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THE AÇAÍ PRODUCTION CHAIN IN THE AMAZON: HISTORICAL EVOLUTION, SOCIOECONOMIC RELEVANCE, AND TECHNOLOGICAL ADVANCES

CADEIA PRODUTIVA DO AÇAÍ NA AMAZÔNIA: UMA REVISÃO SOBRE ASPECTOS HISTÓRICOS, SOCIOECONÔMICOS E TECNOLÓGICOS

CADENA PRODUCTIVA DEL AÇAÍ EN LA AMAZONÍA: UNA REVISIÓN SOBRE ASPECTOS HISTÓRICOS, SOCIOECONÓMICOS Y TECNOLÓGICOS

Viviandra Manuelle Monteiro de Castro Trindade
Master of Science in Environmental Sciences, State University of Pará (UEPA/CCNT), Belém, Pará, Brazil
E-mail: viviandra.trindade@unesp.br

Alfredo Kingo Oyama Homma
Doctor of Science, Rural Economics, State University of Pará (UEPA/CCNT), Belém, Pará, Brazil
E-mail: alfredo.homma@gmail.com

Harleson Sidney Almeida Monteiro
Master of Science in Agronomy (Horticulture), São Paulo State University (UNESP/FCA), Botucatu, São Paulo, Brazil
E-mail: harleson.sa.monteiro@unesp.br

Sinara de Nazaré Santana Brito
Master of Science in Agronomy (Horticulture), São Paulo State University (UNESP/FCA), Botucatu, São Paulo, Brazil
E-mail: sinara.santana@unesp.br

Daví Eduardo Furno Feliciano
Agricultural Engineer, São Paulo State University (UNESP/FCA), Botucatu, São Paulo, Brazil
E-mail: davi-eduardo.feliciano@unesp.br

Marcos Antônio Souza dos Santos
Doctor of Science in Animal Science, Federal Rural University of the Amazon (UFRA/ISARH), Belém, Pará, Brazil
E-mail: marcos.marituba@gmail.com

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Jair Carvalho dos Santos
Doctor of Science in Applied Economics, EMBRAPA Amazônia Oriental, Belém, Pará, Brazil
E-mail: jair.santos@embrapa.br

João Tomé de Farias Neto
Doctor of Science in Agronomy (Plant Genetics and Breeding), EMBRAPA Amazônia Oriental, Belém, Pará, Brazil
E-mail: joao.farias@embrapa.br

Antonia Benedita da Silva Bronze
Doctor of Science in Agricultural Sciences, Federal Rural University of the Amazon (UFRA/ICA), Belém, Pará, Brazil
E-mail: antonia.silva@ufra.edu.br

Abstract

Açaí (*Euterpe oleracea* Mart.) stands out as a product of great socioeconomic, cultural, and environmental importance for the Amazon region, with increasing participation in national and international markets. In this context, the present study aimed to conduct a systematic literature review on the açaí production chain in the Amazon, addressing its historical evolution, socioeconomic relevance, production stages, technological advances, and the main challenges faced across the different links of the chain. The analysis showed that fruit quality is directly associated with the stage of maturation and the conditions of handling, transportation, and processing, factors that influence the physicochemical, microbiological, and sanitary characteristics of the product. It was observed that pulp processing involves critical stages, such as washing, disinfection, blanching, and pulping, which are essential for reducing microbial load and ensuring final product quality. It was also verified that açaí production systems range from traditional extractivism to managed areas and upland cultivation systems, coexisting with different levels of technology and productive organization. Despite the technological advances observed in harvesting, processing, conservation, and sanitary control, challenges related to logistics, occupational safety, labor shortages, hygienic-sanitary control, and the sustainable use of residues generated by the production chain still persist. It is concluded that strengthening the açaí production chain depends on the integration of traditional practices, technological innovation, environmental sustainability, and public policies aimed at valuing Amazonian producers and promoting the sustainable development of the region.

Keywords: *Euterpe oleracea*; Açaí production chain; Food security; Agricultural economy; Amazon region.

Resumo

O açaí (*Euterpe oleracea* Mart.) destaca-se como um produto de elevada relevância socioeconômica, cultural e ambiental para a região amazônica, apresentando crescente inserção nos mercados nacional e internacional. Nesse contexto, o presente estudo teve como objetivo realizar uma revisão sistemática da literatura sobre a cadeia produtiva do açaí na Amazônia, abordando sua evolução histórica, relevância socioeconômica, etapas de produção, avanços tecnológicos e os principais desafios enfrentados nos diferentes elos da cadeia. A análise evidenciou que a qualidade dos frutos está diretamente associada ao estádio de maturação e às

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condições de manejo, transporte e processamento, fatores que influenciam as características físico-químicas, microbiológicas e sanitárias do produto. Observou-se que o processamento da polpa envolve etapas críticas, como lavagem, desinfecção, branqueamento e despolpamento, fundamentais para a redução da carga microbiana e garantia da qualidade final. Verificou-se ainda que os sistemas produtivos do açaí variam desde o extrativismo tradicional até áreas manejadas e cultivos em terra firme, coexistindo com diferentes níveis de tecnologia e organização produtiva. Apesar dos avanços tecnológicos observados na colheita, processamento, conservação e controle sanitário, persistem desafios relacionados à logística, segurança ocupacional, escassez de mão de obra, controle higiênico-sanitário e aproveitamento sustentável dos resíduos gerados pela cadeia produtiva. Conclui-se que o fortalecimento da cadeia produtiva do açaí depende da integração entre práticas tradicionais, inovação tecnológica, sustentabilidade ambiental e políticas públicas voltadas à valorização dos produtores amazônicos e ao desenvolvimento sustentável da região.

Palavras-chave: *Euterpe oleracea*; Cadeia produtiva; Sociobioeconomia; Amazônia; Segurança alimentar

Resumen

El açaí (*Euterpe oleracea* Mart.) se destaca como un producto de gran relevancia socioeconómica, cultural y ambiental para la región amazónica, presentando una creciente inserción en los mercados nacionales e internacionales. En este contexto, el presente estudio tuvo como objetivo realizar una revisión sistemática de la literatura sobre la cadena productiva del açaí en la Amazonia, abordando su evolución histórica, relevancia socioeconómica, etapas de producción, avances tecnológicos y los principales desafíos enfrentados en los diferentes eslabones de la cadena. El análisis evidenció que la calidad de los frutos está directamente asociada al estado de maduración y a las condiciones de manejo, transporte y procesamiento, factores que influyen en las características fisicoquímicas, microbiológicas y sanitarias del producto. Se observó que el procesamiento de la pulpa incluye etapas críticas, como lavado, desinfección, escaldado y despulpado, fundamentales para la reducción de la carga microbiana y la garantía de la calidad final. También se verificó que los sistemas productivos del açaí varían desde el extractivismo tradicional hasta áreas manejadas y cultivos en tierra firme, coexistiendo con diferentes niveles de tecnología y organización productiva. A pesar de los avances tecnológicos observados en la cosecha, procesamiento, conservación y control sanitario, persisten desafíos relacionados con la logística, la seguridad ocupacional, la escasez de mano de obra, el control higiénico-sanitario y el aprovechamiento sostenible de los residuos generados por la cadena productiva. Se concluye que el fortalecimiento de la cadena productiva del açaí depende de la integración entre prácticas tradicionales, innovación tecnológica, sostenibilidad ambiental y políticas públicas orientadas a la valorización de los productores amazónicos y al desarrollo sostenible de la región.

Palabras clave: *Euterpe oleracea*; Cadena productiva; Sociobioeconomía; Amazonía; Seguridad alimentaria.

1. Introduction

The açaí palm (*Euterpe oleracea* Mart.) is a species native to the Amazon biome, widely distributed across floodplain (várzea), seasonally flooded (igapó), and upland (terra firme) ecosystems. Its occurrence extends beyond Brazil to

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other tropical regions of South and Central America, including Venezuela, Colombia, Ecuador, Suriname, and Panama (Mourão, 2010).

Three main palm species are recognized as açaí producers: *Euterpe oleracea*, predominant in the states of Pará and Amapá, responsible for most of the commercial production and characterized by its tillering capacity; *Euterpe precatoria*, dominant in the western Amazon and lacking tillering ability; and *Euterpe edulis*, native to the Atlantic Forest, also non-tillering and historically subjected to intense exploitation for palm heart extraction, resulting in significant population decline (Tavares *et al*., 2022).

In the state of Pará, açaí cultivation and management occupy a prominent position among perennial crops, second only to oil palm cultivation. According to data from the Brazilian Institute of Geography and Statistics (IBGE, 2024), Pará remains the leading national producer, with approximately 1.6 million tons harvested annually over an area exceeding 248,812 hectares, predominantly under managed systems. This production highlights the strategic importance of the region in the national and global açaí supply chain.

Despite its economic and cultural relevance, gaps still exist regarding per capita consumption patterns. Data from the Household Budget Survey indicate significantly higher consumption levels in the states of Pará and Amapá, with annual averages of 15,952 kg and 26,192 kg per capita, respectively, reinforcing the central role of açaí in the regional diet (IBGE, 2019).

The açaí production chain involves more than 150,000 people in the state of Pará, encompassing activities such as harvesting, transportation, processing, and distribution. This system forms a complex and interdependent network ranging from small-scale extractivist producers to large agro-industrial enterprises (Tavares and Homma, 2015).

In this context, smallholders play a fundamental role in supplying fresh fruits, particularly in floodplain and upland areas, while larger companies concentrate processing and industrialization aimed at both domestic and international markets (Billacrês *et al*., 2021).

Açaí pulp, the main product derived from the fruit, is obtained in artisanal

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processing units known as "*food mixer*", which are widely distributed throughout the Amazon region, especially in Pará and Amapá. This product constitutes a staple food for local populations, and its production involves multiple stages that directly influence quality attributes, sanitary safety, sensory characteristics, and consumer acceptance (Bezerra, 2019).

The dynamics of the açaí production chain are strongly influenced by seasonal fluctuations, which affect raw material availability, market prices, and consumption patterns throughout the year. These factors reflect the inherent complexity of the system and highlight the need for a more comprehensive understanding of its structure, organization, and functional relationships.

Despite the growing number of studies on açaí, much of the literature still addresses specific aspects of the production chain in a fragmented manner, such as production, market dynamics, and sanitary quality, without systematically integrating the different links involved, as well as their historical, socioeconomic, technological, and environmental dimensions.

Furthermore, there is a noticeable gap in the critical analysis of the açaí production chain as a complex system, particularly regarding governance, value distribution, sustainability, and the contradictions associated with its integration into global markets. In this context, this study seeks to contribute to filling this gap by proposing an integrated and narrative analysis of the açaí production chain in the Amazon.

1.1 General Objective

To conduct a systematic literature review on the açaí production chain in the Amazon, addressing its historical evolution, socioeconomic relevance, production stages, technological advances, and the main challenges faced across the different links of the chain.

2. Methodological Approach

This study is characterized as a narrative literature review with an integrative and interdisciplinary approach, aiming to synthesize and analyze the scientific and technical knowledge regarding the açaí production chain in the Amazon.

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The bibliographic survey was conducted using the SciELO, Scopus, Web of Science, and Google Scholar databases, complemented by institutional documents from agencies such as IBGE, CONAB, MAPA, Embrapa, and the Ministry of Health. Studies published in both Portuguese and English were considered.

The descriptors used included: açaí production chain, *Euterpe oleracea*, Amazonian sociobioeconomy, açaí consumption, açaí processing, and post-harvest technology, as well as their equivalents in both languages.

The temporal scope prioritized publications between 2000 and 2025, without excluding relevant classical references necessary for the historical contextualization of the açaí production chain.

The inclusion criteria comprised scientific articles, books, technical reports, and institutional documents directly related to the production, processing, commercialization, and socio-environmental aspects of açaí. Studies lacking thematic relevance or methodological rigor were excluded.

The analysis of the studies was organized thematically into the following axes: (i) historical evolution and cultural relevance; (ii) socioeconomic importance and governance of the production chain; (iii) harvesting, transportation, and processing; (iv) technological advances; (v) food safety and sanitary risks; and (vi) environmental sustainability.

It is important to note that, as this is a narrative review, the study does not intend to achieve systematic exhaustiveness, which constitutes a limitation; however, this approach allows for a broader and more comprehensive interpretation of the topic.

3. Literature Review

3.1 Origin and historical trajectory of the açaí palm

The açaí palm (*Euterpe oleracea* Mart.), belonging to the *Arecaceae* family, can reach heights between 15 and 20 m and stem diameters ranging from 12 to 18

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cm (Nascimento *et al*., 2008). Known by various regional denominations, such as “açaí-do-pará,” “açaí-de-várzea,” and “açaí-do-baixo-amazonas”, its fruit is widely consumed in beverage form and plays a central role in Amazonian food systems, as well as in regional economic and cultural dynamics (Queiroga, 2023).

This species is perennial, with flowering typically occurring between 2.5 and 3 years after planting, and fruit production taking place throughout the year. However, production is seasonally influenced, with reduced yields during the rainy season (January to May) and peak production between September and December (Oliveira *et al*., 2007). Propagation occurs both through seeds and basal offshoots, a biological characteristic that supports sustainable management practices and also enables its use as a source of palm heart.

The natural habitat of the açaí palm is floodplain ecosystems, particularly in the state of Pará, which represents the main production hub, especially in the Lower Tocantins region and the Marajó archipelago (Gonçalves *et al*., 2016). The term “açaí” derives from the Tupi word *yasa’y*, meaning “palm of water,” reflecting its intrinsic relationship with riparian environments.

The consumption of açaí dates back to the pre-Columbian period and was widely practiced by Indigenous populations. Ethnic groups such as the Tupinambá, Aruã, Anajá, and Mapuá incorporated the fruit into their daily diet, whereas other groups exhibited more limited consumption patterns (Mourão, 2010). Archaeological evidence suggests the presence of açaí since the Holocene, with records dating back at least 1,500 years (Furquim, 2018).

Traditionally, açaí was prepared in multiple forms, including as a pulp mixed with water, combined with cassava flour, or used in porridges and broths. Beyond its nutritional value, the fruit also held symbolic and spiritual significance for many Indigenous communities, being incorporated into rituals and daily practices (Heckenberger, 2004). Indigenous toponymy further reflects this deep cultural connection.

During the colonial period, chroniclers such as Friar Gaspar de Carvajal and Priest João Daniel documented the consumption of açaí among Amazonian populations, emphasizing its importance as a staple food, particularly during

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periods of scarcity (Carvajal, 1941; Daniel, 2004). Over time, colonial populations gradually incorporated the fruit into their own dietary habits.

Across centuries, traditional knowledge related to harvesting and processing has been preserved by riverine and mixed-heritage populations, with particular emphasis on the role of women in transmitting these practices. Techniques such as the use of fiber sieves and wooden mortars have remained essential in artisanal production systems (Lima *et al*., 2018). As a result, açaí has become one of the primary dietary pillars of the Amazon, especially in floodplain areas and urban centers such as Belém.

Historically, açaí production was associated with extractivism and subsistence consumption, with commercialization largely restricted to local markets until the mid-20th century (Homma *et al*., 2006). In addition to fruit production, the açaí palm is also a source of palm heart, whose exploitation intensified from the 1970s onward, driven by increasing national and international demand (Silva, 2008).

However, the intensive exploitation of palm heart resulted in significant environmental impacts, including the depletion of natural populations and cases of predatory extraction, particularly in relation to *Euterpe edulis* in the Atlantic Forest (Queiroga, 2023). This context highlighted the urgent need for more sustainable management practices in açaí production systems.

From the late 1990s onwards, the açaí production chain underwent a significant transformation, shifting toward pulp production driven by expanding demand beyond the Amazon region. States such as Rio de Janeiro and São Paulo emerged as important consumer markets, while açaí gained international visibility, being exported to countries such as the United States, Japan, and several European nations (Tagore *et al*., 2019).

Currently, the açaí production chain continues to expand, involving actors ranging from extractivists and smallholders to large-scale exporting companies. At the same time, critical challenges persist, particularly regarding environmental sustainability, equitable income distribution, and sanitary quality standards. Addressing these issues requires coordinated actions among public institutions,

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researchers, and traditional communities (Quaresma and Euler, 2023).

3.2 Socioeconomic importance of the açaí palm in the Amazon

Amazonian sociobioeconomy can be understood as a development model based on the sustainable use of biodiversity, associated with the valorization of traditional knowledge, social inclusion, and environmental conservation, seeking to reconcile income generation with ecosystem preservation (Brondizio *et al*., 2016; Garrett *et al*., 2023).

In the context of the açaí production chain, this concept involves not only the economic exploitation of the fruit, but also the maintenance of cultural practices, the conservation of ecosystems, and a more equitable distribution of benefits throughout the production chain.

Açaí is widely consumed in the Amazon region and plays a strategic role in both food systems and socioeconomic development, particularly in the state of Pará, which stands as the world's leading producer, consumer, and exporter of the fruit (CONAB, 2019). In recent decades, açaí has emerged as one of the fastest-growing fruit commodities, consolidating its position as a central component of the regional economy.

Pará accounts for approximately 95% of Brazil's total production, with around 60% consumed locally, 30% distributed to other regions of the country, and 10% destined for export markets (Tavares and Homma, 2015). The expansion of both domestic and international demand has driven the intensification of cultivated and managed areas, reduced dependence on purely extractive systems, and improved postharvest processing practices, positioning açaí as one of the most dynamic agricultural products in the Amazon.

The açaí production chain generates significant socioeconomic impacts, particularly through employment creation and income generation in both rural communities and urban centers. Activities such as harvesting, processing, and commercialization support thousands of families, especially during the harvest season, when labor demand increases substantially. Empirical evidence indicates that açaí constitutes a major source of household income, contributing to improved

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living conditions among riverine, quilombola, and Indigenous populations (Rosário and Filocreão, 2024).

Beyond income generation, açaí functions as a catalyst for regional economic dynamism by strengthening cooperative networks and solidarity-based enterprises. These systems, grounded in principles of cooperation and social equity, facilitate market access for products derived from traditional communities, cooperatives, and small-scale producers (Ribeiro *et al*., 2025).

The increasing valorization of açaí in national and international markets has driven strategies such as Geographical Indication (GI) and socio-environmental traceability, mechanisms that add value to the product and recognize the traditional knowledge associated with its production (Felício, 2001).

Although the commercialization of floodplain açaí still faces challenges related to logistics, production organization, and competitiveness, there is growing potential to strengthen the sector through the recognition of the fruit as a cultural and ecological heritage of the Amazon (Rodrigues, 2021).

In this context, the creation of territorial brands and specific certifications contributes to positioning the product in differentiated markets, meeting the demand for safe, sustainable foods linked to Amazonian sociocultural identity (Fernandes *et al*., 2022). Furthermore, public policies aimed at strengthening the production chain, including incentives for environmental certification, technical training, and improvements in commercialization infrastructure, may enhance the sector's competitiveness and strengthen the integration of small producers into regional and global markets (Ramos; Pontes, 2025).

The growing valorization of açaí in national and international markets has stimulated the adoption of strategies such as Geographical Indication (GI) and socio-environmental traceability. These mechanisms not only add economic value but also recognize and legitimize the traditional knowledge embedded in production systems (Felício, 2001). Furthermore, they align with increasing consumer demand for safe, sustainable products associated with cultural identity and environmental responsibility.

Açaí commercialization occurs across both informal markets, such as street

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fairs and local markets, and formalized channels, including interstate trade and international exports. This expansion has been reinforced by the recognition of açaí as a functional food, characterized by high levels of antioxidants, dietary fiber, and beneficial lipids, thereby expanding its consumption beyond the Amazon region (Tavares and Homma, 2015). In parallel, urbanization processes and the industrialization of pulp production have contributed to product diversification and the emergence of new market niches.

Despite these advances, the distribution of socioeconomic benefits remains uneven. Income concentration within specific segments of the value chain and the limited organizational capacity of primary producers represent persistent structural challenges. Additionally, the expansion of irrigated monocultures and the intensification of floodplain management practices have generated socio-environmental pressures that require stronger regulatory frameworks (Tagore *et al*., 2019).

In this context, public policies aimed at technical training, sanitary compliance, access to credit, and market integration are essential to strengthen productive inclusion. Institutional programs such as the Food Acquisition Program (PAA) and the National School Feeding Program (PNAE) play a strategic role by integrating smallholder production into institutional markets, promoting short supply chains and enhancing food security (Brasil, 2020).

Ultimately, the consolidation of açaí as a strategic commodity depends on the ability to reconcile economic development, social equity, and environmental sustainability. Within the broader framework of the bioeconomy, açaí stands out as a key resource for poverty reduction, the valorization of sociobiodiversity, and climate change mitigation (Quaresma and Euler, 2023). Recent data reinforce this relevance: in 2024, the state of Pará exported 13.45 thousand tons of açaí, representing a 173.55% increase compared to the previous year and generating revenues of US$ 46.59 million (Silva, 2025).

3.3 Açaí consumption: between amazonian tradition and market expansion

In the Amazon region, plant-based products have always played a central

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role in the socioeconomic and cultural structure of local populations, especially among traditional communities.

This relationship dates back to the sustainable practices of Indigenous peoples, focused on subsistence and environmental conservation (Homma, 2014). In this context, plant extractivism stands out as a historical activity associated with the sustainable use of natural resources and biodiversity preservation, directed toward limited markets.

Among the most relevant native fruits is açaí, considered the second most consumed food in the Amazon estuary, surpassed only by cassava flour. The combination of açaí and cassava flour constitutes the dietary base of several communities, highlighting its nutritional importance, cultural relevance, and contribution to regional food security (Mourão, 2010).

The most commonly used types are purple açaí, which is more abundant and has a purplish coloration, and white açaí (Figure 1), characterized by its greenish tone and lower occurrence (Homma *et al*., 2006). Traditionally, consumption occurs in peri-urban areas and rural communities through small processing units known as *"food mixer"* or *"kneader"*. In these places, açaí is consumed with foods such as cassava flour, tapioca, fish, shrimp, or dried meat, and is considered an essential element in daily diets.

The differences in fruit coloration during processing are reflected in the pulp obtained after pulping, as illustrated in Figure 1. White açaí produces a pulp with a light, yellowish-green tone, whereas purple açaí results in a pulp with an intense purplish coloration. These characteristics influence not only the appearance of the final product, but also its commercial acceptance, regional identity, and forms of consumption.

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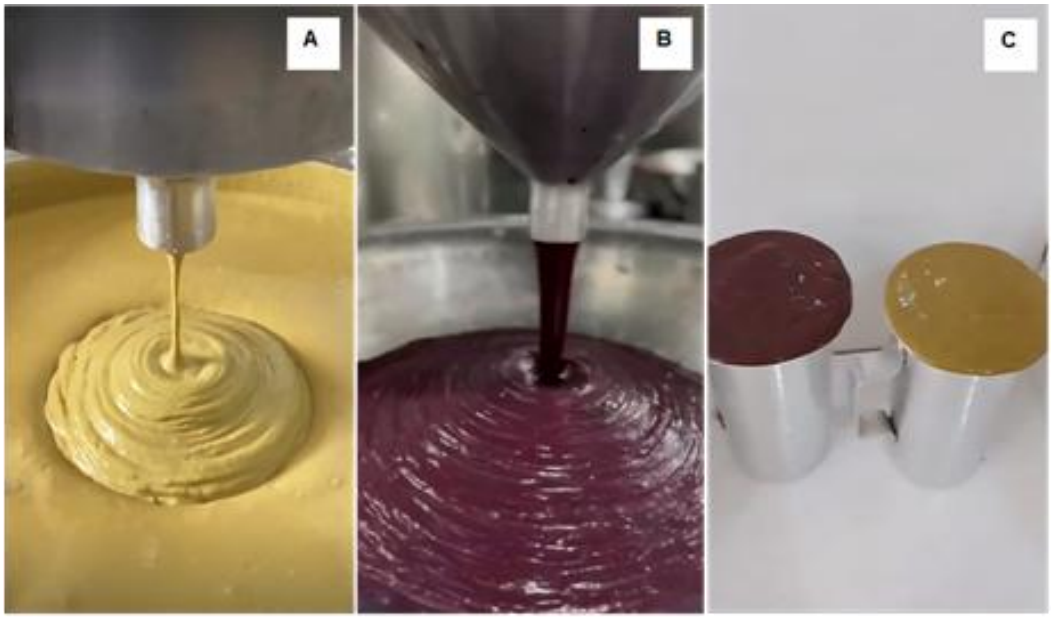
Figure 1. Processed and standardized açaí pulp for packaging. (A) Processed white açaí; (B) processed purple açaí; (C) pulp measured in 1 L containers for packaging.



Source: Trindade, V. M. M. de C., 2026.

In recent years, açaí has evolved from a traditional food into a versatile product, widely explored in various forms of presentation and consumption. The industry has invested in the production of derivatives such as ice cream, popsicles, jams, sweets, juices, açaí powder, energy drinks, açaí pulp, and even coffee made from the fruit seed. Products such as açaí with guaraná syrup, pasteurized pulp, and liqueurs have become increasingly available in supermarkets and health food stores across the country, reflecting the expansion of the consumer market (Pedroso *et al*., 2011), as illustrated in Figure 2.

This national and international popularization has contributed to the transformation of its consumption patterns and has consolidated the fruit as a functional food. The valorization of its nutritional properties rich in fiber, lipids, anthocyanins, and vitamins has favored its inclusion in diets focused on health and well-being, including in urban contexts outside the Amazon region (Schauss *et al*., 2006).

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Figure 2. Industrialized açaí-derived products available at points of sale, including jam, ice cream, powdered coffee, and dietary supplement.

Source: Trindade, V. M. M. C. de, 2026.

In the state of Pará, açaí has also been consolidated as a symbol of regional food identity. From 1995 onwards, with the television series *Malhação* broadcast by Rede Globo, it became part of tourism marketing strategies and new commercialization channels, such as supermarkets, gyms, and coffee shops, expanding its reach among different consumer groups (Homma *et al*., 2006; Santana *et al*., 2007).

Despite this expansion, there are concerns regarding accessibility, especially for low-income populations. During the off-season period, when fruit availability is reduced, prices tend to increase significantly in some cases exceeding R$ 80.00 per liter of thick açaí pulp (2026 data) in the Metropolitan Region of Belém, Pará. This scenario raises concerns about the elitization of consumption and the consequent distancing of açaí from its traditional consumer base, which is more sensitive to price than to quality.

Seasonality is one of the main challenges in the production chain. During the harvest season, there is greater availability and better fruit quality, resulting in lower prices. In contrast, during the off-season, the reduction in supply compromises availability and imposes logistical and economic constraints. This situation

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reinforces the need to expand managed and cultivated areas, as well as the large-scale development of powdered açaí, in order to ensure access to the product and strengthen the production chain.

Finally, açaí consumption highlights its multifaceted nature: in addition to being an essential food, it is also a cultural marker and an expanding economic product. Within the framework of the bioeconomy, it stands out as a strategic vector for sustainable development and the valorization of traditional ways of life (Quaresma and Euler, 2023). Understanding these dynamics requires recognizing the tensions between tradition and market forces, as well as between culture and economy.

3.4 Extractive, Managed, and Cultivated Systems of Açaí Palm

The açaí palm (*Euterpe oleracea* Mart.) occurs naturally in both floodplain (várzea) and upland (terra firme) areas of the Amazon, being more frequently found in floodplain ecosystems, where it exhibits adaptations to periodic flooding and high humidity conditions (Oliveira *et al*., 2000). In this context, açaí production systems range from traditional extractivism to more intensive cultivation systems, differing in terms of management practices, technological use, and environmental interference.

The extractive system is characterized by fruit harvesting from natural populations of açaí palms, located mainly in floodplain and igapó areas, without planned crop establishment. This model depends directly on the natural environmental conditions and constitutes an important source of subsistence and income for Amazonian riverside communities (Nogueira; Figueiredo; Muller, 2005).

In many regions, production dynamics are directly associated with the seasonal flooding and drought cycles of rivers, which influence both productivity and access to harvesting areas (Euller *et al*., 2019). Furthermore, harvesting in floodplain areas presents particular challenges related to limited access and the need for transportation through flooded environments, requiring logistical planning according to the local hydrological regime (Verbicaro; Nunes, 2015).

With the increasing demand for the fruit, especially in recent decades, the management of native açaí stands has intensified. The managed system refers to

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native açaí groves subjected to selective interventions aimed at increasing productivity, including practices such as thinning competing vegetation, area cleaning, and the selection of more vigorous shoots, promoting greater light incidence and improved productivity without complete removal of the native forest (Queiroz; Mochiutti, 2000; Nogueira *et al*., 2013).

Studies involving Amazonian family farming demonstrate that extractive açaí management has high economic relevance for rural workers, contributing to income generation and productive integration into the regional agribusiness sector (Silva *et al*., 2015).

Simultaneously, açaí cultivation in upland areas has expanded. This system is characterized by the planned establishment of crops in areas not subject to periodic flooding, generally associated with irrigation, fertilization, and more intensive agronomic practices. This production model was mainly driven by the need for off-season production relative to floodplain harvests and by the increasing commercial value of the fruit (Farias *et al*., 2011; Homma, 2014).

In the state of Pará, degraded agricultural lands and former cultivation areas have been converted into upland açaí plantations, contributing to increased supply and productivity (Farias *et al*., 2011). Although upland cultivation enables greater production control and regularity, studies indicate that the intensification of production systems may promote ecological simplification, increased dependence on external inputs, and significant environmental changes (Carvalho *et al*., 2021).

In addition to differences related to management and productivity, açaí production systems also present distinct environmental implications. The intensification of extractive exploitation in floodplain areas near the Amazon estuary has, in some regions, favored the formation of areas with high densities of açaí palms, significantly reducing the floristic diversity of floodable forests (Homma, 1993; Freitas *et al*., 2015). Therefore, several studies emphasize the need to adopt sustainable practices capable of reconciling increased production with the conservation of Amazonian ecosystems and the maintenance of local biodiversity (Araújo; Navegantes, 2015; Correa; Cordeiro, 2025).

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3.5 Stages of the açaí production chain

3.5.1 Harvesting of açaí fruits

The first step consists of identifying the ideal stage of fruit maturation. Based on traditional knowledge, harvesters recognize the appropriate harvest point when the fruits exhibit a dark coloration, usually purple or black, a task that requires experience in observing the fruit clusters located more than 5 meters above the ground. Proper maturation is essential, as early or late harvesting compromises the final product quality, affecting both flavor and consistency (Nogueira *et al*., 2018).

Each cluster is composed of numerous fruits that do not ripen uniformly, requiring careful selection. Therefore, harvesting is often carried out selectively, prioritizing ripe fruits and preserving the others for subsequent harvests (Santos *et al*., 2019).

Due to the characteristics of the Amazonian environment, harvesting is predominantly manual. The palms can reach considerable heights, making mechanization difficult. For this reason, simple tools are used, such as machetes and hooked poles, as well as the *"peconha"*, a braided strap that assists in climbing and provides greater safety to the harvester (Homma, 2012).

This type of management, although physically demanding, is essential to preserve the integrity of both the plant and the fruits. The proper use of tools prevents damage to the stipe, ensuring the productive continuity of the palm over successive harvest cycles (Embrapa, 2023).

The açaí harvesting stage involves significant occupational risks, as it frequently requires climbing tall palm trees, exposing workers to falls, injuries, and other accidents. It is a physically demanding activity, often carried out using traditional techniques that require skill, physical effort, and experience.

In this context, according to Ramos and Pontes (2025), the shortage of rural labor constitutes a sensitive issue within the production chain, especially during periods of increased harvesting demand. In many cases, small producers rely on the participation of underage children in fruit extraction activities due to the agility and dexterity required for climbing açaí palm stems.

The expansion of upland plantations and managed floodplain areas, driven

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by increasing market demand, has intensified the need for labor in harvesting activities, contributing to the shortage of specialized workers (Tavares; Homma, 2015). Furthermore, consumer market requirements regarding compliance with labor regulations and restrictions on child labor have promoted changes in hiring practices and harvesting organization, including the adoption of outsourced labor systems or the transfer of harvesting responsibilities to the buyers themselves.

However, the involvement of minors in potentially hazardous activities should not be normalized and must be analyzed in light of labor legislation and the principles of comprehensive protection of children and adolescents. With the approval of Constitutional Amendment No. 20 in 1998, the minimum legal working age in Brazil was established at 16 years, restricting the use of child labor, including in family farming activities (Ferro; Kassouf, 2005).

The sustainable management of açaí stands is essential, especially in floodplain areas. Traditional techniques, such as the use of the *peconha* and adapted poles, contribute to improving harvesting efficiency and reducing environmental impacts. Combined with the knowledge of extractivist communities, these practices strengthen the sustainability of the production chain (Embrapa, 2020).

In parallel, approximately two dozen prototypes have already been developed for cluster harvesting, although not all are viable, with some presenting high complexity involving the use of batteries and sensors. These advances indicate a potential modernization of the activity, with the gradual adoption of technologies that may increase work efficiency and safety (Nascimento, 2024).

Harvesting is influenced by the natural cycles of the species and environmental conditions, requiring harvesters to have knowledge of peak production periods and the characteristics of cultivation areas. In floodplain regions, for example, river levels directly affect access to the palms, whereas in upland areas (*terra firme*) management tends to be more regular (Embrapa, 2021).

After cluster removal, it is recommended that threshing be carried out at the collection site. This manual step consists of separating the fruits from the clusters, facilitating transportation and contributing to fruit preservation by reducing volume

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and improving ventilation. To avoid contamination, this process should be performed on clean surfaces or in sanitized containers (Imazon, 2018).

Another relevant aspect of harvesting concerns the selection of palms to be exploited. In native açaí stands, harvesters commonly prioritize more robust and productive individuals, while respecting the growth of younger plants to ensure natural regeneration of the stands (Homma, 2014). This traditional management reflects local ecological knowledge and a concern for the sustainability of the activity.

Thus, açaí harvesting transcends its economic dimension and constitutes an integral part of the way of life of Amazonian populations. This activity not only contributes to food security and local income generation but also reflects traditional practices of sustainable resource use, which are fundamental for the conservation of forest ecosystems (Oliveira *et al*., 2016).

3.5.2 Açaí transportation

After harvesting, the transportation of açaí to processing units constitutes a critical stage in the production chain due to the fruit's high perishability. Owing to its thin skin and high susceptibility to fermentation, açaí must be processed within 24 hours after harvest, which imposes significant logistical challenges (Cohen *et al*., 2011; Mourão, 2010).

Traditionally, açaí handling and transport involve the use of different types of containers, particularly *rasas*, sacks, and plastic crates. *Rasas* are woven baskets made from arumã stems (*Ischnosiphon ovatus* Kcke.), a species belonging to the Marantaceae family.

These baskets correspond to a local measurement of approximately 14 kg and are traditionally produced by residents of açaí-producing areas. However, their use has been declining due to resource depletion and the increasing adoption of plastic containers.

Sacks, commonly known as onion bags, with approximate capacities of 30 and 60 kg, are also widely used, particularly for transporting larger volumes of fruit. Rectangular plastic crates (basquetas), in turn, are more frequently used during

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unloading, sorting, and transport to processing facilities.

Transportation occurs mainly via river vessels, such as boats and canoes. In this context, *rasas* are better adapted to the curved internal spaces of these vessels, optimizing storage during river transport (Figure 3).

Figure 3. Stages of açaí handling and transportation: traditional use of *rasas* in vessels

(A), transfer to plastic crates (B), and stacking of crates at the processing unit (C).

Source: Trindade, V. M. M. C. de, 2026.

Additionally, when empty, *rasas* can be stacked inside one another, reducing space requirements and allowing placement on the vessel canopy due to their lightweight nature (Homma *et al*., 2006).

On the other hand, during unloading and transport to processing units, plastic crates are more suitable, as they facilitate stacking, ventilation, and product organization. In cases involving longer transport times, the use of ice is common to delay fermentation and preserve fruit quality (EMBRAPA, 2021).

The quality of açaí fruits varies significantly depending on the stage of maturity and transportation conditions. According to Homma *et al*. (2006), fruits classified as *tuíra* correspond to the optimal harvest stage, characterized by an intense dark purple color covered by a thin whitish-gray layer, and are often placed at the top of the *rasa* to enhance product value. In contrast, "*paró"* consists of fruits

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at different stages of maturity, including immature fruits, which reduces their commercial quality. Another important aspect refers to *moqueado* açaí, a term used for fruits harvested on previous days or subjected to delays during transportation, initiating dehydration processes. Additionally, fruits must be protected from rain, typically using tarpaulins, in order to avoid excessive moisture, fermentation, and quality losses.

Beyond physical and commercial changes, handling conditions during transportation directly influence the sanitary quality of the product. Inadequate practices in packaging, hygiene, and fruit protection favor contamination by microorganisms, including *Trypanosoma cruzi*, the etiological agent associated with Chagas disease through oral transmission (Passos *et al*., 2012).

Given these challenges, initiatives aimed at modernizing transportation have gained increasing attention. The adoption of technologies such as insulated containers, refrigeration systems, and traceability tools contributes to reducing losses, preserving quality, and ensuring greater food safety (Embrapa, 2017).

Logistical dynamics also reflect the diversity of producing regions. During the harvest season, there is an intense flow of açaí originating from municipalities such as Cametá, Abaetetuba, Igarapé-Miri, and the Marajó archipelago, supplying markets such as Belém and Macapá (Ribeiro, 2019). This diversity of origins results in variations in fruit quality, influenced by factors such as soil, climate, and management practices.

The role of intermediaries, such as traders, cooperatives, and small-scale merchants, is also noteworthy in transportation logistics. These agents are essential for connecting production areas to consumer markets, especially in regions with structural limitations, ensuring the continuous flow of production (Oliveira, 2025).

In this context, investment in logistical infrastructure, capacity building of stakeholders, and supportive public policies is essential. Measures such as the construction of community ports, access to credit for vessel acquisition, and the strengthening of cooperative systems can improve product flow and increase the efficiency of the Amazonian production chain.

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3.5.3 Processing and commercialization of açaí pulp

The processing of açaí pulp constitutes a central stage in the production chain, responsible for transforming the fresh fruit into a product with higher added value and extended shelf life. This process enables its commercialization in different markets, including national and international ones, contributing to the expansion of the production chain and its integration into new economic circuits (CONAB, 2020).

Following this initial transformation into a marketable product, açaí processing involves a sequence of steps that ensure proper pulp extraction and quality preservation. The process begins with the immersion of fruits in water to soften them, followed by pulp extraction using mechanical pulping machines. This procedure is carried out in batches and allows the separation of the pulp, commonly referred to as “traditional açaí pulp”, from the seeds and other solid residues (Cohen *et al*., 2011).

The pulp accounts for only 10% to 15% of the total fruit weight, whereas the seed may represent up to 90%. Although still underutilized, this residue has potential for various applications, such as charcoal production, animal feed, cosmetics, biofuels, and handicrafts (Moreira and Sousa, 2020). Improper disposal, however, may result in environmental impacts, including leachate generation, methane emissions, and attraction of disease vectors.

In the Amazon region, açaí processing is commonly carried out in small- and medium-scale processing units known as “*food mixer*”, which exhibit varying levels of technological development and formalization (Lima, 2018). In general, processors acquire fruits in local markets and perform small-scale processing for direct sale to consumers. While some establishments operate formally, others function informally, which complicates sanitary control.

Fruit selection should occur at the time of purchase, with careful attention to hygienic-sanitary conditions. However, inadequate storage practices are still common, including contact between raw materials, chemical products, and contaminants, which compromises product safety.

The risks of açaí contamination include physical agents (straw, insects, and

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fragments), chemical contaminants (oils and fuels), microbiological hazards (*Salmonella* spp., coliforms, hepatitis A virus, and *Trypanosoma cruzi*), and mechanical factors (poorly sanitized equipment). Therefore, the adoption of Good Manufacturing Practices (GMP) is essential to ensure food safety (Santos *et al*., 2016).

In response to these vulnerabilities, the Government of Pará State established the Açaí Quality State Program (PEQA), through Decree No. 250/2011, with actions aimed at improving sanitary conditions throughout the production chain (Lopes *et al*., 2021). One of the main initiatives is the blanching tank, which heats the fruit to approximately 80 °C, reducing microbial load and eliminating *T. cruzi* without compromising the sensory characteristics of the product.

According to the Brazilian Ministry of Health, between 2007 and 2023, 4,316 cases of acute Chagas disease were reported in Brazil, with the highest concentration in Pará State, reinforcing the importance of sanitary control in the açaí production chain (BRASIL, 2023). Additionally, outbreaks associated with *Salmonella* and coliforms highlight the need for effective inspection and strict adoption of Good Manufacturing Practices (Cohen *et al*., 2011; Santos *et al*., 2016).

In this context, Figure 4 illustrates the spatial organization into three areas: dirty area (reception, selection, and washing), clean area (processing and storage), and an isolated sanitary area. This division follows GMP principles and contributes to product safety.

Beyond infrastructure, equipment should preferably be made of stainless steel due to its resistance and ease of sanitation. The main equipment includes sorting tables, washing tanks, disinfection systems, blanching units, cooling systems, and pulping machines (Bezerra, 2009).

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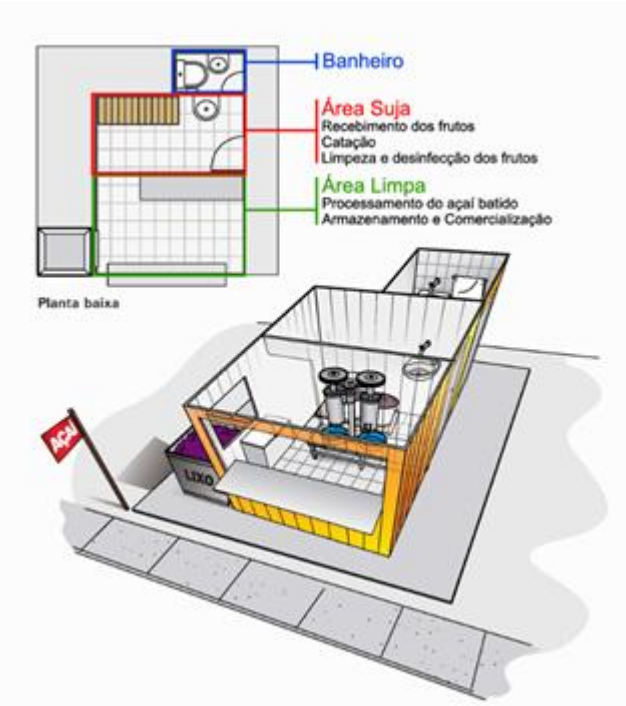
Figure 4 – Layout plan of a suitable açaí processing unit.



Source: EMBRAPA, 2019.

The processing follows standardized steps, from fruit reception to pulping, including washing, disinfection, blanching, and cooling, as presented in Frame 1. These steps are essential for reducing microbial load and preventing contamination.

Frame 1: Steps used before and during açaí processing.

Processing Steps	**Description**
Fruit reception	Verification of origin, supplier conditions, and fruit quality to avoid compromising the final product.
Fruit selection	Removal of impurities such as stones, soil, insects, and other foreign materials, including triatomine bugs. The use of sieves and stainless steel sorting tables is recommended.
Fruit washing	Washing with potable running water to remove impurities originating from the field and transportation.
Fruit disinfection and rinsing	Immersion in chlorinated solution for 20 minutes, followed by rinsing with potable water to remove residual chlorine.

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Blanching and fruit softening	Immersion in water at 80 °C for 10 seconds, followed by cooling in clean water, promoting fruit softening and microbiological safety.
Fruit pulping	Processing in a pulping machine with controlled addition of water, determining pulp consistency.

Source: Authors (2026).

After understanding the processing steps and the hygienic-sanitary precautions involved, the importance of standardizing the final product becomes evident. In this context, Frame 2 illustrates the classification of processed açaí according to its consistency, commonly referred to as thin, medium, or thick, characteristics directly related to the proportion of water added during processing.

This classification is regulated by Normative Instruction No. 01/2000 of the Brazilian Ministry of Agriculture, Livestock, and Supply (MAPA), which establishes identity and quality standards for açaí pulp. These standards are essential to guide production and meet the demands of the consumer market, which is increasingly attentive to food quality and origin.

Frame 2 - Classification of açaí pulp according to processing and total solids content.

Classification	**Description**
Açaí Pulp	Product obtained by mechanical extraction of the fruit, with water addition and filtration, which may also undergo physical preservation methods.
Thick or special açaí (Type A)	Product obtained with water addition and filtration, presenting a high total solids content (above 14%) and a very dense appearance.
Medium or regular açaí (Type B)	Product obtained with water addition and filtration, with total solids content between 11% and 14%, showing intermediate density.
Thin or popular açaí (Type C)	Product obtained with water addition and filtration, with total solids content between 8% and 11%, characterized by lower density.

Source: Authors (2026), based on Normative Instruction N°. 01, January 7, 2000.

Strengthening the açaí production chain relies on the adoption of Good Manufacturing Practices, effective sanitary control, valorization of residues, and the promotion of enterprise formalization. Açaí industrialization represents not only a pathway for income generation but also an opportunity for social inclusion and

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innovation within the Amazonian context.

3.6 Technological Advances in the Açaí Production Chain

Technological advances in the açaí production chain have occurred gradually and heterogeneously across different stages of production, reflecting both the growing demand for the fruit and the structural limitations of the Amazon region. Initially, the main transformations were concentrated in pulp processing.

In 1945, the merchant Ovídio Bastos, based on Mundurucus Street in Belém, developed the first mechanized prototype for açaí pulp extraction, replacing the traditional manual wooden “mashing machines” previously used. With the expansion of the consumer market, especially from the late 1980s onward, pulp extraction machines underwent successive technological improvements, contributing to increased operational efficiency, processing capacity, and productivity within the production chain (Tavares; Homma, 2015).

In the harvesting stage, technological advances were mainly aimed at reducing physical effort and occupational risks associated with climbing açaí palm stems. In the mid-1980s, researcher Carlos Hans Müller, from Embrapa Amazônia Oriental, developed an aluminum harvesting pole equipped with a cutting blade and a container for storing fruit bunches, allowing them to be lowered to the ground through a pulley system and reducing losses during harvesting (Nogueira *et al*., 2005). This equipment represented an improvement of traditional extractive tools, such as the “mané de viagem,” commonly used on tall palm trees with a high risk of accidents.

More recently, new prototypes aimed at harvesting mechanization have been developed, including devices with higher levels of technological complexity, some using batteries, sensors, and automated systems for bunch extraction. Although many of these technologies still present economic and operational limitations, such initiatives demonstrate a trend toward modernization of the activity, with the potential to increase production efficiency, reduce losses, and improve occupational safety conditions (Nascimento, 2024).

Despite these innovations, traditional harvesting methods still predominate in

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many Amazonian production systems and may result in considerable fruit losses during collection (Homma *et al*., 2006; Tavares; Homma, 2015).

In addition to harvesting and processing, significant advances have also occurred in the transportation, preservation, and industrial processing stages. The introduction of the cold chain contributed to reducing post-harvest losses and maintaining the microbiological and sensory quality of the product, although its adoption still faces limitations related to logistical infrastructure and high operational costs, especially in more isolated Amazonian regions.

In industrial processing, technologies such as thermal blanching stand out as essential for microbiological control and the reduction of sanitary risks, in addition to the use of stainless-steel equipment, which promotes better hygienic-sanitary conditions and greater food safety. At the same time, freezing systems, traceability technologies, and residue utilization strategies have become increasingly incorporated into more structured segments of the production chain, in response to market demands for quality, sustainability, and production transparency.

However, the incorporation of these innovations still occurs unevenly throughout the açaí production chain. While industrial sectors and export-oriented markets present higher levels of technological development, traditional practices remain widely present in extractive systems and small-scale processing units, highlighting the structural and technological differences that persist among the various segments of the chain.

3.7 Perspectives of the Açaí Production Chain

The açaí production chain presents promising prospects for economic expansion and the strengthening of the Amazonian sociobioeconomy, while also revealing structural challenges related to governance, sustainability, food security, and value distribution throughout the chain.

In recent decades, the fruit has evolved from being predominantly consumed at the regional level to becoming integrated into global value chains, consolidating itself as one of the main non-timber forest products of the Amazon and frequently being associated with the concept of an Amazonian superfood (Teixeira *et al*.,

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2026). This internationalization process has increased the product's economic visibility and boosted its insertion into increasingly demanding national and international markets.

However, with the growing global demand and international recognition of açaí, concerns regarding production sustainability and the organization of the value chain have also intensified (Cialdella; Navegantes, 2014; Sousa *et al*., 2023). In this context, several authors warn about the risks associated with the expansion of more homogeneous production systems and the increasing adoption of monocultures, a process observed in different producing regions that may compromise biodiversity, ecological resilience, and the sustainability of Amazonian ecosystems (Suarez; Gwozdz, 2023).

Although the commercial valorization of the fruit represents an important source of income for riverside populations, family farmers, and workers involved in the production chain, the literature highlights that market expansion may also deepen socioeconomic inequalities. In many cases, a significant portion of the added value remains concentrated in industrial, logistical, and commercial sectors, while extractivist producers face limitations related to infrastructure, technical assistance, access to credit, and bargaining power (Superti; Pegler, 2018).

Furthermore, the growing demand for the fruit has caused changes in consumption patterns and the commercial circulation of açaí. The increase in exports and the valorization of the product in national and international urban centers have, during certain periods, contributed to significant price increases, affecting the access of Amazonian populations to a food traditionally consumed as a regional dietary staple (Tourrand; Veiga; Boudet, 2021). Thus, the transformation of açaí into a global commodity highlights tensions between economic valorization, food security, and the preservation of cultural practices associated with traditional consumption.

Another important dimension concerns sanitary safety and the informality present in different stages of the production chain. Although informality represents an income-generating alternative for thousands of workers, especially in small-scale processing facilities and artisanal production systems, the lack of traceability,

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sanitary standardization, and adequate infrastructure still constitutes a challenge for product quality and safety (Moraes; Mello, 2022). In this context, mechanisms such as socio-environmental certifications, traceability systems, and Geographical Indications have been identified as strategies capable of adding value to the product and strengthening more sustainable and safer production practices.

Given these contradictions, several studies emphasize the need to develop more integrated and participatory governance models capable of reconciling economic growth, social inclusion, environmental conservation, and the strengthening of the Amazonian sociobioeconomy. Therefore, the future prospects of the açaí production chain depend not only on increasing production and international competitiveness, but also on the implementation of public policies, incentives for sustainable management, the valorization of traditional knowledge, and the strengthening of small producers' participation in differentiated markets (Teixeira *et al*., 2026; Tagore; Monteiro; Canto, 2020).

3. Final Considerations

Açaí stands out as one of the most representative products of the Amazon, holding significant historical, cultural, socioeconomic, and environmental importance. Over the past decades, its production chain has undergone profound transformations, evolving from a product mainly intended for local consumption and subsistence into a commodity integrated into regional, national, and international markets, driven by increasing demand and the expansion of industrial pulp processing.

The review conducted demonstrated that the açaí production chain constitutes a complex and heterogeneous system, involving different production systems ranging from traditional extractivism to managed areas and upland cultivation systems. Although traditional practices still predominate in several segments of Amazonian production, there has been a gradual incorporation of technological advances related to harvesting, processing, conservation, traceability, and sanitary control, contributing to improvements in product quality

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and market competitiveness.

However, important structural challenges remain, particularly regarding logistics, informality, occupational safety, shortage of specialized labor, hygienic-sanitary control, and the unequal distribution of economic benefits throughout the production chain. Furthermore, the expansion and intensification of production systems require greater attention to environmental sustainability, biodiversity conservation, and the valorization of traditional communities involved in the activity.

In this context, strengthening the açaí production chain depends on the integration of traditional knowledge, technological innovation, and public policies aimed at the sustainable development of the Amazon. Thus, açaí represents not only the valorization of a traditional Amazonian food consumed since Indigenous peoples, but also an important symbol of Amazonian socio-bioeconomy and of the transformations from extractivism to managed and cultivated production systems over recent decades.

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