Discoveries in Agriculture and Food Sciences - Vol. 12, No. 3
Publication Date: June 25, 2024
DOI:10.14738/dafs.123.17106.
Ascheri, J. L. R., Ascheri, D. P. R., Arévalo, A. M., Petri, P. Z., Colque, R. J. B., & da Silva, E. M. M. (2024). Use of Amazon Regional Products, Co-Products in Sustainable Agroindustry. Discoveries in Agriculture and Food Sciences, 12(3). 01-28.

Use of Amazon Regional Products, Co-Products in Sustainable Agroindustry

José Luis Ramírez Ascheri
Food Extrusion and Physical Properties Lab, Embrapa Food Technology, Av. das Américas, 29501, Guaratiba, Rio de Janeiro, Brazil

Diego Palmiro Ramírez Ascheri
Postgraduate of Agricultural Engineering Course, UEG -Anápolis Campus of Exact and Technological Sciences - Henrique Santillo, Br 153, 3105, Fazenda Barreiro do Meio, Anápolis, Goiás, Brazil

Arturo Meléndez Arévalo
Postgraduate Program Food Science and Technology. Federal Rural University of Rio de Janeiro; BR 467, km 7, 23890-000, Seropedica, RJ, Brazil

Paola Zampirolli Petri
Postgraduate Program in Nutrition and Health, Health Sciences Center, Federal University of Espírito Santo, Vitória, ES

Ronel Joel Bazán Colque
Postgraduate Program Food Science and Technology. Federal Rural University of Rio de Janeiro; BR 467, km 7, 23890-000, Seropédica, RJ, Brazil

Erika Madeira Moreira da Silva
Postgraduate Program in Nutrition and Health, Health Sciences Center, Federal University of Espírito Santo, Vitória, ES

ABSTRACT

The Amazon region harbors a treasure trove of biodiversity, encompassing a vast array of flora and fauna that offer tremendous potential for sustainable agroindustry. This abstract explores the utilization of Amazon regional products and co-products in fostering sustainability within the agroindustrial sector. Harnessing the rich biodiversity of the Amazon, agroindustries can integrate a diverse range of products and co-products into their operations, facilitating a circular economy model that minimizes waste and maximizes resource efficiency. By tapping into indigenous knowledge and traditional practices, innovative approaches can be developed to transform raw materials into high-value products, promoting economic development while preserving the ecological integrity of the region. Furthermore, by supporting local farmers and indigenous communities in the production and trade of these crops, agroindustries can contribute to poverty alleviation and social empowerment. For instance, residues from açaí processing can be transformed into nutrient-rich animal feed or organic fertilizers, while by-products from Brazil nut extraction can be utilized in the production of cosmetics,

pharmaceuticals, and biofuels. Through innovative processing technologies and value chain optimization, these co-products can be transformed into lucrative revenue streams, enhancing the economic viability of agroindustrial enterprises.

Keywords: sustainability, amazon natural food source, extrusion, agroindustry, byproducts.

INTRODUCTION

The Amazon, with its vast tropical forests, mighty rivers and unparalleled wealth of wildlife, is one of Earth's most precious treasures. In addition to its natural beauty, the region plays a vital role in maintaining global environmental balance. However, the Amazon's biodiversity faces significant threats due to the expansion of agriculture, logging, mining and other human activities. In this dissertation, we will explore the importance of maintaining biodiversity in the Amazon region, the challenges faced and the opportunities for its preservation.

The Amazon is home to a significant proportion of the planet's biodiversity, with countless plant and animal species that have yet to be discovered and studied. Its biological diversity plays crucial roles in several aspects:

Climate Balance: Amazon forests act as a carbon sink, absorbing large amounts of carbon dioxide from the atmosphere and helping to regulate the global climate. The loss of biodiversity in the Amazon could lead to a massive release of carbon into the atmosphere, exacerbating global warming.

Ecosystem Services: The biological diversity of the Amazon is fundamental for the provision of essential ecosystem services, such as water purification, pollination of agricultural crops, and regulation of the soil nutrient cycle.

Medicine and Biotechnology: Many species of plants and animals in the Amazon have medicinal properties and potential for the development of new medicines and technologies.

Challenges for Maintaining Biodiversity

Despite its importance, Amazonian biodiversity faces a series of significant challenges, such as deforestation. The expansion of agriculture, logging and infrastructure has caused large-scale deforestation in the Amazon, resulting in habitat loss and species extinction.

On the other hand, climate change has been a topic of international entities, with few results in favor of the planet. Rising temperatures and unpredictable precipitation patterns are affecting Amazon ecosystems, making some areas more susceptible to wildfires and prolonged droughts. Urban expansion and infrastructure must also be considered, as population growth and urban expansion in the region are leading to the fragmentation of natural habitats and degradation of the environment. In this sense, the path is preservation.

Despite the challenges, there are significant opportunities for preserving Amazonian biodiversity.

The preservation of biodiversity in the Amazon region is essential not only for the well-being of local communities, but also for the global environmental balance. We face important challenges, but we also have opportunities to promote sustainable practices and ensure a healthy future for this vital region. Protecting the Amazon requires concerted efforts at local, national and international levels, and it is essential that everyone takes responsibility for caring for this natural treasure and exceptional products.

Amazon Natural Resources

Exploring native products from the Amazon can offer numerous benefits to the food agroindustry, considering both the perspectives of bioeconomy and social development.

Biodiversity Conservation: The Amazon rainforest is one of the most biodiverse regions on the planet, housing a wide range of plant species with potential for food production. By using native products from the Amazon, the agroindustry can contribute to the conservation of biodiversity, providing economic incentives for the preservation of natural habitats.

Sustainable agricultural practices: Many native Amazonian crops are adapted to the local ecosystem and require minimal consumption of water, fertilizers and pesticides. By promoting the cultivation of these crops, the agribusiness can encourage sustainable agricultural practices that reduce environmental impact and promote long-term food security.

Diversification of food sources: Incorporating native Amazonian products into the food supply diversifies the range of available food sources, reducing dependence on some staple crops. This diversification increases food security by making the food supply more resilient to climate change, pests and diseases.

Nutritional benefits: Native Amazon products tend to have unique nutritional profiles, rich in vitamins, minerals and photochemicals that are beneficial to human health. By incorporating these products into the food supply, the agribusiness can contribute to improving public health and combating malnutrition.

Cultural Preservation: Many indigenous communities in the Amazon region have deep cultural connections to traditional food cultures. By supporting the cultivation and commercialization of native Amazonian products, agribusiness can help preserve indigenous knowledge and cultural heritage, promoting social cohesion and identity among local communities.

Economic Development: Investing in the production and marketing of native Amazonian products creates economic opportunities for local communities, especially indigenous peoples and small farmers. This can help reduce poverty, inequality and rural-urban migration, contributing to more inclusive and sustainable economic development in the region.

Carbon Sequestration and Climate Mitigation: The Amazon rainforest plays a crucial role in global climate regulation by sequestering carbon dioxide from the atmosphere. Supporting sustainable agroforestry systems that incorporate native Amazonian crops can help mitigate climate change by preserving forest cover and increasing carbon storage in soils and biomass.

As a result, exploiting native Amazonian products offers a holistic approach to food production that integrates environmental sustainability, social equity and economic development. By taking advantage of the region's rich biodiversity and respecting the knowledge and rights of indigenous peoples. The food agroindustry can contribute to building a more resilient and inclusive food system for the benefit of present and future generations, given that the Amazon region of Brazil is rich in biodiversity, offering a multitude of plant products suitable for use in the sustainable food agroindustry.

Some of these products we will discuss below.

Açaí Fruits: Açaí fruits are small, dark purple fruits that grow on the açaí palm tree. They are known for their high antioxidant content and are commonly used in smoothies, juices and bowls (Figure 1).

Figure 1. Açaí Fruits and derived
Source: Photo: Alexander Ruiz Acevedo/Shutterstock.com;

https://www.infoescola.com/plantas/acai/ extracted in: 15-03-2024

- Let's consider that until January 2022, the agroindustry has become increasingly interested in Açaí due to its growing popularity as a superfood. Açaí berries are harvested from açaí palm trees native to the Amazon rainforest and are known for their rich antioxidant content and potential health benefits. The agroindustry has explored several ways to capitalize on this demand:

1. Commercial Cultivation: Efforts have been made to cultivate Acai palm trees commercially to meet the growing demand for Acai berry products. This involves crop management techniques to ensure optimal growth and yield.
2. Processing and Production: The agroindustry processes Açaí berries into various products, such as Açaí pulp, Açaí juice, Açaí powder and Açaí-based supplements. This

involves advanced processing techniques to preserve the nutritional value of the berries and extend their shelf life.

3. Export: Açaí products are exported to international markets, where they are sold as health foods and dietary supplements. The agribusiness focuses on meeting quality standards and ensuring traceability throughout the supply chain to maintain consumer trust.
4. Product Diversification: In addition to traditional Açaí products, such as pulp and juice, the agribusiness is exploring innovative ways to incorporate Açaí into other food and beverage products, such as smoothies, energy bars and ice creams. This diversification helps to expand the Açaí market and attract different consumer demographics.
5. Research and Development: The agroindustry invests in research and development to explore new uses and applications for Açaí. This includes studying their health benefits, developing new product formulations and exploring their potential in the cosmetic and pharmaceutical industries.

Overall, the use of Açaí by the agroindustry revolves around meeting consumer demand for healthy and functional foods, while also exploring new opportunities for growth and innovation. Parte superior do formulário

Nutraceutical Point of View

Açaí has gained significant attention in recent years due to its potential health benefits and high antioxidant content. From a nutraceutical point of view, several discoveries have been made regarding the properties and uses of açaí,

This is based on a relatively high content of polyphenols, which in turn has been associated with a number of reported antioxidants, anti-inflammatory, antiproliferative and cardioprotective properties (Heinrich, et al., 2011):

Antioxidant properties: Açaí fruits are rich in antioxidants, mainly anthocyanins, pigments that give the fruits their deep purple color. These antioxidants help neutralize harmful free radicals in the body, thereby reducing oxidative stress and inflammation.

Nutrient content: Acai berries are a good source of essential nutrients such as vitamins A, C and E, as well as minerals such as potassium, calcium and magnesium. They also contain healthy fats, dietary fiber and protein.

Heart Health: Some studies suggest that regular consumption of açaí can help improve heart health by reducing cholesterol levels and improving blood circulation. The antioxidant and anti-inflammatory properties of açaí may also contribute to cardiovascular health (Oppitz, et al., 2022; Romualdo, et al., 2015). Extracts derived from Euterpe oleracea have exhibited a spectrum of mainly pharmacological properties in vitro, including antiproliferative activities., anti-inflammatory, antioxidant and cardioprotective (Heinrich, et al., 2011).

Weight management: Acai berries are often marketed as a weight loss or weight management supplement due to their purported ability to increase metabolism and suppress appetite.

However, the scientific evidence supporting these claims is limited and more research is needed to confirm its effectiveness in this regard.

Skin Health: The antioxidants and vitamins found in açaí may have benefits for skin health, including reducing signs of aging, promoting collagen production and protecting against UV damage. Some skincare products contain açaí extract for these reasons (Laurindo, et al., 2023). Energy boost: Acai berries are sometimes touted as a natural energy booster due to their nutrient content, including carbohydrates for quick energy release. However, the evidence supporting this claim is anecdotal and more research is needed to validate its effectiveness.

Immune support: Acai's high vitamin and antioxidant content may help support immune function by combating oxidative stress and inflammation, although specific studies on its immune-boosting properties are limited (de Souza, et al., 2023).

Açaí can be consumed in a variety of ways, including fresh fruit, frozen pulp, juices, supplements and powders. It is commonly blended into smoothies, bowls, and other recipes, or taken as a dietary supplement in capsule form.

On the other hand, the co-products resulting from the exploitation of açaí, we have the seeds, which researchers have pointed out as a potential source of lipids, fibers and antioxidants and phenolic compounds (Melo et al., 2021; Tacin, et. al, 2019), material which can compose formulations and subsequent processing by thermoplastic extrusion.

While açaí offers potential health benefits, it is essential to note that no food or supplement can guarantee health results on its own. A balanced diet rich in a variety of fruits, vegetables, whole grains and lean proteins, along with regular physical activity, is critical to overall health and well-being.

Brazil nut: The Brazil nut is a large, edible seed that grows inside the pods of the Brazil nut tree. They are rich in selenium, a potent antioxidant, and are often consumed as a snack or used in baking and cooking (Oliveira, et al., 2019; Bligh, et al., 2020). (Figure 2.)

Brazil nuts, native to the Amazon rainforest, have been used in several ways in the food agroindustry:

Direct Consumption: Brazil nuts are commonly consumed as a snack or incorporated into various recipes. They are often roasted and salted to enhance the flavor.

Ingredient in food products: Brazil nuts are used as an ingredient in a wide variety of food products, including baked goods, confectionery, granola bars, trail mixes, and cereals. They can add texture, flavor and nutritional value to these products.

Nut butter and spreads: Brazil nuts can be ground into a paste or butter, similar to peanut butter or almond butter, that can be used as a spread or incorporated into recipes.

Nutritional supplements: Brazil nut extract or oil is sometimes used as a dietary supplement because of its high selenium content, an essential mineral with antioxidant properties.

Dairy alternatives: Brazil nuts are used to produce plant-based milk alternatives, such as Brazil nut milk, which serves consumers with lactose intolerance or who opt for vegan diets.

Figure 2: Brazil nut.
Source: https://www.mahta.bio/pages/castanha-do-brasil. extracted in:15-03-2024

Culinary Oil: Brazil nut oil is extracted from nuts and used in cooking and food preparation. It has a distinct flavor and is often used as a finishing oil on salads or drizzled over dishes to add flavor.

Cosmetics and personal care products: Brazil nut oil is also used in cosmetics and personal care products due to its moisturizing properties. It can be found in lotions, creams and hair products. Animal Feed: Brazil nut flour, a by-product of oil extraction, can be used as an ingredient in animal feed formulations, providing a source of proteins and nutrients for livestock.

Overall, Brazil nuts play a significant role in the food agroindustry, not only for their distinct flavor and nutritional benefits, but also for their versatility in various food and non-food applications.

From a Nutraceutical Point of View

Brazil nuts are known for their rich nutritional profile and potential health benefits, making them a popular choice in the world of nutraceuticals. Here is an overview of what has been discovered about Brazil nuts from a nutraceutical perspective, how they are used and the benefits they offer:

Nutritional Composition: Brazil nuts are packed with essential nutrients, including selenium, magnesium, copper, phosphorus, manganese and vitamin E. They are particularly known for their exceptionally high selenium content, with just one nut providing well over 100 % of the recommended daily dose at intake.

Selenium Content: Selenium is a vital mineral with antioxidant properties that plays a crucial role in several physiological functions, including thyroid health, immune function and antioxidant defense mechanisms. Brazil nuts are one of the richest dietary sources of selenium, and regular consumption can help meet the body's selenium needs.

Antioxidant properties: The high selenium content in Brazil nuts contributes to their potent antioxidant properties. Antioxidants help neutralize harmful free radicals in the body, reducing oxidative stress and inflammation and thus potentially lowering the risk of chronic diseases such as heart disease, cancer, and neurodegenerative disorders (Brasil, et al., 2017); Brazil nuts have phenolics and flavonoids in free and bound forms and are rich in tocopherol, phytosterols and squalene. The possible beneficial effects of these compounds are due to their antioxidant and antiproliferative activities, which are associated with a reduced risk of developing atherosclerosis and cancer (Yan, 2011).

Cardiovascular Health: Some research suggests that selenium and other antioxidants in Brazil nuts may have cardioprotective effects by improving lipid profile, reducing inflammation and improving endothelial function. Regular consumption of Brazil nuts may help support heart health and reduce the risk of cardiovascular disease (Santos, et al., 2019.

Thyroid Function: Selenium is essential for the synthesis and metabolism of thyroid hormones. Adequate intake of selenium from Brazil nuts can help maintain optimal thyroid function, which is crucial for regulating metabolism, energy production, and overall well-being.

Mood and Cognitive Function: Selenium is also associated with mood regulation and cognitive function. Some studies suggest that selenium deficiency may be linked to mood disorders such as depression and cognitive decline. Consuming Brazil nuts as part of a balanced diet can help support mental health and cognitive function.

Immune support: Selenium is known to play a key role in immune function. Adequate selenium intake can help strengthen the immune system, improve the immune response to infections, and reduce the risk of autoimmune diseases. Incorporating Brazil nuts into your diet can contribute to overall immune health (Brasil, et al., 2015).

Bone Health: Brazil nuts contain essential minerals such as magnesium and phosphorus, which are vital for bone health. These minerals, along with selenium and other nutrients, support bone density and strength, reducing the risk of osteoporosis and fractures.

How they are used: Brazil nuts are usually eaten raw or roasted as a snack. They can also be chopped and added to various dishes such as salads, cereals, baked goods and desserts. Some people also use Brazil nut oil in cooking or as a nutritional supplement.

Brazil nuts are a nutrient-rich food with significant health benefits, mainly due to their high selenium content. Regular consumption of Brazil nuts as part of a balanced diet can support cardiovascular health, thyroid function, immune function, mood regulation, cognitive function and bone health. However, it is essential to consume them in moderation due to their high calorie and selenium content. According to the conclusion of (Yan, 2011) it was found that Brazil nuts are a rich source of unsaturated fatty acids, proteins, fibers, micronutrients, vitamins and phytochemicals, with high levels of Se that promotes the reduction of aging process and stimulates the immune system, and protect against heart disease and certain forms of cancer. The components present in Brazil nuts can intervene in the prevention of cancer, although they have not been fully elucidated by numerous mechanisms. Phytochemical extracts exhibit antioxidant and antiproliferative activities, and most of the total antioxidant and antiproliferative activities come from the combination of phytochemicals and Selenium.

Cupuaçu: Cupuaçu is a tropical fruit related to cocoa, with creamy pulp, widely used in making juices, desserts and cosmetics. It has a unique flavor that is a mix of chocolate and pineapple.

Figura 3: Cupuaçu fruit.
Source: https://www.fsp.usp.br/sustentarea/2017/06/29/que-alimento-e-esse-cupuacu/
Núcleo de extensão universitária da USP. Extracted in: 15-03-2024. Sustentarea.

The food agroindustry is increasingly taking advantage of Cupuaçu, a tropical fruit native to the Amazon rainforest, due to its unique flavor and nutritional properties. Here are some ways the food agroindustry is taking advantage of Cupuaçu:

Drinks: Cupuaçu is used in the production of various drinks such as juices, smoothies and cocktails. Its creamy texture and tangy flavor make it a popular choice for creating refreshing drinks.

Desserts and Confectionery: Cupuaçu is often incorporated into desserts, chocolates, ice creams and sorbets. Its flavor profile, described as a mix of chocolate and pineapple with a touch of banana, gives the sweets an exotic touch.

Functional Foods: Due to its high antioxidant content and potential health benefits, Cupuaçu is being used in the production of functional foods, such as energy bars, protein shakes and health supplements. These products cater to health-conscious consumers looking for natural alternatives.

Cosmetics: Cupuaçu butter, extracted from the fruit's seeds, is known for its moisturizing properties and is used in the formulation of skin products such as lotions, creams and lip balms. Its emollient nature makes it a popular ingredient in cosmetics.

Flavor enhancer: Cupuaçu is used as a natural flavor enhancer in various food products, including yogurts, cereals and sauces. Its versatile flavor profile allows it to complement a wide variety of dishes.

Export Market: Cupuaçu's popularity is not limited to its native region; it is also gaining strength in international markets. Food agribusinesses are capitalizing on this trend by exporting Cupuaçu-based products to countries where there is demand for exotic fruits.

In general, the food agroindustry is recognizing the potential of Cupuaçu as a versatile ingredient with diverse applications, from drinks and desserts to cosmetics and functional foods. This trend is expected to continue as consumers increasingly seek out unique and nutritious food options.

From a Nutraceutical Point of View

Cupuaçu (Theobroma grandiflorum) is a fruit native to the Amazon rainforest, closely related to cocoa. From a nutraceutical point of view, Cupuaçu has gained attention for its potential health benefits and unique nutritional composition.

Nutritional Composition: Cupuaçu is rich in several nutrients, including vitamins (such as vitamin C), minerals (such as calcium and phosphorus) and phytochemicals (such as polyphenols). It also contains a good amount of dietary fiber and healthy fats, mainly monounsaturated fats (Bligh, et al. 2020). Antioxidant properties: Cupuaçu contains high levels of antioxidants, mainly polyphenols such as flavonoids and tannins. These antioxidants help fight oxidative stress in the body, reducing the risk of chronic diseases and promoting general health (Oliveira et al., 2019; Santos, et al., 2019). Potential health benefits:

Heart Health: The monounsaturated fats in Cupuaçu, along with its antioxidants, can contribute to heart health, lowering LDL cholesterol levels and reducing the risk of cardiovascular disease. Digestive Health: The dietary fiber in Cupuaçu can aid digestion, promote regular bowel movements and support intestinal health.

Skin Health: The antioxidants in Cupuaçu can help protect the skin from oxidative damage caused by UV radiation and environmental pollutants, potentially slowing the aging process and promoting healthier skin (Martins, et al., 2019). Cupuaçu butter is rich in healthy fats and serves as an excellent emollient that can help restore the skin's natural moisture barrier. Due to its low melting point, cupuaçu butter softens when applied to the skin, allowing rapid

absorption. Its high fat content helps retain moisture to rehydrate the skin, increase elasticity, and diminish signs of aging such as fine lines and wrinkles. Additionally, its high antioxidant content can protect the skin from harmful compounds such as ultraviolet (UV) radiation, environmental pollutants and cigarette smoke.

Improved mood: Some studies suggest that Cupuaçu may have mood-improving properties, possibly due to its theobromine content, a compound also found in chocolate that can promote feelings of relaxation and well-being.

Energy boost: Cupuaçu contains natural sugars and is often used as an ingredient in energy drinks and supplements, providing a natural energy boost without the crash associated with caffeine.

Ways of Use:
Whole Fruit: Cupuaçu can be consumed fresh or used in various culinary preparations, such as juices, smoothies, desserts and jellies.

Extracts and supplements: Cupuaçu extracts and supplements are available in several forms, including powders, capsules and liquid extracts. These forms offer a practical way to incorporate Cupuaçu into your diet, especially for those looking to enjoy its health benefits in a concentrated way.

Cosmetics: Cupuaçu butter, derived from the fruit's seeds, is a popular ingredient in skin care products due to its moisturizing and emollient properties.

Overall, Cupuaçu presents itself as a promising nutraceutical due to its rich nutritional profile, antioxidant content and potential benefits to heart health, digestion, skin, mood and energy levels, (Oliveira, et al., 2018; Costa, et al., 2020). However, more research is needed to fully understand its mechanisms of action and confirm its effectiveness in promoting health and well-being.

Camu camu: Camu camu is a small, tart fruit native to the Amazon rainforest. It is extremely rich in vitamin C and is often used to make juices, jellies and supplements (GRIGIO, et al., 2022), Figure 4.

Camu-camu, this small fruit native to the Amazon rainforest, has gained attention in food and agriculture due to its exceptionally high vitamin C content and potential health benefits. See how it is being used:

Functional Foods and Drinks: Camu-camu is being incorporated into several functional foods and drinks, such as juices, smoothies, energy bars and supplements. Its high vitamin C content makes it a popular choice for products marketed for immune support and general health.

Natural Food Coloring: The rich color of the camu-camu fruit makes it a potential natural food coloring agent. Its vibrant hue can be used in a variety of food products, including drinks, desserts and confectionery.

Figura 4. Camu camu fruit.
Source: https://www.crodapersonalcare.com/pt-br/product-finder/product/5653-cosme-phytami_1_camu_1_camu- CRODA. Extracted in: 15-04-2024.

Nutraceuticals and Dietary Supplements: Due to its high antioxidant content and potential health benefits, camu-camu is used in the production of nutraceuticals and dietary supplements. These supplements often target consumers seeking antioxidant support, immune system enhancement, and overall well-being (Santos, et al., 2022).

Cosmetics and personal care products: Camu-camu extract is also making its way into cosmetics and personal care products due to its antioxidant properties. It is believed to offer skin health benefits, including anti-aging effects and protection against environmental damage.

Flavoring Agent: In addition to its nutritional benefits, camu-camu has a unique acidic flavor that can enhance the flavor profile of many food products and beverages. It is used as a natural flavoring agent in items such as fruit snacks, yogurt and ice cream.

Potential pharmaceutical applications: Research is underway to explore potential pharmaceutical applications of camu-camu, particularly in the development of medications or treatments targeting various health problems. Its high content of bioactive compounds, including antioxidants and polyphenols, makes it an intriguing candidate for further study.

Overall, the food and agribusiness industry increasingly recognize camu-camu as a valuable ingredient with nutritional, functional and potential health-promoting properties, leading to its incorporation into a wide range of products designed to promote well-being and improve health. the consumer experiences.

From a Nutraceutical Point of View

Camu camu (Myrciaria dubia) is a small, tart fruit native to the Amazon rainforest in Peru, Brazil, Colombia and Venezuela. It has gained attention in recent years due to its impressive nutritional profile and potential health benefits. From a nutraceutical point of view, several discoveries and uses of camu camu have been identified:

High vitamin C content: One of the most notable discoveries about camu camu is its exceptionally high vitamin C content. It contains significantly more vitamin C than citrus fruits like oranges or lemons. This makes it a potent natural source of this essential nutrient, which is crucial for immune function, skin health and antioxidant activity. According to García-Chacón et al., (2023), the bioactivity of vitamin C is determined by the action of both ascorbic acid (AA) and its oxidation product, dehydroascorbic acid (DHAA). Compared to other Amazonian fruits, such as açaí (Euterpe oleracea) (84.0 ± 10 mg AA/100 g), acerola (Malpighia emarginata) (1357 ± 9.5 mg AA/100 g), bacuri (Platonia insigni) (2.4 ± 0.3 mg AA/100 g), myrtle (Ugni molinae) (181.0 ± 1.8 mg AA/100 g), or jabuticaba (Myrciaria jaboticaba) (238 ± 2.2 mg AA/100 g), camu camu is one of the main natural sources of vitamin C (1882 ± 43.2 mg/100 g).

Antioxidant properties: Camu camu is rich in antioxidants, including phenolic compounds and flavonoids. These antioxidants help neutralize harmful free radicals in the body, reducing oxidative stress and inflammation. Studies suggest that the antioxidant properties of camu camu may contribute to its potential health benefits, including protection against chronic diseases such as heart disease and cancer, acting as an anti-hyperglycemic, antidepressant, antiproliferative, antihepatoxic, antihemolytic, antimutagenic, skin rejuvenating cells. (García-Chacón, et al., 2023).

Immune support: Due to its high vitamin C content, camu camu is often used to support immune function. Vitamin C plays a fundamental role in the immune system, stimulating the production of white blood cells and increasing their ability to fight infections. Consuming camu camu can help increase the immune response and reduce the risk of infections, especially during times of stress or illness.

Anti-inflammatory effects: Some research suggests that the antioxidants found in camu camu may have anti-inflammatory effects. Chronic inflammation is associated with several health problems, including arthritis, cardiovascular disease, and autoimmune disorders. By reducing inflammation in the body, camu camu can help alleviate symptoms and improve overall health. Skin Health: Vitamin C is essential for collagen synthesis, which is crucial for maintaining healthy skin. The antioxidant properties of camu camu can help protect the skin from damage caused by UV radiation, pollution and other environmental factors. Some skincare products also include camu camu extract for its potential anti-aging and brightening effects.

Mood and Cognitive Function: Preliminary research suggests that the antioxidants in camu camu may have neuroprotective effects, which could potentially benefit mood and cognitive function. However, more studies are needed to fully understand camu camu's impact on brain health.

Camu camu can be consumed in a variety of ways, including fresh fruits, juices, powders and dietary supplements. It is often used as a natural remedy for colds and flu, as well as a general health tonic. However, it is essential to note that while camu camu offers promising health benefits, more research is needed to confirm its effectiveness and ideal dosage for specific health conditions. As with any supplement, it is best to consult a healthcare professional before adding camu camu to your regimen, especially if you have any underlying health conditions or are taking medications (da Silva, et al, 2012; Langley, et al, 2014).

Guaraná: Guaraná is a climbing plant native to the Amazon basin and its seeds contain a high caffeine content. Guarana is commonly used in energy drinks, soft drinks and dietary supplements (Marques, et al., 2019), Figure 5.

Figure 5: Guaraná fruit.
Source: https://mundoeducacao.uol.com.br/biologia/guarana.htm. Extracted in: 15-03-2024.

Guaraná, a plant native to the Amazon basin, is widely used in the food and beverage industry for its stimulating properties and distinctive flavor. Here are several ways guarana is used:

Energy Drinks and Beverages: Guarana is a common ingredient in energy drinks and beverages due to its high caffeine content. It is often included along with other energy-boosting ingredients to provide consumers with a natural alternative to synthetic caffeine.

Soft drinks: Guarana extract or flavoring is used in some soft drinks to enhance flavor and potentially provide a slight boost of energy. It is particularly popular in South America, where guarana-based soft drinks are commonly consumed.

Nutritional supplements: Guarana is used in some nutritional supplements marketed for its purported energy-boosting effects. These supplements can come in the form of capsules, powders, or liquid extracts.

Functional Foods: Guarana is incorporated into various functional food products, such as energy bars, snacks and even ice cream, to provide consumers with a natural source of energy. Weight Loss Supplements: Some weight loss supplements include guarana because of its potential to increase metabolism and suppress appetite. However, scientific evidence supporting these claims is limited.

Cosmetics and personal care products: Guarana extract are sometimes used in cosmetics and personal care products for its antioxidant properties and potential benefits for the skin.

Overall, guaraná's popularity in the agri-food industry stems from its caffeine content, which provides a natural boost of energy, as well as its distinct flavor profile, which adds depth to many products. However, it is essential to note that although guarana is generally recognized as safe when consumed in moderation, excessive caffeine intake can lead to adverse effects, so it is essential that consumers are mindful of their consumption levels. According to Pinaffi, et al., the 2020 Brazilian Food Supplementation Law recently recognized that guaraná (Paullinia cupana) contains bioactive substances, thus supporting its role as a functional food ingredient. The health benefits of guarana are associated, at least in part, with its phenolic compounds.

From a Nutraceutical Point of View

From a nutraceutical point of view, several discoveries and uses have been associated with guaraná:

Caffeine content: Guarana seeds contain high levels of caffeine, typically more than coffee beans. This makes guarana a popular natural source of caffeine, which can provide a stimulating effect on the central nervous system. According to Hack, et al. (2023) acute ingestion of guarana had a small effect on response time (faster performance) during a variety of cognitive tasks, without affecting accuracy. It is not known whether the changes were linked to the caffeine content or other bioavailable substances in guaraná. Additional studies that directly compare combined doses of caffeine versus guarana are needed to understand their effects on cognitive performance. Several benefits have also been demonstrated in adults who consistently used guarana. Habitual consumption appears to lead to a lower incidence of hypertension, obesity and metabolic syndrome.

In addition to the benefits attributable to the alkaloid content described above, the antioxidant properties are very important. In the seeds of this plant, in fact, the polyphenol content is around 7 to 9%. There are mainly condensed tannins such as catechins and epicatechins.

Antioxidant properties: Guarana seeds contain a variety of antioxidants, including tannins, catechins and epicatechins. These compounds have been studied for their potential health benefits, such as reducing oxidative stress and inflammation in the body (Aldhahrani, 2021).

Energy and Alertness: Due to its high caffeine content, guarana is often used as a natural energy booster and cognitive enhancer. It can help improve focus, alertness, and mental performance, similar to other caffeine-containing substances Torres, et al., (2021).

Weight control: Some studies suggest that guarana can help with weight control and appetite control. Caffeine can increase metabolism and thermogenesis, potentially leading to greater calorie burning. Additionally, guarana extract is often included in weight loss supplements for its stimulating properties.

Improved mood: Consumption of caffeine, including that from guarana, has been associated with improved mood and a feeling of well-being. It can improve mood by stimulating the release of neurotransmitters like dopamine and serotonin in the brain.

Physical Performance: Guarana supplements are sometimes used by athletes and fitness enthusiasts to improve physical performance and endurance. The stimulant effects of caffeine can help reduce fatigue and increase endurance during exercise.

Mental Performance: Guarana has been studied for its potential cognitive benefits, including improving memory, concentration and reaction time. These effects are largely attributed to caffeine's ability to increase alertness and cognitive function.

Guarana is typically consumed in a variety of forms, including capsules, tablets, energy drinks and teas. Dosage and form of consumption may vary depending on the intended purpose, with some individuals preferring guarana supplements for a convenient, standardized dose, while others may enjoy guarana-infused beverages for a more traditional form of consumption.

However, it is essential to use guarana responsibly, as excessive caffeine consumption can cause adverse effects such as insomnia, nervousness, tachycardia and digestive problems. Individuals with certain medical conditions or caffeine sensitivity should consult a healthcare professional before using guarana supplements.

Buriti Fruit: The buriti fruit is the fruit of the moriche palm tree, native to the Amazon rainforest. It is rich in vitamins A and E, as well as essential fatty acids. Buriti fruit oil is often used in cosmetics and skin care products**.**

Figure 6: Buriti Fruit
Source: https://monografias.brasilescola.uol.com.br/biologia/aspectos-quimicos-farmacologicos-polpa-oleo-fruto-buriti-mauritia-flexuosa.htm. Extracted in 15-03-2024

The buriti fruit, derived from the Mauritia flexuosa palm tree, native to South America, mainly Brazil, is increasingly used in the food agribusiness industry for its nutritional properties and unique flavor. Here are some ways to use it:

Food Products: The buriti fruit is processed into various food products, such as juices, jams, jellies and sweets. These products take advantage of the natural sweetness and characteristic flavor of the fruit.

Functional Foods: Due to its high vitamin content, mainly vitamins A and C, as well as minerals and antioxidants, buriti is being incorporated into functional foods, such as energy bars, smoothies and healthy drinks.

Cosmetics: In addition to the food industry, buriti fruit oil is also used in cosmetics and skin products for its moisturizing and antioxidant properties. It is found in products such as moisturizers, lip balms, and hair care items.

Supplements: Buriti fruit extracts are used as supplements, mainly for their purported health benefits, such as boosting immunity, improving skin health, and supporting eye health due to their high beta-carotene content.

Nutritional Enrichment: In regions where vitamin deficiencies prevail, buriti is used to fortify food products, providing essential nutrients to combat malnutrition.

Flavoring: The characteristic flavor of buriti is also used as a natural flavoring in various food products, giving a tropical and exotic touch to dishes and drinks.

In general, the food agroindustry is recognizing the potential of the buriti fruit not only for its nutritional value, but also for its versatility in various applications, from food and beverages to cosmetics and supplements.

From a Nutraceutical Point of View

The buriti fruit, scientifically known as Mauritia flexuosa, is a tropical fruit native to South America, found mainly in the Amazon rainforest. It has gained attention in recent years due to its potential nutraceutical properties. Here is what has been discovered about buriti from a nutraceutical point of view, how they are used and the benefits they offer:

Nutritional Composition:

Rich in antioxidants: Buriti is rich in antioxidants such as carotenoids (especially beta-carotene), tocopherols and polyphenols. These compounds help neutralize free radicals, reducing oxidative stress and inflammation in the body (Avila-Sosa, et al., 2019).

Vitamins and Minerals: Contains significant amounts of vitamin C, vitamin E, vitamin A (as beta-carotene) and minerals such as potassium and calcium, contributing to general health and immunity support.

Fatty Acids: Buriti is also a source of essential fatty acids, mainly oleic acid (omega-9) and palmitic acid. These fatty acids are crucial for maintaining healthy cell membranes and supporting various bodily functions. Pulp oil can act as an immunomodulator against enteropathogenic Escherichia coli, according to Cruz, et al., (2020).

Buriti (Mauritia flexuosa), also known as moriche or aguaje palm, is a tropical fruit native to South America, found mainly in the Amazon rainforest region. It is known for its nutritional benefits and nutraceutical potential. Some of the main nutraceutical components and benefits of buriti can be considered:

Vitamin A: Buriti is exceptionally rich in vitamin A, mainly in the form of beta-carotene. Beta-carotene is a precursor to vitamin A, which is crucial for maintaining healthy vision, skin and immune function. Buriti's high vitamin A content is particularly beneficial for eye health and may help protect against night blindness and other vision-related problems.

Antioxidants: Buriti is rich in antioxidants, including vitamin E, phenolic compounds and carotenoids. These antioxidants help neutralize harmful free radicals in the body, reducing oxidative stress and inflammation. Antioxidants are essential for overall health and can help prevent chronic diseases such as cardiovascular disease, cancer and neurodegenerative disorders.

Fatty Acids: Buriti oil, extracted from the pulp of the fruit, is rich in essential fatty acids, including omega-3, omega-6 and omega-9 fatty acids. These fatty acids are important for maintaining healthy cell membranes, supporting brain function, reducing inflammation, and promoting cardiovascular health.

Phytochemicals: Buriti contains several phytochemicals, such as flavonoids and polyphenols, which contribute to its antioxidant and anti-inflammatory properties. These compounds have been studied for their potential health benefits, including protection against chronic diseases and processes related to aging.

Skin Health: Due to its high content of vitamin A, vitamin E and antioxidants, buriti oil is often used in skin care products. It is believed to hydrate the skin, reduce inflammation, promote collagen production and protect against sun damage. Buriti oil can help improve skin elasticity, reduce the appearance of wrinkles and fine lines, and soothe irritated or damaged skin.

Nutritional Support: In addition to its specific nutraceutical components, buriti provides essential nutrients such as vitamin C, B vitamins, potassium and iron, important for overall health and well-being.

Although buriti offers numerous potential health benefits, more research is needed to fully understand its mechanisms of action and therapeutic applications. Furthermore, it is essential to consume buriti and its products as part of a balanced diet, rather than relying solely on them for health benefits.

Traditional and Modern Uses:
Cosmetics: The oil extracted from the buriti fruit is popularly used in skin and hair products due to its moisturizing and emollient properties. Helps nourish and hydrate the skin, as well as protecting it from environmental damage.

Nutritional supplements: Buriti fruit extract or oil is used in dietary supplements, often marketed for their antioxidant content and potential health benefits.

Culinary Purpose: In regions where buriti fruit is abundant, it is consumed fresh or used in traditional dishes. The fruit pulp can be transformed into juices, jellies or desserts, providing not only a pleasant flavor but also nutritional benefits.

Health Benefits:
Skin Health: The antioxidants and fatty acids in buriti oil can help improve skin elasticity, reduce wrinkles, and protect against UV-induced damage, promoting overall skin health and a youthful appearance.

Eye health: The high concentration of beta-carotene (a precursor to vitamin A) in buriti fruit is beneficial for eye health, supporting vision and reducing the risk of age-related macular degeneration and other eye diseases.

Immune support: The vitamin C content of buriti fruit contributes to immune function, helping the body defend itself against infections and diseases, Romualdo, et al., (2024).

Anti-inflammatory effects: The antioxidant and anti-inflammatory properties of buriti fruit may help alleviate conditions related to inflammation, such as arthritis and cardiovascular disease (Barboza et al., 2022).

Cardiovascular Health: The presence of healthy fats like oleic acid, along with antioxidants, can support heart health by reducing cholesterol levels and improving blood vessel function.

Consequently, buriti offers a range of potential nutraceutical benefits due to its rich antioxidant content, essential nutrients and fatty acids. Whether consumed fresh, made into an oil or incorporated into skincare products, it provides a natural source of nutrition and can contribute to overall health and well-being. However, as with any supplement or natural remedy, it is essential to consult a healthcare professional before incorporating buriti or its derivatives into your diet or skin care routine, especially if you have any underlying health conditions or concerns (Barboza et al., 2020).

Babassu (Attalea speciosa): Babassu (Figure 6) produces fruits that contain seeds with oil used in cooking, soap making and cosmetic products. The oil is similar to coconut oil and has several applications in the food and cosmetic industries. On the other hand, studies have shown the possibility of use as biofuel, according to Bouaid, et al., (2015). As a sustainable fuel, babassu oil is promising because it is only harvested wild in tropical forests, so it does not contribute to deforestation. Fruit peels can also be used as biomass for fuel after harvesting the oilseed (Moreira, et al., 2018).

USE OF CO-PRODUCTS

Certainly, Amazonian fruits, when industrialized, can generate various residues or co-products, which can be used to achieve greater sustainability.

The use of waste or co-products generated during the industrialization of Amazonian fruits can in fact contribute to greater sustainability. Here are some ways this can be achieved:

Bioactive extracts: Considering an example of Camu camu, according to Santos et al., (2022), it is clear that although camu-camu pulp has important properties, a large part of its raw material, considered waste (around 50 %) and formed by important bioactive compounds, can give rise to new products, such as bioactive extracts to be used by the pharmaceutical, chemical and food industries, ingredients for bakery products, dairy products and several other sectors, which constitutes opportunities, in addition to contribute to the reduction of agro-industrial waste and the preservation of the environment (da Costa, et al., 2022). Equivalently, we can consider grape skins, residue from obtaining juice and making wine. Different studies have been carried out with the intention of taking advantage of this rich source of antioxidants (Fontoura et. al., 2022; Ascheri et al., 2019).

Bioenergy Production: Organic waste from fruit processing can be used to generate bioenergy through processes such as anaerobic digestion or combustion. This can help offset energy requirements for the processing facility or even contribute excess energy back to the grid.

Composting and Soil Enrichment: Fruit waste can be composted and used as an organic fertilizer to improve soil health and fertility. This can increase agricultural productivity in the region and reduce the need for chemical fertilizers.

Value-added products: Co-products derived from fruit processing, such as peels, seeds and pulp waste, can be further processed to create value-added products. For example, fruit peels can be used in the production of pectin, dietary fiber supplements or natural food coloring. Seed oils can be extracted for use in cosmetics, pharmaceuticals or biofuels. As an example, in the case of buriti, according to Resende, et al., (2019) buriti by-product flours have the potential to be used as sources of dietary fiber and natural antioxidants in foods.

Animal Feed: Some fruit by-products can be used as raw material for livestock or aquaculture, reducing the demand for conventional food sources. This can also create additional revenue streams for fruit processing facilities.

Biodegradable Packaging: Innovative materials can be developed from fruit waste for use in packaging applications. Biodegradable packaging made from materials such as fruit peels can help reduce plastic use and minimize environmental impact.

Water Treatment: Processes such as phytofiltration can utilize certain fruit plants to treat wastewater from processing facilities, removing pollutants and contaminants before discharge. This helps maintain water quality in surrounding ecosystems.

Community Development: Involving local communities in the collection and processing of fruit waste can create employment opportunities and stimulate economic development in rural areas. This can promote a more sustainable and inclusive approach to industrialization.

By implementing these strategies, industrialized processing of Amazonian fruits can become more sustainable, minimizing waste generation, maximizing resource efficiency and creating positive environmental and social impacts.

Thermoplastic Extrusion in The Transformation of Agroindustry Co-Products

Among the co-product transformation processes, thermoplastic extrusion technology (Figure 7) is one of the most recommended.

Thermoplastic extrusion technology is often recommended among co-product transformation processes for several reasons:

Versatility: Thermoplastic extrusion can process a wide range of materials, including various thermoplastics, additives and fillers. This versatility allows the production of a diverse range of products (Ascheri, 2023).

Figure 7: Feed extruder from Wenger® Company, Manufacturer located in Sabetha, Kansas, USA.

Extracted-from: https://www.seafoodbrasil.com.br/extrusao-de-racoes-etapas-tecnologia-e-aplicacoes.

Cost-effective: The extrusion process is generally efficient and can be highly automated, leading to cost savings in terms of labor and production expenses.

High yield: Extrusion lines can operate continuously, resulting in high production yield. This is particularly advantageous for large-scale production.

Precision control: Modern extrusion equipment allows precise control over processing parameters such as temperature, pressure and speed. This allows for the production of consistent, high-quality products.

Flexibility in product design: Extrusion technology offers flexibility in designing complex shapes and structures. This is especially valuable for producing customized or specialized products to meet specific requirements.

Environmental Benefits: Thermoplastic extrusion is generally considered a more environmentally friendly process compared to other manufacturing methods. It often produces less waste and consumes less energy, especially when using recycled materials.

Scalability: Extrusion processes can be easily scaled up or down to accommodate diverse production demands, making them suitable for both small and large-scale operations.

Overall, the combination of versatility, economy, precision control and environmental benefits of thermoplastic extrusion technology makes it a highly recommended option for co-product transformation processes in various sectors, from agribusiness.

Food extrusion technology has revolutionized the use of co-products in the food agroindustry, allowing the creation of several valuable products. Some of the main products obtained from food agroindustry co-products through food extrusion technology include:

Extruded snacks: Using co-products derived from the processing of grains such as cereals, -brans- vegetables and by-products from milling processes, extruded snacks such as puffs, chips and pellets can be produced. These snacks are usually seasoned and flavored to enhance their flavor and appeal.

Textured vegetable protein (TVP): Co-products such as soybean meal and other vegetable proteins can be extruded to produce TVP, which is used as a meat substitute in various food products such as burgers, sausages and meat analogues.

Breakfast cereals: Extrusion technology allows the production of a wide variety of breakfast cereals using co-products such as those resulting from the production and milling of corn grains, wheat flour, rice flour and other grains. Products such as flakes, chips and puffed cereals are commonly manufactured.

Pet food: Co-products from the food agribusiness industry, including grains, proteins and fiber, can be extruded to produce pet foods with specific nutritional profiles. Extrusion technology ensures the production of tasty and digestible pet food products.

Fortified food products: Food extrusion technology allows the incorporation of vitamins, minerals and other nutrients into co-products of the food agroindustry, resulting in fortified food products, such as extruded snacks, breakfast cereals and nutritional bars.

Functional ingredients: Co-products such as bran, germ and fiber can be extruded to produce functional ingredients used in a variety of food applications, including baked goods, dairy products and beverages. These ingredients can contribute to increasing nutritional value or functional properties.

Animal feed: Food extrusion technology can be used to process co-products from the food agribusiness industry into nutritious animal feed pellets. By optimizing the extrusion process, feed digestibility and palatability can be improved, leading to better animal health and performance.

Biodegradable packaging materials: Some research explores the use of co-products from the food agroindustry, such as starches and fibers, to produce biodegradable packaging materials

through extrusion technology. These materials offer a sustainable alternative to conventional plastics.

These are just a few examples of the diversity of products obtained through food extrusion technology from co-products of the food agroindustry. The versatility of extrusion technology continues to drive innovation in the use of co-products, contributing to sustainability and added value in the food industry.

In this sense, those resulting from the manufacture of Amazonian fruits, in the same way, can be used prior to sanitization of the co-products, drying, storage and subsequent processing by extrusion.

Some regional products from the Amazon, whose co-products can be used in food extrusion:

The Amazon region, the vast and biodiverse region of South America, is rich in a variety of regional products, many of which can be used as co-products in food extrusion processes. Some of these regional products include:

Cassava is a staple crop in many parts of the Amazon. Its roots are rich in starch, which makes it a valuable ingredient for food extrusion.

Bananas are a type of banana that is less sweet and richer in starch than the regular banana. They are widely cultivated in the Amazon and can be used in food extrusion due to their starch content.

Yam is another starchy tuber crop grown in the Amazon. They can be processed and used in food extrusion to add texture and nutrition to food products.

Açaí berries are native to the Amazon rainforest and are known for their antioxidant properties. Although not a direct source of starch, açaí pulp or extracts can be used in extruded food products to improve flavor and nutritional value.

Brazil nuts, these nuts are native to the Amazon rainforest and are rich in healthy fats and proteins. Although not typically used directly in food extrusion, Brazil nut oil or flour can potentially be incorporated into extruded products for nutritional or flavor purposes.

Camu Camu, this fruit, also native to the Amazon, is extremely rich in vitamin C. Although it is not directly involved in food extrusion, its extracts can be used as a nutritional additive in extruded foods.

Another Amazonian fruit, cupuaçu, is related to cocoa and has a creamy, exotic flavor. Its pulp or butter could potentially be used in extruded food products to add flavor and texture.

These products, whether in their whole form or as extracts, can contribute to the nutritional profile and flavor of extruded food products, making them valuable co-products in food processing.

References

Aldhahrani A. Protective effects of guarana (Paullinia cupana) against methotrexate-induced intestinal damage in mice. Food Sci Nutr. 2021 May 19;9(7):3397-3404. doi: 10.1002/fsn3.2101,

Alódia Brasil, Fernando Allan de Farias Rocha, Bruno Duarte Gomes, Karen Renata M. Oliveira, Tayana Silva de Carvalho, Evander de Jesus O. Batista, Rosivaldo dos Santos Borges, Jan Kremers & Anderson Manoel Herculano (2017). Diet enriched with the Amazon fruit açaí (Euterpe oleracea) prevents electrophysiological deficits and oxidative stress induced by methyl-mercury in the rat retina. Nutritional Neuroscience, 20:5, 265-272, DOI: 10.1080/1028415X.2015.1119378.

Ascheri, José Luis Ramírez. Thermoplastic Food Extrusion, Questions, and Answers - A Simplified Approach. Ed. Atena, Ponta Grossa, 2023, V.1. p.57. DOI: 10.22533/at.ed.390221612.

Bouaid A, boulifi N El, Martínez M, Aracil J (2015) Biodiesel Production from Babassu Oil: A Statistical Approach. J Chem Eng ProcessTechnol 6: 232. doi:10.4172/2157-7048.1000232.

de Carvalho, Anna Paula Azevedo, Conte-Junior, Carlos Adam. (2021). Health benefits of phytochemicals from Brazilian native foods and plants: Antioxidant, antimicrobial, anti-cancer, and risk factors of metabolic/endocrine disorders control, Trends in Food Science & Technology, v.111, Pages 534-548. Doi: 10.1016/j.tifs.2021.03.006.

Costa, R. S. Da., Santos, O. V. Dos., Lannes, S. C. Da S., Casazza, A. A., Aliakbarian, B., Perego, P., Ribeiro-Costa, R. M., Converti, A., & Silva Júnior, J. O. C. (2020). Bioactive compounds and value-added applications of cupuassu (Theobroma grandiflorum Schum.) agroindustrial by-product. Food Science and Technology, 40(2), 401–407. https://doi.org/10.1590/fst.01119.

da Costa Araújo, P. A.; dos Santos Garcia, V. A.; Osiro, D.; de Souza França, D.; Vanin, F. M.; de Carvalho, R. A. Active compounds from the industrial residue of dry camu-camu. Food Sci. Technol. 2022, 42, e0532. DOI: 10.1590/fst.05321.

da Silva FC, Arruda A, Ledel A, Dauth C, Romão NF, Viana RN, de Barros Falcão Ferraz A, Picada JN, Pereira P. (2012). Antigenotoxic effect of acute, subacute and chronic treatments with Amazonian camu-camu (Myrciaria dubia) juice on mice blood cells. Food Chem Toxicol. Jul;50 (7):2275-81. doi: 10.1016/j.fct.2012.04.021.

de Oliveira AI, Mahmoud TS, do Nascimento GN, da Silva JF, Pimenta RS, de Morais PB. Chemical Composition and Antimicrobial Potential of Palm Leaf Extracts from Babaçu (Attalea speciosa), Buriti (Mauritia flexuosa), and Macaúba (Acrocomia aculeata). Scientific World Journal. 2016; 2016:9734181. doi: 10.1155/2016/9734181.

de Souza Silva, A.P.; de Camargo, A.C.; Lazarini, J.G.; Franchin, M.; Sardi, J.d.C.O.; Rosalen, P.L.; de Alencar, S.M. Phenolic Profile and the Antioxidant, Anti-Inflammatory, and Antimicrobial Properties of Aç aí (Euterpe oleracea) Meal: A Prospective Study. Foods 2023, 12, 86.

Fontoura, Laís Martins; Ascheri, José Luis Ramírez; Bazán-Colque, Ronel Joel. (2022). Impact on antioxidant activity of including grape peel flour in a novel sorghum-based extruded food. Ciência e Tecnologia de Alimentos (Online). , v.42, p.1 - 10, 2022. doi.org/10.1590/fst.35121.

Francisca Belkise de F. Moreira, Rita de Cássia de Freitas Bezerra, Francisco Eduardo Arruda Rodrigues, João Carlos da Costa Assunção, Tathilene Bezerra Mota Gomes Arruda. (2018) In situ Transesterification of Babassu

for Production of Biodiesel as Sustainable Energy Option for Aratuba Community in State of Ceará, Brazil. The Electronic Journal of Chemistry. v.10, n.2.

Hack B, Penna EM, Talik T, Chandrashekhar R, Millard-Stafford M. (2023). Effect of Guarana (Paullinia cupana) on Cognitive Performance: A Systematic Review and Meta-Analysis. Nutrients. Jan 14;15(2):434. Doi: 10.3390/nu15020434.

Grigio, M. L., Moura, E. A., Carvalho, G. F., Zanchetta, J. J., Chagas, P. C., Chagas, E. A., & Durigan, M. F. B. (2022). Nutraceutical potential, quality and sensory evaluation of camu-camu pure and mixed jelly. Food Science and Technology, 42, e03421. https://doi.org/10.1590/fst.03421.

Jose Luis Ramirez Ascheri, Ronel Joel Bazan Colque, Luana Manfioletti Borsoi, Diego Palmiro Ramirez Ascheri, Arturo Melendez Arevalo and Erika Madeira Moreira Da Silva. (2019) Extrusion Cooking using Fruits Peels, Whole Cereals and Grains. Global Journal of Nutrition & Food Science, v.1, n.5. DOI: 10.33552/GJNFS.2019.01.000524.

Juliana María García-Chacón, Juan Camilo Marín-Loaiza, and Coralia Osorio. (2023). Camu Camu (Myrciaria dubia (Kunth) McVaugh): An Amazonian Fruit with Biofunctional Properties–A Review. ACS Omega v.8 (6), 5169-5183. DOI: 10.1021/acsomega.2c07245.

Langley PC, Pergolizzi JV Jr, Taylor R Jr, Ridgway C. Antioxidant and associated capacities of Camu camu (Myrciaria dubia): a systematic review. J Altern Complement Med. 2015 Jan;21(1):8-14. doi: 10.1089/acm.2014.0130. Epub 2014 Oct 2. PMID: 25275221; PMCID: PMC4296744.

Laís M. Resende, Adriana S. Franca, Leandro S. Oliveira. (2019) Buriti (Mauritia flexuosa L. f.) fruit by-products flours: Evaluation as source of dietary fibers and natural antioxidants, Food Chemistry, v. 270, p. 53-60, doi.org/10.1016/j.foodchem.2018.07.079.

Laurindo, Lucas Fornari, Sandra Maria Barbalho, Adriano Cressoni Araújo, Elen Landgraf Guiguer, Arijit Mondal, Gabrielle Bachtel, and Anupam Bishayee. 2023. "Açaí (Euterpe oleracea Mart.) in Health and Disease: A Critical Review" Nutrients 15, no. 4: 989. https://doi.org/10.3390/nu15040989.

Mariana Bento Cruz, Wellington da Silva Oliveira, Renata Lázara Araújo, Adenilda Cristina Honório França, Paula Becker Pertuzatti. (2020) Buriti (Mauritia Flexuosa L.) pulp oil as an immunomodulator against enteropathogenic Escherichia coli, Industrial Crops and Products, v.149, ,10.1016/j.indcrop.2020.112330.

Marques, L. L. M., Ferreira, E. D. F., Paula, M. N. de., Klein, T., & Mello, J. C. P. de .. (2019). Paullinia cupana: a multipurpose plant - a review. Revista Brasileira De Farmacognosia, 29(1), 77–110. https://doi.org/10.1016/j.bjp.2018.08.007.

Michael Heinrich, Tasleem Dhanji, Ivan Casselman, (2011). Açai (Euterpe oleracea Mart.)—A phytochemical and pharmacological assessment of the species' health claims, Phytochemistry Letters, v.4, n. 1. Doi.org/10.1016/j.phytol.2010.11.005.

Natália L. Barboza, Josias Martins dos Anjos Cruz, Renilto Frota Corrêa, Carlos Victor Lamarão, Alessandra Ramos Lima, Natália Mayumi Inada, Edgar Aparecido Sanches, Jaqueline de Araújo Bezerra, Pedro H. Campelo. (2022). Buriti (Mauritia flexuosa L. f.): An Amazonian fruit with potential health benefits. Food Research International, v.159, doi: 10.1016/j.foodres.2022.111654.

Oppitz, S.J.; Garcia, M.V.; Bruno, R.S.; Zemolin, C.M.; Baptista, B.O.; Turra, B.O.; Barbisan, F.; Cruz, I.; Silveira, A.F.D. Supplementation with açaí (Euterpe Oleracea Martius) for the treatment of chronic tinnitus: Effects on perception, anxiety levels and oxidative metabolism biomarkers. CoDAS 2022, 34, e20210076.

Pinaffi ACDC, Sampaio GR, Soares MJ, Shahidi F, de Camargo AC, Torres EAFS (2020). Insoluble-Bound Polyphenols Released from Guarana Powder: Inhibition of Alpha-Glucosidase and Proanthocyanidin Profile. Molecules. Feb 5;25(3):679. doi: 10.3390/molecules25030679.

Priscilla Siqueira Melo, Miriam Mabel Selani, Regina Helena Gonçalves, Jennifer de Oliveira Paulino, Adna Prado Massarioli, Severino Matias de Alencar. (2021). Açaí seeds: An unexplored agro-industrial residue as a potential source of lipids, fibers, and antioxidant phenolic compounds, Industrial Crops and Products, v.161, 2021, Doi: 10.1016/j.indcrop.2020.113204.

Raúl Avila-Sosa, Andrés Felipe Montero-Rodríguez, Patricia Aguilar-Alonso, Obdulia Vera-López, Martin Lazcano-Hernández, Julio César Morales-Medina, Addí Rhode Navarro-Cruz, "Antioxidant Properties of Amazonian Fruits: A Mini Review of In Vivo and In Vitro Studies", Oxidative Medicine and Cellular Longevity, vol. 2019, Article ID 8204129, 11 pages, 2019. DOI:10.1155/2019/8204129.

Rodrigues MF, da Silva JW, de Lima JS, Ramos BA, Paz ST, Lomonaco D, Zampieri D, Ximenes RM. Antiulcer activity of Mauritia flexuosa L.f. (Arecaceae) pulp oil: An edible Amazonian species with functional properties. Fitoterapia. 2024 Feb 12; 174:105857. doi: 10.1016/j.fitote.2024.105857.

Romualdo, G.R.; Fragoso, M.F.; Borguini, R.G.; de Araújo Santiago, M.C.P.; Fernandes, A.A.H.; Barbisan, L.F. Protective effects of spray-dried açaí (Euterpe oleracea Mart) fruit pulp against initiation step of colon carcinogenesis. Food Res. Int. 2015, 77, 432–440.

Santos, I. L.; Miranda, L. C. F.; da Cruz Rodrigues, A. M.; da Silva, L. H. M.; Amante, E. R. Camu-camu [Myrciaria dubia (HBK) McVaugh]: A review of properties and proposals of products for integral valorization of raw material. Food Chem. 2022, 372, 131290, DOI: 10.1016/j.foodchem.2021.131290.

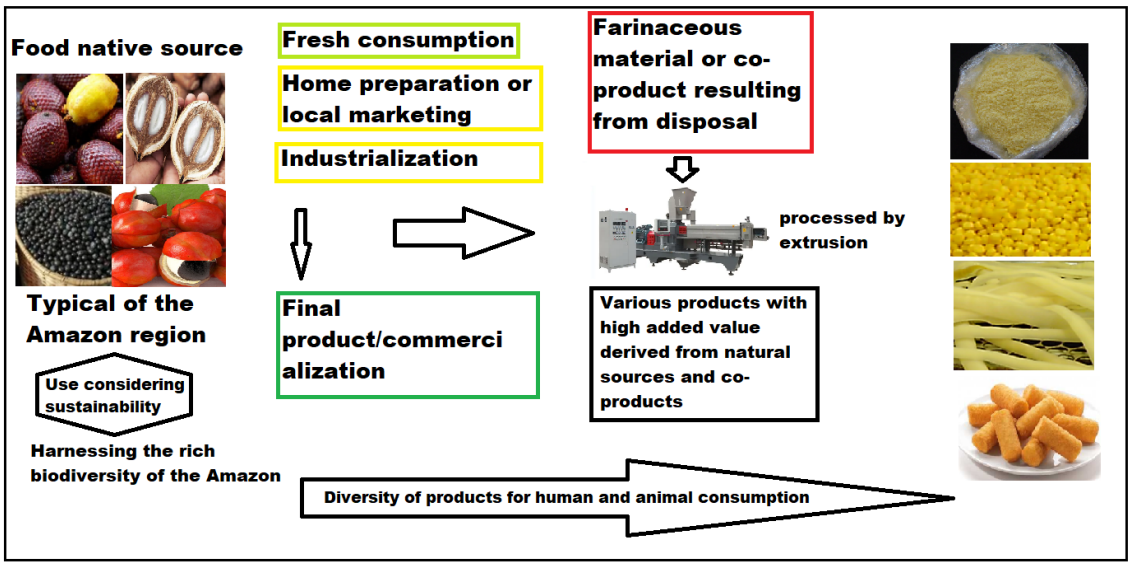
Tacin, M.V.; Massi, F.P.; Fungaro, M.H.P.; Teixeira, M.F.S.; de Paula, A.V.; de Carvalho Santos-Ebinuma, V. Biotechnological Valorization of Oils from Agro-Industrial Wastes to Produce Lipase Using Aspergillus sp. from Amazon. Biocatal. Agric. Biotechnol.; 2019; 17, pp. 369-378. Doi.org/10.1016/j.bcab.2018.11.013.

Teixeira GL, Ibañez E, Block JM. Emerging Lipids from Arecaceae Palm Fruits in Brazil. Molecules. 2022 Jun 29;27(13):4188. doi: 10.3390/molecules27134188.

Torres EAFS, Pinaffi-Langley ACDC, Figueira MS, Cordeiro KS, Negrão LD, Soares MJ, da Silva CP, Alfino MCZ, Sampaio GR, de Camargo AC. Effects of the consumption of guarana on human health: A narrative review. Compr Rev Food Sci Food Saf. 2022 Jan;21(1):272-295. doi: 10.1111/1541-4337.12862.

Yang, Jun. (2009). Brazil nuts and associated health benefits: A review. LWT - Food Science and Technology. 42. 1573-1580. 10.1016/j.lwt.2009.05.019.

GRAPHICAL ABSTRACT



Funding details:
The any Funding did not support this work.

Disclosure statement:
The authors report there are no competing interests to declare.