric.

The upper part of the model is presented in the form of a bodice with a clean line, which fits slightly into a heart-shaped neckline. The straps are thin and almost invisible, which gives the illusion of lightness and invisible support. The sleeves are translucent and airy, which are additionally attached as an accessory, because the model can do without them. Inspired by the ballet costume of romanticism, they give an airy, dreamy image. The lower part of the model is represented by a multi-layered skirt, consisting of several layers of tulle, which creates the impression of volume and lightness without weight. This multi-layering is borrowed from the multi-layered layer of the crinoline, characteristic of this period. The length reaches the ankles, which is typical of romantic barrel skirts, and allows for smooth movement, creating an aura of elegance.

The details of this model are the miniature shiny accents, which are discreetly located on the top and on the tulle skirt, reminiscent of stardust or moon glare. Another detail is the delicate satin ribbon in the waist area, which emphasizes the delicate feminine shape of the waist.

The main color solutions are silver, ice blue or milky white. Gentle ethereal shades were chosen to enhance the illusion of lightness, light and unearthly beauty.

Despite the inspiration from the Romantic era and the ballet costume, this model is broken through the modern fashion idea through the use of light fabric and lightweight construction, which makes it comfortable to wear. The clean lines of the bodice through decorative and constructive lines provide a modern minimalist look that imitates the tight underbust of the corset. The dress may be suitable for both gala events and creative photo shoots or stage performances.

Figure 2c presents an evening dress model with mystical elegance, "Gothic Lady". This model is a modern version of the esthetics of dark romanticism and mysticism of the early 19th century. This dress is inspired by the images of Gothic novels and the dark poetry of the era. The dress combines the dramatic silhouette of romanticism with mystical elegant elements that are refracted under the prism of the outfit.

The dress is made of satin and multi-layer tulle, which creates a sense of depth and theatricality. The details are exquisite with emphasized black lace and fine embroidery with metal threads.

The upper part of the model is presented in the form of a cortet. Its decorative-constructive structure emphasizes the waist, giving a pronounced silhouette. Decorated with brocade floral ornaments and metallized details. The neckline is V-shaped, which is emphasized with fine lace, which gives a touch of seduction and mystery. The sleeves are flared. They are inspired by medieval and Gothic robes. Their construction starts tight at the top and flares dramatically from the elbows down. The lower part is a long multi-layered skirt made of tulle and satin. The silhouette of the skirt is smoothly cut from the waist down, which is reminiscent of the evening dresses of the romantic era. The length of the back is longer, resembling a train for a more dramatic finished effect.

Delicately woven threads in the embroidery of Gothic elements in the form of vines and roses. The main colors of the model are deep burgundy and black. In the details, silver or graphite accents can be noticed in the embroidery and lace. Despite its retro-romantic esthetics, this model is adapted to modern fashion trends through a lightweight construction that gives comfort and freedom of movement. The model is presented through the modern reading of the Gothic aesthetic, through new contemporary materials and cuts. This outfit is suitable for evening events, theatrical performances or an alternative wedding look.

4. VICTORIAN ERA

Figure 3 presents contemporary models inspired by the Victorian historical period. Figure 3a presents a model of an extravagant evening dress with a corset and veils, “The Mysterious Viscountess”. This model is a modern vision of the emblematic esthetics of the late Victorian era at the end of the 19th century, dominated by a lush silhouette, dramatic texture and richly ornamented details. The design of the model draws inspiration from the romance and mystique of Victorian fashion, skillfully adapting to the modern vision through its innovative construction and materials.

The model is made of satin, delicate lace and light voile tulle, which creates multi-layered depth and drama. The main fabric is silk satin with a silk finish, which gives smoothness and a luxurious shine. Lace inserts and translucent ruffles are used to achieve an ethereal lightness and mystery that are characteristic of the Victorian style.

The upper part of the model is presented as a fitted corset with a decorative-constructive construction with an emphasized waist. The collar is high, wrapped in lace, which is a typical element of the evening Victorian dress. The sleeves are long and narrow, made of black lace. The lower part is presented with a long voluminous skirt, which is cut from several layers of tulle, which creates an exceptional visual effect when moving. Delicate black veils are attached to the lower part of the skirt, which are revealed during movements, which emphasizes the drama of the silhouette.

Decorative elements, such as the brooch, which is placed on the collar and the front of the corset, give a luxurious finish.

The design of the model relies on the contrast between solid black and red accents, which emphasize the emotional saturation of the model, which it wants to convey. The red details are delicate, but enough to bring dramatic contrast to the model.

The “Mysterious Viscountess” model combines typical Victorian elements with an interpretation of new contemporary trends. One of these solutions is the lack of heavy padding and crinolines; instead, a light multi-layered tulle is used to add volume. The corset construction is adapted through soft padding and elastic inserts for comfort. Another advantage is that the material has anti-wrinkle properties.

a) The Mysterious Viscountess b) City lady c) Gothic Queen

Fig. 3. *Fashion design in Victorian era style*

Figure 3b presents a model of a modern business dress with Victorian elements, “City Lady”. This model is a modern interpretation of the classical esthetics of the Victorian era, which is adapted to the dynamics of the modern city woman. The design of the model is based on the idea of elegance and authority, combined with a touch of romanticism and retro radiance. The silhouette of the dress refers to the second half of the 19th century, but at the same time is balanced with the practical minimal line, which is suitable for the modern business environment. The model is made of a fine wool blend with elastane, providing a comfortable structure and comfort when worn. Accent elements are the lace on the collar and sleeves, complemented by decorative metal buttons with engravings, which are characteristic of Victorian decorative accents. The construction of the upper part is presented close to the body, with an emphasized waist, reminiscent of Victorian corsets, but with an adaptation for the modern city woman without the rigid construction. The collar is high and clean with an elegant lace trim, which was a symbol of social status in the Victorian era. The sleeves are medium length, fitted at the arm, with a slight buffoon structure at the shoulders; this is a reference to late Victorian fashion, when the shoulders began to gain volume. The lower part of the model is presented as a straight skirt with knee-length and a discreet slit at the back, which provides freedom of movement. The cut of the skirt emphasizes the line of the hips and waist without unnecessary volume, making it suitable for a modern office or cocktail event.

Details, such as metal buttons, are inspired by Victorian uniforms and coats and are located along the front of the dress. Discreet lace details are inserted to soften the strict silhouette of the model.

The color scheme is carefully selected with deep noble tones of dark blue, which emphasize the formal character of the model and are reminiscent of the heavily saturated colors of Victorian outfits. The accents of additional details with silver motifs are reminiscent of the noble esthetics of the 19th century.

The model for the "City Lady" was created with functionality and comfort in mind. One of these advantages is the lack of a hard corset, which is replaced with an elastic but structural fabric. The length is comfortable for modern urban everyday life. The model is easy to maintain.

Figure 3c presents a model of a dramatic evening dress with Victorian elegance “Gothic Queen”. The model is an interpretation of the late Victorian aesthetic, inspired by the mysticism and drama of Gothic fashion from the end of the 19th century. The dress combines the typical Victorian corset elements, lush fabrics and ornamental details with the characteristics of modern minimalism and architectural purity. This model is an evening outfit suitable for special events, where an impressive and impressive vision is mandatory, which in turn radiates strength, elegance and mystery.

The suitable material for making this dress is the luxurious black velvet material with a matte effect and a soft to the touch. It is also combined with a fine layer of satin and tulle at the bottom. The corset and cuff are decorated with handmade floral and geometric lace, which are made of silk threads. For an additional decorative effect, metal ornaments and gold threads are included, which are woven into the seams.

The upper part of the model is presented in the form of a highly fitted corset with structural decorative constructive seams and internal pads to maintain the shape. It is made of black velvet and is complemented by a golden lace edging as an accent. The sleeves are long and narrow at the top, which expand from the elbows to the wrists with dramatic volume. The ends of the sleeves end with lace cuffs, reminiscent of elegant evening Victorian sleeves. The lower part of the model is presented as a long asymmetrical skirt, which consists of several layers of tulle and satin. The length of the front part is shortened, and at the back it is elongated, resembling a train, which gives additional volume to the back of the dress. This volume is characteristic of the fashion of the late 19th century.

The main colors of the model are deep black, which is traditional for Gothic esthetics. As an accent, gold is used to enhance the drama and the feeling of noble elegance.

Although inspired by the "Gothic Queen" model from Victorian fashion, the dress is practical with an intention for modern taste and comfort. Soft fabrics and elegant inserts replace heavy historical cuts. The internal construction of the corset is lightweight, without the use of metal rails. Also, the asymmetrical design and long train are well-balanced to ensure freedom of movement.

5. ART NOUVEAU

Figure 4a presents an evening dress model with metal ornaments typical of the Art Nouveau aesthetic “The Golden Muse”. This model is a contemporary interpretation of the feminine idea of esthetics characteristic of the historical period of the Art Nouveau style of clothing (1890 – 1914), also known as the Belle Époque. This style draws its inspiration from the ornamental forms in nature, curved and curved lines, and also decorative elegance. The design of this dress model is influenced by the famous illustrations of Alphonse Mucha, in which the woman is surrounded by floral motifs and exquisitely crafted ornaments. This model represents the artistic spirit of this era, represented through a sophisticated evening dress with a contemporary interpretation.

The material that is suitable for making the model presented in Figure 4a is high-quality silk with a slight satin sheen in champagne. The light-free structure of the model emphasizing the natural shape of the body creates a smooth and free movement of the body when walking. The upper part of the model is richly decorated with hand-embroidered floral ornaments made of gold metallic threads and beads. The gentle texture of the fabric is complemented by the delicate shapes of leaves and vines, which are characteristic of the natural motifs of Art Nouveau.

The construction and silhouette of the model "Golden Muse" are considered in several separate parts. The upper half is represented by a bustier with straps. The bustier is softly draped; it is made of ethereal silk on a satin base. The drapery starts from the waist in the asymmetrical position set by the left half of the model, directed from the center to the shoulders. This method creates a stylized flower-shaped look, which is characteristic of the female figures represented in the decorative panels of spring characteristic of Art Nouveau. The model's straps are elegant and thin. They are decorated with golden elements that are reminiscent of the elegance of wrought iron. This is a common motif in the architecture and applied arts of Art Nouveau. The model is sleeveless, which emphasizes the delicate shapes of the shoulders and neckline. The sleeves are replaced by metal ornaments that form the line of the collar and pass around the circumference of the biceps of the arms. These ornaments are a modern interpretation of the jewel ornaments of the early 20th century. The construction of the skirt is a falling line with light asymmetrical folds, reminiscent of the skillfully stylized corollas of flowers. The skirt is made of silk with a satin sheen. The back is slightly elongated, forming a delicate train which harks back to the evening dress of the Belle Époque era.

a) The Golden Muse b) The Whirlwind of Irises c) Modern Goddess

Fig. 4. *Fashion design in Art Nouveau style*

The decorative elements and accessories in this model are the gold embroidery, which is located along the neckline, giving the feeling of a transition between the fabric and the ornaments. Another element is the appliqués. They are small and handmade floral motifs made of metal threads and silk threads. The model can be combined with a diadem or bracelets with floral elements, which are inspired by Art Nouveau art.

The color palette chosen for this model is muted gold, which transitions to champagne, which gives the silhouette radiance and warmth. The decorative elements are in shades of old gold, and the appliqués have pastel accents of gold.

This model is adapted to modern trends by using light fabrics with high elasticity and a breathable structure for increased comfort. Also, instead of heavy metal decorative elements, they have been replaced with modern alloys to reduce weight. Another advantage is the hidden side zippers that make the model easy to wear. Also, the model is made without a corset, which preserves the soft silhouette characteristic of the free lines of the Art Nouveau style.

Figure 4b shows a bohemian dress with abstract lines and an Art Nouveau aesthetic, “The Whirlwind of Irises.” This model focuses on the natural dynamics characteristic of Art Nouveau. The design is inspired by the delicate curves of iris flowers, one of the common floral motifs in the works of Alphonse Mucha. The dress conveys a sense of movement, lightness, and sensitivity that is characteristic of this period, while at the same time refracted through a contemporary bohemian reading.

The main material for the production is a light, translucent organza with a soft sheen in violet and pastel light purple colors. The fabric was chosen for its airiness and ability to follow the natural movement of the body.

The construction is made in a wavy shape with freely falling elements that are reminiscent of the leaves on the stems of irises. The neckline is in the shape of a heart. Textile threads are woven into the upper part, which is a symbolic reference to the intertwined ladders and lianas, as one of the main motifs of Art Nouveau. The sleeves are translucent and voluminous. They are made of organza with an elegantly gathered structure. The lower part is freely falling with an emphasized natural waist line. The skirt is made of several layers of organza and chiffon, which are arranged in asymmetrical folds, recreating the visual effect of a vortex or a water jet. The skirt is shaped with a slightly shortened front and extended at the back, which resembles a train, which enhances the Bohemian lightness and ease of the dress.

In the modern interpretation of the model, elastic and breathable fabrics are used, which provide comfort and freedom of movement. Also, the minimal use of rigid structures is replaced by decorative constructive seams.

Figure 4c presents a model of an avant-garde evening dress with architectural design and Art Nouveau esthetics called the “Modern Goddess”. This model represents the modern adaptation of the main visual principles of Art Nouveau, which are interpreted through a minimalist and architectural approach. This design recreates the connection of natural forms and structural elegance, characteristic of the golden age of the style in 1809–1914. The composition of the silhouette seeks harmony between the smooth line and the constructive rigor, recreated through the aesthetic approach that is characteristic of both the Art Nouveau style and contemporary modern fashion.

The dress is made of satin with a silky sheen, which is complemented by translucent organza and decorative metal applications. The main fabric has a satin finish, which provides a smooth and shiny surface, resembling the shiny sheen of a metal surface. The translucent organza with its transparent effect creates an impression of airiness and lightness, which contrasts with the strict line of the silhouette.

The color palette used for this model is emerald green, which is combined with golden accents in the form of fine threads and metal elements that refer to the decorative lines of Art Nouveau.

The upper part of the model is presented as a bodice that follows the shape of the body with the help of decorative constructive lines. The neckline is in a heart shape. The design includes a high collar that hugs the neck. From the neckline to the collar line, it is covered with lace with floral motifs. The sleeves are long, fitted at the top and gradually widen, resembling flowing leaves. They are made of translucent organza, which creates the illusion of a slight airy movement with each step. The lower part of the model is presented as a smooth elongated line with a slightly emphasized waist, which recreates an elegant and clean silhouette. The skirt ends with a slight elongated train, which complements the feeling of monumentality and airiness.

The following design solutions have been applied to the modern version of the model: the use of modern light and elastic fabrics, which provide freedom of movement, despite the sculptural nature of the model's silhouette. Another solution is the avoidance of heavy corset structures through the technological shaping of the decorative constructive lines of the cut.

7. CONCLUSION

Based on the presented designer models analyzing the four historical clothing styles – Empire, Romanticism, Victorian and Art Nouveau clothing styles, it can be concluded that fashion heritage continues to have a significant influence on contemporary fashion design. Each of the models examined demonstrates how the characteristic aesthetics and constructive elements of individual historical eras can be presented through the prism of modern innovative trends, technologies and current innovative materials without losing the connection with their cultural, historical and artistic value.

The created models show how the past can be recreated in a new current context while managing to preserve the basic visual representation of the elements and the emotional impact of historical styles. Through carefully selected silhouettes, decorations and materials as well as design solutions, a balance is achieved between nostalgia for the elegance of past historical eras and the requirements of the modern lifestyle and fashionable needs in clothing.

In this context, it can be concluded that the knowledge and understanding of historical clothing fashion will not only enrich contemporary design, but has the ability to open up new opportunities for innovation and creative expression. This transience between the tradition of historical clothing notes and modern trends is a key factor in the creation of sustainable, culturally aware and aesthetically justified clothing fashion in the present as well as future projects.

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ANNALS OF THE UNIVERSITY OF ORADEA
FASCICLE OF TEXTILES, LEATHERWORK

THE ISSUE OF INDUSTRIAL SURVIVAL: THE CASE OF HEMP IN THE TEXTILE SECTOR

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Abstract: *In an era marked by ecological degradation, resource scarcity, and the urgent need for sustainable industrial practices, the textile sector faces a critical question of survival. Hemp (Cannabis sativa L.), a historically significant yet long-neglected fiber crop, is re-emerging as a viable solution to many of the challenges confronting modern textile manufacturing. This paper examines hemp not only as a sustainable raw material but as a symbol of industrial resilience. Its low environmental footprint, high biomass yield, and minimal input requirements position hemp as a strategic alternative to resource-intensive crops like cotton. Furthermore, hemp fibers possess intrinsic qualities—durability, biodegradability,—that align with the demands of a circular economy. The research highlights recent global and regional shifts in policy, investment, and consumer interest that are redefining hemp's role in textile production. Particular attention is paid to the constraints of processing infrastructure, regulatory ambiguity, and market adaptation, which continue to hinder widespread adoption. Ultimately, this study frames hemp as a litmus test for the textile industry's ability to evolve under pressure and to prioritize long-term ecological and economic survival over short-term gains. This paper explores the potential of hemp as a sustainable textile fiber, highlights recent industrial developments, and evaluates the challenges related to its cultivation, processing, and regulatory environment—particularly in emerging markets such as Turkey, where renewed interest and investment are on the rise.*

Key words: *Sustainability, Industrial Hemp, Textiles, Hemp Seeds, Fibers*

1. INTRODUCTION

"Design, Production and Branding" with its technical, economic, aesthetic and social aspects are the main concerns of today's societies as a whole. Land wars have given way to the optimum use of existing land and resources. Considering all polluting factors, especially the protection of water, soil and air, a new production process, the "Green Industrial Revolution" based on "Sustainability and Circular Economy" has begun. "Sustainability of Humanity" depends on agricultural and industrial production. Human activities on earth are under increasing pressure due to limited material resources and environmental problems. After the Industrial Revolution, factors such as excessive use of resources, accumulation of waste, uncontrolled gas emissions to the ecological system and the decrease in drinking water, which cause "unsustainable" results with traditional methods in all industries, have emerged. At this point, industrial hemp has begun to attract the attention of the whole world as an environmentally friendly raw material.

First of all, it should be noted that hemp / hemp (Cannabis) is divided into 3 main species, Cannabis sativa, Cannabis indica and Cannabis ruderalis. These species have different physical and chemical properties. In this article, Cannabis sativa, which has no narcotic problems and is produced with certified seeds, will be discussed in general terms. Since this type of hemp contains less than 0.3% tetrahydrocannabinol (THC), it cannot be converted into cannabis / recreational substance by any chemical or mechanical method. Industrial hemp farming is no different from agricultural products such as corn, wheat, barley, sugar beet. In fact, banning industrial hemp farming is no different from banning the planting of basic textile fibers such as cotton and linen. The hemp industry can develop without any risk with the active implementation of controlled planting legislation and the use of certified seeds. When international reports are examined, no relationship has been found between the development of the industrial hemp sector and cannabis use. On the contrary, this year the United Nations (UN) [1] Commission on Narcotic Drugs decided to reclassify cannabis, removing it from the list of the most dangerous drugs such as heroin and synthetic pills. Although this does not mean that cannabis is free, it shows that the image of cannabis is changing on a global scale. It should be noted again that cannabis plants produced for cannabis purposes and industrial hemp plants are completely different plant species. It is possible for the cannabis sector to develop rapidly in Türkiye as a result of the establishment of interdisciplinary commissions and expert boards and their coordinated work with law enforcement to eliminate possible abuses in different countries [2].

Fig. 1. *First Developed Turkish Hemp Seeds Plant*

2. GENERAL INFORMATION

2.1 Raw Material 4.0 - Are We Ready for the Raw Material Revolution?

Industry 4.0, robot-based production, dark factory, big data, automation methods, production technologies have reached unbelievable dimensions in the last 50 years. It has become almost impossible to supply raw materials and to keep up with the pace of production technologies and consumption. Inventions such as steam, electricity and basic machine elements in the industrial revolution have transformed into advanced robotic manufacturing systems today, and subsequently, it has become necessary to move to a new era that we can define as the “Raw Material Revolution” in fast production technologies. Raw material is, in its most general definition, “the basic unprocessed structure used in the production of a product”. For example, “The raw material of paper is cellulose.” Cellulose is one of the most important natural polymers used in manufacturing after synthetic petrochemical raw materials. The hemp plant has a serious potential among renewable and environmentally friendly cellulose sources compared to petroleum derivatives. Hemp is the only plant that can simultaneously provide solutions to the recently discussed resource scarcity, depletion of wood stock and environmental problems. While water wars, oil wars, brand wars, production and customer wastes have gained value and a new era that we can generally call “Garbage / Waste Wars” has begun. While developed countries used to dispose of their wastes such as used clothes, shoes, packages, bottles by transporting them to developing countries, these wastes have now become an important source of raw materials. In order not to lose resources, each country is trying to recover its own wastes and this process is being carried to industrial dimensions. At this point, the European Union countries have a broad consensus on supporting recovery and recycling projects. There can be no production without raw materials and no competition without production [3].

Image 2. From land to factory sustainable fibers

2.2 The Birth of the New Plastic - What is Hemp?

Despite increasing academic studies and its popularity in different sectors, the hemp industry needs comprehensive R&D studies on the most basic issues such as seed breeding, ecological compatibility, and harvesting technologies. It is expected that hemp will become widespread by going through similar processes, just as plastic R&D / P&D became widespread after the discovery and processing of crude oil and an unlimited plastic product range was created today. It is among the trends that hemp will take its place in daily life much faster than plastic due to its renewable and environmentally friendly nature compared to oil. Making hemp farming efficient and feasible will accelerate hemp-based sectors. The ability of hemp to enter mass production as a raw material depends on sufficient agricultural organization and planting in large plots. At this point, obtaining and processing a sustainable cellulose source, which is new to the whole world, leads to an innovation-based competition start and system transformation in the industry. In fact, aside from the application of medical hemp, the industrial hemp sector has started to develop almost simultaneously all over the world, except for China. Textile based countries has also a high potential to be a pioneer in this developing sector. In today's world where the oil status quo is being questioned and alternative sustainable structures are in demand, it is quite possible for Türkiye to embrace hemp wholeheartedly and become a leader in the global market by selecting products suitable for our infrastructure and industry. Both the final product and the technology and systems used during the production of that product can be easily developed in our country. In addition to the export of the final product, machinery and technology exports are also possible with hemp.

Fig. 3: Hemp based samples developed by author [4].

2.3 Benefits of Hemp Production

- Its rapid growth and high biomass (cellulose) per acre are the most important solutions to the "raw material crisis" as this structure can be used in countless sectors.
- It is an environmentally friendly raw material at every stage of the process from seed to final product, compared to production methods that cause environmental pollution. It has been proven in the light of scientific data that it improves the soil and air during production.
- Sustainable solutions can be provided with hemp-based structures to sectors at the top of the hierarchy of needs such as clothing, shoes, food and shelter.
- As a result of global deforestation (due to industry, disasters and population), afforestation and forest restoration have become necessary. Hemp offers a very quick solution to this problem.
- It has successful applications for "cleaning the soil and increasing its fertility" as it can remediate contaminated soils through phytoremediation and can be cultivated without

pesticides.

- It is a plant that can offer an alternative to farmers in places where cultivation is difficult or as a rotational crop, thanks to its ability to grow in very different geographical conditions without being affected by external factors such as rodents, fungi and weeds.
- The textile and ready-to-wear sector depends on polyester and cotton fibers. Polyester fiber is a petrochemical-based synthetic structure. Cotton, on the other hand, is not ecological due to the fact that it pollutes the field during production, low productivity per acre, delicate production, and chemical maintenance requirements. Polyester and cotton meet approximately 90% of all fiber consumption. Hemp has the potential to be a third fiber in these consumption amounts.
- Hemp fiber production requires fewer workers and processes than other fibers, which is an important advantage for sustainability during production.

Image 4: Turkish seeds-based fiber and oil

2.4 Key issues regarding Industrial Hemp

- **There is a risk that hemp may turn into hashish, heroin and marijuana!** Cannabis, like all plants, has a large family and has been produced throughout history as a source of herbal raw materials or as a recreational substance. The classification of this ancient plant as only a narcotic is a serious perspective problem. While Cannabis indica, Cannabis sativa and Cannabis ruderalis could be separated very easily and clearly even before science and technology, in today's information age, it is possible to provide controlled production of hemp (Cannabis sativa) as a source of herbal raw materials only.
- **Are there hemp seeds suitable for different countries like Turkish soil?** Contrary to popular belief, Türkiye has historically hosted high-tonnage hemp cultivation as a hemp production center. Hemp cultivation was practiced in the vast majority of our country, especially in the provinces where it was permitted, until a generation or two ago. In fact, during the examinations, seeds collected from different regions were improved and certified under the names of “Vezir” and “Narlı”. In addition to these, new seed improvement projects continue at full speed. There are only 52 certified hemp seeds of German origin, and similar targeted seed improvement studies will continue in Türkiye.
- **Hemp is stronger than carbon and steel! Hemp does not burn! Hemp is antibacterial!** There are hundreds of such baseless information. Such statements mislead well-intentioned

hemp investors and strengthen the theses of groups that have a certain prejudice against hemp. As we have mentioned in general; hemp is a source of cellulose and cellulose-based structures can be given technical features through chemical processes. In particular, the cotonization process, which is becoming widespread, is basically designing hemp fiber as a sustainable textile fiber suitable for daily use. In addition to its countless qualities and benefits such as its contribution to the soil, its sustainability, carbon footprint, efficient production, unlimited usage area, and being the main raw material for mass production, hemp does not need unscientific approaches and unfounded praise. It is enough to look at the rapidly growing market share to understand the importance of hemp.

- **Hemp investment provides a very fast financial return!** Unlike other ventures, the expectation of hemp investors is that the investment will turn into “financial profit in a short time.” On the contrary, what those who will invest in the hemp sector should pay attention to is that the risks and opportunities that will arise when doing this business for the first time should be analyzed well.
- **Bureaucracy, politics and cannabis!** The hemp industry is a sector where the need for unity is expected more than other industries. The concern that hemp will be banned again due to politicians is expressed by different investors and they are hesitant to make investments due to this concern. Hemp awareness should be increased and one of the important national issues should be openly discussed in different channels. Especially, the expression of this emphasis at every stage of the bureaucracy will create a guarantee for the investor. Hemp is viewed positively or negatively according to the worldview and personality of individuals. Here, it is essential to save hemp from the “according to me – according to you” with a simple and standard language. Hemp is a national issue and is above politics. It will be a serious loss for our country’s industry if it is sacrificed to hesitation, suspicion, assumption and fear.

Image 5: Different area hemp production trials

- **Hemp is the business of farmers!** Today, no sector can survive alone. In this case, it is a mistake to leave hemp to the work of only one group. Hemp is a series of processes from seed to the targeted final product, and each step of these processes must be integrated with each other and interdisciplinary work is required. It is not possible for us to compete with the world in hemp without the unity of bureaucracy-science-sector.

3. CONCLUSIONS

Hemp Vision

After the Covid pandemic, hemp plays a leading role in the new world's search for sustainable raw materials. In order not to miss the train in the hemp industry, which has a five-ten-year history compared to advanced technological industries with a century-long development process, it is quite possible for developing countries to quickly adapt to hemp R&D and P&D studies and specialize in areas suitable for the country's infrastructure, and to brand as an outcome of this. While branding requires serious competition in developed sectors, the possibility and probability of branding in hemp is much higher. Our reaching a challenging position not only in hemp end products (textiles, oil, etc.) but also in hemp technology (machinery, know-how) depends on the planned investments we will make in the 5-10 year period [5].

Success in hemp depends on the holistic handling of all processes from seed to final product and the evaluation of the input-output balance with the highest added value products. Therefore, it is essential to start the hemp industry in the optimum way with interdisciplinary coordination and to manage the process correctly. Investing in hemp with temporary enthusiasm and urban legends will reflect negatively on the hemp sector - as in narcotic discourses - and will cause disappointment. Attributing entrepreneurial mistakes to hemp has caused serious damage to the sector in the last 5 years. These negativities are due to the wrong planning of the entrepreneur rather than hemp itself. First of all, it should be noted that hemp is not a plant/sector that will reach unlimited profit or break-even point quickly and make a profit in one year. This erroneous assumption misdirects all potential components of the sector and leads to an unnecessary pricing policy. The two main problems that worry domestic and foreign investors are the high costs of planting and harvesting and the lack of a ready market for the resulting material. Overcoming these two main problems is possible with serious and detailed feasibility R&D. A similar initial process is valid for all countries. The basic paradox here is: “Which comes first, the chicken (industry) or the egg (agriculture)?” With a serious and unprejudiced preparation of the feasibility, first the appropriate seed and planting area must be determined, then the design and production of value-added hemp products must be ensured [6].

Finally, evaluating hemp with a “Life Cycle Analysis (LCA)” rather than just the profit and loss provided by the developed product would be much more useful in understanding the importance and seriousness of the issue. The profit and loss analysis of the hemp business should be made by taking into account numerous side outputs such as improving the soil, contributing to the carbon tax, increasing harvest yield with rotational planting, and transforming the textile sector from a polluting to an environmentally friendly identity.

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