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SUSTAINABLE TECHNICS IN FASHION INDUSTRY- BIO MATERIALS AND VIRTUAL PROTOTYPING (PRACTIC APPLICATION)

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Abstract. *At the documentary synthesis stage for the elaboration of this work, it was found that, in the rush for external characteristics that imitate natural leather, producers of innovative "plant-based" or "bio-based" materials often use coatings made of petroleum products which makes them not 100% biodegradable. The aim of this work it to create a biodegradable and ecologic material which presents exterior characteristics related to natural leather and from which can be created functional clothing products. The interest in this field is reflected by the increasing wish of combining innovation and sustenability in fashion design, outlining the development of ecologic alternatives to traditional materials. At the basis of the search for the right biomaterial recipe for the collection to be made is the bio-leather recipe published in open access by Fabricademy, an intensive multidisciplinary learning program. By recreating the original recipe and carrying out multiple experiments, a new bio-material recipe was obtained, whose properties correspond to the requirements of the materials needed to make the collection. At the basis of the creation of the collection's models is the study of current fashion trends, the trendboard and the elaborate moodboard. The prototype of the basic model of the elaborated collection was initially made in a 3D drawing with the help of specialized software. The stage of making the model itself involves not only transforming digital designs into physical products, but also exploring the properties and possibilities offered by bio-materials in the context of making clothes. Through this approach, it investigates how new materials can be effectively integrated into the fashion design process, trying to find a balance between innovation, sustainability and functionality. This work represents a step towards a future in which fashion is not only the expression of style, but also of awareness and respect for the nature.*

Keywords: *biodegradable, environmentally friendly, model collections, sustainability.*

1. INTRODUCTION

Biomaterials represent a revolutional domain and in continue evolution in fashion industry, offering innovative solutions to sustenability challenges which face this industry. This materials are derivates from biological sources and are projected to interactionate with biological systems, either to replace or to improve them. There inclusion in fashion is not just a trend, but a necessity in the current context of awareness of the ecological impact and need for sustainability.

Traditionally, the fashion industry has been criticised for its unsustainable practices, such as the excessive use of natural resources, waste production, and carbon emissions. Biomaterials offer a promising alternative to this problem.

In the aim of reducing the environmental impact of fashion industry, a wide range of solutions, including fabrication of biomaterials, has been found. There are researches that prove that the fashion industry is responsible for 10% of world's annual carbon emission. Sustenable substances are mandatory if we want to modify garnment production into a more sustenable industry.

Biomaterials offer an enviromental friendly alternative. However, there are challenges in terms of production costs, widespread availability and durability compared to traditional materials. The

"Environmental Assessment of Textiles" offer a comprehensive perspective on the environmental challenges associated with the textile industry. Through their detailed analysis of the impact to the nature of textile fabrication, Laursen and LæReid contribute in the development of sustainable strategies and raise awareness to the importance of green practices in the fashion industry. [1]

The economic impact of the transition from traditional materials, such as those derived from petroleum, to bio- based materials, are disscused in studies by authors Patel, A. & Verma, N. and Desai, V. & Nair, R. [2,3] Biomaterials, although they are being more expensive at the first stages of searching and development, have the potential to become more accessible while the technology develope. [2] There is a lot of excitement around biomaterials and their challenges, such as production costs, lack of infrastructure, and strict regulations, which can hinder widespread adoption. [3]

A multidisciplinary perspective is adopted, highlighting the importance of collaboration between different academic and industrial fields to develop an effective curriculum. "There is an increased need for biomaterials specialists, and universities and research institutions are responding by offering study and training programs in this emerging sector." [4]

Biomaterials needs different methods of cultivation and production, which are often less harmful to the environment due to the absence of chemical pesticides and reduced water consumption. [5,6] Biomaterials, such as mushroom skin and algae fibres, have the potential to significantly reduce water consumption and wastes compared to traditional textile production methods. [6]

2. EXPERIMENTAL PART

2.1. Artistic design of the collection

Contemporary fashion trends are not only reshaping the fashion industry, making it more innovative, sustainable, and inclusive, but also, significantly, is influencing society. They contribute to a better understanding and acceptance of human diversity and promote a future in which the way we dress is in harmony with the values of respect for the environment and human diversity. These changes underline the role of fashion as a powerful cultural and social force, capable of inspiring and influencing attitudes and behaviors globally.

The trendboard developed (figure 1), after the trend analysis, is meant to bring to the fore the femininity of the body in contemporary fashion.

Figure 1. Trendbord

The Moodboard (figure 2) focuse on the intimate connection between the body and furniture, exploring textures of bio lether, shapes and fluidity which reflect and compliment human's body. The visual centralises natural skin tones, from light tones of beige to dark brown, reminding about earth and organic elements.

Figure 2. Moodbord

Fashion trends analysis for spring- summer season 2024, such as the trendboard and moodboard, served as an inspiration source for the fashion collection making. The elaborate collection of 5 outfits focuses on a minimalist approach to fashion design, with subtle accents that create visual interest while maintaining a cohesive and neutral color palette. Each outfit is designed to highlight different elements of the female form, using asymmetry, transparency and layering strategically, exploring the balance between form and functionality, playing with length and accents of interest.

Figure 3. Model sketches of the elaborate collection

Each outfit present a fluid and feminine silhouette, with an accent in waist and in bust's line. The silhouettes are varied, from straighter shapes to ones that follow the curve of the body.

2.2. Biomaterials' obtaining

The recipe behind the creation of the biomaterial, from which the main model of the collection will be made, is the bioplastic recipe from orange wastes. The project of Susana Jurado, Elisenda Jaquemot and Nuria Bonet, „Squeeze The Orange", aims to create from leftovers new things, being the response to the open call: „Remix el Barrio". [7] The following ingredients are needed to make the recipe: orange peels, sodium alginate, glycerine, coconut oil, wool fibres and calcium chloride.

The process of obtaining bio leather based on orange peels includes the following stages: preparing the orange peel (drying and grinding), mixing components, auditioning the wool fibres, drying the biomaterial. After the drying process, the bio-leather is ready for cutting and sewing. In order to obtain a biomaterial that will correspond to the appearance and structure characteristics necessary for the realization of the models of the designed collection, several tests and experiments will be carried out, modifying the basic recipe.

Table 1
Experiments of obtaining the biomaterial

Necessary ingredients	The obtained result	
	Short description	Photos
I. Original recipe based on sodium alginate with the addition of orange peel		
- 125g sodium alginate, - 421g glycerine 99,5%, - 20g wool fibres, - 56g coconut oil, - 120g drying orange peel, - 5 litres of water, - calcium chlorine solution.	The colour of the material obtained, due to the pigment in the orange peel, is a light orange and is semi-transparent to light. The density and presence of an unusual texture are provided by orange peel, while the elasticity, stability of the material and its strength are due to the woollen fibres in the composition.	
II. Updated recipe- biomaterials based on cotton fabric		
- 125g sodium alginate, - 421g glycerine 99,5%, - cotton fabric 100%, - 56g coconut oil, - 120g drying orange peel, - 5 litres of water, - calcium chlorine solution.	The experiment demonstrated that textile fabric can be used as a basis for bio leather. A natural, 100% biodegradable fabric was used, so as not to negatively influence the concept of sustainability. The rare fabric has been selected so that the biomass can penetrate between the fibers, thus ensuring a solid connection with the textile base.	
III. Update recipe – without wool fibre		
The same components and quantities were used as in the case of the recipes described in experiment I and II. Only the wool fibres were excluded from the recipe.	The material obtained is quite resistant, but it is not as pleasant to the touch compared to the version that contains wool in the composition.	
IV. Update recipe- replacing orange peel powder with coffee grounds		
- 125g sodium alginate, - 421g glycerine 99,5%, - 56g coconut oil, - 120g coffee grounds, - 20g wool fibre, - 5 litres of water, - calcium chlorine solution.	The biomaterial obtained has similar characteristics to the biomaterial obtained in experiment I, the only difference being the colour. Due to the pigment in the coffee grounds, the material took on an intense shade of dark brown.	
V. Update recipe- with coffee grounds, without wool fiber		

- 125g sodium alginate, - 421g glycerine 99,5%, - 56g coconut oil, - 120g coffee grounds, - 5 litres of water, - calcium chlorine solution.	The material obtained is quite resistant, pleasant to the touch.	
VI. Update recipe – without wool fibre and addition of food waste		
- 125g sodium alginate, - 421g glycerine 99,5%, - 56g coconut oil, - 20g wool fibre, - 5 litres of water, - calcium chlorine solution.	The resulting biomaterial is thin, but at the same time quite resistant and elastic. Due to the small thickness, it turned out to be more suitable for creating folds in clothes. The biomaterial obtained is more transparent, having a milky white colour.	

2.3. Observations and recommendations

As a result of the recipes, the following recommendations were established:

1. The original recipe can be remade easily, provided that all the necessary components are available, in order to obtain bio leather suitable for making clothes.

2. The most complicated and lengthy stage is the process of drying the bio leather. It is divided in two phases: in the first 2-3 days, the biomass hardens in the frame lined with a waterproof material, after which it must be transferred to a mesh frame. To understand when the bio leather is ready to transfer from the first frame to the second, in the first 3 days, you need to pick it up from the edges and observe how easily it detaches from the foil. If a wet trace remains on the foil, this means that the bio leather is not yet ready and there is a high risk that it will break when transferred. For complete drying, 7-10 days are needed.

3. In the process of drying, the bio leather reduce itself with about 1/3 from initial dimension after moulding into the shape.

4. The biomass must be evenly distributed on the surface where it is poured using a plastic spatula. The thickness of the bio leather can be adjusted with the plastic spatula, distributing the mass in a thin or thick layer.

5. After pouring the biomass into the form, it must be sprayed with a solution of calcium chloride. This not only speeds up the drying process, but also influences the appearance of the skin (without the addition of calcium chloride, the bio leather came out thicker and less uniform).

6. Upon contact with water, the liquid coconut oil, at room temperature, becomes solid. Because of this, it is necessary to mix all the components very well with each other using a blender.

7. Experiments III and V demonstrated that wool fibers are a very important component for the creation of bio leather. Wool fibers give the material structure, softness and tear resistance. Due to this component, bio leather becomes more suitable for sewing clothes and for further use.

8. Experimental methods have shown that leftovers from the food industry, such as orange peel, can be replaced by other components (e.g. coffee grounds). It has also been proven that these additives are not essential components in the composition of bio leather and their use can be dispensed with. Their main role is to add density to the material, color it with natural pigments and give the material a specific smell.

9. Although experiments I, II, IV and VI showed an interesting result and the quality of bio leather proved to be suitable for the creation of clothes, it was decided that the biomaterial obtained in experiment VI is the most suitable for the realization of the collection elaborated in the present work.

2.4. 3D model design

The process of designing the model proposed for realization in Clo3D involves several essential steps to transform the idea of a bio leather set into a detailed and achievable digital design. The 3D visualisation, made with the help of Clo3D, allows us to give up the consumption of resources (such as time, material, electricity) for the creation of prototypes, allowing us to obtain the desired fit on the figure through the 3D visualisation.

The stages of creating the 3D clothing model include:

1. selecting the avatar from the Clo3D library and customising it;
2. elaboration of the basic construction of the product;
3. positioning the landmarks on the avatar's body and executing the digital stitches and the initial simulation;
4. creating the inner layers;
5. creating templates and framing milestones;
6. placing textures and graphic effects (figure 4);

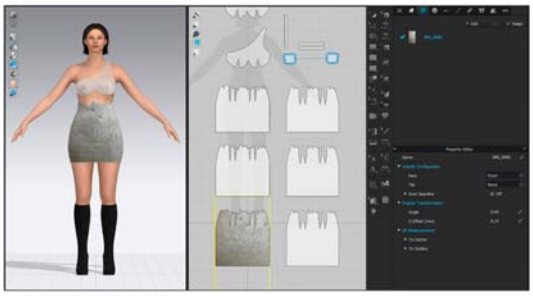

Figure 4. Placing textures and graphic effects

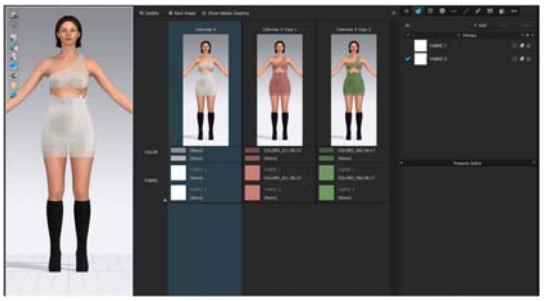

Figure 5. Diversification of the assortment by using different types of biomaterials

7. diversification of the assortment by using different types of biomaterials (figure 5);
8. creating the renderer;
9. visualisation of the final model (figure 6).

Figura 6. Visualisation of the final model

2.5. Realisation of physical model

The stage of making the real model allowed testing the reality and functionality of the biomaterial in the context of clothing making.

It should be emphasised that the whole process had a profoundly experimental character. The lack of precedent or experience gained in creating garments from bio leather added a considerable degree of complexity to the project. During this process, it has been observed that working with bio leather has distinct particularities compared to traditional textiles. The differences were noted in several phases of the production process.

The first differences were noticed at the cutting stage. Unlike the traditional materials, biomaterial does not exhibit yarn directions, such as warp and weft. There is also no well-defined front and back of the material. These two aspects were advantageous for us, because the amount of material available is limited and its quality is not uniform, so we were able to select the best parts of the material for tailoring and place the details to have enough biomaterial for all the component parts of the product. This advantage gave us the opportunity to experiment with the placement of the pieces and explore new design possibilities, adapting to the unique characteristics of bio leather and making the most of the available resources.

In the process of sewing, the biomaterial turned out to be quite easy to process and did not require special equipment; the results are uniform and secure. The biomaterial requires special processing, as previously mentioned, in areas with greater stress, areas such as the drawstring, the place of insertion of the zipper on the skirt, as well as the straps and adjustment straps of the top. These areas are doubled with leather inserts.

Figure 7. Cord Area Processing

3. RESULTS AND DISCUSSION

By analysing current trends, the importance and need for a more environmentally conscious approach in contemporary fashion is highlighted. The exploration and implementation of biomaterials in harmony with the aesthetics of the female body, represents an important step in embracing fashion that not only celebrates beauty, but also promotes ecological responsibility.

The design process, from the creation of 3D patterns to the actual realisation of products, emphasises the efficiency and benefits of using modern technology in reducing resource consumption and accelerating the product development process. It demonstrates how emerging technologies can contribute to a more sustainable design process, without compromising the quality or aesthetics of the final products.

The technological process of making the model demonstrates that the bio leather obtained offers new perspectives in the creation of clothing, challenging traditional norms. In the cutting process, it has been observed that bio leather offers flexibility due to the lack of specific fibre directions and a clear differentiation between the front and the back, allowing an efficient use of the material. However, challenges such as the inability to use traditional methods of marking material required creative solutions. At the assembly stage, the additionally load-bearing details were reinforced with genuine leather inserts (figure 8), showing a balance between biomaterial innovation and the practical needs of fashion design. This step was important for ensuring the durability and functionality of the finished product.

Figure 8. Skin preparation stage

The experience of sewing bio leather was positive, the material proving to be easy to handle and sew without requiring special equipment. The resulting seams were uniform and secure, indicating the potential of bio-leather as a viable alternative to traditional materials in fashion design.
This experience highlights the adaptability of the biomaterial for various applications in fashion design. The ease with which this material is worked and the strength of the seams has important advantages, especially in combination with the reinforcement measures applied in key areas.

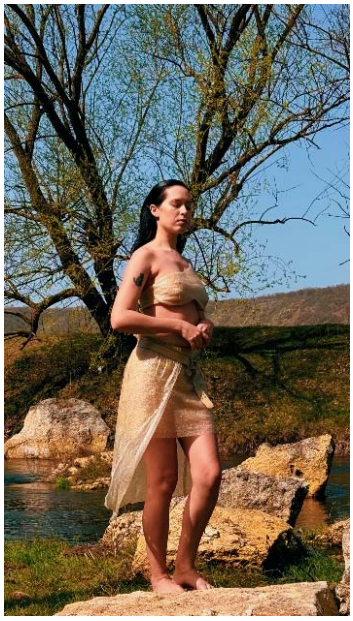

Figure 9. Final prototype

Since the final prototype obtained is proposed to be worn under normal conditions, the issue of the resistance of the biomaterial was raised. It was observed its durability in the process of worn through the shape stability. While wearing the product, it gives a feeling of comfort by feeling cool when it is worn in summer or warm if it is worn under other clothes.

Also, the biomaterial was tasted in aqueous medium. The beginning of the decomposition process was observed in the first hour of contact with water. After 24 hours its total decomposition is observed, except for wool fibers. It should be mentioned the possibility of reusing wool fibers in obtaining other biomaterial samples. From the experiments result the following recommendations: periodic cleaning with the help of a soft cloth soaked in soapy water solution; storage in a dry, well-ventilated place, away from sunlight and other direct heat sources.

Through the use of bio leather, an innovative and environmentally friendly material, it demonstrates how traditional approaches in tailoring and assembly can be adapted to meet the needs of new and unique materials.

4. CONCLUSIONS

Biomaterials allow designers to explore new aesthetics and functionalities, paving the way for innovations in design and production. From clothes made from mushroom leather to accessories made from bioplastics, the possibilities are almost endless. These materials not only offer an eco-friendly alternative, but also bring a new aesthetic and textural dimension to contemporary fashion. Therefore, the integration of biomaterials into the fashion industry is not only a step towards a more sustainable future, but also a source of innovation and creativity. With huge potential to reshape the way we think, design and consume fashion, biomaterials can play a crucial role in transforming the fashion industry into one that is more responsible and attentive to its impact on the planet.

The paper illustrates how material innovation can be successfully integrated into traditional tailoring processes, paving the way for new possibilities in sustainable and eco-friendly design. The observations in the process of making the model proposed for elaboration are valuable for the adjustment of the working techniques and for the continuous optimization of the process of creating clothes from biomaterials.

These discoveries contribute not only to academic development in the field of fashion design, but also to industrial practices, promoting a more conscious and environmentally friendly approach.

With all these advantages, there are challenges in the widespread adoption of biomaterials in light industry. Their production can still be expensive compared to traditional materials. In addition, continuous research is needed to improve the durability and functionality of these materials.

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