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Poly(lactic Acid) and Acai Fiber composite: development and potential as a biomaterial with local resources

Abstract The acai (Euterpe oleracea Mart.) production chain is vital for the Brazilian Amazon, yet the high generation of waste poses a significant environmental and social challenge. The present article reports experimental practices for the development of polymer composites, with a Poly(lactic acid) matrix and Acai Fiber reinforcement, processed by extrusion and thermal pressing. The color variation between the samples was evaluated using the CIELab system. This research demonstrates how design, in dialogue with materials engineering, can propose innovative solutions to complex issues, creating value beyond mere function. The study highlights the role of design in formulating solutions within a challenging local context and its potential for environmental and social impact, providing a new direction for the acai production chain. Results show samples with variations in color and texture, confirming the technical viability of the solution and reinforcing the academic value of the research as a contribution to disciplinary knowledge.

Keywords Materials, agro-industrial waste, production processes, experimental materials, biodiversity.

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Compósito de Poli(ácido lático) e Fibra de Açaí: desenvolvimento e potencial como biomaterial com recursos locais

Resumo *A cadeia produtiva do açaí (Euterpe oleracea Mart.) é vital para a Amazônia brasileira, mas a alta geração de resíduos representa um desafio ambiental e social significativo. O presente artigo relata práticas experimentais para o desenvolvimento de compósitos poliméricos, com matriz de poli(ácido lático) e reforço de fibra de açaí, processados por extrusão e prensagem térmica. A variação de cor entre as amostras foi avaliada usando o sistema CIELab. Esta pesquisa demonstra como o design, em diálogo com a engenharia de materiais, pode propor soluções inovadoras para questões complexas, criando valor além da mera função. O estudo destaca o papel do design na formulação de soluções dentro de um contexto local desafiador e seu potencial de impacto ambiental e social, fornecendo uma nova direção para a cadeia produtiva do açaí. Os resultados mostram amostras com variações de cor e textura, confirmando a viabilidade técnica da solução e reforçando o valor acadêmico da pesquisa como uma contribuição para o conhecimento disciplinar.*

Palavras-chave *Materiais, resíduos agroindustriais, processos de produção, materiais experimentais, biodiversidade.*

Compuesto de Poli(ácido láctico) y fibra de açaí: desarrollo y potencial como biomaterial con recursos locales

Resumen *La cadena de producción de açaí (Euterpe oleracea Mart.) es vital para la Amazonia brasileña; sin embargo, la alta generación de residuos plantea un importante desafío ambiental y social. El presente artículo informa sobre prácticas experimentales para el desarrollo de compuestos poliméricos, con una matriz de poli(ácido láctico) y refuerzo de fibra de açaí, procesados por extrusión y prensado térmico. La variación de color entre las muestras se evaluó utilizando el sistema CIELab. Esta investigación demuestra cómo el diseño, en diálogo con la ingeniería de materiales, puede proponer soluciones innovadoras a problemas complejos, creando valor más allá de la mera función. El estudio destaca el papel del diseño en la formulación de soluciones dentro de un contexto local desafiante y su potencial de impacto ambiental y social, proporcionando una nueva dirección para la cadena de producción de açaí. Los resultados muestran muestras con variaciones de color y textura, lo que confirma la viabilidad técnica de la solución y refuerza el valor académico de la investigación como contribución al conocimiento disciplinario.*

Palabras clave *Materiales, residuos agroindustriales; procesos de producción, materiales experimentales, biodiversidad.*

Introduction

In a scenario marked by resource depletion and waste accumulation, circularity emerges as a vital production model. In this context, design assumes a central role. The design process, by integrating creativity with technical possibilities, not only identifies new opportunities but also adds value to production chains (Renfors, 2024).

Given the urgency imposed by climate change and the need to mitigate its effects, the bioeconomy emerges as a fundamental pillar for circularity. By utilizing renewable biological resources and converting waste into new materials, it offers an innovative approach that reduces dependence on fossil fuels and carbon emissions (Araujo et al., 2024). This production model aligns with global sustainability goals, a central theme of international discussions, such as COP 30, held in Belém, Pará, Brazil.

Design, in partnership with other disciplines, has a crucial role to play in shaping future competencies (Bak-Andersen, 2022). The hands-on, reflective process moves beyond traditional academic boundaries, fostering a deeper understanding of how design can influence the economy, environment, and society.

This focus on experimentation prepares students for future challenges, cultivating essential skills like critical thinking, interdisciplinary collaboration, and strategic problem-solving. These competencies are vital for navigating a world that demands sustainable and context-aware solutions. By engaging in real-world projects, students learn to transform challenges into opportunities for innovation, thereby generating significant social and economic value.

Brazil is one of the largest agricultural and extractive producers in the world. In recent years, the processing industry has generated large amounts of waste, which can be reused efficiently (Santos et al., 2024b). Among the most promising species is Acai (*Euterpe oleracea Mart*.); driven by the fruit's growing popularity, its production chain has become one of the most important in Brazil. On the other hand, the interest and demand to serve an external market are responsible for the high production of waste, which in many situations is discarded irregularly in the urban areas of the region.

The development of composites reinforced with natural fibers has been highlighted as an alternative technology in the development of biomaterials. Thus, they provide a lower environmental impact in the processing of new materials, combined with biodegradability, variations in shapes, colors, surfaces and textures (Wearn; Montagna; Passador, 2020). Biodegradable polymers are the main components of these materials, with emphasis on PLA – Poly(lactic Acid), a material from renewable resources, recyclable and compostable, popularly applied in filaments for 3D printing and rapid prototyping (Lyn et al., 2024).

In view of the above, this study aims to report the process for developing composites with a PLA matrix and acai fiber reinforcement, in addition to the color variation of the samples using the CIELab system. The methodological approach follows an exploratory and experimental character, with the purpose of testing combinations through experiments. As a result, samples with uniform colors, smoothness, irregular texture and the presence of fibers on their surface were obtained, evident according to the increase in fiber load.

One of the main contributions of the research is the understanding of Design as an area for research and redefinition of raw materials. Another relevant point is the need for studies and experiments to be closer to the ways of knowing and living present in the Amazon. The importance of reflections and discussions is due to the gaps between theoretical action and practical exercise on the Amazon territory, in addition to a growing interest in finding new applications for the biodiversity of the region.

Design, Composite materials and Poly(lactic acid)

Historically, the development and advancement of society were directly linked to the skills of producing and manipulating materials to meet human needs. In some cases, it is common to associate certain civilizations with their relationship with materials (Callister; Rethwisch, 2020). The world and perceptions of materials are undergoing changes, driven by the need to find sustainable solutions. As a result, knowledge of materials is becoming very important for designers, not only to develop new products, but also to have a better understanding of their properties and values (Lefteri, 2017).

From this context, a variety of possibilities can be understood within the experimentation with raw materials. Proximity to the knowledge and manipulation of materials allows designers to control the manufacturing of their own projects, with the ability to design based on sustainability criteria and break a barrier in the exploration of new resources, capable of representing valuable and sustainable alternatives (Bak-Andersen, 2022).

Design professionals who intend to develop new materials must manage different nuances in a material project. Practical handling and laboratory experience provide technical and experimental information that is essential for a product project, capable of being translated into various aspects. One of the Design approaches to material development is exemplified in the Ma2E4 toolkit.

According to Camere and Karana (2018), the method aims to assist designers and researchers in understanding the evaluation of a given material at different levels: sensory, interpretative, affective and performative. The set consists of an instruction manual, perception tests, characterization maps, affective vocabulary and a bank of interpretative images. The techniques can be applied together or separately.

Composites consist of two distinct phases: one called the matrix, which is continuous and involves another called reinforcement. By combining the two phases, a new material is obtained with specific combinations according to the combination of the two raw materials (Callister; Rethwisch, 2020). The use of vegetable fibers as reinforcement for materials dates back to 300 BC and, with technological advances, they are currently used in reinforcements such as cork, orange peel, grass residue or coffee (Potluri, 2019).

Biomaterial is a term used to indicate materials that have a specific biological association (Myers, 2022), as is the case of PLA (derived from the fermentation of agricultural resources such as corn or sugar cane) and acai fiber, a vegetable-based component. The definition can include surgical materials compatible with insertion into the human body, or based on living organisms, which does not apply to this research. The new materials have made a great contribution to the culture of Design and to the development of sustainable solutions. With applications involving the use of unconventional components, they combine different possibilities through experimentation and technical characterization (Lee et al., 2020).

Poly(lactic acid) (PLA) has a wide range of applications, meets different industrial or artisanal demands, and can be transformed into transparent films, fibers or injection molded. The material has been popularly used as a filament for 3D printing and is generally used in packaging or products with a short life cycle, such as: trays, disposables, bags, bottles and cups (Lefteri, 2017).

In order to improve its properties, Poly(lactic acid) is generally modified by the addition of different additives, including plasticizers. Polyethylene glycol (PEG) is an excellent plasticizer for the raw material, as it helps to disperse fillers in composites and is a biodegradable material. PEG presents faster degradation rates than PLA in its pure state, a factor that facilitates the biodegradation process when processing composites (Lyn et al., 2024).

Acai (Euterpe oleracea Mart.)

Bioeconomy encompasses the production, use, conservation, and regeneration of biological resources to create sustainable economic value. It leverages knowledge, science, technology, and innovation to provide a wide range of products and services across various economic sectors. This broad definition moves beyond traditional nature-based economies by highlighting the crucial role of innovation, localized strategies, and knowledge systems in harnessing the value of biodiversity (Tan; Lamers, 2021).

Among indigenous species with notable bioeconomic significance, the acai palm (Euterpe oleracea Mart.), in figure 1, holds a central position in local economies and food security, particularly in floodplain areas. Its fruit, rich in carotenoids and phenolic compounds, has been a key component of the dietary and cultural traditions of riverside communities that manage native acai groves in floodplain environments (Silva et al., 2025).

Figure 01. Acai palm and Acai fruit.
Source: Authors, 2025.

Until the end of the 1990s, the fruit was not considered, in financial terms, a relevant activity for market logic. The scenario has changed due to national and international interest, linked to the natural benefits and marketing of the pulp. Currently, the acai industry is one of the most important economic sources for the northern region. A survey shows that in 2023, 1,741,757 tons of the fruit were produced, with the state of Pará being the largest producer (167.625 tons), followed by Amazonas state (43.877 tons). In terms of production value, the production generated R$ 7,770,712,00 thousand in the year, approximately 1,461,274,00 USD dollars (IBGE, 2025).

The main disadvantage of the production chain is the amount of biomass waste, composed of the stone, fibers (which revert to the stone) and sludge from the pulp processing. The amount of waste generated varies from 71% to 95% of the processed mass of the fruit (Bufalino et al., 2018). The waste, as shown in figure 02, is accumulated in deposits, placed in front of commercial acai establishments or in peripheral areas, which increases urban pollution and reinforces a scenario of predatory development in the region.

Figure 02. Acai waste in an urban context in Belem city (Para – Brazil).
Source: Authors, 2025.

From a material point of view, acai waste is an attractive object of research, as it is an abundant industrial byproduct. Different alternatives have been found, such as: for the development of composites with a polyurethane matrix and castor bean resin (Cavalcanti et al., 2021; Lima et al., 2018), non-woven fabric for textile material (Cohen; Santos, 2022) and use of particles for application in civil construction (Barbosa et al., 2019).

In a previous study, it was found that the importance of the production chain is reinforced by the viability and use of its by-products for other activities. However, the lack of studies and experiments in Design directs investigations to focus on technical parameters of materials (Cohen; Ayres, 2025). To bridge this gap, the present study proposes an exploratory methodology integrating technical characterization with design sensibilities, as detailed below.

Materials and methods

Regarding the methodological procedures, this research is characterized as exploratory. This modality aims to provide greater familiarity with the problem studied, in addition to improving ideas and/or verifying possibilities for solutions. The research was structured in three stages: (i) Preparation of the material; (ii) Experimentation and (iii) Tests and Analysis, as shown in figure 03.

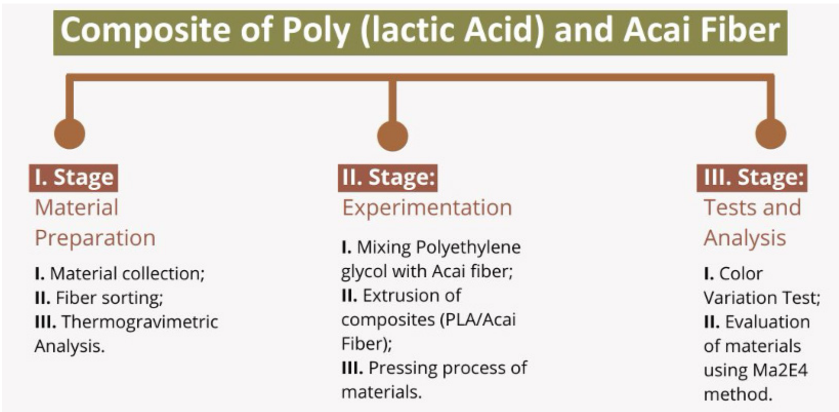

Figure 03. Diagram of the stages of experimentation with the biomaterial. **Source:** Authors, 2025.

The method used in the development of materials is experimental, with the purpose of testing new combinations through laboratory experiments and evaluating the results obtained. For Design research, the experimental method is applied as a tool for visualizing perceptions and potential applications of materials (Bak-Andersen, 2022).

Material preparation

The acai residues were collected in bags of residual material, found on the streets of Belem (Para - Brazil), generated by commercial pulping establishments. During the process, running water and a nylon sieve were used for cleaning. After drying, at room temperature, the fibers and seeds were manually separated, according to figure 04.

Figure 04. Process of preparation the acai fiber.
Source: Authors, 2025.

The Poly(lactic acid) used was from the manufacturer 3D Fila (Minas Gerais - Brazil) in opaque white (non-transparent) color, 1.75 mm diameter and processing temperature between 185 - 220 °C. To facilitate the dispersion of fibers in the matrix, Polyethylene glycol 6.000 was applied to the composite mixtures, purchased from Sigma Aldrich (Missouri – United States of America), with a processing temperature between 60 - 63 °C.

In order to identify the ideal temperature for processing the composites and to avoid fiber degradation, Thermogravimetric Analysis was performed. The experiment was carried out on a DTA-60 thermobalance (Shimadzu) under a synthetic air atmosphere, conducted at room temperature up to 750 °C, at a heating rate of 10 °C min-1.

Experimentation

The materials were named, according to the proportion of fibers and the PEG content, as: PEG/FIBER 25 (25% Fiber / 75% PEG), PEG/FIBER 50 (50% Fiber / 50% PEG) and PEG/FIBER 75 (75% Fiber / 25% PEG). Within these proportions, five possible compositions with Poly(lactic acid) were evaluated, in two different proportions. In total, five samples were prepared for the possibilities reported, as shown in Table 01.

Table 01. Samples of PLA/Acai fiber processed.
Source: Authors, 2025.

90% PLA + 10% PEG/FIBER	25 (25% FIBER / 75% PEG)
	50 (50% FIBER / 50% PEG)
	75 (75% FIBER / 25% PEG)
80% PLA + 20% PEG/FIBER	25 (25% FIBER / 75% PEG)
	50 (50% FIBER / 50% PEG)

The processing began with the mixing of the fibers with Polyethylene glycol in a heating blanket, at a temperature of 60 °C. After this process, the material was cooled to room temperature and crushed in a batch mill. The material was then processed with PLA in a Filmaq3D STD extruder, at a temperature of 185 °C, extrusion speed of 3 rpm. The filaments obtained were pelletized and pressed in a hydraulic press for 10 min, at 180 °C and a pressure of 5.5 t, coated in Kapton sheets.

Tests and analysis

To evaluate the color variation in the composites, characterization was performed using colorimetry in the CIELab coordinate system. In this test, the luminosity (L*), the chromatic coordinates (a* and b*) and the total color variation (ΔE*), in relation to the standard (white PLA), were determined using a Konica Minolta 600 D spectrophotometer. The measurements were taken at five different points on each sample. The results show the average values of the five points of the samples, with their respective standard deviations exported by Excel software.

To understand potential perceptions of the composites, the comparative method proposed by Camere and Karana (2018) was used, so that the researcher had the opportunity to make an assessment at the sensory level and interpret the information together with the results of the processes. A scheme with specific characteristics and their opposites was adapted, in which 0 is a neutral point and from there comparisons are made.

Results and Discussion

The results of the thermogravimetric analysis of the acai fiber, figure 05, demonstrate a curve with water loss from the material around 80 °C, or perhaps the decomposition of low molar mass compounds. This represents the degradation of 10% of the material. The main degradation stage begins around 200 °C and is associated with the degradation of hemicellulose, cellulose and lignin (Oliveira et al., 2016). This temperature indicates the beginning of biomass degradation and is used to limit the maximum temperature in the processing of lignocellulosic materials (Sena Neto et al., 2013).

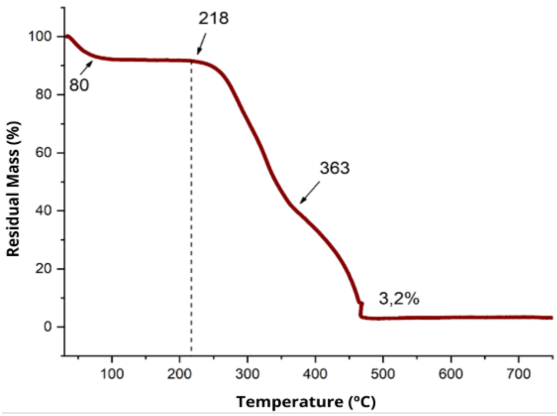

Figure 05. Thermogravimetric Analysis in the acai fiber.
Source: Authors, 2025.

For the experimentation in the development of Poly(lactic acid)/acai fiber biomaterial, one of the objectives was to obtain a uniform and homogeneous material. It became necessary to reduce the length of the fibers so that they could disperse during processing with PLA and so that the material would not clump together during extrusion. The physical characteristics of acai fibers are lightness, rough texture, and ease in agglomerating among themselves. This set of properties made it difficult to transform the fiber into powder during grinding. When mixing acai fibers with PEG, the fibers agglomerated into a rigid structure, which allowed the fiber size to be reduced. Figure 06 illustrates the results of the steps of this process.

Figure 06. Process of mixing Polyethylene glycol with acai fibers.
Source: Authors, 2025.

In the literature, there are examples of studies in which PEG was used to improve the processing of composites with plant fibers. Chihaoui et al. (2022) demonstrate the potential of Polyethylene glycol to disperse lignocellulosic nanofibers in composites with PLA. Long et al. (2019) present a study in which the processability of Poly(lactic acid) composites with bamboo fiber was improved with the addition of PEG to the mixture, the plasticizer being responsible for increasing the flowability of the polymer. As a result, the fibers were more intensely involved in the matrix.

In this research, the equipment used to process the PLA and acai fiber composite allowed precise control over the heat supplied to the materials in the processing flow. The filament extruder handles flow and retraction easily, and there is only one heat region to monitor. Small changes in flow rates are necessary for a new material, compared to several heat regions in a heat press (Patel; Taufik, 2024).

One of the decisive factors for choosing this production process was that, compared to conventional techniques, such as solvent casting, extrusion offers advantages in scalability and environmental sustainability, especially for industrial-scale production (Lyn et al., 2024). This scenario reinforces the importance of research and reports with different results, for mapping techniques and procedures by other researchers. Figure 07 shows the PLA/Acai fiber composites after the extrusion process and transformation into pellets of the filaments. At first, it is possible to notice the variation in colors, as the amount of fiber load in the composites was increased. It is important to highlight that these composites did not come out uniformly in the extruder, which resulted in filaments with irregular diameters and made it difficult to granulate the composites.

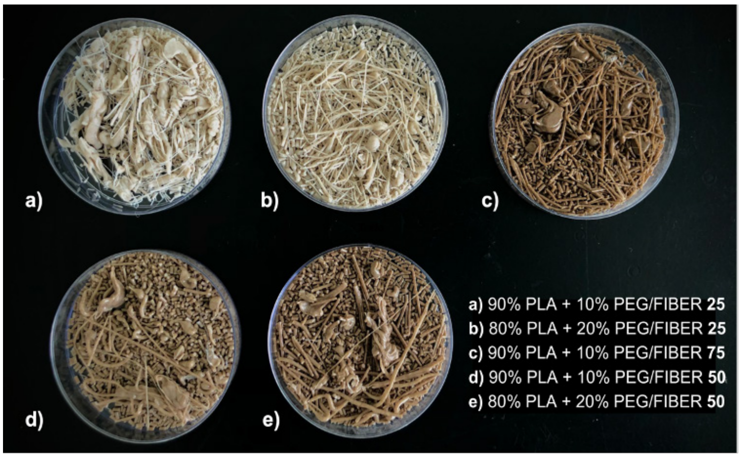

Figure 07. Result of sample processing in the extruder.
Source: Authors, 2025.

After pressing the composites, it was possible to verify the color variation in the samples of 90% PLA + 10% PEG/Fiber 25 and 80% PLA + 20% PEG/Fiber 25, as shown in Figure 08. With the pressing, samples with uniform colors, irregular textures and the presence of fibers on their surface were obtained. This variation in the texture and the details of the acai fibers on the surface of the composites could only be seen after pressing the materials and became more evident as the fiber load in the compositions increased.

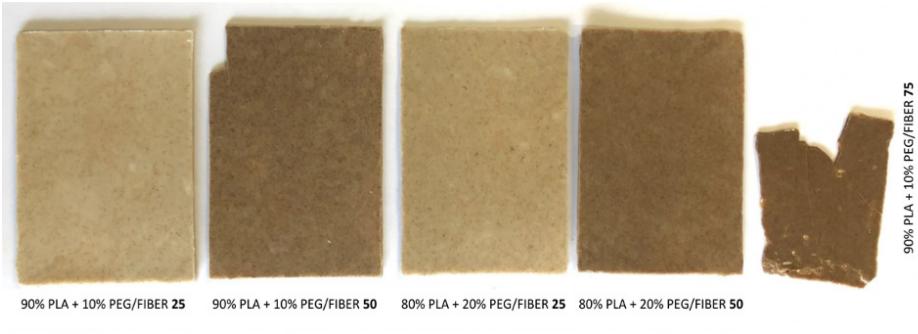

Figure 08. Result of PLA processing and Acai Fibers after pressing.
Source: Authors, 2025.

One of the challenges in composite extrusion and pressing techniques was controlling their properties to prevent the materials from degrading. Extrusion is a process driven by thermal energy, and the quality of the connection and the stability of the structure depend on the heat provided by the equipment during the processing phase (Huseynov et al., 2024). Temperature is among the most significant process variables that directly impact the properties of the components.

Figure 09 illustrates a failure in the processing of the 90% PLA + 10% PEG/Fiber 75 samples. During the pressing process of the composites, in addition to allowing a shiny finish to the material, the Kapton sheets prevented the pellets from adhering to the metal structure of the molds. Despite the good structure of the composite, the samples with this proportion were not easily removed from the mold.

Figure 09. Sample of 90% PLA + 10% PEG/Fiber 75.
Source: Authors, 2025.

In addition to color variation, one of the most interesting sensory characteristics of composites after processing is the surface where it is possible to see details of the acai fibers, as shown in Figure 10. When a composite with natural materials presents such characteristics, it is possible to construct concepts and associations with other materials, which encourages and arouses curiosity in potential users of products (Cavalcanti et al., 2021).

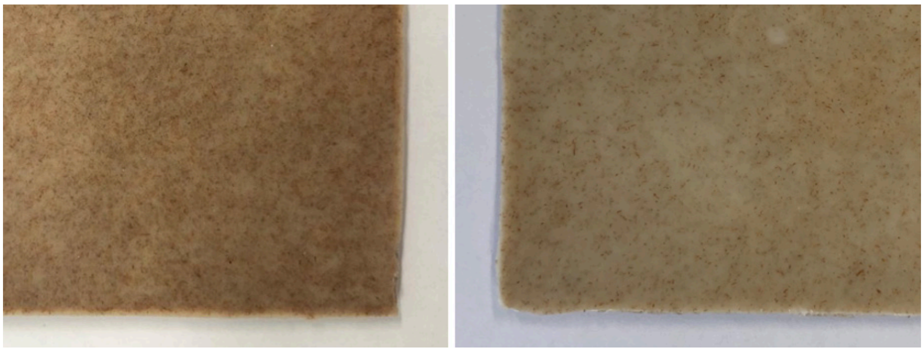

Figure 10. Surface of PLA/Acai Fiber composites.
Source: Authors, 2025.

Finally, after completing the mapped procedures, an intuitive, purely experimental test was conducted to evaluate the direct processing of the PLA, PEG, and acai fiber mixture using only the heat press, bypassing the extrusion stage entirely. Following the parameters of the previous experiments, this test aimed to observe how the mixture would behave, whether it would yield a similar surface finish, and if eliminating the extruder was a viable alternative. Figure 11 illustrates the quantity of material separated for this test, as well as the results.

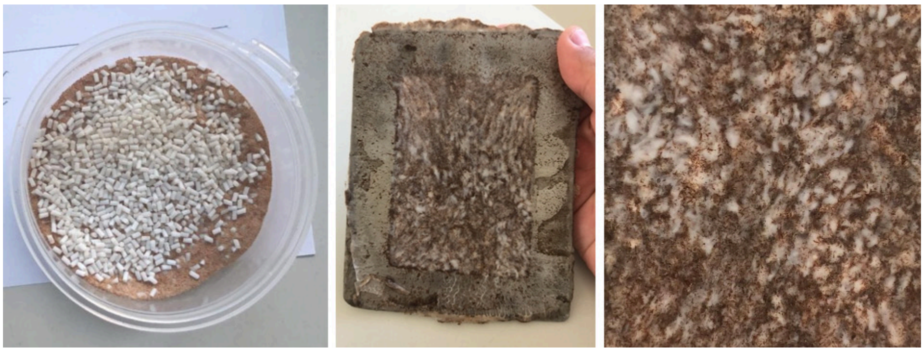

Figure 11. Experimental test for mixing the materials without the extrusion step.
Source: Authors, 2025.

Although the pressing temperature was close to the extrusion processing temperature, the resulting material did not achieve a satisfactory mixture compared to the consolidated samples shown previously. The absence of the extrusion step led to a lack of uniformity, reinforcing that the established, multi-stage process remains essential for obtaining a homogeneous composite. Nonetheless, this direct pressing approach opens interesting opportunities for artistic and aesthetic investigations, where the resulting variations in texture can be intentionally explored.

As a way to verify color variation technically, characterization was performed through colorimetry. According to Table 02, ΔE* increases when more fiber is added to the composites, that is, as the percentage of fibrous material increases, the value of ΔE* increases. In other words, the more fiber, the darker the material tends to be (darker, in relation to white PLA).

Table 02. CIELab coordinates and ΔE* values of PLA/Acai fiber composites. **Source:** Authors, 2025.

	Δ L*	Δ a*	Δ b*	Δ **E***
90% PLA + 10% PEG/FIBER **25**	-18,81	5,09	5,66	**20,29 (darker)**
90% PLA + 10% PEG/FIBER **50**	-35,80	7,74	6,93	**37,27 (darker**)
90% PLA + 10% PEG/FIBER **75**	-47,94	9,25	6,84	**49,30 (darker)**
80% PLA + 20% PEG/FIBER **25**	-23,82	5,96	7,01	**25,53 (darker)**
80% PLA + 20% PEG/FIBER **50**	-42,03	8,28	6,41	**43,31 (darker)**

There are examples in the literature of research in which the addition of fillers to PLA composites promoted a variation in the color of the polymer. The use of thyme and curry essential oils as plasticizers helps to change the color variation of the composites, in addition to attributing characteristics such as transparency in films, opacity in filaments and changes in physical characteristics (Zabidi et al., 2022). Another example is the insertion of soy protein as a color modifying agent in PLA, giving it a yellowish appearance. This characteristic is attributed to the beige color of the soy protein, with the change in color being intensified with the addition of plasticizer (Morais et al., 2022).

Even though it is a visible variation throughout the entire process, the colorimetry test exposes exact numbers and values that allow a potential categorization regarding the change in the material's property, in addition, color is an extremely important variable for different design projects. Other potential analyses include comparing the change with other agro-industrial waste in similar processes, or verifying the change in the total color variation if any stage of the process described in the research is adapted.

This stage of the project resulted in the creation of a color palette, Figure 12. The palette ranges from light beige to dark brown, directly influenced by the amount of acai fiber added to the PLA matrix. This range of hues, which reflects the essence of the source material, was named after its Amazonian context. The lighter samples, which have a lower fiber content, were named Iaça and Iacy, in homage to the legend of the "fruit that cries" and the princess whose eyes gave rise to the palm tree. The darker samples, containing a higher concentration of fiber, were named Mairarú, Várzea, and Igarapé, referencing the natural environments of the Amazon—the floodplains and waterways where the acai palm flourishes (Santos et al., 2024a).

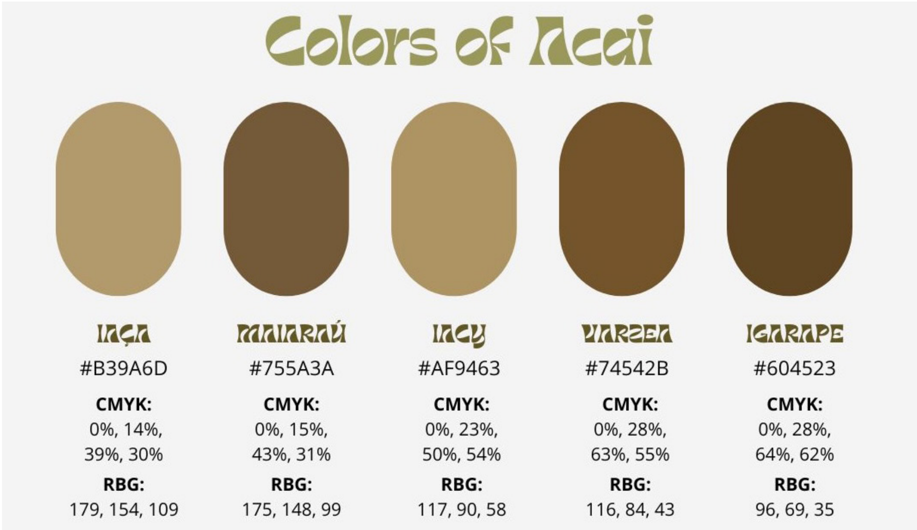

Figure 12. Color palette based on ΔE* values of composites.
Source: Authors, 2025.

Traditionally, in science and engineering, materials are characterized only technically, through techniques that aim to verify the structure and measure the properties of the materials, in addition to questions about logistics and infrastructure for their processing (Camere; Karana, 2018). By combining the technical characterizations of acai fiber, the understanding of its processing and sensory qualities, this research directs the possibility of profiling applications, comparing it with similar materials and future investigations to understand the perception of potential users.

Despite the environmental benefits of biomaterials with natural fibers, these composites may not be well regarded in comparison to commercially established materials. Negative connotations include "poor", "low quality", "unattractive" and "second-rate". The results obtained in this research were considered satisfactory regarding the investigation of the feasibility of processing and obtaining a new material through experimentation with Poly(lactic acid) and acai residues. The results of the evaluation of the PLA/Acai fiber samples according to the Ma2E4 method (Figure 13), in general, showed a hard, smooth, light and fibrous material with an irregular texture, since the acai fibers were randomly dispersed on the surface. The composites proved to be neutral to temperature and to the touch, hot or cold.

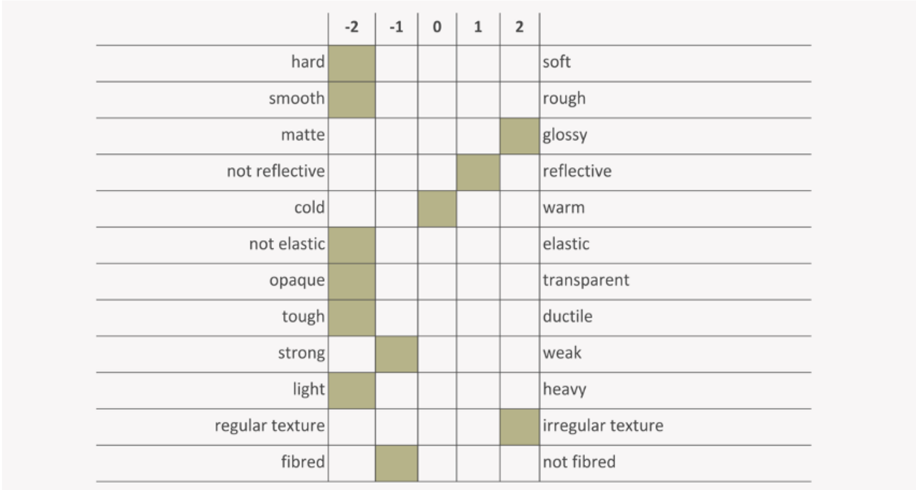

Figure 13. Evaluation of biomaterials using the Ma2E4 method.
Source: Cohen; Ayres, 2024.

The shiny and reflective appearance of the material is attributed to the Kapton sheet used in the pressing process of the composites in pallet format. Only the 90% PLA + 10% PEG/FIBER 75 sample, pressed without the Kapton sheet, presented a matte and non-reflective surface. It is worth noting that at the time of the investigation, the categorization of words such as hard, non-elastic and resistant was based on initial and empirical perceptions, in accordance with the proposal of the Ma2E4 method, which requires physical tests, such as tensile tests, to technically evaluate such properties. In addition to creating comparative parameters between the samples, it allows us to understand which proportion of composite allowed the improvement of the PLA properties with the addition of acai fibers.

Conclusions

Through a design-led, experimental approach, this study demonstrates the viability of transforming waste from the acai production chain into valuable new materials. This proves the potential of a design that engages with the local reality of the Amazon. By obtaining composites of PLA and acai fiber with unique variations in color and texture, the project not only addresses a waste problem but also highlights how design can innovate in the creation of biomaterials with unique sensory characteristics.

This research advances scientific knowledge by demonstrating a robust interdisciplinary methodology that seamlessly integrates materials science and design. Through a speculative and experimental approach, the study not only investigates the technical properties of materials but also explores their potential for re-signification within a specific context. The project serves as a compelling model for future work, illustrating how the fusion of material experimentation and design can lead to truly innovative and sustainable solutions tailored to local needs

We hope this study inspires the development of product prototypes and future investigations into user perception, deepening the discussion on the social impact of design solutions. The developed raw material is a democratic alternative that can strengthen the local production chain, generate new economic opportunities, and contribute to improving living conditions in urban and peripheral areas of the Amazon, all while promoting the preservation of the forest's biodiversity through the sustainable use of its resources.

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