

# Perspectives on Sustainable Management of Jackfruit Trees for Food Consumption in Rio de Janeiro, Brazil <sup>†</sup>

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**Abstract:** Given the emerging challenges of climate change on the food system, alternative solutions that promote food security for the Brazilian population while conserving ecosystems and supporting smallholder farmers are needed. This study sought to explore the potential of one solution: the use of green jackfruit as a culinary alternative to meat. This study investigated consumer perception of jackfruit through an online survey completed by 330 individuals and through interviews with jackfruit entrepreneurs. The research highlighted a knowledge gap in Brazilians' perception of the food uses of green jackfruit and the need for a change in food culture to expand its use.

**Keywords:** food security; nutrition; Brazil; jackfruit; entrepreneurship; biodiversity; climate change; family agriculture; protected areas; exotic species



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## 1. Introduction

In the face of the daunting challenge to adequately feed the world's population, policymakers around the world are making commitments to take action, such as the United Nation's Sustainable Development Goal Two to “end hunger, achieve food security and improved nutrition and promote sustainable agriculture” by 2030. Yet transforming the food system into one capable of providing the entire population with healthy foods, while simultaneously protecting the environment and respecting the local culture, is a challenge in contemporary society. In this context, the debate on food production alternatives that are more sustainable with respect to social, environmental, and economic factors requires interdisciplinary research and action that consider the local realities and opportunities of each territory. This involves thinking about foods that grow naturally and abundantly in the ecosystems of differing regions and that are resilient to the environmental changes that accompany climate change.

This research aimed to explore an example of one such type of food, the jackfruit, which fulfills this function in a specific territory, the state of Rio de Janeiro, Brazil. Jackfruit, a fruit of the jackfruit tree (*Artocarpus heterophyllus* Lam.), is abundant in different regions of the country, especially in areas of the Atlantic Forest biome and on the properties of small landholder farmers. The fruit has many nutritional properties and can be used in a variety of ways in cooking, including as a culinary substitute for meat and starches when used in its unripe, non-sweet form. The jackfruit tree, in turn, has a much greater capacity to withstand the effects of climate change than large-scale crops such as wheat and corn. In fact, the jackfruit has recently been called a “miracle crop” by leading food security specialists. According to the President of the International Tropical Fruits Network, “[Jackfruit] is easy to grow. It survives pests and diseases and high temperatures. It is drought resistant. It achieves what farmers need in food production when facing a lot of challenges under climate change” [1].

At the same time, the jackfruit tree is an exotic species in Brazil that is felt by conservation professionals and managers of some protected areas to exhibit invasive or opportunistic behavior in the Atlantic Forest [2,3]. The management of jackfruit in protected areas and respective buffer zones in the state of Rio de Janeiro is a priority and a challenge for managers. Current control plans are generally based on species elimination or reduction through girdling and the use of herbicides, often producing inadequate results and creating other environmental problems [4].

Despite the jackfruit's abundance, nutritional properties, and culinary variety, the fruit is highly underutilized by the Brazilian population, especially when in its green form. In fact, the jackfruit often is perceived negatively by many individuals. With the growing vegetarian movement in Brazil, there are several entrepreneurs in Rio de Janeiro trying to change this attitude, seeking to bring jackfruit to the forefront of Brazilian gastronomy. Additionally, the sustainable management of the jackfruit trees on a large scale—especially on the outskirts or periphery of Rio de Janeiro—can not only generate income for smallholder farmers and promote food security, but also provide an alternative control method for this exotic species inside and near protected areas—“eat it to beat it”, as some jackfruit entrepreneurs say.

However, to create a growing market of new consumers of green jackfruit products and promote large-scale sustainable management of the tree, it is necessary to understand why the fruit is underutilized in Brazil, especially in its green form. Currently, there is a lack of academic literature or evidence-based research that explains this underutilization, including the negative perception many Brazilians have of the fruit and the tree. This research aimed to contribute to filling this gap and better understand how residents of Rio de Janeiro perceive jackfruit, with the goal of supporting the creation of solutions by jackfruit entrepreneurs to overcome the existing barriers and promote models for sustainable jackfruit management.

## 2. Materials and Methods

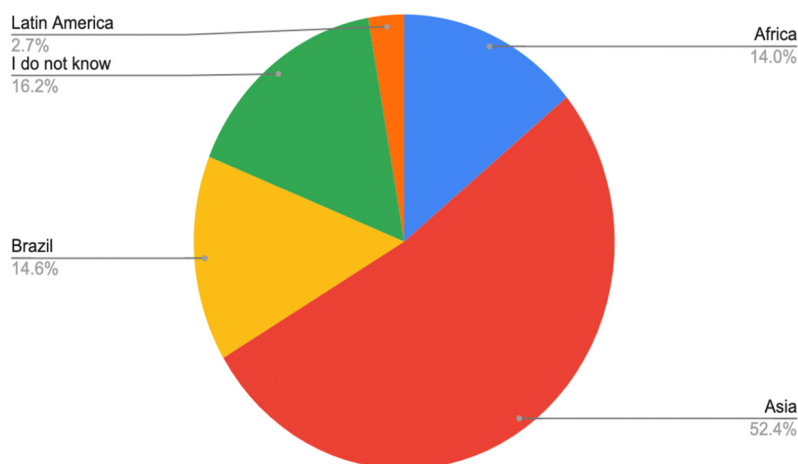
To investigate the underutilization of green jackfruit for food consumption in Brazil, both qualitative and quantitative methods were employed to study the perception of the fruit by Brazilians in Rio de Janeiro. The research was conducted between June and September 2020 and was approved by the Research Ethics Committee of the Federal University of the State of Rio de Janeiro, under Protocol number 797/2016. Permission of the participants was obtained by signing an electronic Informed Consent Form (ICF). Open interviews were conducted with three entrepreneurs from Rio de Janeiro who commercialize green jackfruit. The interviews focused on exploring the challenges of the market and consumer perception of green jackfruit from a business perspective, as well as to understand the entrepreneurs' supply chains and current business models. In addition, a semi-structured questionnaire online was answered by 330 people to evaluate various aspects of Brazilians' perceptions about and familiarity with the jackfruit tree and jackfruit as a food. The questions were divided into 3 main topics: (1) perception of the jackfruit tree, (2) perception of the green jackfruit as food, and (3) personal data. The online questionnaire was distributed to a convenience sample, mainly to students at local universities, public servants, and associated networks of the researcher and her advisors. The results were analyzed using graphics and textual description.

## 3. Results

The participants in the survey came from a variety of backgrounds such as lawyers, landscapers, nutritionists, public servants, entrepreneurs, farmers, park rangers, doctors, educators, journalists, designers, therapists, and architects. The majority have backgrounds in higher education, with 35% being students or professors in academia. The age breakdown of the participants is the following: 33% were between 18 and 30 years old, 29% between 30 and 40 years old, 19% between 40 and 50 years old, and 19% over 50 years old. Only 15% of the participants were vegetarians.

Five of the survey questions related to participants' knowledge and perception of the jackfruit tree as a species. An amount of 52.4% of participants were correct in affirming that the species is native to Asia while 14.3% believe that jackfruit comes from Brazil, confirming that the tree is perceived by some as a native species. These results can be viewed graphically in Figure 1.

What region of the world does the jackfruit tree originate?

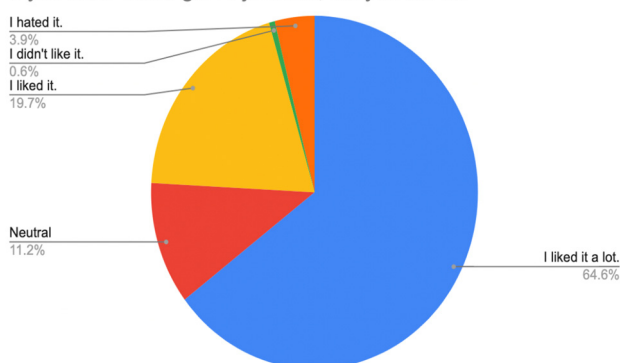


**Figure 1.** Graphical representation of question number 5 on the survey to assess participants' knowledge of the jackfruit tree's origin.

Regarding being considered an invasive plant, 57% disagreed that jackfruit is an invasive species and that it harms the ecosystems in which it inhabits, and only 11% believe that all jackfruit should be removed from protected areas. Of those 11% who support removal, 70% of them are biologists or ecologists. An amount of 88% of respondents believe that using jackfruit for food is better than removing trees. These answers reveal that the majority of this multidisciplinary sample perceives jackfruit as an opportunity for food consumption and is generally not aware that the jackfruit tree is considered an invasive species by many biologists and conservationists. However, biologists in the state of Rio de Janeiro mainly perceive it as a threat to biodiversity.

The questionnaire also included eight questions aimed at assessing the participants' familiarity with green jackfruit as a food. 53.9% of the participants (178 individuals) answered that they had eaten green jackfruit. Of these 178, 84.3% (150 people) responded that they liked or loved the taste of the green jackfruit. See Figure 2 for a more detailed breakdown of the responses.

If you have eaten green jackfruit, did you like it?



**Figure 2.** Graphical representation of question number 8 on the survey to assess consumer taste of green jackfruit.

In addition, only 23% of those who responded yes to having consumed green jackfruit were vegetarians. Additionally, only 14.9% of participants had prepared a meal using green jackfruit at home. Of these 48 individuals, nearly 40% responded that they believed food preparation with green jackfruit was difficult.

The survey also sought to identify which forms of jackfruit are most commonly consumed in Rio de Janeiro. The survey results reflect what had been seen in the literature, showing that the most common recipe is the jackfruit “coxinha”—a small, fried croquette. Other popular recipes mentioned by the participants included moqueca (a Brazilian stew), bacalhau, strogonoff, and empadão (a savory pie).

The interviews with jackfruit entrepreneurs in Rio de Janeiro complemented the results of the online survey, shedding insight into the historical context and current challenges around the use of jackfruit as a food. According to one entrepreneur, whose organization, Mão na Jaca, works to transform the negative perception of the fruit with workshops and small-scale commercialization, the fact that jackfruit was used, mainly in colonial times, as food for enslaved people in sugarcane, charcoal, and coffee plantations, has had consequences to this day. “The culture of using green jackfruit in savory dishes never arrived here. To feed the slave labor force, there was no interest in spreading a culinary culture. To this day, jackfruit is primarily consumed freshly ripe, or in sweets—another Portuguese heritage. However, its integral use is hampered by the exclusive consumption of the fruit when its ripe—our cultural reference for its consumption. As a result, we have a huge waste of this fruit, which is so abundant in several Brazilian cities”.

Another jackfruit enterprise, located on the outskirts of Rio de Janeiro, is growing its processing production capacity with the aim to purchase jackfruits from smallholder farmers near and around protected areas for income generation and to control the spread of the exotic species. In their experience, they find that landowners and smallholder farmers who have jackfruit on their properties generally do not perceive the tree as useful, seeing it as a burden due to the excess of massive fruits that fall and rot on the ground, attracting flies and other animals. The rural landowners are generally unaware of its consumption in its green form and do not know that commercialization opportunities exist. This same enterprise has been reaching out to restaurants and food distributors to sell its jackfruit products. According to the sales director of the enterprise, while a growing number of vegetarian restaurants are beginning to use green jackfruit in their recipes, many chefs and food storeowners are skeptical about using green jackfruit, having never heard of its use in savory dishes. Those who do know it also tend to want the “shredded” jackfruit, which is only one of many parts of the fruit that can be used, demonstrating that the food market is not yet familiar with the different modalities of the product.

#### 4. Discussion

##### 4.1. Consumers and the Jackfruit Market in Rio de Janeiro

While this study was a preliminary descriptive study, we believe that these initial results are sufficiently positive to justify a larger scale, well designed study in the future to more definitively assess Brazilians’ attitudes towards jackfruit. The fact that 53% of survey participants have consumed green jackfruit suggests that the fruit in its green form may have moderate recognition in Rio de Janeiro, at least for individuals with higher education that live in the city. Beyond this, the results of the survey also demonstrate that those who try green jackfruit generally like the taste, thereby showing the potential for its acceptability in its non-ripe form, in which the fruit is used in savory dishes, for a larger audience. Interestingly, as only 15% of participants considered themselves vegetarians, it is clear that the consumption of green jackfruit is not restricted to this subgroup. However, as most participants have a background with higher education and are therefore more likely to have a medium to high income level, it would be important to repeat the survey with a more diverse audience to understand if individuals without higher education have a similar familiarity with and acceptance of the fruit. The interviews with the entrepreneurs who work in the periphery of Rio de Janeiro—regions with generally lower income and

less educated populations—reveal that, based on their experience, familiarity with green jackfruit is low.

The present study points out that less than 15% of participants had prepared a meal at home using green jackfruit, and that of these individuals, 40% found it difficult to prepare. These data illustrate two challenges that the green jackfruit market faces. First, that the utilization of the green jackfruit in a domestic setting in the kitchen is rare, even for those that are familiar with and have consumed the product. This could be due to a lack of knowledge of how to prepare the product, as well as a lack of access to processed green jackfruit in supermarkets. The fact that many respondents found it difficult to prepare a meal with jackfruit suggests that there exists a need to create and expand the production of sub-products that are consumer-friendly and easy to prepare. In the United States, for example, it is common to find prepackaged green jackfruit that has been cooked and prepared in flavored sauces. The jackfruit entrepreneurs interviewed all reported that work shops and hands-on courses in which participants are trained in how to use the green jackfruit in recipes is essential for expanding the jackfruit market.

#### *4.2. Understanding How Perceptions Affect Jackfruit Consumption*

While the survey results indicated at least a moderate degree of familiarity with green jackfruit, the entrepreneurs interviewed conveyed that they often confront negative prejudices about jackfruit from potential buyers. One entrepreneur suggested that the historical context of the jackfruit, in which it was principally used as food for enslaved and impoverished people and always in its ripe form, has contributed to this prejudice. While there is little academic research that investigates the perception of jackfruit in Brazil, one author points out that part of this cultural prejudice in Brazil could be related to the strong smell of jackfruit when it is rotting on the ground—a smell that many Brazilians, especially in the northeast and southwest of the country, recognize and associate negatively. “One of the hypotheses raised to understand the low consumption of this fruit is its very strong characteristic aroma, which immediately leads to appreciation or rejection” [5] (p. 7). In general, most of the population only knows the possibility of consuming mature jackfruit, which is generally limited to the preparation of desserts. On the other hand, the green jackfruit has a much wider range of culinary uses than the mature one, but the majority of the population still does not know its uses in cooking. As mentioned, for the proper use of green jackfruit in gastronomy, it is necessary to process it. However, this process can be laborious—as confirmed by the survey—since the rind of the fruit is hard and produces a sticky gum [6]. It is possible that this difficulty, associated with the lack of knowledge of how to process the fruit, represents factors that discourage the consumption of green jackfruit.

Another potential barrier to more widespread consumption and sustainable use of green jackfruit that requires further research is the fact that many researchers from the field of biology and forestry perceive jackfruit as an invasive species in the Atlantic Forest of Rio de Janeiro. According to the survey results, 75% of biologists and forest engineers who responded to the online survey agree that jackfruit is an invasive species that harms the ecosystems in which it occurs. Based on the personal experiences of the jackfruit entrepreneurs, the species’ reputation as a “villain” contributes to the lack of sustainable management models. Instead of perceiving the abundance of fruits as an opportunity for income generation for rural landowners and to promote food security, most control strategies focus on total removal of the trees, using techniques such as injecting herbicide or ringing. However, often these strategies are not always effective. For example, in the Tijuca National Park, “between 2000 and 2005, they cut 1571 trees and rung another 813, in addition to uprooting almost 40,000 seedlings, without any proven efficacy in terms of real reduction of jackfruit populations in the park” [4]. Beyond this, the jackfruit tree has become so common in certain parts of the Atlantic Forest in Rio de Janeiro that many fauna species depend on the fruit for their survival; therefore, radical removal can cause other imbalances in the ecosystem if not done gradually and carefully. The “eat it to

beat” management model seeks to control the spread of the species in forests through the consumption of the fruits, preventing the hundreds of seeds from the large fruits from falling and germinating. According to the entrepreneurs, while many park managers and forest conservation policymakers are often hesitant to consider such a method for jackfruit management, some decisionmakers are open to exploring this alternative, as the need to find solutions that integrate human communities within and around protected areas with conservation is growing. However, for policy change to occur, it is essential that more research be conducted on the alternative management method—fruit collection as opposed to tree ringing or use of herbicides—and investigate if such a model can effectively promote control of the species and therefore biodiversity conservation.

#### *4.3. Success Cases of Sustainable Jackfruit Management*

One of the entrepreneurs interviewed for the study has created a small but successful example of how jackfruit trees in a protected area can be managed by local communities and used to generate income for the residents. Vale Encantado, in Alto da Boa Vista, a community in the buffer zone of the Tijuca National Park, is known for its use of green jackfruit for culinary use, serving dishes at its ecotourism restaurant and selling processed jackfruit to restaurants in Rio de Janeiro. The 140 residents of the community are descendants of workers from the 19th century coffee farms that occupied the mountainous slopes of the area, which is now Parque da Tijuca [7]. In 2005, the president of the Homeowners’ Association, with support from a French NGO, ABA-QUAR/PARIS, founded a sustainable ecotourism cooperative in which he became president. Promoting trails and other experiences in the forest, the cooperative also created a restaurant for visitors that serves dishes that use local ingredients, including jackfruit, whose harvest already exists in the culture of extractivism in the community. The “jacalhau” dish (inspired by the traditional Brazilian cod recipe) and jackfruit pies served at the restaurant have gained fame in the city.

This cooperative started selling processed green jackfruit to several restaurants in Rio de Janeiro. According to the interview with the president of the Cooperative, in 2019 the cooperative processed 600 jackfruits in total, each jackfruit weighing between 7 and 15 kg, extracted from 30 trees. Based on these numbers, the cooperative sold approximately 6 tons of jackfruit in 2019. The project employs 10 women from the community in the processing center and 4 men for collecting the fruits. The Vale Encantado model is an example of jackfruit management in protected areas that uses jackfruit as food and promotes income generation for residents in the protected area’s buffer zone. This case can serve as an inspirational model for other commercial jackfruit initiatives in Brazil that generate a positive socio-environmental impact close to environmentally protected areas. As mentioned, it would be important to study the impact on biodiversity and other ecosystem factors in this model in order to create a better dialogue with forest conservation policy makers in regard to exotic species control.

#### *4.4. Jackfruit for Food Security and Nutrition in the Context of Climate Change*

While exploring alternatives to exotic species control is one important aspect of potential benefits of jackfruit consumption, the primary area in which this research focuses is how its use as a food source can contribute as a solution to promoting food security and nutrition in the context of climate change. Due to its abundance, high level of nutrition, and ability to reproduce in different climatic conditions, jackfruit is being called the “miracle crop” by researchers in the field of food security and is being seen as a food with great potential for the agricultural challenges that are emerging from climate change [8]. Climate change will accelerate food shortage risks; inconsistent rains, droughts, increased temperatures will occur, and already has reduced yields from cash crops such as corn, wheat, and soybeans—on which both humans and livestock animals depend [9]. The soil is deteriorating between 10 and 100 times faster than it is being formed in the world, threatening the fertility of land for growing food [9]. Higher concentrations of carbon dioxide in the atmosphere will also reduce the nutritional quality of food, while the increase in temperature reduces crop



yields and harms livestock [9]. Climate change can lead to shortages in food production in developing countries, impacting disproportionately small farmers and the most vulnerable populations. Brazil is an agricultural country, dependent on the export of these cash crops that are being threatened by climate change, and on small farmer production for the country's internal consumption.

There is a growing global need to take advantage of locally produced food that grows naturally and abundantly and is resilient to environmental changes resulting from the climate crisis. In Brazil, jackfruit shows the potential to be one of these foods. Its resilient qualities together with its abundance of yield make jackfruit a promising alternative to more fragile crops in the rapidly changing global climate. Jackfruit is drought-resistant, grows easily in degraded soils, and doesn't require pesticides. Indian researchers have also recognized the fruit's great potential to alleviate world hunger, emphasizing the fruit's caloric and nutritional density. According to Shyamala Reddy of the University of Agriculture and Science in Bangalore, India, "It's a miracle that it can provide both nutrients and calories, everything; If you eat just 10 or 12 segments of this fruit, you won't need food for the other half of the day" [1].

This caloric and nutritional density, combined with the plant's resilience to changing climate factors and its abundance in Brazil, makes jackfruit a suitable food to contribute to food security in the context of climate change and environmental and economic crises. Indeed, the importance of accessing local, abundant, and resilient foods such as jackfruit has been highlighted in the new context of the worldwide COVID-19 pandemic. The pandemic is impacting the global food system, especially as movement restrictions between and within countries disrupt entire food supply chains, logistic services, and agricultural workers, affecting food availability. The pandemic and economic crisis is causing a decrease in income, an increase in the unemployment rate, and even a reduction in informal work, putting the most vulnerable populations and those with low purchasing power at risk of worsening food insecurity [10].

Jackfruit is already being used as a solution in this context, as seen in India, where demand for jackfruit has soared since the lockdown in late March 2021: "Coronavirus caused fear of chicken and people switched to jackfruit. In Kerala, the blockade caused an increase in demand for green jackfruit and seeds due to shortage of vegetables with border restrictions" [11]. In the context of COVID in Brazil, where now "tens of millions of people living in poverty are again facing hunger", jackfruit could also function as a possible means to combat food insecurity in this crisis [12]. The urban and peri-urban areas of the state of Rio de Janeiro are full of jackfruit trees, and these could provide healthy, low-cost food for people in peripheral communities who face food supply difficulties.

The jackfruit's nutrition, culinary variability, and resilience to climate change, in addition to its abundance in the country, make it a fruit with a large potential in becoming an alternative, healthy food source in Brazil. However, if Brazil wants to take advantage of this opportunity, it will have to invest in green jackfruit production models to achieve scale and impact, as well as, importantly, as shown by this study, support jackfruit entrepreneurs in transforming the negative perception and/or lack of knowledge of jackfruit by potential consumers.

## 5. Conclusions

Academic research that explores the underutilization of this abundant and highly nutritious fruit in Brazil is still in its infancy. This study sought to fill this knowledge gap by attempting to better understand Brazilians' perception of jackfruit and the jackfruit tree, recognizing that a cultural dietary change is necessary to make possible the expanded use of green jackfruit as a food in the Brazilian diet. Future larger scale studies that include a more representative sample of the population can more definitely examine the issue.

Moreover, the research highlighted one example of a successful green jackfruit venture in Rio de Janeiro that has been able to, on a small scale, manage jackfruit trees in a protected area of forest while providing healthy food and generating income for the local community.

This business can serve as a model for enterprises based on jackfruit management for food consumption, as well as for policymakers in forest conservation and food policy to learn and study the potential for replication of such a model.

The authors hope that, soon, the management of jackfruit for food consumption will not be just an “alternative” practice, but a mainstream part of the diet so that every Brazilian grows up eating jackfruit where it is abundant, and each jackfruit is part of the balance of nature in the forest of the Atlantic Forest biome.

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**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

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**Conflicts of Interest:** The authors declare no conflict of interest.

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