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Implementation of Green Innovation in Designing Sustainable Tourism Souvenirs Using Biocomposite Material from Waste of Empty Palm Oil Bunches (EFB) to Support IKN Branding as the Greenest Country Capital in the World

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Abstract

Souvenirs have an important role in supporting regional economic development, souvenirs can also function as an important symbol of identity and culture because they can contribute to the preservation and promotion of local traditional heritage. But on the other hand, the souvenir industry also has the potential to damage the environment. Therefore, it is important to ensure that souvenir production and consumption practices use sustainable principles. The increasing level of deforestation and forest degradation in East Kalimantan due to IKN development needs to be balanced with green innovation. One of them is exploring renewable materials as raw materials for superior regional products. Indonesia has an abundance of empty oil palm fruit bunches (EFB), for every 1 ton of palm oil there is 23% or 230 kg of EFB waste. With its quality and uniqueness, this EFB biocomposite material is suitable as the basic material for sustainable tourism souvenirs as an Indonesian identity. This research aims to develop sustainable tourist souvenir designs made from EFB waste as one of the branding of IKN souvenirs for the international market. The identification in this research used the Design-driven Material Innovation (DDMI) method. DDMI is a product design design model that starts from material development from understanding material characteristics, and creating product lines, to communicating the uniqueness of materials to the market. This research produces designs and prototypes of sustainable tourist souvenir products that are ready to be made on an industrial scale.

Keywords: Biocomposite, EFB, Green innovation, IKN, Sustainable tourism souvenir.

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Abstrak

Cinderamata memiliki peran penting dalam mendukung pembangunan ekonomi daerah, cinderamata juga dapat berfungsi sebagai simbol identitas dan budaya yang penting karena dapat berperan dalam mendorong pertukaran budaya, serta berkontribusi dalam pelestarian dan promosi warisan adat setempat. Namun di sisi lain, industri cinderamata juga berpotensi merusak lingkungan. Oleh karena itu, penting untuk memastikan bahwa praktik produksi dan konsumsi cinderamata menggunakan prinsip berkelanjutan, serta memperhatikan aspek keberlanjutan lingkungan. Meningkatnya tingkat deforestasi dan degradasi hutan di Kalimantan Timur akibat pembangunan IKN perlu diimbangi dengan inovasi hijau sebagai upaya menghasilkan produk, proses atau teknologi baru yang ramah lingkungan. Salah satunya dengan eksplorasi material terbarukan sebagai bahan baku produk unggulan daerah. Indonesia memiliki limbah Tandan kosong kelapa sawit (TKKS) yang melimpah, dalam setiap 1 ton kelapa sawit terdapat limbah TKKS sebanyak 23% atau 230 kg. Dengan kualitas dan keunikannya, material biokomposit TKKS ini sangat layak digunakan sebagai material dasar souvenir wisata berkelanjutan sebagai identitas Indonesia (IKN). Tujuan dari penelitian ini adalah untuk mengembangkan desain souvenir wisata berkelanjutan berbahan limbah TKKS sebagai salah satu branding souvenir khas IKN untuk pasar internasional. Identifikasi yang dilakukan pada penelitian ini menggunakan Design-driven Material Innovation (DDMI). DDMI adalah model perancangan desain produk yang berangkat dari pengembangan material mulai dari pemahaman karakter material, membuat lini produk, hingga bagaimana mengkomunikasikan keunikan material pada market. Penelitian ini menghasilkan desain dan prototipe produk souvenir wisata berkelanjutan yang siap diproduksi dalam skala industri.

Kata Kunci: Biokomposit; Green innovation; IKN;; sustainable tourism souvenir; TKKS

1. Introduction

In the past 25 years, Indonesia has lost almost a quarter of its forest land. The areas with the highest degradation are in Kalimantan and Sumatra, which in 2016-2017, lost 68% and 51% of their forest areas. This deforestation occurred mainly due to logging that was not in accordance with regulations and was not balanced by reforestation (replanting), as well as the conversion of forests into industrial areas (Nurfatriani, et al., 2018). The rate of increase in deforestation and forest degradation in East Kalimantan is very significant, from 89,000 hectares per year to 157,000 hectares per year, along with the development of the Archipelago as the new National Capital City (IKN) (Irmawan, et al., 2023). This needs to be balanced with innovation to produce new products, processes, or technologies that are environmentally friendly, efficient in the use of resources, and reduce negative impacts on the environment, namely Green Innovation (Guinot, et al., 2022). The development of the IKN is followed by the development of the tourism sector and the creative economy in it (Supriyanti, et al., 2023). Tourism and souvenirs are interrelated industries that contribute significantly to the economic development of many countries (Syaputra, et al., 2022). On the other hand, the souvenir industry also has the potential to hurt the environment.

Data from the United Nations World Tourism Organization (UNWTO) shows that there is an impact of tourism on global warming as an important issue in the 21st century (Scott, et al., 2019). This arises based on tourism that does not fully consider the economic, social, and environmental impacts (Spenceley, et al., 2019). In a study related to carbon footprint, it was stated that the ratio of emissions contributions that have an impact on climate change and the environment includes transportation 56.3%, souvenirs 23.2%, accommodation 9.8%, food and beverages 7.4%, and 3% other activities (Kitamura, et al., 2020). Thus, the increase in the size of the tourism industry in a region will be directly proportional to the amount of emissions released. The world tourism industry also focuses on implementing "Sustainable tourism souvenirs for SDGs" which aims for sustainable development. International trends like this require actions that include the concept of sustainability, not only developed countries but also developing countries like Indonesia must focus on preparing for this ideal condition (Trupp, et al., 2020).

In 2022, Indonesia was recorded as the largest palm oil-producing country in the world (Data from the United States Department of Agriculture (USDA). Every 1 ton of palm oil produces waste in the form of empty oil palm bunches (EFB) of 23% or 230 kg (United States Department of Agriculture, 2023). This is a very large amount and has the potential to be used as a new material. Solid waste from the palm oil industry contains high organic matter, but when the waste handling process is not carried out properly it will pollute the environment (Pakpahan, et al., 2020). EFB can be processed into a strong but lightweight biocomposite if combined with mycelium as a matrix (adhesive) (Lubis, et al., 2023). With its quality and uniqueness, this EFB biocomposite material is very suitable for use as a basic material for sustainable souvenirs as a means of branding the IKN in realizing green tourism.

To realize the world's ideals as stated in the Sustainable Development Goals (SDGs), joint efforts are needed to realize them. One of the problems that occurs in various countries is the damage to the terrestrial ecosystem caused by the condition of the proportion of degraded forests to the total land area (Brodjonegoro, 2022). This research supports the SDGs, especially in the following 4 points:

- **Industry, innovation and infrastructure:** providing new material innovations in the tourism industry
- **Sustainable cities and communities:** realizing the IKN as a sustainable city by supporting the formation of green tourism
- **Responsible consumption and production:** ensuring sustainable souvenir production and consumption patterns
- **Life on land:** stopping forest desertification, restoring land degradation, and stopping the loss of biodiversity by reducing the consumption of forest wood as raw material for souvenirs

This paper explains the creative process of recycling Empty Oil Palm Bunches (EFB) waste using mycelium matrix into Sustainable Tourism Souvenirs designs using the Design-driven Material Innovation (DDMI) method. DDMI is a product design model that starts from material development starting from understanding the character of the material, creating a product line, to how to communicate the uniqueness of the material to the market (Hornbuckle, 2020). DDMI has four steps as follows:

1) **Sensing** - The stage where the designer studies the context in which the material will be applied, as well as its users. The lifestyle and aesthetic qualities desired by the user are elaborated. In addition to understanding the user, designers at this stage study the technical and aesthetic characteristics, as well as the performance of the material.
2) **Sensemaking** - The stage where designers begin to develop product ideas that can be made with the material and its scenarios. Designers build a vision of the material by asking the 4 W questions: What (describe), Why (explain), Will (predict), and What if (estimate).
3) **Specifying** - To give a new meaning to a product, design elements need to be defined precisely. At this stage, designers select ideas that already exist in the previous stage to become a prototype
4) **Setting up** - At this stage, designers have chosen a prototype that is worthy of being developed. At this stage, the narrative story of the product with the new material is built.
5) **Placing** - The stage where designers think about product placement in the market. Whether it will be offered to B2B or B2C clients.

2. Methods

The approach used in this study is qualitative with the type of exploratory research "research through design" where this study seeks to gain new knowledge from design activities. This study uses Design-driven Material Innovation (DDMI), a systematic design method using innovative materials that have never been applied before, which involves five stages of the process including; data collection, sensing, sensemaking, specifying, setting up, and placing (Tubito, et al., 2019). This study also contributes to the realm of product design science by guiding product designers on how to create new innovative materials using the stages of DDMI.

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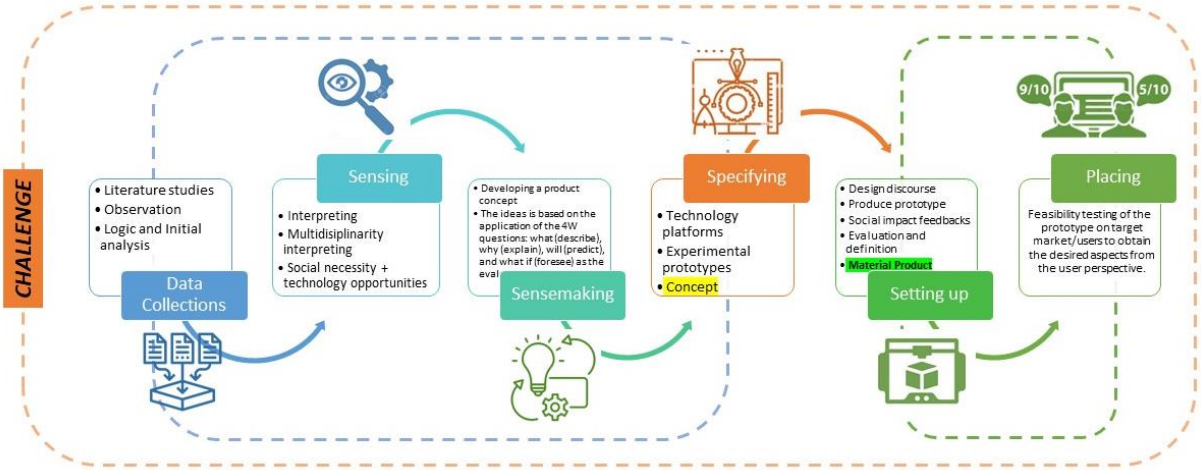

Figure 1: Research with Design Driven Material Innovation Method

2.1. Data Collection (Data Collection)

This research begins with collecting data through "technical-cognitive" which includes logic, observation, and initial analysis regarding the main material to be developed. Next, "sensor-analysis" was carried out to find out the literature about production lines or processes that could be applied to this research. This research is supported by literature studies sourced from several databases, namely ResearchGate, Portal Garuda, Core, DOAJ, and ScienceDirect. All literature articles were reanalyzed by applying inclusion and exclusion criteria. This step includes 3 main actions;

1. In-depth analysis of materials which is the basis for obtaining technical knowledge in the development of EFB and Mycelium materials.
2. Benchmarking material positioning to find new product and market development opportunities.
3. Feel the material directly. At this point, the emphasis is on aesthetic experiences obtained directly through observation.

2.2. Sensing

The next stage is to determine the state of the art of EFB biocomposite materials using a mycelium matrix. Researchers carried out a series of experiments to gain an in-depth understanding of the characteristics and limitations of biocomposite materials made from EFB and mycelium. After obtaining sufficient literature regarding the potential of the biocomposite material, researchers then began searching for the most appropriate context to apply it to the specified target user.

2.3. Sensemaking (Feelings)

In this phase, researchers begin the process of developing a product concept that is consistent with the properties of the materials involved. From this concept, several initial idea drawings were created. The selection of these ideas is based on the application of the 4W questions consisting of what (describe), why (explain), will (predict), and what if (foresee) as the evaluation method used.

2.4. Specifying (Determining)

Next, the stages of sensemaking are translated into product language based on the most suitable product selected, taking into account the aspects of viability, desirability, and feasibility

2.5. Setting Up (Setting Up)

The structuring or preparation of story narratives from the EFB and mycelium biocomposite prototypes aims to convey messages to potential consumers which include product innovation as well as social and environmental impacts.

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2.6. Placing (Placement)

The final stage aims to determine how to place biocomposite products on the market. In this phase, a prototype feasibility test is carried out on the target user to obtain the desirability aspect from the user's perspective. Material and design innovation are the advantages of visual communication in this research.

3. Result and Discussion

The research results are described sequentially based on the DDMI stages.

3.1. Sensing

Exploration of EFB Biocomposite Material with Mycelium Matrix. Studies on biocomposites that use EFB as the main material with a fungal/mycelium matrix are still difficult to find. Testing was only carried out on certain types of mushrooms that had been tested on EFB media, including the straw mushroom *Pleurotus ostreatus, Volvariella volvacea,* and *Ganoderma boninense.*

Figure 2: Stages of Making EFB and Mycelium Biocomposite

Table 1: Comparison of the Growth of Mycelium Hyphae on the Substrate

Comparison	Mushroom species	Growing media	Optimal composition	Hyphal growth rate
Pleurotus ostreatus		Empty palm oil bunches + sawdust	50% EFB + 50% sawdust	27 days
Volvariella volvacea		Empty palm oil bunches + straw	750 grams EFB + 250 grams straw	23 days
Ganoderma boninense		Empty oil palm bunches	100% EFB	>25 days

Table 1 shows the measurement of the growth rate of mycelial hyphae until the entire backlog produces all mushroom primordials.

Empty oil palm bunch (EFB) biocomposite material using a mycelial matrix is made to prevent future environmental damage as well as environmental recovery. The manufacture of biocomposites must meet the standards of strength and durability sufficient for a souvenir product. At the final stage of sensing, a visual analysis is carried out on the advantages and disadvantages of the EFB biocomposite with mycelial matrix.

Table 2: Experimental Results Analysis

Variable	Advantages	Disadvantages
Shape	Adaptable to mold	There is potential for shrinkage and expansion with a tolerance of up to 1.5mm
Texture	It has a distinctive texture	Requires a smoothing process in product finishing
Uniqueness	The material is relatively light and 100% biodegradable	Further research is needed regarding the product recycling process
The Process	EFB Biocomposites with Mycelium Matrix	Requires a printing time of 20-30 days
Resistance	Resistant to temperatures up to 150°C	Not resistant to oil

Taking these advantages and disadvantages into consideration, the researcher decided to direct the product concept to the design of kitchen equipment, such as tea sets, which require heat-resistant materials.

3.2. Sensemaking

The concept of sustainable tourism souvenir design was developed with the following questions;

1) **What:** The design of sustainable tourism souvenirs with environmentally friendly biocomposite materials is intended for today's society, has a fast-paced lifestyle, and are environmentally friendly.
2) **Why:** The mechanical properties of biocomposite materials made from EFB raw materials with a light mycelium matrix and resistant to high temperatures and water are suitable for use as kitchenware.
3) **Will:** Biocomposite materials made from EFB raw materials with a mycelium matrix are 100% biodegradable so they can decompose and do not pollute the environment after their useful life is over.
4) **What if:** This study examines the advantages of these materials by creating prototypes of souvenirs that are attractive in design, and competitive so that they are expected to be an alternative material to replace wood in souvenirs.

3.3 Specifying

The chosen sustainable tourism souvenir design concept is an authentic product in the form of a set of tea utensils. This concept is supported by research showing that Indonesian people prefer environmentally friendly products in the categories of tableware and beverages, as well as fashion, over other product categories. EFB biocomposite material is suitable for use in making souvenirs in the form of tea sets for several main reasons:

1. **Durability and Strength:** EFB biocomposite has quite good strength and resistance to damage, making it suitable for everyday use in tea sets.
2. **Lightweight and Practical:** This material is lightweight, so tea sets made from EFB biocomposite are easy to lift and use, and are not easily broken.
3. **Aesthetic and Unique:** Coccus biocomposite provides a unique and aesthetic appearance, with distinctive patterns and textures from EFB fibers and mycelium, making it visually appealing.

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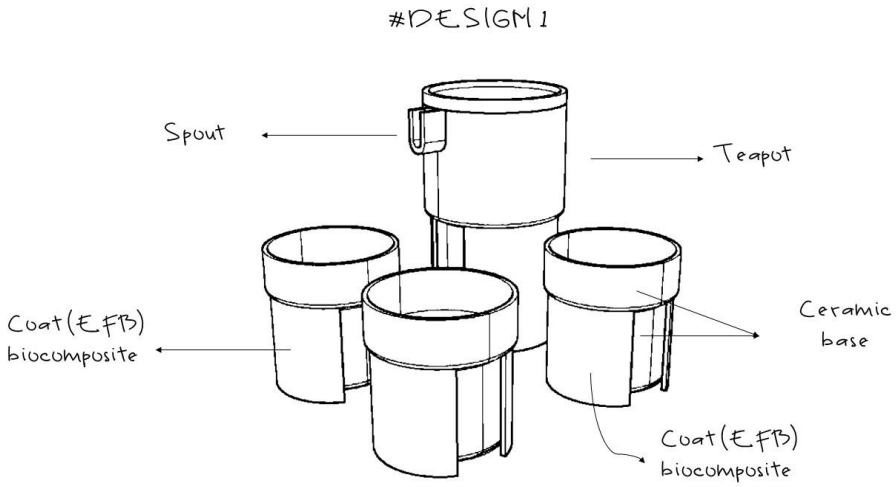

Figure 3: First Idea Sketch

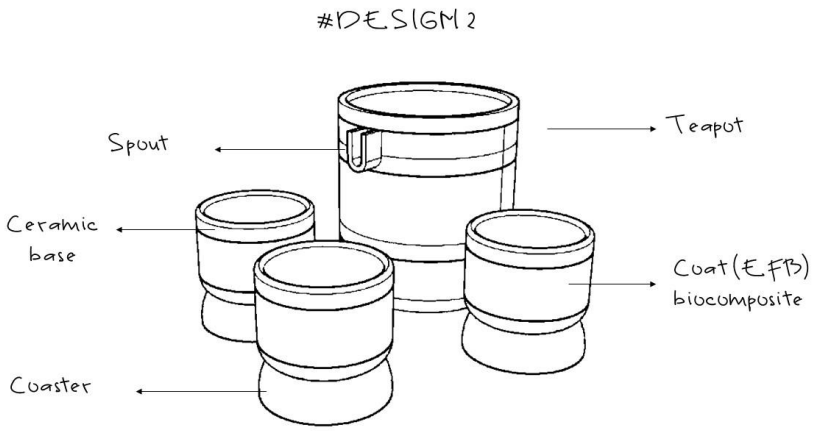

Figure 4: Second Idea Sketch

Based on the two designs, design 2 was finally chosen because it had the highest level of desirability, reflected the advantages of recycled materials, and was technically easier to produce, resulting in less unused material waste.

3.3. Setting Up

Figure 5: Final Prototype

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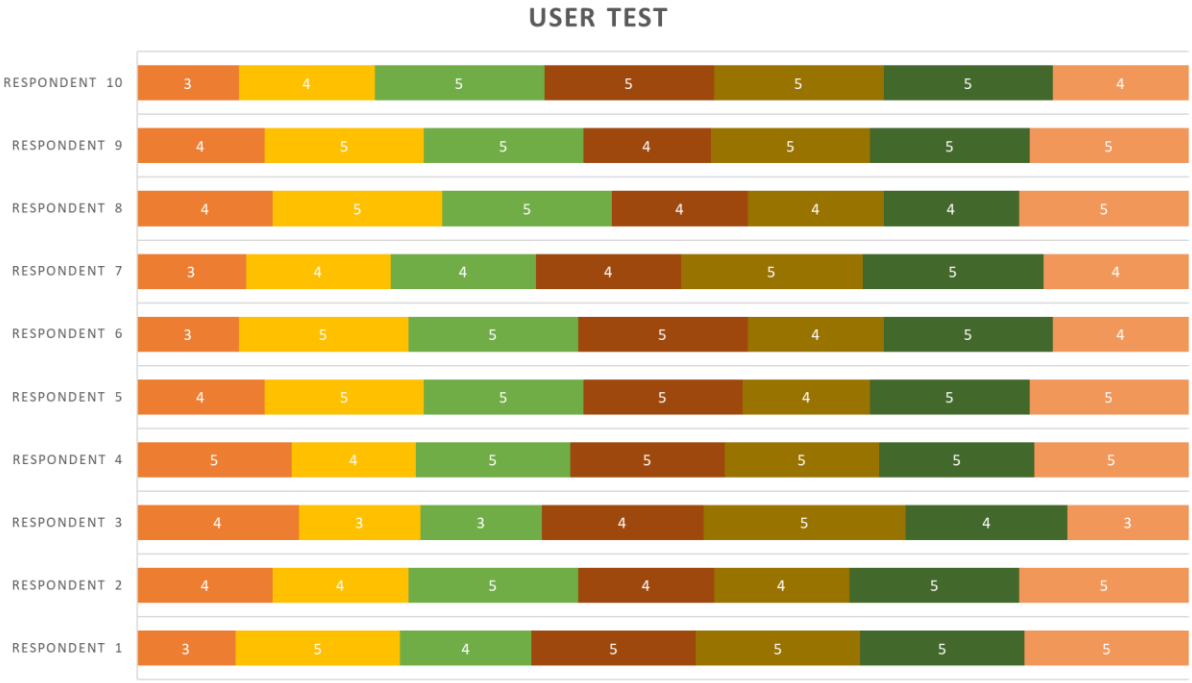
The narrative behind the selected product is that tea sets are souvenirs that are often used in state agendas, for several reasons related to symbolism and diplomacy. This tea set not only functions as a gift, but also reflects the cultural identity and diplomatic status of a country, as well as a way to strengthen relations between countries through appreciation and respect. This is in line with one of the goals of making sustainable tourism souvenirs to support the branding of the IKN as the greenest capital city in the world.

3.4. Placing

At this stage, a user test was conducted on 10 IKN visitors aged 27-40 years, who live outside of Borneo Island. To find out user desires, the variables asked are aspects of the novelty of the design idea, suitability of the concept and form of the product, environmentally friendly (sustainable), aesthetics, function, comfort, size, and price. In the trial procedure, the respondents saw and tried the tea set product. The results of the trial can be seen in table 2.

Table 2: Product Trials on Potential Consumers



	Respondent 1	Respondent 2	Respondent 3	Respondent 4	Respondent 5	Respondent 6	Respondent 7	Respondent 8	Respondent 9	Respondent 10
Price	3	4	4	5	4	3	3	4	4	3
Size	5	4	3	4	5	5	4	5	5	4
Ergonomy	4	5	3	5	5	5	4	5	5	5
Functionality	5	4	4	5	5	5	4	4	4	5
Aesthetic	5	4	5	5	4	4	5	4	5	5
Sustainability	5	5	4	5	5	5	5	4	5	5
Design Ideas	5	5	3	5	5	4	4	5	5	4

Scale explanation: strongly disagree (1), disagree (2), neutral or no opinion (3), agree (4), strongly agree (5).

Based on the results of the user test, most respondents were interested in the idea of a tea set design using an environmentally friendly concept approach. The appearance of the tea set with a combination of ceramic materials and EFB biocomposites was also considered unique, aesthetic and had its appeal. Regarding product size and comfort level, it also received good marks from respondents. The price offered was considered comparable to the innovation involved in it. The suggestion given was to add color and design variants that would make the product more attractive.

From a series of studies exploring EFB biocomposites through five stages it is sensing, sensemaking, specification, setting up, and putting, it can be concluded that several factors play an important role in determining the success of the DDMI method.

- **Knowledge of Production Techniques:** At the sensing stage, the designer's understanding of existing production techniques is essential. By adapting existing production techniques to the use of waste, the process can be accelerated. This is consistent with previous research which states that currently designers are often asked to develop their own materials, which is referred to as "material exploration".
- **Knowledge of Market Trends:** At the sensemaking stage, an understanding of market trends helps designers in designing waste-processed products that are in demand by the market, with the aim of accelerating the acceptance of these products. In the context of this study, designers choose tea set products as souvenirs that are often used in state events because of their symbolism and diplomacy. This tea set not only functions as a gift, but also reflects the cultural identity and diplomatic status of a country, as well as strengthening relations between countries through awards and respect. This is in line to make sustainable tourism souvenirs in support of the branding of the IKN as the greenest capital city in the world.
- **Knowledge Integration:** At the specification stage, designers must be able to combine various knowledge about materials, markets, and production technologies obtained from the sensing and sensemaking stages.

4. Conclusion

This study broadens insight into product design by explaining the processing of biocomposite materials using the DDMI technique. The aim is to assist product designers in processing waste into primary materials to design environmentally friendly products. In addition, this study also provides new references related to innovations in renewable materials as basic materials for making creative products, especially souvenir products to increase the competitiveness of MSMEs in the surrounding area. In using the DDMI method to process EFB biocomposites, several factors need to be considered, such as knowledge of production techniques, insight into market trends, and knowledge integration. The limitations of this study lie in the processing of EFB waste combined with mycelium into biocomposites, where the production process is still ineffective due to the limited time of the study because to produce truly complete EFB biocomposite materials, it takes a long time to grow and form mycelium on EFB perfectly. Therefore, further research can be focused on the development of more effective mycelium growth methods and the development of industrial-scale production engineering tools to optimize production. In addition, this study has not discussed in depth the potential for visual communication design of packaging and branding for promotion. Therefore, further research can examine the graphic aspects of this packaging, because visual communication design on packaging is very important to convey environmentally friendly messages well and optimally in the Sustainable Tourism Souvenir Design process.

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