Biocomposite Utilising Garut Sheep Wool Material Using Smocking Technique

Rachmania Sukma Anjani[1] and Asyifa Rachmadina Jiniputri[2]

[1] Institut Teknologi Bandung, Indonesia, anya.rachmaniaa27@gmail.com
[2] Institut Teknologi Bandung, Indonesia. asyifa.jiniputri@office.itb.ac.id
anya.rachmaniaa27@gmail.com

Abstract. One of the efforts in implementing the idea of Sustainable Development Goals (SDGs) is the creation of alternative textile materials in the form of biocomposites that combine natural matrix and fibers to enhance mechanical properties with natural materials. The demand for biocomposites increased from around 2.05 million tons in 2017 to approximately 2.43 million tons in 2024 as reported by European Bioplstics (2018). These data indicate that biocomposites are becoming an appealing material for consumers in this era. Especially in their application to fashion products, which still require further comprehensive studies. Additionally, according to [8], the utilization of wool from existing sheep in Indonesia has not been significant so far. Therefore, it is recommended to explore the potential of sheep wool as a material for the handcraft industry.This research utilizes gelatin and agar-agar as the matrix, along with Garut sheep wool as the filler. Biocomposites have favorable characteristics for textile applications, such as having strong tensile strength, and adjustable thickness and elasticity, thus having the potential to be utilized in artwear products. The method employed in this study involves the creation of materials through the boiling of gelatin (144gr), agar-agar (22gr), Garut sheep wool (5gr), glycerin (49ml), and natural dye, indigofera, for approximately 15 minutes. The result in liquid form, is then poured into a plastic container and left to dry for approximately 3-4 days. The produced sheets are further processed using smocking techniques. The outcome of this research is a textured textile sheet measuring 20x20 cm, visually resembling coral formations found in the ocean. The modular samples then combined by following the design inspired by coral reefs, incorporating its composition and forms. In conclusion, biocomposite as an alternative material can be created using gelatin, agar-agar, and Garut sheep wool, resulting in textiles suitable for application in artwear, offering new visual and imagery possibilities. If further research is conducted, the biocomposite material in this research has the potential to be applied to interior products, packaging, and supporting materials for the automotive industry.

Keywords: Biocomposite, Garut Sheep Wool, Smocking, Artwear

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1 Introduction

One rapidly developing industry that plays a significant role in Indonesia is the textile industry. Its growth is promising, reaching approximately 0.85% per year (Amdani,2004). According to the Minister of Research and Technology Regulation No. 38 of 2019 on National Research Priorities (NRP) for the years 2020-2024, the focus is on engineering with one of its points being the development of fiber, textile, and textile product technologies, including value-added and environmentally friendly fiber and textile products. Dwi Ngesti Suwitaningsih also revealed data indicating that the global population currently consumes resources 1.7 times more than the Earth can provide, sparking the concept of Sustainable Development Goals (SDGs). One effort to implement this concept involves replacing more environmentally friendly materials to support this rapid industrial development. Alternative or sustainable materials are those used throughout the industrial economy, produced according to demand, and renewable without depleting or damaging natural resources and environmental balance). Environmental awareness has driven researchers to create new composites using more than one reinforcement of natural resources, a concept known as hybridization. Hybridization involves combining natural matrices and natural fibers to enhance the mechanical properties of the resulting material, known as a biocomposite [1]. Biocomposite materials are renewable, allowing their production process to reduce energy consumption and production costs [2].

A biocomposite consists of a natural polymer matrix and natural fibers as reinforcement. The matrix serves to protect and bind the fibers to effectively withstand forces, requiring materials that are resilient, flexible, and chemically resistant. Natural fibers are used as fillers to enhance characteristics such as stiffness, strength, and other required mechanical properties of the composite material. Fiber fillers are used to bear most of the forces acting on biocomposite materials, necessitating strong, rigid, and brittle fibers [9]. Natural fibers are derived from sources like plants and animals. One of the natural fibers extensively used in Indonesia is the wool of the Garut or Priangan sheep. The Garut sheep has convincing potential for wool utilization due to being a crossbreed between local sheep and the merino sheep, a renowned wool producer [5].

According to data, the global demand for bioplastics is expected to rise from around 2.05 million tons worldwide in 2017 to approximately 2.44 million tons in 2022. Biocomposite research has diversified significantly, extending beyond construction materials to rapidly growing fields like bioplastics, which involve the reinforcement of cellulose-based materials, such as wood plastic composites (WPC) or injection-molded natural fiber-polymers [2]. The addition of natural fibers or fillers can enhance the quality of bioplastic materials, as they act as the polymer matrix in the biocomposite [6]. This data suggests that biocomposites are poised to attract consumers in this era, particularly in applications within the fashion industry where studies are still limited. Additionally, according to [8], the utilization of wool from existing sheep in Indonesia remains underexploited, highlighting the potential for utilizing sheep wool for handicraft industries. Biocomposites with a mixture of sheep wool fibers using smocking technique have the potential for application in fashion products that align with its character. This study focuses on enhancing the strength of biocomposite that has wool fibre on it using the smocking technique. The final artwork takes inspiration from various coral formations found in the ocean. The smocking technique is employed to enhancing the strength of the biocomposite itself. Application to artwear products is used to optimize the forms obtained from the smocking technique, resulting in novel visuals, shapes, and imagery for materials and techniques that have seen limited exploration.

In light of the background information provided, the research problem is articulated as follows: firstly, previous research highlights the necessity of enchanching the mechanical properties of a composite material composed of agar-agar and gelatine, hereafter referred to as a biocomposite by incorporating sheep wool material and employing the smocking technique. Secondly, the biocomposite material enriched with a blend of sheep wool fibers using the smocking technique holds significant potential for application in the fashion industry, particularly in the creation of artwear products that align with its inherent characteristics.

Building upon this research formulation, the study aims to achieve two primary objectives: firstly, to investigate the impact of incorporating sheep wool fiber material into the mixture of agar-agar and gelatine using the smocking technique on the enhancement of the mechanical properties of the biocomposite. Secondly, to innovate the creation of artwear products by utilizing biocomposite material infused with sheep wool fibers and crafted with the smocking technique.

Furthermore, in exploring the subject matter, it is important to note that Garut sheep known for their various applications, although they typically exhibit slow wool growth. The coarse fur of Garut sheep characterized by the presence of a considerable medulla, result in cavities along the length of the wool fiber. Additionally, smocking technique, as defined by WordNet Princeton, is a decorative stitching method used to create folds and textires through intricate hand-stitching. It serves the dual purpose of gathering and securing fabric with stitches while allowing for flexibility and stretch and also regulating the fabric's width by uniting it in tight, small folds.

2 Research and Method

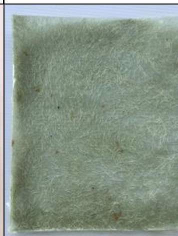
The methodology used in the research process is a combined qualitative approach. The qualitative method is used to explore the extent to which the smocking technique can be applied to the characteristics of biocomposite sheets. Reference guides for the polymer matrix composition of the biocomposite come from previous research conducted by [7]. The filler composition of the biocomposite is based on the "Bioplastic Cook Book" by [4].

Experimentation is carried out to determine the appropriate composition of biocomposite materials to achieve sheet quality suitable for smocking technique. Exploration in this research involves exploring the smocking design technique and color exploration. Creating a concept involves planning, sketching, moodboarding, and creating an image board along with theme selection. This is an important step to set boundaries and focus for the research. The experiment begins by cooking biocomposite sheets which is subsequently molded into a plastic board container measuring 40x80cm. The mixture comprises glycerin, gelatine, agar-agar, wool, indigo paste, and several additional ingridients such as fragrances and sodium benzoate. The sheets are then left to dry in the sun for approximately 3 days. The next step involves removing the sheets from the mold and cut them into 20x20cm pieces, which serve as the size for one module. Each modul is sewn according to a pre-determined smocking pattern using nylon thread. The modules are joined together by sewn to each other. The final product requires 125 modules with 4 different smocking pattern.

2.1 Biocomposite Material Experiment

This experiment was conducted to determine the appropriate and effective composition of biocomposite materials. It aimed to identify the correct treatment and amount of sheep wool fiber to achieve the maximum mechanical properties of the biocomposite.

Table 1. Biocomposite Material Experiment

N	1	2	3	4	5
Picture					
Recipe	Water (245 ml) Gelatine (63 gr) Glycerin (21 ml) Agar-agar (16 gr) Sheep's wool (2,5 gr)	Water (210 ml) Gelatine (54 gr) Glycerin (18 ml) Agar-agar (14 gr) Sheep's wool (2 gr)	Water (210 ml) Gelatine (54 gr) Glycerin (18 ml) Agar-agar (8,5 gr) Sodium benzoate (1 gr) Jasmine fragrance solution (2 ml) Sheep's wool: (cut into small pieces) (2 gr)	Water (210 ml) Gelatine (54 gr) Glycerin (18 ml) Agar-agar (8,5 gr) Sheep's wool (6 gr): (the sheep wool fibers were soaked in a soda solution with the following proportions: 20 grams of fiber, 2 liters of water, and 10 grams of soda.)	Water (210 ml) Gelatine (54 gr) Glycerin (18 ml) Agar-agar (8,5 gr) Sheep's wool (6 gr): (The mixture was left in the soda solution for 5 days until it resembled a paste.)

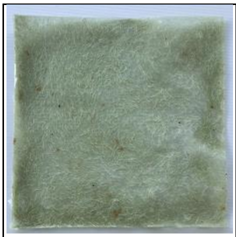
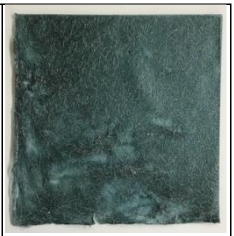
Analysis	Sewing was difficult due to lack of flexibility and excessive thickness.	The length of the sheep wool fibers caused clumping in some areas and uneven thickness.	Thickness became uniform by cutting the sheep wool fibers into smaller pieces and reducing the amount of agar-agar, resulting in a more liquid solution.	The visual appearance of the sheep wool fibers disappeared as they integrated into the solution.	The biocomposite structure was stickier and required more time to dry.

Based on the above experiment, biocomposite number 3 was selected as it exhibited good flexibility and strength, making it suitable for the semocking technique. Additionally, the texture of the sheep wool fiber was still visible. The thickness of the sheet was even without clumps. It is suggested to add a scented solution and a preservative (sodium benzoate) to prevent fungal growth and reduce unpleasant odors from the biocomposite sheet.

2.2 Color Exploration

Color exploration on the biocomposite material was conducted to determine the appropriate amount of natural indigo dye to achieve different final colors. Indigo paste was selected for dyeing due to its stable color results throughout the cooking and drying processes. Indigo dye also offers a wide range of color variations. In this exploration, the indigo paste was dissolved in water and added to the solution during cooking. The biocomposite recipe used for the dyeing experiment was recipe number 3 in the Table 1.

Table 2. Color Exploration Result on Biocomposite

			
Water (9 ml) Indigo Paste (6 gr) Indigo Solution (1 gr)	Water (9 ml) Indigo Paste (6 gr) Indigo Solution (3 gr)	Water (9 ml) Indigo Paste (6 gr) Indigo Solution (5 gr)	Water (9 ml) Indigo Paste (6 gr) Indigo Solution (9 gr)

Based on the results of dyeing experiment, it can be concluded that natural indigo dye can produce shades of green and blue as well as their derivatives. Moreover, the dyeing process did not affect the texture of the sheep wool fibers visible on the surface of the biocomposite material. The colors explored in the above table can be used as a color palette for creating the final artwork to match the concept.

2.3 Smocking Exploration

Exploring the smocking technique aimed to determine the extent to which this technique could be applied to the previously created biocomposite material experiment. The smocking patterns were inspired by various coral formations based on their growth. Coral animals are the primary builders of coral reef ecosystems. Small coral animals, known as polyps, form colonies collectively referred to as coral. According to the Lifeform Coremap Manual, coral types are classified based on their growth forms into seven types: (a) Branching, (b) Tabulate, (c) Mushroom, (d) Digitate, (e) Massive, (f) Encrusting, and (g) Foliose as depicted in Figure I. The exploration involved creating basic patterns first.

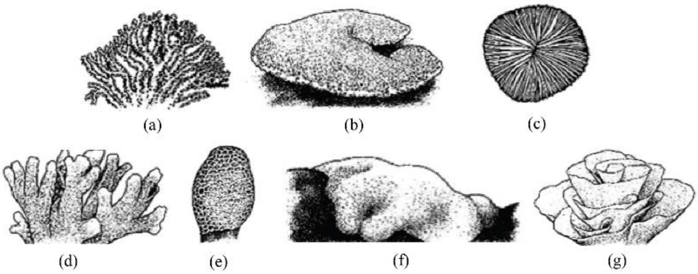
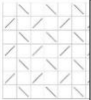
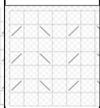
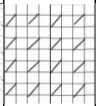
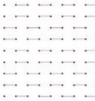
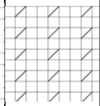
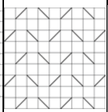
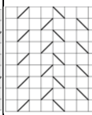
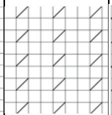
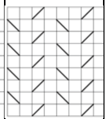


Fig. 1. Coral Growth Form

Table 3. Smocking Exploration Result on Biocomposite

	1	2	3	4	5	6	7	8	9
Coral Texture									

Smocking Result									
Smocking Pattern									

Based on the experiment in creating the biocomposite material, an initial analysis of its physical and mechanical properties was conducted:

1. Biocomposite with a matrix of agar-agar and gelatin with Garut sheep wool as filler possesses suitable characteristics and potential for the smocking design technique because it has the appropriate thickness.

2. The thickness of the biocomposite needs to be considered for achieving optimal smocking patterns. Excessive thickness obscures the pattern, while overly thin material becomes brittle and lacks dimension.

3. For a neat final appearance, nylon thread is recommended for smocking due to its transparent color, ensuring it doesn't disrupt the final visual outcome. Additionally, nylon thread is stronger than cotton thread.

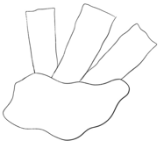
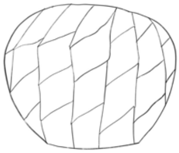
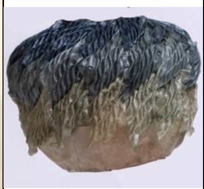
4. Not all smocking patterns are applicable to biocomposite sheets. Triangular or rectangular patterns can cause excessive stress on the sheet, increasing the likelihood of tearing.

5. The smocking patterns that can be progressed to the next stage are numbers 4, 5, 6, 7, 8, and 9. These patterns produce clear and visible designs. Moreover, they are not time-consuming, making them effective for creating larger quantities.

2.4 Module Combination

The next step after combining the module shapes in Table 3 is to create a complete sketch of a coral formation consisting of the assembled modules themselves. The sketch is based on the reference shape of coral colonies. This step is taken to facilitate the process of composing the overall garment shape, ensuring balance and silhouette.

Table 4. Module Combination Sketch

Form of Coral Colonies				
Module Combination Sketch				
Result				

3 Result

3.1 Tabumalatte

This product yields a more dimensional outcome resembling massive coral types, with a block-like appearance. The upper part of the look resembles tabulate coral, where the surface is flat, thin, and branches horizontally.

Fig.2. Product Result (Tabumallate)

3.2 Tateralle

Tateralle is the second look in the Vari Coralli collection. The shape of Tateralle resembles digitate coral, characterized by its branching, tight branching, and regular sideways growth. This shape is visualized in the upper part of the look, balanced with a fit body lower part for an elegant impression.

Fig.3. Product Result (Tateralle)

4 Conclusion

Based on the experiments and explorations conducted, the following preliminary conclusions can be drawn:

1. Biocomposite with an agar-agar and gelatin matrix along with Garut sheep wool as filler has suitable characteristics for exploring the smocking technique. These characteristic include having sufficient thickness and tensile strength, ensuring that they don't tear when stitched and bonded together. However, not all smocking patterns can be applied to biocomposite sheets.

Triangular or rectangular patterns can cause excessive stress on the sheet, increasing the likelihood of tearing.

2. Adding sheep wool fiber material to the biocomposite enhances its structural composition. The material can be sewn and does not tear easily.

3. The mechanical properties of the biocomposite are also improved due to the smocking technique. When smocked biocomposite modules are combined, their strength is significantly enhanced, making them more resistant to tearing.

4. Biocomposite material with a mixture of sheep wool fibers using the smocking technique can be used as a base material for garment creation.

References

[1] Borba, P. M., Tedesco, A., & Lenz, D. M. (2013). Effect of reinforcement nanoparticles addition on mechanical properties of SBS/curauá fiber composites. Material Research, 17, 412–419.

[2] Cassanova, Bsf. (n.d.). Bio Komposit, (pp. 1-3).

[3] Craik, J. (2009). Fashion: The Key Conc*ept.* Berg.

[4] Dunne, M. (n.d.) Bioplastic Cook Book. Retrieved from https://issuu.com/nat_arc/docs/bioplastic_cook_book_3

[5] Hudaya, A. (2014). Laju Pertumbuhan dan Kualitas Wol Domba Batur dan Domba Garut. [Doctoral dissertation, Institut Pertanian Bogor].

[6] Ibrahim, N.I., Shahar, F.S., Sultan, M.T.H., Shah, A.U.M., Safri, S.N.A., Mat Yazik, M.H. (2021). Overview of Bioplastic Introduction and Its Applications in Product Packaging.16.

[7] Rachmani, Aqila. (2021). Eksplorasi Material Biodegradable Plastic dengan Pewarna Alam pada Produk Kriya [Bachelor's Thesis, Bandung Institute of Technology].

[8] Syamyono O., Inounu & Yamin, M. (2003). Karakteristik Bulu Domba Priangan dan Persilangannya. JITV, 8(3), 205-210.

[9] Van Vlack. (2005). Ilmu dan Teknologi Bahan, Erlangga.