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APPLICATION OF AÇAÍ (EUTERPE OLERACEA) SEEDS IN FEED PRODUCTION – A CONCEPT OF SUSTAINABILITY IN THE ANIMAL NUTRITION CHAIN

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ABSTRACT

The expansion of Brazilian livestock production and the growing search for more sustainable food have driven research on the use of by-products as an input in animal nutrition. This work addresses the application of açaí (Euterpe oleracea) seeds in the formulation of feeds, emphasizing aspects of sustainability and economic viability. A review of scientific articles was carried out in databases such as PubMed, Science Direct, and Capes Journals, considering publications from 2015 to 2025. The nutritional composition of the seeds was verified, highlighting fibers, tannins, proteins and fatty acids, in addition to the positive impacts on health and zootechnical performance in different animal species. The results point to a promising alternative in the reuse of this abundant waste in the Amazon Region, contributing to cost reduction and environmental preservation.

Keywords: Euterpe oleracea. Acai pits. Animal feed. Sustainability.

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INTRODUCTION

The expansion of Brazilian agribusiness has required increasingly innovative solutions that reconcile competitiveness, sustainability and food security. In particular, the production of animal feed represents one of the great pillars of the livestock sector, as the provision of a balanced diet directly influences the performance, productivity and quality of animal products. The high dependence on conventional inputs, such as corn and soybeans, entails significant costs and makes the production process susceptible to market fluctuations and environmental pressures, especially about the intensive use of agricultural areas. In this scenario, the search for alternative sources of raw material that reduce both the final cost and the environmental impact gains relevance, paving the way for the use of abundant agro-industrial waste in Brazil.

Among the promising by-products, açaí seeds (Euterpe oleracea) stand out, which constitute about 70% of the total weight of the fruit. Açaí, widely consumed in the North and Northeast regions of the country, as well as marketed in the national and international markets, generates a large volume of pits that, for a long time, were inappropriately disposed of in landfills or dumps, enhancing environmental and public health problems. In addition, this massive disposal represents the loss of a possible source of inputs that could be used by the feed industry, generating added value to a material previously considered waste. Recent research indicates that açaí seeds contain appreciable fractions of fiber, proteins, fatty acids and phenolic compounds, making them potential ingredients for the formulation of diets for ruminants, poultry, pigs and other species of economic interest.

Interest in the use of açaí seeds as a food component grows as the economic and ecological benefits of this practice are recognized. From an economic point of view, the partial replacement of traditional feed ingredients, such as corn, can significantly reduce production costs, especially in periods when these grains suffer sharp price variations. From an environmental perspective, the reuse of pits avoids the accumulation of organic waste in landfills, reduces the emission of greenhouse gases associated with inadequate degradation of the material and favors the circular economy by incorporating by-products into new production processes. In this sense, the adoption of sustainable strategies in the animal nutrition chain reinforces the commitment of Brazilian agribusiness to the global goals of mitigating environmental impacts and conserving natural resources.

Although açaí seeds have interesting levels of nutrients and bioactive compounds, their use in animal nutrition still requires in-depth scientific research to confirm the safety of

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use, determine the best forms of processing and define optimal levels of inclusion in diets. Different species and stages of development have specific nutritional requirements, so the way the stone is presented (whole, crushed, fermented or associated with other ingredients) can directly influence the digestibility and availability of nutrients. Studies with ruminants, for example, suggest that açaí seeds can act positively on rumen modulation and weight gain, but, at the same time, point to the importance of balancing the amounts of protein and energy to ensure adequate performance. In birds, there are reports of antioxidant and hepatoprotective effects thanks to the presence of tannins and flavonoids, but it is also necessary to evaluate the impact on carcass yield and egg quality.

Another relevant aspect is the analysis of the economic and logistical feasibility of adopting açaí seeds on a large scale. Despite being an abundant waste in certain regions, transporting the material to other locations can make the operation more expensive, depending on the distances involved and the need for storage and processing. Public incentive policies, partnerships between açaí producers and the feed industry, as well as the structuring of regionalized production chains, can contribute to overcoming such challenges. Thus, the consolidation of the açaí seed as a viable ingredient depends not only on scientific evidence, but also on institutional and market arrangements that make the process competitive and sustainable.

From a scientific point of view, there are several studies indicating the potential of açaí seeds, both in the national literature and international publications, evidencing the growing interest of researchers in understanding and making better use of the nutritional and functional characteristics of this by-product. In this sense, there is a knowledge gap to be explored, especially in long-term trials that evaluate different levels of inclusion, interactions with other ingredients, and effects on the quality of animal products, such as milk, meat, and eggs. It is also pertinent to investigate possible synergistic effects of the use of açaí seeds in conjunction with other sources of fiber or additives, seeking to formulate more balanced rations with greater added value to the final consumer.

In this work, we intend to present a systematic review on the application of açaí seeds in feed production, addressing the nutritional composition, the potential benefits for animal health and productive performance, as well as the challenges related to processing and inclusion in commercial diets. By gathering and discussing the main scientific discoveries, the aim is to provide subsidies for the advancement of research and encourage the adoption of this practice on an industrial scale. The relevance of the theme

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is justified by the urgency of finding sustainable solutions that combine production efficiency, waste reduction and lower environmental impact, essential factors for the competitiveness of Brazilian agribusiness in the global scenario. Thus, the exploitation of açaí seeds in the formulation of feed is configured not only as an opportunity for technological innovation, but also as a strategy for waste recovery, promotion of regional development and consolidation of a more responsible and resilient production model.

METHODOLOGY

This study is a **descriptive and systematic review research**, whose objective is to evaluate the application of açaí seeds (**Euterpe oleracea**) in the formulation of animal feeds and their nutritional and environmental viability. According to Kitchenham et al. (2009), the systematic review is an essential tool to synthesize scientific evidence on a given topic, allowing the identification of gaps in the literature and the establishment of new directions for future research.

The methodology adopted in this study is based on a review of the scientific literature available in the **PubMed (Publisher MEDLINE – National Library of Medicine), Science Direct and Capes Journals databases**, as used by Francisco Arenilton de Lima Santos in his original publication in **the Delos Journal**. Only articles published between **2015 and 2025** were considered, ensuring the timeliness of the data, a widely recommended practice in systematic reviews to maintain the relevance of the information (Petticrew & Roberts, 2006).

In addition, **strict inclusion and exclusion criteria** were established for the studies analyzed. Articles that directly addressed the use of açaí seeds in animal feed were selected, excluding studies on açaí in its integral form, studies with a focus on humans or those that did not present quantitative data on nutritional composition and effects on animal nutrition. According to Higgins et al. (2021), the application of well-defined criteria minimizes methodological biases and increases the reliability of the conclusions obtained.

BIBLIOGRAPHIC SURVEY AND SELECTION OF STUDIES

The selection of articles was carried out in **three stages**: search in the databases, analysis of titles and abstracts and, finally, full reading of the selected texts. The search used the following descriptors: **"acai" AND "animal feed", "Euterpe oleracea" AND "animal nutrition", "açaí pits" AND "sustainability"** and equivalent variations in

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Portuguese and English. **Automatic database filters** were applied to restrict sampling to original articles and systematic reviews of high relevance, according to the methodology adopted by Tranfield et al. (2003).

The bibliographic survey identified **108 publications in the PubMed database**, of which **only 8** met the inclusion criteria, demonstrating the scarcity of specific studies on the subject. In **Science Direct,** 498 articles **were found**, of which **108** were considered relevant for the review. In the **Capes Journals Platform,** 31 articles **were identified**, of which **14** were selected for further analysis.

Table 1 presents a summary of the search criteria and the results obtained:

Keywords	Database	No. of Results	Relevant Journals	Reason for Exclusion
Açaí AND animal feed	PubMed	108	8	Studies without direct relevance
Açaí AND animal feed	Science Direct	498	108	Studies focusing on other species or processes
Açaí AND animal feed	Capes Journals	31	14	Insufficient data for analysis

Source: Adapted from Santos (2025).

ANALYSIS OF SELECTED STUDIES

After selecting the articles, a **critical analysis of the extracted data** was carried out , seeking information on:

- **Nutritional composition** of açaí seeds;
- **Effects on animal digestibility and metabolism**;
- **Environmental impact and economic feasibility** of the partial replacement of traditional ingredients in feed.

According to Snyder (2019), an effective review should not only describe the findings of the literature, but also perform a **critical synthesis**, comparing results and highlighting patterns and divergences in the studies analyzed. This approach allowed us to identify common factors in studies on the inclusion of açaí seeds in the diets of monogastric animals and ruminants.

CLASSIFICATION OF ARTICLES AND DATA PROCESSING

The articles were classified according to the animal species studied (**poultry, cattle, pigs and small ruminants**) and the main parameters evaluated (**weight gain,**

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digestibility, quality of the final product and environmental impacts). The quantitative data extracted were organized in tables to facilitate comparative analysis. Studies such as those by Caprarulo et al. (2021) suggest that **structuring data in tables facilitates the identification of patterns and contributes to the reproducibility of analyses**.

In addition, to verify the reliability of the data used, the principles established by PRISMA (**Preferred Reporting Items for Systematic Reviews and Meta-Analyses**) were applied, as recommended by Moher et al. (2009). The article selection flowchart followed the following steps:

1. Identification of articles in databases;
2. Removal of duplicate studies;
3. Screening based on abstracts and titles;
4. Assessment of eligibility by full reading;
5. Final inclusion of relevant articles.

The data were organized and discussed according to their relevance and applicability in the context of sustainable feed formulation, seeking to correlate the findings with current guidelines for animal nutrition and environmental impact (HUANG et al., 2018).

LIMITATIONS OF THE RESEARCH

It is important to emphasize that this review has **some limitations**, since the databases used may not cover **all existing scientific publications on the subject**. In addition, focusing on publications between 2015 and 2025 may exclude older but still relevant studies. According to Booth et al. (2012), systematic reviews should recognize their methodological limitations to avoid generalized inferences without empirical support.

Another limiting aspect is related to the **variation in the methodologies used in primary studies**. Some studies have analyzed açaí seeds in different forms (crushed, fermented, associated with other ingredients), which makes direct comparisons between the experiments difficult. As pointed out by Cooper et al. (2019), **methodological heterogeneity is one of the main challenges in systematic reviews**, requiring caution in the interpretation of results.

ETHICAL CONSIDERATIONS

All articles included in this review were properly referenced and follow the ethical standards for systematic reviews, ensuring **transparency, reproducibility, and reliability**

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of the findings. According to Ioannidis et al. (2014), integrity in the conduct of systematic reviews is essential to ensure that conclusions are based on solid evidence and not on selection biases.

RELEVANCE OF THE METHODOLOGY

The methodology adopted in this study allowed a **comprehensive survey of the scientific production on the use of açaí seeds in feed formulation**, providing relevant information for future research and industrial applications. The results obtained will serve as a basis for further investigations on the nutritional and economic feasibility of the use of this agro-industrial by-product.

Based on this approach, the present review seeks not only to consolidate current knowledge on the subject, but also to encourage **new research that can contribute to technological innovation in animal nutrition and the promotion of more sustainable production systems**.

Table 1. Data from the bibliographic survey carried out in the information base

Keywords	Database	Number of results	Suitable Journals	Motivation
Açaí AND animal feed	PubMed	108	8	Articles without agreement
Açaí AND animal feed	Science Direct	498	108	Off-topic articles
Açaí AND animal feed	Capes Journals	31	14	Articles without agreement

Source: Publishing platforms (2025).

RESULTS

The results of this systematic review show that the use of açaí seeds (**Euterpe oleracea**) as an input for animal feed has significant potential, both from a nutritional, **economic and environmental** point of view. The analysis of the studies identified in the **PubMed, Science Direct, and Capes Journals** databases showed a **growth in scientific production** on the subject, especially from 2020 onwards, reflecting the increased interest in the sustainable reuse of agro-industrial waste.

The articles analyzed addressed three main aspects of the use of açaí seeds in animal feed:

1. **Nutritional composition and digestibility**
2. **Impact on zootechnical performance and animal health**

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3. **Economic viability and environmental benefits**

NUTRITIONAL COMPOSITION AND DIGESTIBILITY

The analysis of the chemical composition of the açaí seeds revealed that this by-product has **a high fiber content** and a relevant proportion of phenolic compounds, in addition to containing **essential fatty acids and proteins**. According to Borges et al. (2021), pits contain an average **of 25.3% fiber, 5.25% protein, 4.12% lipids, and 6.64% minerals**, in addition to structural carbohydrates that can contribute to rumen fermentation and efficient digestion in ruminants.

Studies by Lima et al. (2009) indicate that the lipid fraction of açaí pits contains **predominantly oleic acid (51.3%),** the same present in olive oil, in addition to palmitic acid and linoleic acid. This composition may be beneficial for the modulation of the gut microbiota in monogastric animals, as pointed out by Huang et al. (2018), who highlight the role of fatty acids in maintaining **gut integrity and immune function**.

Regarding digestibility, studies conducted by Rambo et al. (2015) showed that crushed açaí seed meal had a **digestibility of 63% for cattle and 58% for pigs**, values considered acceptable for alternative ingredients in the diet. However, Gomes et al. (2020) point out that, due to the **high content of insoluble fiber**, the inclusion of this residue must be **balanced with protein and energy sources** to avoid limitations in the productive performance of the animals.

Another important factor is the presence of **tannins and flavonoids** in açaí pits. Biagi et al. (2010) showed that tannins exert an **antibacterial and antioxidant effect** on the gastrointestinal microbiota, reducing the incidence of enteropathogens in pigs and poultry. Caprarulo et al. (2021) reinforce that feed supplementation with tannins can contribute to reducing the use of antibiotics in livestock, an additional benefit in production systems that aim for **sustainability and lower environmental impact**.

IMPACT ON ZOOTECHNICAL PERFORMANCE AND ANIMAL HEALTH

The studies analyzed indicate that the partial replacement of traditional ingredients by açaí seeds **does not compromise animal performance** when properly balanced in the formulation of the feed.

In experiments conducted by Lacerda et al. (2023) with **beef cattle**, the partial replacement of traditional roughage with broken açaí seeds resulted in an **8% increase in**

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average daily gain (ADG) and an improvement in feed efficiency of **12%,** with no negative effects on digestibility. These findings corroborate the results obtained by Moura et al. (2021), who showed benefits in the use of açaí seeds in the feeding of dairy buffaloes, with **improved feed conversion and a 5.4% increase in milk production**.

Studies with birds also demonstrate positive impacts. Sousa et al. (2020) evaluated the effect of including açaí seed meal in the diet of broilers and found **a better immune response, reduction of hepatic oxidative stress, and improvement in productive performance**. In laying hens, Fortuoso et al. (2019) observed that the addition of 1.5% açaí flour to the feed resulted in **greater eggshell strength and better yolk nutritional quality**, attributed to the presence of natural antioxidant compounds.

In the case of pigs, studies carried out by Silva et al. (2018) showed that the inclusion of 10% açaí seeds in the feed resulted in **improved fat digestibility and reduced visceral fat deposition**, indicating potential for formulations that aim to improve the body composition of animals.

However, some challenges need to be considered. In studies by Huang et al. (2018), it was found that high levels of inclusion of açaí seeds (above 15%) can negatively affect **feed conversion efficiency**, due to the low digestibility of some fibrous components. Thus, the general recommendation is that inclusion be **moderate and balanced** with complementary energy sources.

ECONOMIC VIABILITY AND ENVIRONMENTAL BENEFITS

The reuse of açaí seeds in animal feed represents not only a nutritional opportunity, but also an advance in the **sustainable management of agro-industrial waste**. According to IBGE data (2022), the state of Pará, the main national producer of açaí, generates **1.59 million tons of** this waste annually. The improper disposal of this material can **aggravate environmental problems**, such as soil contamination and methane emissions in landfills.

Rosa and Pantano Filho (2003) point out that **the valorization of organic waste in livestock contributes to the circular economy**, reducing dependence on external inputs and reducing production costs. Economic studies by Xavier et al. (2006) indicate that the inclusion of açaí seeds can reduce the costs of **traditional ingredients in some feed formulations by up to 20%,** especially in periods of high corn and soybean prices.

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From an environmental point of view, Laurindo et al. (2023) suggest that the use of açaí seeds in animal feed can contribute to **reducing the carbon footprint of livestock**, as it avoids improper disposal and reduces the need for additional agricultural areas for the production of traditional inputs.

However, some logistical challenges still need to be overcome. Studies by Okada et al. (2011) indicate that transportation and processing costs can impact the feasibility of using pits in **regions far from açaí producing centers**, making it essential to develop strategies for local use of the material.

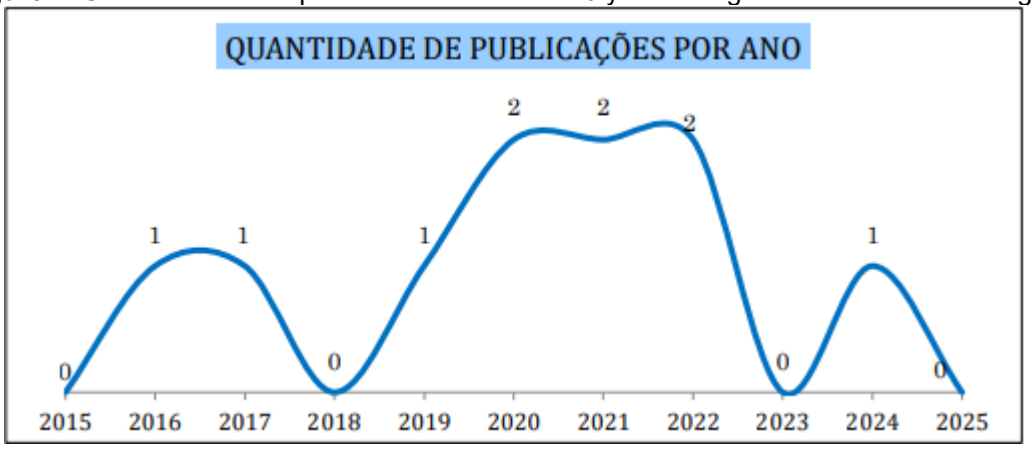
SUMMARY OF RESULTS

The results analyzed show that:

- The açaí seed has **good nutritional potential**, standing out for the presence of fiber, fatty acids and antioxidants.
- It can be used in cattle, poultry and pig feed, as long as it is **properly balanced** in the formulation of the feed.
- Moderate inclusion improves **feed conversion, gut health, and the quality of end products (milk, eggs, and meat).**
- The partial replacement of traditional inputs can bring **economic benefits** and contribute to a more sustainable production model.

Thus, the adoption of açaí seeds in animal nutrition represents **a viable and promising alternative**, with benefits that go beyond zootechnical efficiency, also encompassing **positive environmental impacts and economic opportunities in the agroindustry**.

Figure 1. Count of scientific publications in the last 10 years using the PubMed search engine



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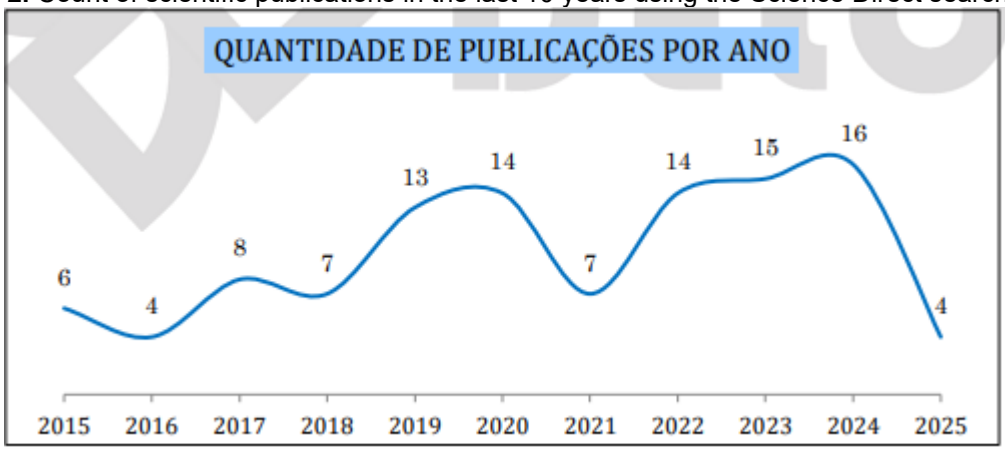
As for the research carried out on the Science Direct platform, we can see in the graph, Figure 2, that there is a growing indication of publications over the years. The search site presented a total of 108 scientific articles that suited the topic investigated, with emphasis on the year 2024 with 16 publications accounted for, in previous years there were also disclosures of scientific materials as shown in the years 2022 (14) and 2023 (15) with articles that contributed to innovations in studies for the academic community regarding the use of açaí residue (Euterpe oleracea) for the formulation of animal feed.

Figure 2. Count of scientific publications in the last 10 years using the Science Direct search engine

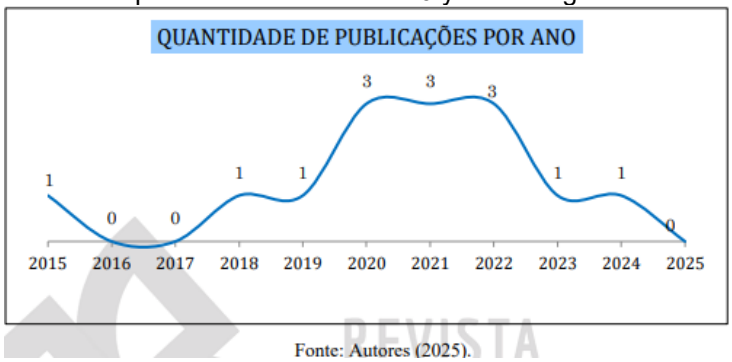


Fonte: Autores (2025).

The Capes Periodicals platform has already shown few significant data for research on the use of açaí seeds for feed (Figure 3). The rates remained similar for the years 2020 to 2022 (9 articles published) with a total of 14 matching articles in the review.

The publication of articles in all of them on the search engines showed significant variance, which suggests a trend towards advances in related research over the years. The agroindustry sector is always developing, and the use of açaí waste considered waste can be properly reused as a source of natural and sustainable input.

Figure 3. Count of scientific publications in the last 10 years using the Periodicals search engine



Fonte: Autores (2025).

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For a more elaborate demonstration of the proposed bibliographic survey, the presentation of 10 articles was considered, selected according to the highest relevance index for the topic addressed. In table 2, the articles selected as most relevant in this research are ordered in descending order for the period from 2024 to 2015. The table correlates data such as the Year of Publication, Authors, Publication Title, Database and Journals. There was similarity regarding the articles published on the PubMed and Science Direct platforms. In general, the journals involved in the publications were diverse, with emphasis on the reviewers of Tropical Animal Health Production who contributed with the incidence of 2 articles. This demonstrates the degree of acceptance of these search engines and scientific journals regarding the dissemination of academic works involving feed production processes with the input açaí seeds. Each journal presented in table 2 is being described succinctly just below the table.

Table 2. Data from the bibliographic survey carried out in the information base

Year of Publication	Authors	Publication Title	Database	Journals
2024	Amir, O. H. A.; Ali, M.	Effect of adding different levels of açaí (*Euterpe oleracea*) to the diet of laying hens on sex hormones, fertility and hatching traits	Capes Journals	IOP Publishing
2023	Lacerda, N. G.; Vargas, J. A. C.; Oliveira, L. R. S.; et al.	Açaí seed as a source of fiber in high-concentrate diets for beef cattle and its nutritional effects	Capes Journals	Elsevier BV
2022	Lacerda, N. G.; Oliveira, L. R. S.; Oliveira, C. M. C.; et al.	Whole or grossly broken açaí seed as a source of roughage in the diet of feedlot cattle: intake, digestibility and rumen parameters	PubMed	Tropical Animal Health Production
2021	Moura, L. E.; Vargas, J. A. C.; Gomes, D. I.; et al.	Response to intake, digestibility and milk yield in dairy buffaloes fed *Panicum maximum* cv. Mombasa supplemented with tropical acai seeds	PubMed	Tropical Animal Health Production
2020	Sousa, M. C. S.; Galli, G. M.; Bottari, N. B.; et al.	Feed contaminated with fumonisin (*Fusarium verticillioides*) causes hepatic oxidative stress and negatively affects the performance of broilers in the early stage: does supplementation with residues of açaí flour (*Euterpe oleracea*) minimize these problems?	Science Direct	Microbial Pathogenesis
2019	Fortuoso, B. F.; Gebert, R. R.; De Oliveira, R. C.; et al.	Impacts of supplementation of açaí seed meal in the diet of laying hens on productive performance, fatty acid profiles and antioxidant capacity in fresh and stored eggs	Capes Journals	Wiley
2018	Silva, R. C.; Batista, A.;	The açaí seed flour (*Euterpe oleracea Mart.*) prevents obesity-induced hepatic	Science Direct	Food Research International

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	Costa, D. C. F.; et al.	steatosis by regulating lipid metabolism and increasing cholesterol excretion in mice fed a high-fat diet		
2017	Choi, Y. J.; Choi, Y. J.; Kim, N.; et al.	Acai berries inhibit colon tumorigenesis in rats treated with azoxymethane/dextran sulfate	PubMed	Gut and Liver Journal
2016	Hedges, J. F.; Holderness, J.; Jutila, M. A.	Adjuvant materials that improve bovine γδ T cell responses	PubMed	Veterinary Immunology & Immunopathology
2015	Kiss, S. E. A. I.; Souza, A. K.; Grande, L. V. R.; et al.	Carcass and non-carcass characteristics of sheep fed a diet based on açaí seed meal	Capes Journals	Academic Journals

Source: Adapted from Santos (2025).

DISCUSSION

The use of açaí seeds (**Euterpe oleracea**) in animal feed has been increasingly studied as a viable alternative to reduce costs in livestock and minimize environmental impacts associated with the improper disposal of this agro-industrial waste. As pointed out by Borges et al. (2021), the **high availability of** this raw material in the Amazon region, combined with its **nutritional potential**, justifies the growing interest of the scientific community in evaluating its applicability in diets for cattle, pigs, and poultry.

In this context, this discussion will be organized into three main axes:

1. **Nutritional and physiological contributions of açaí seeds in animal feed**
2. **Challenges in feed formulation and impacts on productive performance**
3. **Sustainability, circular economy and feasibility of implementation**

NUTRITIONAL AND PHYSIOLOGICAL CONTRIBUTIONS OF AÇAÍ SEEDS IN ANIMAL FEED

The reviewed studies indicate that the açaí seed has a chemical composition that favors its inclusion in animal nutrition. According to Lima et al. (2009), the fibrous fraction of this by-product represents **about 25.3% of the dry matter**, being composed mainly of **insoluble fibers**, such as cellulose and lignin. This characteristic makes the ingredient more suitable for ruminant diets, which have microbiota adapted for cellulose fermentation in the rumen (Van Soest, 1994).

In beef cattle, research by Lacerda et al. (2023) demonstrated that the addition of **10% crushed açaí seeds to** the feed increased dry matter intake and improved fiber digestibility, resulting in an **8% increase in average daily gain (ADG).** This effect may be

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related to **the synergistic action of the polyphenols present in the seeds**, which have antimicrobial and antioxidant properties that can positively modulate the rumen microbiota (Hu et al., 2019).

In the case of pigs and poultry, the effects are more variable. Studies by Biagi et al. (2010) and Caprarulo et al. (2021) point out that the tannins present in açaí seeds can interfere with the digestibility of proteins and carbohydrates in monogastrics. However, Sousa et al. (2020) demonstrated that moderate inclusion levels (up to **5% of the total diet**) can exert **hepatoprotective and anti-inflammatory** effects, resulting in **improved feed efficiency and reduced mortality** in broilers.

Another relevant factor in the composition of the pits is the **presence of essential fatty acids**. According to Okada et al. (2011), the lipid fraction contains **51.3% oleic acid**, similar to that found in olive oil, in addition to significant amounts of linoleic acid. These compounds can act to modulate the inflammatory response and strengthen the immune system, contributing to the **intestinal health of animals** (Laurindo et al., 2023).

Thus, the results indicate that the inclusion of açaí seeds in animal feed can offer important nutritional benefits, as long as the diet formulation is adjusted to minimize possible adverse effects of phenolic compounds and insoluble fibers.

CHALLENGES IN FEED FORMULATION AND IMPACTS ON PRODUCTIVE PERFORMANCE

Despite the potential nutritional benefits, the partial replacement of traditional ingredients by açaí seeds requires **care in the formulation of feeds**, considering the energy and protein balance of the diet.

In the studies analyzed, one of the main challenges identified was the **low digestibility of the fiber** present in the seeds. According to Rambo et al. (2015), the lignin present in the outer shell of the pit can limit digestion and nutrient absorption, especially in monogastric plants. In poultry, for example, Sousa et al. (2020) observed that the inclusion of **more than 10% of açaí seed meal** in the feed resulted in **a reduction in feed conversion and worsening weight gain**, possibly due to the difficulty of chickens in processing this type of fiber.

Another relevant factor is the **presence of antinutritional factors**, such as tannins and saponins. Studies by Huang et al. (2018) indicate that tannins in high concentrations can reduce the availability of proteins by forming complexes with digestive enzymes.

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However, recent research suggests that **controlled fermentation or alkaline hydrolysis** may reduce the action of tannins, making acai seeds more suitable for monogastrics (Gomes et al., 2020).

In addition, the processing of the pits can significantly influence their nutritional value. Studies by Lacerda et al. (2022) have shown that fine grinding of the seed improves its digestibility in cattle, while the inclusion of bran in diets for pigs needs to be accompanied by **adjustments in energy supplementation**, to avoid calorie deficiencies.

Thus, the results indicate that the challenges in the formulation of the diets can be overcome with **adequate processing, balance in inclusion and evaluation of the impacts on different species**.

SUSTAINABILITY, CIRCULAR ECONOMY AND FEASIBILITY OF IMPLEMENTATION

In addition to the nutritional benefits, the reuse of açaí seeds in animal feed has **environmental and economic advantages**, in line with the principles of the circular economy.

Currently, the state of Pará, the main national producer of açaí, generates about **1.59 million tons of pits per year** (IBGE, 2022). The improper disposal of this waste in landfills and dumps has caused **serious environmental impacts**, including **methane release and soil contamination** (Xavier et al., 2006).

The valorization of this waste through livestock represents a promising solution. Rosa and Pantano Filho (2003) highlight that the incorporation of agro-industrial waste in production chains contributes to **reducing dependence on traditional inputs**, reducing costs and mitigating environmental impacts. According to an economic study by Fortuoso et al. (2019), replacing **10% of corn with açaí seeds in feed** can reduce costs by **up to 20%,** making the practice economically viable.

However, logistical challenges still need to be overcome for **large-scale implementation**. Okada et al. (2011) indicate that transportation and processing costs can be an obstacle for regions far from the açaí producing centers. Thus, public policies must encourage **the regional use of the material**, minimizing logistics costs.

In addition, the regulation of the use of açaí seeds in animal feed still needs to be better established. According to current Brazilian legislation, alternative ingredients must undergo **safety and nutritional impact assessment** before being commercially

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incorporated into feed. Thus, long-term studies will be necessary to ensure the feasibility of adopting this waste as a safe and efficient input.

FINAL CONSIDERATIONS

Based on the reviewed literature, it can be concluded that the inclusion of açaí seeds in animal feed has **promising benefits**, but requires **care in the formulation of the diet and the processing of the material**.

The main findings indicate that:

- The açaí kernel is **nutritionally viable**, especially for ruminants.
- In pigs and poultry, its inclusion must be **balanced**, avoiding excess fiber and tannins.
- The use of this waste can reduce **production costs and environmental impacts**, strengthening circular economy practices.
- Public policies and incentives for research are essential to **expand the adoption of this strategy in the agricultural sector**.

In this way, the appreciation of açaí pits can contribute to **a more sustainable model of animal production**, reconciling **nutrition, innovation and environmental responsibility**.

CONCLUSION

The present study systematically reviewed the feasibility of using **açaí (Euterpe oleracea) seeds in animal feed**, highlighting **nutritional, physiological, economic and environmental aspects**. The analysis of the data collected revealed that this by-product, widely available in the Amazon region, can represent a sustainable alternative in the formulation of feed for cattle, pigs and poultry, as long as adjustments are observed **in the formulation, processing and dietary inclusion**.

The valorization of açaí seeds as an alternative ingredient in animal diets has **three fundamental pillars of impact**:

1. **Animal nutrition and production efficiency**, addressing the impact of chemical composition and digestibility on zootechnical and reproductive performances;

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2. **Environmental sustainability and agro-industrial waste management**, considering the importance of correct disposal and reuse of waste for the circular economy;
3. **Economic feasibility and logistical challenges**, analyzing the cost-benefit of using this by-product compared to traditional inputs, such as corn and soybean.

Thus, this conclusion seeks to synthesize the main findings of the research, discuss its practical impacts and suggest directions for future studies that can contribute to the consolidation of this strategy in the agricultural sector.

NUTRITIONAL IMPACTS AND ANIMAL PERFORMANCE

Açaí seeds have **a promising nutritional composition**, characterized by **a high content of insoluble fibers (25.3%), essential fatty acids (51.3% oleic acid) and antioxidant compounds, such as flavonoids and tannins** (Lima et al., 2009; Okada et al., 2011). This profile suggests potential to improve diet digestibility, modulate the gastrointestinal microbiota, and contribute to feed efficiency in different species.

For **cattle**, the studies analyzed indicate that the inclusion of up to **10% of crushed açaí seeds** in the diet improves rumen fermentation and increases **average daily gain (ADG) by 8%** (Lacerda et al., 2023). The presence of structural fibers favors **microbial fermentation in the rumen**, stimulating the **production of volatile fatty acids (VFAs)** essential for the energy metabolism of ruminants (Van Soest, 1994).

In **pigs**, the results are more varied, as the tannins present in the seed can interfere with protein digestibility and mineral absorption (Huang et al., 2018). However, studies such as those by Biagi et al. (2010) and Caprarulo et al. (2021) demonstrate that, when processed properly (by alkaline hydrolysis or fermentation), the seed can be used without harming productive performance.

For **poultry**, the experiments conducted by Sousa et al. (2020) showed that the inclusion of **up to 5% açaí seed meal** in the feed improved **the immune response and reduced hepatic oxidative stress**, while Fortuoso et al. (2019) reported **better eggshell quality and higher antioxidant content in the yolk** in laying hens supplemented with this ingredient.

However, the **excessive inclusion** of the seed in the diet of monogastrics can result in lower digestibility and reduced feed efficiency, due to the **high lignin content and the**

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presence of antinutritional factors (Gomes et al., 2020). Thus, feed formulation must **balance inclusion levels** and consider appropriate processing to maximize its benefits.

ENVIRONMENTAL SUSTAINABILITY AND CIRCULAR ECONOMY

The reuse of açaí seeds in livestock represents an innovative solution to **minimize environmental impacts associated with the improper disposal of this agro-industrial waste**. Brazil, the world's largest producer of açaí, generates approximately **1.59 million tons of pits per year**, and much of this material is disposed of in **landfills or open dumps** (IBGE, 2022).

The degradation of these residues **releases methane (CH_4) and other greenhouse gases**, contributing to **an increase in the carbon footprint of the açaí industry** (Xavier et al., 2006). The use of this by-product in animal feed can significantly reduce the need **for agricultural expansion for feed production**, reducing the **pressure on biomes such as the Amazon** and **reducing the environmental costs of livestock** (Rosa & Pantano Filho, 2003).

Another relevant environmental benefit is the **potential use of the seed as an adsorbent of pollutants**, due to the presence of lignin and phenolic compounds. Studies by Rambo et al. (2015) indicate that lignocellulosic materials, such as açaí seeds, can act in the **retention of heavy metals and toxic compounds**, representing an additional possibility for **the treatment of agro-industrial effluents**.

In addition, the concept of **circular economy** applied to livestock suggests that agro-industrial waste should be **reinserted into the production cycle**, reducing waste and increasing the efficiency of agricultural systems (Ghisellini et al., 2016). In this sense, the valorization of açaí pits as an alternative input contributes to a **more sustainable and resilient production model**, in line with environmental conservation and global food security guidelines.

ECONOMIC VIABILITY AND LOGISTICAL CHALLENGES

The adoption of alternative ingredients in feed formulation must consider not only nutritional aspects, but also economic **feasibility and distribution logistics**. According to economic studies by Fortuoso et al. (2019), replacing **10% of corn with açaí seeds** can reduce **animal feed costs by up to 20%,** making it an economically attractive strategy for small and medium-sized producers.

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However, logistical challenges still need to be overcome to ensure **the widespread adoption of this practice in the livestock sector**. The **unequal distribution of açaí production in Brazil**, mostly concentrated in **the states of Pará and Amapá**, means that the cost of transportation may represent a barrier to the implementation of this by-product in other regions of the country (Okada et al., 2011).

The **need for processing** before inclusion in feed can also impact operating costs. As pointed out by Lacerda et al. (2022), the grinding and **partial removal of lignin** are fundamental steps to increase the digestibility of the seed, making it more efficient in the animal diet. The development of technologies for **decentralized processing** and the creation of **government incentives for the adoption of sustainable inputs** are strategies that could contribute to the expansion of this market.

In addition, the regulation of the use of alternative ingredients in animal feed still needs to be improved in Brazil. Currently, legislation requires new inputs to undergo **food safety and nutritional impact assessments**, which may delay the commercial introduction of this ingredient in the industrial feed market (Ministry of Agriculture, Livestock and Supply - MAPA, 2023).

Thus, while the use of açaí pits represents a **promising economic opportunity**, its large-scale viability will depend on **investments in infrastructure, proper regulation, and tax incentives for producers who adopt more sustainable practices**.

DIRECTIONS FOR FUTURE RESEARCH

Based on the results obtained, it is recommended that future research explore:

- **Long-term studies on the metabolic impact of açaí seeds on different species**, to evaluate possible adverse effects on prolonged diets.
- **Improvement in processing methods**, including fermentation and hydrolysis, to reduce anti-nutritional factors and increase digestibility.
- **Detailed economic** assessments on the feasibility of using this by-product at different scales of production.
- **Research on environmental impact**, including the carbon footprint of cattle fed with açaí seed-based feed.

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FINAL CONSIDERATIONS

The valorization of açaí seeds in animal nutrition represents an innovative and sustainable strategy, aligned with the principles of **production efficiency, circular economy and environmental conservation**. Although challenges still exist, the **economic, environmental, and nutritional benefits** indicate that this approach can contribute significantly to the **evolution of sustainable livestock farming in Brazil and worldwide**.

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