Amazonian Foods

Science, Culture and Sustainability

Edited by

Fernanda Barbisan, Verônica F. Azzolin and Paula Kohler Carpilovsky

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2025

Ethics International Press, UK

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN (Hardback): 978-1-83711-532-7

ISBN (Ebook): 978-1-83711-533-4

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Chapter 1

The Amazonian Diet: From Pre-Columbian Peoples to Contemporary Riverine Communities

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Abstract

The pre-Columbian peoples, who originated the Amazonian peoples, cultivated and managed the soil in a sophisticated manner, resulting in fertile lands such as the 'Terras Pretas de Índio' (Indian Black Lands). Species such as cassava, cocoa, açaí and Brazil nuts were fundamental to their diet and continue to be consumed today, standing out for their nutritional benefits and therapeutic potential. Recent archaeological research has revealed complex pre-Columbian villages, evidencing advanced agricultural and environmental management practices. The traditional diet, consisting of gathered fruits, fish and game, or 'subsistence farming,' has been replaced by industrialised products, reflecting

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a worrying dietary transition. Studies point to an increase in the consumption of processed foods and the consequent rise in obesity and malnutrition in riverside communities, reflecting a diet low in nutrients and high in sugars and fats. The preservation of the Amazonian diet not only reinforces the cultural and nutritional identity of local populations, but also plays an essential role in the conservation of the forest and the ecological balance of the region.

KEYWORDS: Food transition; Indigenous peoples; Riverine communities; Health.

Introduction

Although often considered an untouched environment, the Amazon has had its landscapes modified by indigenous peoples since their arrival at least 13,000 years ago. The Amazon rainforest invaded by Europeans in the 16th century was not pristine, but rather the result of thousands of years of land management by the indigenous people who lived there. Despite variations in mobility patterns among indigenous peoples, most obtained food through the cultivation of plant species, forest management practices, gathering of natural resources, hunting and fishing (Clement et al., 2024).

Research published in Science indicated that pre-Columbian peoples were great soil managers, as they exploited and manipulated various plants. The study pointed to about 85 species of trees and plants generally used as food, namely: cocoa, sweet potato, cassava, Brazil nuts, cupuaçu, açaí, pineapple, and maize (Peripato et al., 2023).

Regarding cassava, an important food source for ancient and present-day Amazonian peoples, the study by Peripato et al., 2023, pointed out that the ancients had gigantic ceramic ovens for preparing flour, and archaeological findings even point to flour 'industries.' In areas close to rivers, fish consumption was more intense; in more remote areas, hunting land animals such as pacas, tapirs, and tortoises was fundamental.

The Amazonian diet is closely linked to the way of life and traditional knowledge of indigenous and riverine peoples, and these foods have been and continue to be fundamental to the nutrition and survival of these populations. (Figure 1)

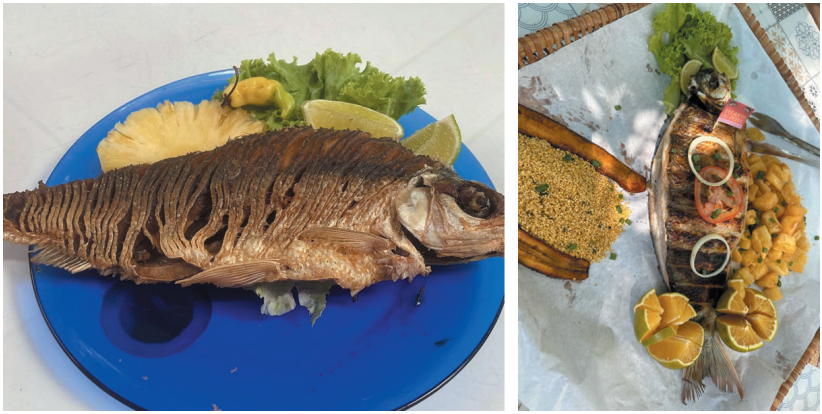

Figure 1 *Typical dishes of the Amazonian Diet. On the left, fried Jaraqui fish, and on the right, roasted Matrinxã fish with banana farofa.*

Photo credit: The authors

Understanding their origin and evolution is essential for us to value the food practices that are part of the cultural heritage of the Amazon, contributing to pride in cultural identity and the consequent strengthening of local communities, in addition to the preservation of the forest and the ecological balance of the region.

Historical Context of the Amazonian Diet

Pre-Columbian peoples and their relationship with the environment

Indigenous societies lived in the Amazon since pre-Columbian times, long before the arrival of colonizers. They had extensive knowledge of the soil and how to manage it, which allowed these peoples to create a variety of earthworks for soil cultivation and social functions such as leisure and ceremonies. They planted trees around these sites, which shows the domestication of species (Peripato et al., 2023).

The extent of these transformations in the forest by pre-Columbian peoples is still poorly understood, however, with the advancement of science, some changes in the forest made in the pre-Columbian era have been detected by mapping with sensors equipped with optical technology (equipment known as LIDAR), which can detect light and measure distances due to the emission of thousands of laser pulses per second, similar to an X-ray. The mapping made it possible to detect in detail pre-Columbian settlements hidden under the Amazon rainforest. 0.08% of the Amazon basin was mapped in the study (Peripato et al., 2023).

Archaeological discoveries from scanning 5,315 km² of forest revealed 24 earthworks in the Guiana Shield of the Amazon, while in the south of the Amazon in the Upper Xingu Basin in Mato Grosso, the study pointed out that in the 13th to 15th centuries there were villages of up to 500,000 square metres inhabited by up to 5,000 people, with dams, embankments, pits, bridges and roads connecting to other villages, defensive and ceremonial sites in the southwestern Amazon, and riverside sites in floodplains in the

central Amazon (Peripato et al., 2023). This indicates the development of societies.

Gathering, hunting, and fishing practices

In 2020, Colonese and colleagues published a study on the diet of people who lived on the Brazilian Amazon coast between 1,000 and 1,800 years ago. This study was made possible by analyzing stable carbon and nitrogen isotopes in collagen, evaluated in ceramics and bones found at archaeological sites in Maranhão.

The scientists pointed to evidence that the diet of the populations living in that region was based mainly on plants such as maize, cassava and pumpkin and the consumption of land animals such as paca, agouti and brocket deer. These findings indicate that these pre-Columbian peoples were skilled at hunting and forest management with plant cultivation (Colonese et al., 2020).

Clement et al. (2024) cite that regardless of the level of horticultural practice, indigenous people domesticated the forests around their settlements, creating clusters of fruit trees and palm trees. Some of these fruit species are still dominant in the Amazon today, and six of them can produce more protein and other nutrients than all the cattle in the Amazon, namely: *Euterpe precatoria* and *Euterpe oleracea* (açaí); *Oenocarpus bataua* (patauá); *Mauritia flexuosa* (buriti); *Theobroma cacao* (cocoa) and *Bertholletia excelsa* (Brazil nut).

Other practices that influence the abundance of plants of human interest and transform forest landscapes are soil enhancement and the use of fire, which create environmental filters that favours certain plants with nutritional capacity. The combination of these practices in pre-Columbian settlements favoured the formation of

Terras Pretas or *Terras Pretas de Índio* (Clement et al., 2024), soils of anthropogenic origin, whose formation is associated with agricultural practices, being the result of the combination of fish and game remains, seeds and charred plant material. The oldest record of black earth comes from the banks of the Madeira River in Rondônia, dating back 6,000 years.

The domestication of species populations can occur alongside the domestication of landscapes (Clement et al., 2021) and, considering the widespread extent of sites modified by pre-Columbian management and cultivation practices, the Amazon can be seen as an ancient socio-ecological system (Peripato et al., 2023).

Traditional Foods and Their Nutritional Importance

Many of the foods that were part of the diet of pre-Columbian peoples continue to be consumed by today's indigenous and riverine populations. From the extensive diversity of the Amazonian diet, notable examples include some foods such as açaí, cupuaçu, guaraná, Brazil nuts, tucumã and cassava, which, in addition to being consumed directly, is used to make flour and tucupi. The traditional diet not only satisfies hunger, but the high nutritional value of these foods also contributes to prevention. More recently, these foods have been studied as potential sources for the development of disease treatment strategies.

Açaí, for example, is rich in lipids, which is why it is classified as an energy-dense food. When compared to other fruits, açaí pulp has a higher dietary fiber content and lower carbohydrate content . It also contains calcium, magnesium, potassium, manganese, copper, nickel, boron, chromium and vitamins such as B1, B6 (Laurindo et al., 2023).

In the review published by Laurindo et al. 2023, the compilation of studies indicated that açaí has antioxidant action, thus protecting the components of our cells from damage caused by free radicals, and anti-inflammatory action. These properties are related to the prevention and treatment of risk factors for various chronic non-communicable diseases such as diabetes, dyslipidemia (excess fat in the blood), hypertension and cardiovascular diseases. In addition, the authors cite other properties such as anticarcinogenic, antimicrobial, protective of blood vessel health, anticonvulsant, antileishmanial and ageing decelerator. Açaí also appears to contribute positively to the health of the liver, lungs and brain.

Oxidative stress results from an imbalance between the generation of oxidising compounds (which damage cells when in excess) and the action of antioxidant defence systems. According to Barbosa et al. 2010, oxidative stress results from an imbalance between oxidising compounds and antioxidants, favouring the excessive generation of free radicals or the failure of antioxidant mechanisms to remove them. Thus, this process leads to the oxidation of biomolecules with consequent loss of their biological functions and/or homeostasis, which manifests as potential oxidative damage to cells and tissues, with the capacity to induce various chronic diseases. The brain is an organ that is particularly vulnerable to oxidative stress due to its high energy consumption, which greatly increases the risk of mitochondrial damage and consequent dysfunction of this organelle, which can lead to neuron death and psychiatric disorders or neurodegenerative diseases.

Given this context, the Biogenomics research group led by Prof. Ivana Cruz and Dr. Euler Ribeiro examined the in vitro role of açaí in modulating mitochondrial function and oxidative metabolism. The study, conducted in partnership with the University of Toronto

in Canada, evaluated the ability of an açaí extract to reverse mitochondrial dysfunction caused by the pesticide rotenone in human neural cells. The results of the study showed that açai not only increased the amount of protein and enzymatic activity of mitochondrial complex I, but also reduced the reactive species that cause cell damage and damage to lipids. Mitochondrial complex I is essential for cell energy production, as it initiates the electron transport chain, which culminates in the formation of ATP (energy for cells). Given these results, açaí appears to contribute positively to the treatment of psychiatric disorders such as bipolar disorder and schizophrenia, both of which are already related to mitochondrial dysfunction of Complex I. (Machado et al., 2016).

Another example of a traditional food already recognised by science as beneficial to human health is the Brazil nut, which has a high selenium content and powerful antioxidant and immune-boosting properties. The seed is also rich in amino acids, antioxidant vitamins, phenolic compounds and phytosterols. In addition to their biological functions, bioactive compounds and essential fatty acids have therapeutic effects in the prevention of chronic diseases through their antioxidant effects.

Recently, Silveira et al., 2024 conducted an 8-week controlled trial involving 56 overweight or obese women, who were divided into 2 groups, both following an energy-restricted diet. One group did not consume Brazil nuts, while the other consumed 8g per day, approximately 347.2 μg of selenium. The results of the study indicated that Brazil nut consumption decreased pro-inflammatory markers and intestinal permeability. This suggests that Brazil nut intake may be a promising complementary dietary strategy for controlling low-grade inflammation and improving intestinal permeability in overweight/obese women. The authors note that

these results may be dependent on the selenium obtained through nut consumption.

Cassava itself, a staple food in the Amazon region, is a source of energy and complex carbohydrates. In addition to various pharmacological properties, according to a review by Mohidin et al., 2023, cassava has antioxidant action, which contributes to protective effects on the liver and kidneys. It also has anti-inflammatory, analgesic, anticancer, antibacterial, and antidiabetic properties. It also stands out for its potential to reduce cholesterol levels, promote collagen synthesis and fibroblast proliferation, favouring the wound healing process. Other actions mentioned in studies include its antidiarrheal activity and effect against helminth infections. It is important to note that the review mainly included studies with cells and animals, and few clinical trials, so these results may be somewhat biased. In any case, cassava does appear to be a beneficial food for health.

Studies indicate that regular consumption of Amazonian foods is associated with the prevention of chronic non-communicable diseases. Throughout this book, you will be introduced to a rich diversity of Amazonian fruits, with their health benefits already pointed out by science and their potential uses for the development of products that help fight diseases.

Amazonian Diet and Longevity

In the first edition of the book *Dieta Amazônica* (Amazonian Diet), authors Euler Ribeiro and Ivana Cruz mention that the idea for the book came from the results obtained from research conducted by the two authors and their teams with elderly people in Amazonas, both in the capital city of Manaus and in the interior, as in

the case of the studies they conducted in Maués. The researchers began their studies on the Amazonian Diet in 2007, in a partnership between the then Open University for the Third Age and the Federal University of Santa Maria. During their studies, the municipality of Maués drew attention to the research, in which data from the Brazilian Institute of Geography and Statistics (IBGE) showed a rare case in Brazil: 1% of the population of that municipality was aged 80 or over.

The results of the first phase of the studies indicated that this higher number of long-lived elderly people was not a 'demographic coincidence' resulting from migratory events. A study was conducted comparing the health profile of elderly people in Maués, in the interior of Amazonas, with those living in Manaus, the state capital, and the results showed that the incidence of diseases such as diabetes, hypertension, cardiovascular disease and cancer was lower among the elderly in Maués.

The researchers soon realised that there was something special about the population of Maués, and from their surveys they noted that this population maintained a diet very similar to that of pre-Columbian peoples, i.e. a nutritious diet. They hunted, fished, gathered and cultivated their own subsistence crops, thus getting physical exercise. Due to their way of life and limited access to news and events outside the community, they were a low-stress population and reported good quality, restorative sleep. It was thus verified that among the riverine population, almost all of these factors that contribute favourably to healthy longevity were present.

Another factor that drew attention in the diet of the Maués riverine population was the habitual consumption of guaraná, a plant native to the Amazon that is traditionally consumed in the form of

a drink. The seed of the plant is roasted and ground into a paste that is shaped into a stick, left to dry, and when the riverine resident wants to consume it, they grate the stick on the tongue of the Pirarucu fish, thus obtaining a fine powder diluted in water, sometimes sweetened with honey. This drink is called 'çapó' or 'cápo' and can be consumed in rituals or on a daily basis, as if it was a cup of coffee.

To assess the influence of regular guaraná consumption on metabolic morbidities, the group conducted an epidemiological study of an elderly population in Maués.

This research was linked to a doctoral thesis by the group coordinated by the aforementioned researchers. The study showed that elderly people in Maués who habitually consumed guaraná had a lower prevalence of obesity and systemic blood pressure, lower levels of LDL cholesterol (bad cholesterol) and biomarkers of oxidative stress, which is one of the basic physiological conditions for the onset of chronic non-communicable diseases. The set of results constituted the first epidemiological report suggesting a possible protective role of regular guaraná consumption against cardiometabolic diseases (Krewer et al., 2012).

Several studies by the research group have already demonstrated important activities of guarana for human health, such as: anti-inflammatory, antioxidant, anti-fatigue, neuroprotective, cardioprotective, and protective against induced hepatotoxicity. More details about the studies already published and the health properties of guarana will be presented in the chapter dedicated to this fruit.

As the Amazonian diet consists of various fruits, the research group led by Dr. Euler and Dr. Ivana studied other fruits such as

tucumã, cubiu, açai, Brazil nuts, and more recently, studies are being developed with cocoa and cupuaçu.

Food Transition in Contemporary Riverside Communities

The replacement of traditional diets in these regions with eating patterns based on processed foods, which are higher in calories and lower in nutrients, with high sugar and animal fat content, has been termed the nutritional transition. This phenomenon, associated with a sedentary lifestyle, has had a profound impact on global health, affecting economically vulnerable populations most severely (Reis, 2024).

Thus, as in the rest of the world, the dietary transition in communities in the Brazilian Amazon has been taking place and reflects significant changes in consumption habits and patterns, influenced by socioeconomic, cultural, and environmental factors. Traditionally, the riverside diet was based on foods derived from hunting, fishing, gathering, and small subsistence crops. However, recent studies indicate a gradual replacement of these foods with industrialised products rich in sugars (De Melo et al., 2021). Industrialised products compete with local food production, gradually changing the cultural eating habits of the regions (Santos et al., 2024).

Gama et al. 2022 conducted a study in rural Coari (AM) with the aim of identifying dietary patterns among 492 riverine communities in the middle Solimões River region and identified four distinct dietary patterns: 'vegetables' (vegetables, tubers, fruits), 'Brazilian' (chicken, eggs, rice, beans), 'traditional riverine' (fish, flour, milk) and 'meat and sweets' (game and pork, sweets). The extractive nature of riverine food is present in the most isolated communities, and the consumption of other foods was associated with better social conditions.

The Family Budget Survey (POF) conducted by the Brazilian Institute of Geography and Statistics (IBGE) in 2008-2009 showed that in the state of Amazonas there was a drop of almost 50% in the consumption of fresh fish and manioc flour.

A survey of riverside communities (Figure 2) in the Mamirauá Sustainable Development Reserve followed women from seven riverside communities between 2002 and 2009. In 2009, there was a significant increase in the consumption of purchased foods, as opposed to those previously produced or collected by families, such as cassava, fish, and fruit. On the other hand, there was an increase in the consumption of protein, salt, fats and sugars, leading to an incidence of overweight and related diseases. In addition, the researchers noted that there was a decrease in daily physical activities, especially those related to subsistence (Da Gloria and Pirepata, 2019).

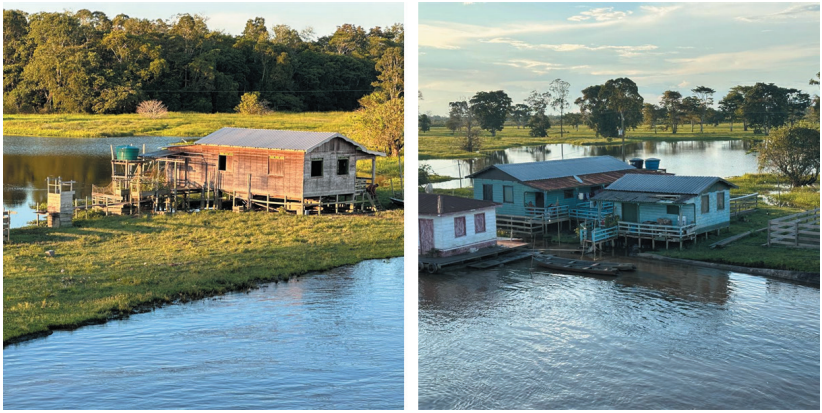

Figure 2 *Riverine Houses and Communities in the State of Amazonas- Brazil*

Photo credit: The authors

In 2021, Santos assessed the impact of ultra-processed foods on the bodies of riverine communities in the middle Solimões region of Amazonas, using data collected in 2015 through food recall inter-

views with 36 riverine families who lived off fishing and subsistence farming. The interviews were conducted over five consecutive days during the dry season (October to December). The interviews included 36 men and 36 women aged between 18 and 49 years old. In summary, the results showed high levels of consumption of ultra-processed and urban foods, with a significant correlation between Body Mass Index and Subscapular Skinfold and the consumption of ultra-processed foods. The data show that 61% of men and 55.4% of women were not eutrophic, being overweight or obese to varying degrees.

Another study was conducted with data from the Brazilian Ministry of Health, using routine data collected by professionals from the Unified Health System (SUS) available in the Food and Nutrition Surveillance System (SISVAN) for the year 2019. In total, the researchers analysed data from 14,000 individuals aged 0 to 101 years old. The study found that 6.5% of riverside children up to 5 years of age in Brazil are underweight according to World Health Organisation recommendations – 57% higher than the national average of 4.13%. These children are also short for their age, and among adults, obesity was found in 23% of women and 11% of men. The authors cite that the existence of obese individuals in the same population where there is a deficit in weight and height among children is indicative of poor food quality (Aguiar et al., 2023).

In recent years, the riverside population has improved access to other types of food, mainly due to significant increases in industrialisation and access to trade and services. Social income transfer programmes, such as Bolsa Família and Bolsa Floresta, may have played an important role in increasing the purchasing power of these families. This is one of the possible reasons why the region is

undergoing a rapid nutritional transition, due to greater access to processed foods. (Gama, et al., 2022).

Another aspect that needs to be mentioned is that fish catches are heavily dependent on fluctuations in water levels, with periods of low and high water regulating the availability of fish in Amazonian rivers. In recent years, there have been climatic events with extreme droughts that have had drastic consequences for fishing, agriculture and the lives of riverine communities themselves, for whom the river is their main means of transport. It is important to note that fish populations take some time to recover after extreme droughts, meaning that the impacts of the frequency and intensity of extreme events in recent decades have not yet been mapped. For example, the jaraqui, a fish that is symbolic of the Amazon region, takes an average of two years to reach a size suitable for fishing. In other words, droughts in previous years may not have killed this fish, but they probably reduced the availability of food for the animal, which impacts its development. There are no studies, but there is a general perception in traditional Amazonian communities that there has been a decrease in the capture of species and a reduction in the size of fish (Borba, 2023).

It cannot be forgotten that the impact of drought on agriculture, which, in addition to destroying current crops, can also encourage the presence of pests that destroy plantations, including cassava, one of the main products consumed and used for subsistence by local populations.

Nutritional transition is a reality in Amazonian communities. The possibility of access to industrialised foods may seem like progress, but it is not always so, as it has a significant impact on the health and way of life of riverside populations. An increase in diseases

related to poor nutrition, such as obesity, overweight and child malnutrition, is already occurring in communities.

It should also be noted that this dietary transition is also the result of the need for survival in many cases. This is because the extreme weather events that have been occurring reduce the availability of food, often making communities dependent on processed foods and leaving them more vulnerable.

Final considerations

Preserving the Amazon means preserving the food identity of communities, which has been constantly changing, affecting the Amazon's food and cultural richness. Since the Amazonian diet is rooted in the traditional knowledge and practices of indigenous and riverine peoples, it represents not only a source of nutrition but also a cultural and ecological heritage. However, the advance of nutritional transition, driven by the introduction of ultra-processed foods and lifestyle changes, has had significant impacts on the health and food security of riverine populations. The increase in chronic diseases points to the need for educational interventions and public policies that encourage a return to traditional food practices, associated with a more sustainable environment.

One way to encourage environmental preservation is by promoting scientific research that highlights the health benefits of Amazonian Diet, which could encourage the population to cultivate these plants and/or preserve native forests. This would also revive interest in these products. It is necessary, through educational measures, to inform the Amazonian populations of the importance of preserving the Diet in their daily lives so that they can remain healthy and live long lives

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Chapter 2

Açaí (*Euterpe oleraceae*)

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Abstract

Açaí is a dark purple fruit that comes from the açaí palm tree (*Euterpe oleracea* Mart.), which is native to the Amazon region. The use of açaí began with indigenous cultures and has recently become popular worldwide. This is due to a series of evidence indicating that açaí is a multifunctional plant with potential benefits for human health, mainly due to its high antioxidant and anti-inflammatory efficiency. The action of açaí in promoting health and preventing diseases is attributed to the presence of several bioactive phenolic compounds found not only in the fruit, but also in the leaves, pulp, bark and seeds of the açaí palm. Thus, although the fruit is the most consumed part of the plant, whether in the form of pulp, juice, ice cream, among others, other parts of the açaí

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palm can also be used as raw material for the pharmaceutical, food and cosmetic industries.

KEYWORDS: Palm tree; Health benefits; Bioactive molecules

Introduction

There are two main species of açaí in the Amazon: *Euterpe precatoria* (solitary açaí, more common in the state of Amazonas) and *Euterpe oleraceae* (clumping açaí, more common in the state of Pará). Açaí belongs to the palm family (*Arecaceae*), native to several countries in the Amazon region of Central and tropical South America, including Brazil, Ecuador and Venezuela (Laurindo et al., 2023).

The state of Pará is by far the largest producer, accounting for about 90% of national production, while Amazonas, despite being the second largest producer, contributes only to about 1% of national production (Idesam, 2021). Given this fact and that the overwhelming majority of consumption is of *Euterpe oleraceae*, in this chapter we will focus our attention on this species

Açaí is popularly known as açaí – do – Pará, açaizeiro or açaí-detoceira (Ulbricht et al., 2012). The palm trees (Figure 3) have stems that can reach 30 metres in height and 18 centimetres in diameter; they predominantly have a multi-stem pattern that can reach up to 45 stems in their full stage of development. At the base of each stipe, reddish, dense, superficial and fasciculated roots with aerenchyma and lenticels create an aggregated network 30 to 40 centimetres above the ground. The stems of the açaí palm tend to be cylindrical, ringed and erect. Scars from senescent leaves form nodes and internodes along the stem of the açaí. In addition, the cluster-shaped inflorescences of açaí palms comprise staminate

and pistillate flowers. Açaí berries are spherical and organised in clusters formed by hundreds of individual fruits. Each açaí berry has a diameter of 1.0 to 2.0 centimetres and an average mass of 1.5 grams (Chang; Alasalvar; Shahidi, 2019; Henderson, 2000).

Externally, the açaí fruit is dark purple. The ripeness of the fruit is determined by its outer colour, which is black when fully ripe. Internally, the fruit contains a seed surrounded by oily pulp that is 1.0 to 2.0 millimetres thick. The flavour of the fruit is similar to that of raspberries. Although the açai seed weighs only between 0.6 and 2.8 grams, it accounts for up to 85% of the volume of an individual açai berry. (Laurindo et al., 2023; Rogez, et al., 2011).

Figure 3 *Açai (Euterpe oleraceae). Left: View of an açaí grove by the river. Right: Close-up of an açaí bunch, highlighting the fruits.*

Photo credit: The authors

The use of açai in the form of pulp, powder, juices, syrups and others began with indigenous cultures and became popular worldwide because many of its benefits were reported, leading to ethnopharmacological research highlighting its phytochemical constituents and biological activities, which made the fruit popu-

lar and increasingly processed by industry. Among its benefits, we can mention its anti-inflammatory (Machado et al., 2016) and antimicrobial properties, improvement of cardiovascular health, strengthening of the immune system (De Souza et al., 2022) and potential antiproliferative action against prostate cancer cells (Jobim, ET AL., 2019).

Brazil generates more than US$9 billion in revenue from açaí (Matta, et al., 2020; Silva, et al., 2023; Figueiredo, et al., 2022). The açaí production chain plays an important role in northern Brazilian society due to the jobs and income it generates. In addition, açaí is a fundamental source of nutrients.

Since people from Pará and Amazonas have a tradition of consuming açaí, in 2019, the North region accounted for 99% of açaí fruit production in Brazil (Idesam, 2021), producing 1.6 million tonnes. About 95% of Brazilian açaí comes from extractivism and/or management. Açaí travels a long way in its production chain before reaching large consumer centres, whether in Brazilian capitals (mainly in the North) or even on other continents. Basically, after harvesting the açaí, farmers sell the fruit to traders along the Amazon River. The traders then sell the crop wholesale to market representatives. After processing the açai into frozen pulp, market representatives sell the frozen pulp or preserve it for later use in the export market. It is important to note that açai palm trees grow exclusively in the Amazon biome. Therefore, fresh açai berries are unobtainable outside Brazil (Matta, et al., 2020).

Chemical constituents responsible for therapeutic action

Several bioactive compounds are part of the phytochemical composition of açaí, with emphasis on polyphenols, which are the major components of the plant and primarily responsible for its important biological properties. Polyphenols have potential antioxidant capacity and are therefore associated with the benefits conferred by açaí against various diseases related to oxidative stress. The main secondary metabolites of polyphenols present in açaí include anthocyanins and proanthocyanidins, as well as other flavonoids, phenolic acids and lignans (Laurindo et al., 2023).

The phytochemical profile of açaí seeds consists of 28.3% polyphenols, with proanthocyanidins being the main components found, in addition to flavonoids such as catechin and epicatechin. The seeds are also rich in fatty acids, including lauric, myristic, palmitic, palmitoleic, oleic, and linoleic acids (Laurindo et al., 2023; Martins et al., 2021).

The pulp of the açaí berry is characterised by its abundant anthocyanin content, of which cyanidin 3-glycoside and cyanidin 3-rutinoside are the most predominant. Several flavonoids have been identified in the pulp, such as homoorientin, orientin, taxifolin deoxyhexose, isovitexin, scopoletin, catechin, epicatechin, and gallocatechin-3-gallate, in addition to a variety of phenolic acids, fatty acids (especially oleic acid, palmitic acid and linoleic acid), sterols and amino acids. Carotenoids are another class of phytochemicals present in the pulp of açaí, with a predominance of lutein, α-carotene, 13-cis-β-carotene and 9-cis-β-carotene (Belmonte-Herrera et al., 2022; Carvalho et al., 2016; Laurindo et al., 2023; Schauss et al., 2006).

In addition, extracts from the leaves and roots of the açaí palm have been shown to contain hydroxycinnamic acids, which are known to exhibit biological properties such as antiviral, anti-inflammatory, and antioxidant activity. The leaves have also been characterised by the presence of flavonoids derived from C-glycosyl apigenin and luteolin (Brunschwig et al., 2016; Laurindo et al., 2023).

Functional properties

A wide range of studies, ranging from preclinical trials, such as *in vitro* (using cells isolated from an organism) and *in vivo* (in animals) research, to clinical trials (studies conducted in humans), have shown that açaí has very promising functional properties for promoting health (Laurindo et al., 2023).

Starting with one of its most studied properties, it is reported that the fruit has high antioxidant capacity. Thus, it has been demonstrated that açaí acts to combat oxidative stress, both by stimulating the activity of antioxidant enzymes already present in the human body, such as catalase and superoxide dismutase, and by neutralising free radicals that induce damage to cellular structures. It is important to note that oxidative stress is a mechanism common to several pathologies, including neurodegenerative diseases such as Alzheimer's and Parkinson's, cardiovascular diseases and cancer. Thus, the antioxidant capacity associated with the consumption of açaí in its different forms becomes a great ally to health (Carvalho et al., 2016; De Souza et al., 2022).

Machado et al. (2016) evaluated the neuroprotective effects of açaí on neurons exposed to rotenone, a compound that induces dysfunction in complex I of the mitochondrial electron trans-

port chain, generating excessive production of reactive oxygen species (ROS) that are capable of inducing oxidative stress, causing disruption of cellular homeostasis. Even at the brain level, ROS are related to the development of neuropsychiatric disorders. The *in vitro* study indicated that açaí extract can act as an antioxidant agent in the presence of mitochondrial complex I deficiency, restoring mitochondrial function and neutralising cellular damage caused by oxidative imbalance. The authors also suggest that açai extract has significant pharmacological capacity and could be a new alternative for research into the development of drugs for neuropsychiatric diseases.

Another medicinal property of açaí that has been well documented in the literature is its ability to reduce the synthesis of pro-inflammatory cytokines and the expression of pro-inflammatory signalling pathways while inducing increased secretion of anti-inflammatory cytokines, acting as an inflammatory regulatory and inhibitory agent. Like its antioxidant activity, the fruit's anti-inflammatory capacity is associated with the large amount of phenolic compounds present in its chemical composition (Machado et al., 2019; Laurindo et al., 2023).

As mentioned earlier, antioxidant capacity is largely responsible for the neuroprotective activity associated with açaí in preclinical studies. Although research evaluating the impact of açaí on cognitive function and brain health is limited, with a need for further studies, some reviews suggest the fruit as a natural alternative to oxidative and inflammatory damage, which are considered primary mechanisms for inducing neurodegenerative diseases (D'Amico et al., 2022; De Souza et al., 2022).

A study conducted on mice subjected to a model of Parkinson's disease showed that supplementation with açaí resulted in a reduction in motor and non-motor symptoms and neuronal cell death in the dopaminergic tract. Although quite preliminary, these data are promising, since the treatment of Parkinson's disease is focused on symptom relief rather than disease prevention, and they pave the way for further research (D'Amico et al., 2022).

In addition to its potential neuroprotective activity, studies suggest that açaí also has the ability to reduce pain perception and promote analgesia, act against microorganisms such as bacteria and parasites, decrease ulcer formation, reduce fat levels in the body (antilipidemic activity), control glycaemic indices (antidiabetic activity), protect against liver diseases, including hepatic steatosis, alleviate the discomfort associated with tinnitus symptoms in humans, exert antihypertensive activity, reducing the effects of high blood pressure, and protect against cardiovascular, renal and neoplastic diseases (Laurindo et al., 2023).

Tinnitus is a health problem that has significant social and economic impacts, and its pathophysiology appears to be related to oxidative stress. Considering the antioxidant properties of açaí, supplementation with this fruit could have therapeutic potential in the treatment of chronic tinnitus (Opptiz et al., 2022). Thus, a randomised, placebo-controlled clinical trial was conducted with 30 participants, aged 50.5 years on average, comprising 14 men and 16 women, all with normal hearing thresholds or mild sensorineural hearing loss in both ears. The volunteers were divided into two groups: Placebo Group and Açaí Group (100 mg of açaí extract). The assessments carried out before and after three months of intervention included the Tinnitus Handicap Inventory (THI), the Beck Anxiety Inventory (BAI) and blood tests were also performed for