



**BLENDS DE BIOMASSA DA SOCIOBIOECONOMIA AMAZÔNICA PARA PRODUÇÃO DE
PELLETS ENERGÉTICOS**
**BLENDS OF AMAZONIAN SOCIOBIOECONOMY BIOMASS FOR THE PRODUCTION OF
HIGH-EFFICIENCY ENERGY PELLETS**

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RESUMO

O presente artigo visa apresentar os critérios que orientaram o pedido de patente BR102025008531-3, que introduz composições inovadoras de biomassa (blends) formulados a partir de resíduos lignocelulósicos subutilizados da sociobioeconomia amazônica, como caroços e fibras de açaí, cascas de castanha-do-pará, cascas e caroços de tucumã e cupuaçu, além de resíduos de madeira de manejo florestal e silvicultura, como: pinus, eucalipto, pau-preto, mogno, andiroba e outras espécies. Alinhada aos princípios da economia circular e da transição energética, a invenção proposta visa a produção de pellets energéticos de alta eficiência para aplicações industriais. Combinando os componentes em proporções variáveis (10-90%), os pellets resultantes exibem características otimizadas: poder calorífico superior (PCS) > 17 MJ/kg, teor de umidade < 10%, teor de cinzas < 2% e resistência mecânica > 95%. O processo produtivo envolve etapas convencionais de secagem, moagem, mistura e compactação sob alta pressão. Entende-se que tais pellets representem uma alternativa sustentável para geração de energia térmica para a produção de etanol de milho, secagem de grãos, siderurgia e geração de energia elétrica na região amazônica, promovendo a valorização de resíduos regionais e contribuindo para uma matriz energética diversificada e de baixo carbono.

Palavras-chave: Pellets; Biomassa; Blends Energéticos; Sociobioeconomia; Economia Circular.

ABSTRACT

The present article aims to present the criteria that guided the patent application BR102025008531-3, which introduces innovative biomass compositions (blends) formulated from underutilized lignocellulosic residues of the Amazonian socio-bioeconomy, such as açaí pits and fibers, Brazil nut shells, tucumã and cupuaçu shells and pits, as well as wood residues from forest management and silviculture, including pine, eucalyptus, pau-preto, mahogany, andiroba and other species. Aligned with the principles of the circular economy and the energy transition, the proposed invention aims at producing high-efficiency energy pellets for industrial applications. By combining the components in variable proportions (10–90%), the resulting pellets exhibit optimized characteristics: higher heating value (HHV) > 17 MJ/kg, moisture content < 10%, ash content < 2%, and mechanical durability > 95%. The production process involves conventional stages of drying, grinding, mixing, and compaction under high pressure. These pellets are understood to represent a sustainable alternative for thermal energy generation such as corn ethanol production, grain drying, steelmaking, and electricity generation in the Amazon region, promoting the valorization of regional residues and contributing to a diversified and low-carbon energy matrix.

Keywords: Pellets; Biomass; Energy Blends; Sociobioeconomy; Circular Economy.



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1 INTRODUCTION

The global energy transition demands the pursuit of renewable and sustainable energy sources capable of mitigating the environmental impacts associated with fossil fuels and fostering low-carbon development. In this context, biomass remains a strategic resource, especially in countries with vast forest cover such as Brazil. Converting biomass into energy pellets represents a well-established technology to increase its energy density, facilitate transport and storage, and optimize its use in industrial combustion processes (GARCIA, 2010). The pellet (Figure 01) is a granular biofuel made from ground plant biomass compacted under high pressure through the holes of pelletizing dies, resulting in a product with high calorific value and good mechanical durability (QUÉNO et al., 2019). However, traditional pellet production often focuses on homogeneous raw materials, such as pine and eucalyptus wood residues, or residues from large monocultures, such as sugarcane bagasse (DA SILVA, 2020).

Figure 01- Physical Configuration of the Pellets



In parallel, the principles of the circular economy are gaining momentum, encouraging the reuse and valorization of residues as a means to reduce the extraction of virgin resources and minimize the generation of environmental liabilities. Applying these concepts to the bioenergy value chain opens opportunities for the utilization of a diverse range of lignocellulosic residues, many of which are currently underutilized or improperly discarded. The Amazon region, with its rich socio-biodiversity, generates significant volumes of residues from the processing of products such as açaí, Brazil nuts, cupuaçu, and tucumã, as well as residues from sustainable forest management and silviculture (LOPES-ASSAD, 2023; ALVES, 2022). These residues from the Amazonian socio-bioeconomy have promising physicochemical characteristics for bioenergy production, such as high lignin content and considerable calorific value (BRAGA et al., 2023; ALVES, 2022). However, their heterogeneity and the lack of adapted technologies for their joint processing pose technical and logistical challenges. The state of the art in pellet production, although advanced for conventional biomasses, still only incipiently explores the potential of strategically combining (blending) multiple regional residues to obtain solid biofuels with optimized properties for specific high-thermal-demand industrial applications, such as boilers for corn ethanol production, grain drying, and steelmaking furnaces.



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Furthermore, the reality of Amazonian communities imposes a practical urgency in the search for sustainable energy solutions adapted to local conditions. Universal electricity provision is still far from being achieved in the Brazilian Amazon, due to geographic barriers, population dispersion, and technological and economic limitations (XAVIER et al., 2006), meaning that the proposed product could contribute both to regional energy security and to expanding the utilization of local residues, aligning with the objectives of the circular economy and the reduction of greenhouse gas emissions (BACELLAR; ROCHA, 2010).

Given the convergence of these contexts, the present work, based on patent application BR102025008531-3, explores the formulations and potential of biomass blends from the Amazonian socio-bioeconomy for the production of high-energy-efficiency industrial pellets. The study addresses the identification of potential raw materials, the proportions of the mixtures, the pelletizing process, and the characteristics of the resulting pellets, highlighting their advantages within the framework of the circular economy and the energy transition. The goal is to demonstrate the technical and environmental feasibility of valorizing these regional residues, transforming them into an energy product with added value and contributing to a more diversified, resilient, and sustainable industrial energy matrix.

2 MATERIALS AND METHODS

The methodology adopted in this work is based on the description of the process in patent application BR102025008531-3 (CARNEIRO; D'ANGIOLELLA, 2025), which, although still under confidentiality at the National Institute of Industrial Property (INPI), presents part of the biomass blend formulation strategy and the production of energy pellets (Figure 02) from residues of the Amazonian socio-bioeconomy, as follows:

2.1 Selection and Preparation of Raw Materials

The lignocellulosic raw materials selected for the composition of the blends are residues from sustainable production chains in the Brazilian Legal Amazon, including: açaí residues (fiber and pit – *Euterpe oleracea*), Brazil nut shells (*Bertholletia excelsa*), tucumã shells and pits (*Astrocaryum vulgare* and *Astrocaryum aculeatum*), cupuaçu shells and pits (*Theobroma grandiflorum*), and wood chips/sawdust/shavings from forest management and/or silviculture.

The initial preparation involved drying the raw materials at a controlled temperature, preferably between 90°C and 110°C, to reduce the moisture/mixture content to below 10%. After drying, the residues were ground to reduce particle size, preferably to an average size of 2 mm. Granulometric uniformity facilitates mixing and subsequent compaction.

2.2 Formulation of Blends and Pelletizing

The blends were formulated by combining two or more of the ground raw materials. The proportion of each component in the blends ranged from 10% to 90% by mass, adjusted according to the desired energy and physicochemical requirements for the final industrial application. The proportions defined for performance optimization are kept as industrial trade secrets. The homogeneous mixture of blend components was then subjected



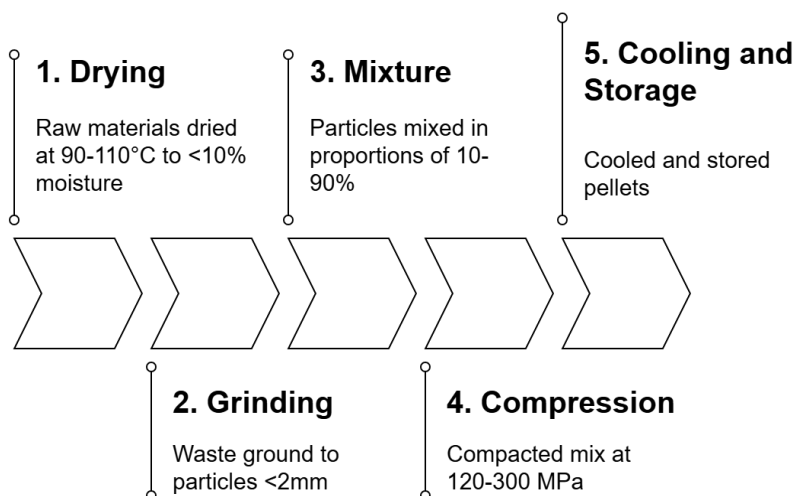
to the compaction/compression (pelletizing) stage. A pellet press or extruder was used, applying high pressure, preferably in the range of 120 MPa to 300 MPa. This process resulted in cylindrical pellets with diameters ranging from 3 mm to 13 mm.

Finally, the freshly formed pellets were cooled to room temperature and subsequently stored under controlled conditions to preserve their physicochemical properties until use.

2.3 Pellet Characterization

The pellets produced from the different blends were characterized for their main energy and physical properties, as established in the invention, using standard methods (ABNT/ISO) for determination: Higher Heating Value (HHV), Residual Moisture Content, Ash Content, Mechanical Durability, and Bulk Density.

Figure 02- Production Process Overview



3 RESULTS AND DISCUSSION

As claimed in the patent application presented in this work, the pellets consistently exhibited a Higher Heating Value (HHV) above 17 MJ/kg (equivalent to 4.72 kWh/kg or 4,037.6 kcal/kg), reaching up to 21 MJ/kg depending on the specific composition of the blend. This is a significantly high value for densified biomass and competitive with traditional wood pellets, indicating high efficiency in energy conversion during combustion. Optimizing the proportions of the different residues in the blend (ranging from 10% to 90% for each component) allows the HHV to be modulated, adapting the fuel to the specific needs of the industrial process. The high lignin content present in most of the selected Amazonian residues (BRAGA et al., 2023; ALVES, 2022) positively contributes to the elevated calorific value, also acting as a natural binder during pelletizing.

The physical quality parameters were also found to be adequate. Residual moisture content was consistently kept below 10%, a crucial factor to ensure stability during storage, prevent biological degradation, and optimize combustion efficiency. Ash content—a critical parameter for the maintenance of boilers and furnaces - was controlled at levels below 2%. This low ash



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content minimizes operational problems such as slag formation and fouling, while also reducing costs associated with the final disposal of ash (GARCIA, 2010). Mechanical durability, above 95%, ensures pellet integrity during transport, handling, and feeding into combustion systems, reducing losses from breakage and the generation of fines. The bulk density of the pellets ranges from 600 to 850 kg/m³, providing high volumetric energy density. This represents a significant logistical advantage compared to raw biomass, reducing transportation and storage space costs (GARCIA, 2010).

The production process uses conventional stages, which favors its implementation and scalability without the need for more complex and costly technologies such as torrefaction or steam cracking, mentioned as alternatives in the state of the art. Producing these pellets from blends of residues from the Amazonian socio-bioeconomy represents a practical example of applying the principles of the circular economy. Residues such as açai pits, Brazil nut shells, and cupuaçu shells—which often constitute environmental liabilities or are underutilized (LOPES-ASSAD, 2023; ALVES, 2022) - are transformed into a product with considerable added value. This process not only prevents improper disposal but also reintegrates these materials into a new production cycle, generating economic and social value for local communities engaged in socio-bioeconomy supply chains.

4 CONCLUSIONS

The present work, based on the aforementioned invention, demonstrates the technical potential and strategic relevance of using blends of lignocellulosic residues from the Amazonian socio-bioeconomy for the production of high-energy-efficiency industrial pellets. The proposed approach is directly aligned with the principles of the circular economy and appears to contribute significantly to Brazil's energy transition efforts. The use of a production process based on conventional stages (drying, grinding, mixing, and compaction) provides simplicity and economic feasibility to the solution, distinguishing it from more complex and costly alternatives. By offering a solid biofuel that is dense, stable, and delivers good energy performance, the invention emerges as a sustainable alternative to fossil fuels and other biomass sources, contributing to the decarbonization of key industrial sectors.

It's concluded that the production of pellets from biomass blends of the Amazonian socio-bioeconomy is a promising solution that integrates technological innovation, environmental sustainability, and regional development.

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