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Local criteria for the selection of wild food plants for consumption and sale in Alagoas, Brazil

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ABSTRACT

Understanding the reasons for the consumption of certain plant resources instead of others has important implications for biological conservation. This study aimed to answer the following question: What are the factors that determine the consumption and trade of certain wild fruit species among extractivists from two rural communities in northeastern Brazil? This study developed a participatory approach to identify the fruit species known and/or used by extractivists. The selected species were presented to the extractivists using semi-structured interviews. A Likert scale (from 1 to 5) was used by interviewees to assign scores to 17 wild fruits in terms of local consumption, commercial potential, taste, nutritional potential, absence of adverse effects, post-harvest durability, additional uses, temporal availability (fruit), spatial availability (fruit), spatial availability (plant), ease of collection, and ease of cultivation. Multiple regression analyses were performed to show the variables that best explained (1) the number of users, (2) the consumption intensity among users, (3) the number of traders, and (4) the commercial potential. The results showed that the spatial availability of the individual was the most outstanding variable to explain both the number of users and traders. However, for extractivists that trespass the availability barrier, taste is the most important driver of the consumption intensity and the commercial potential of plants. In contexts in which edible wild plants do not form the base of the local diet, taste may be more relevant in relation to other variables such nutritional potential.

Keywords: Edible plants; Ethnobotany; Local knowledge; Selection criteria.

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Significance Statement

This manuscript evaluates the most important drivers of wild food plant consumption and commercial potential in local communities of NE Brazil. The originality of the research includes the use of a method that has not been used for this purpose. It allowed us to search for motivations that are not necessarily conscious. It is also the first research, to our knowledge, that points out, in the context of wild food plants, differences between the factors that explain the number of users and those that explain the consumption intensity. Finally, this paper brings results that can help understanding human behaviors towards plant collection and consumption so as to show that this phenomenon is multifactorial and may not be explained in simple terms.

INTRODUCTION

A major focus of ethnobotany is understanding why certain plant species are selected for a specific use rather than others. This understanding has important implications for biocultural conservation (Gama et al. 2018). Some studies show that people do not randomly select plants (Moerman 1979; Robles Arias et al. 2020). However, most studies that address selection criteria and use patterns have focused on studying medicinal plants (Gama et al. 2018; Santos et al. 2018). Despite extensive ethnobotanical investigations on wild food plants, few have addressed the reasons that make people consume some plants more than others (Serrasolses et al. 2016).

Wild food plants play an important role in the diet of various communities, especially in developing countries (Reddy et al. 2007). In some cases, they support the subsistence of rural families and generate income from their sale (Belcher et al. 2005; Mahapatra and Panda 2012; Molina et al. 2014). The exploitation and consumption of these wild food plants vary according to the region and/or communities where they are available (Pieroni and Quave, 2005).

The literature has shown that the selection of edible wild plants is associated with several factors, such as geopolitics, ethnicity, religion, socioeconomic aspects, accessibility, culture, plant availability, nutritional potential, energy value, and ease of cultivation. Such factors can influence individual preference, leading to certain plants being used more than others by people (Bellia and Pieroni 2015; Bussmann et al. 2016; N'Danikou et al. 2011; Ong and Kim 2016; Pieroni and Quave 2005; Pieroni and Sõukand 2018; Silva 2017; Sorokowska et al. 2017; Sõukand and Pieroni 2016; Stryamets et al. 2015; Turner et al. 2011).

In addition, studies show that sensory aspects such as taste, smell, and texture are also important factors for the selection of wild food plants, with taste highlighted in several studies as the main reason for people to consume these plants (Sousa et al. 2019, Thakur et al 2017; Serrasolses et al. 2016; Cruz et al. 2014; Ghirardini et al 2007).

Although studies on the reasons for the consumption of wild food plants are not a recent topic, they usually assess such motivations using objective questions, in which people indicate why they consume or value certain plants more or less than others (N'Danikou et al. 2011; Serrasolses et al. 2016). However, motivations for human behaviors, including food selection (Jacquier et al. 2012; Köster 2009), are not always conscious and therefore may not be entirely captured with the use of objective questions. New and important information can arise from access to information not directly available, which can help strengthen or weaken the predictive power of certain variables.

Moreover, most ethnobotanical studies do not distinguish between the number of people that use a species for a given purpose and the intensity of use. It is possible, for example, that a few people use a species, but, among these people, it has a high intensity of use. Such a distinction is relevant in the context of wild food plants because the drivers of popularity (number of people that consume the plant) and intensity (significance of the consumption among users) may vary.

Therefore, this study aimed to access people's perception of possible factors associated with wild food plant consumption and sale and evaluate the variables with greater explanatory power using statistical

models. Although perception itself is influenced by physical, physiological, cultural, and psychological aspects (Bell 2001)—and therefore is not free from bias—the differential of this framework is that it seeks explanatory variables for consumption and sale that cannot be assessed using objective questions, precisely because they are not conscious motivations.

Based on a case study conducted in a community on the southern coast of the state of Alagoas, Brazil, we determined the factors that explain the differential use of wild food plants among extractivists of rural communities in northeastern Brazil. This study analyzed only wild fruit trees. Fruit trees were selected because they are the main target of collection in the forests of the studied region.

MATERIAL AND METHODS

Study site

The stuy involved local residents (extractivists) from the Retiro Village and the Fazenda Paraíso Settlement (Figure 1), both located in the municipality of Piaçabuçu, state of Alagoas, in the Northeast region of Brazil (coordinates: 10°24'20" S and 36°26' 04" W), at an elevation of 3 m (Alagoas 2018). The municipality has rainy tropical climate with a dry summer and rainy season in autumn/winter, rainfall of 1217.5 mm/year, and an average annual temperature of 24.9°C (UFCG 2020).

The communities are close to the Environmental Protection Area of Piaçabuçu, a protected area established in 1983 comprising 18,000 ha (Cabral et al. 2006). The region has dunes, flooded areas, and restinga forests (Cabral et al. 2006), from which most native fruit species are extracted.

Extraction of non-timber forest products is the main economic activity of the two study sites. Most houses in the Retiro Village and the Fazenda Paraíso Settlement are masonry houses (Figure 2). The Retiro

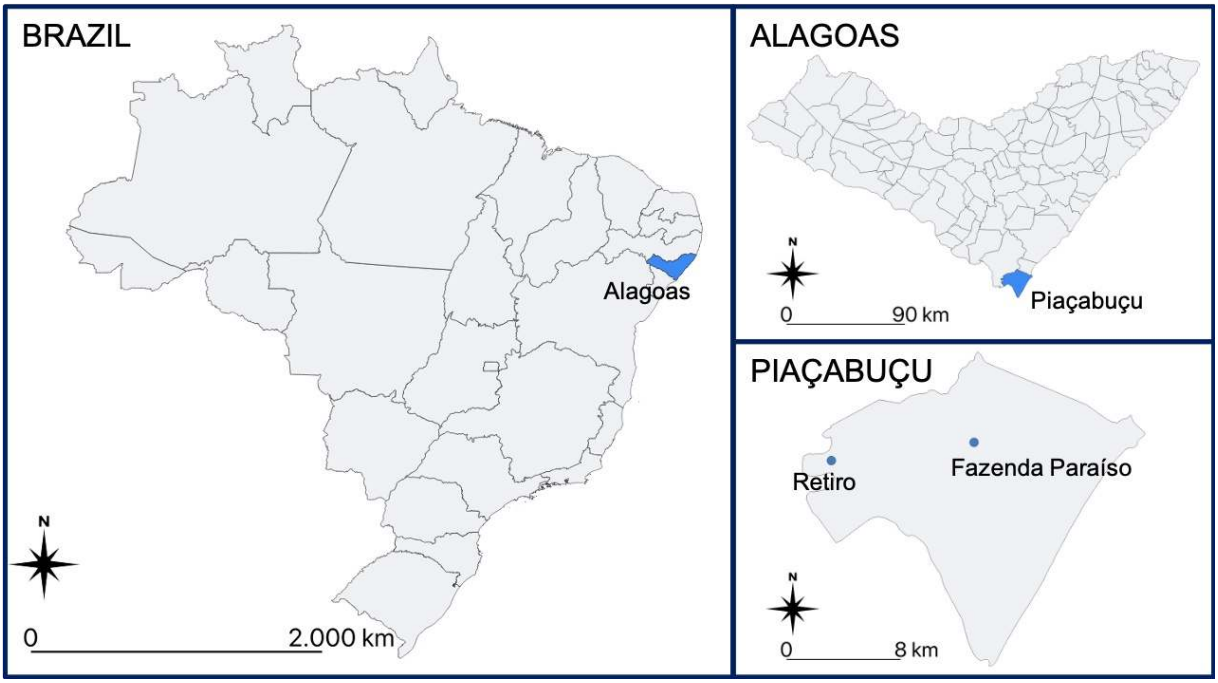

Figure 1. Location of the Retiro Village and the Fazenda Paraíso Settlement in the municipality of Piaçabuçu, state of Alagoas, Northeastern Brazil.

Figure 2. Partial view of the Retiro Village (A) and the Fazenda Paraíso Settlement (B) in the municipality of Piaçabuçu, state of Alagoas, Northeastern Brazil.

Village has 369 families and has municipal schools and a municipal health facility. The Paraíso Farm Settlement consists of 14 families and has no health center or schools, forcing residents to go to downtown Piaçabuçu to use these services.

Selection of plants and data collection

A participatory workshop was convened to identify the species of native fruit trees known and/or used by communities and people living nearby. The workshop was held in the Paciência community, located between Retiro and Paraíso communities, with the participation of 12 extractivists from different local communities. The workshop was held near both communities so that they could easily access the workshop site. In addition, the workshop was organized by the president of the Associação Aroeira, a

Table 1. Edible wild plants (woody fruit) known by extractivists from Retiro and Paraíso communities, municipality of Piaçabuçu, state of Alagoas, Northeast region of Brazil.

Ref. no	Family	Scientific name	Popular name
*	Ximeniaceae	*Ximenia americana* L.	Ameixa
*	Myrtaceae	*Psidium* sp.	Araçá
18189	Anacardiaceae	*Schinus terebinthifolia* Raddi	Aroeira
*	Anacardiaceae	*Spondias* sp.	Cajarana
65217	Myrtaceae	*Myrciaria floribunda* (H. West ex Willd.) O. Berg	Cambuí
65218	Arecaeae	*Syagrus coronata* Becc.	Coco-ouricuri
65219	Arecaeae	*Attalea funifera* Mart.	Coco-piaçaba
65220	Chrysobalanaceae	*Chrysobalanus* icaco L.	Gagiru
65221	Chrysobalanaceae	*Moquilea tomentosa* Benth.	Goiti
65222	Fabaceae	*Inga laurina* (Sw.) Willd.	Ingá
18188	Myrtaceae	*Syzygium cumini* (L.) Skeels	Jamelão
*	Rubiaceae	*Genipa americana* L.	Jenipapo
18191	Sapotaceae	*Manilkara salzmannii* (A.DC.) H.J.Lam	Maçaranduba
*	Apocynaceae	*Hancornia speciosa* Gomes	Mangaba
*	Sapindaceae	*Talisia esculenta* (A. St.-Hil.) Radlk.	Pitomba
18298	Anacardiaceae	*Spondias purpurea* L.	Seriguela
18192	Fabaceae	*Tamarindus indica* L.	Tamarindo

*Identified in the field

community association for local extractivists of wild plants. The workshop had good attendance as the participants were used to holding meetings.

The workshop participants mentioned 15 wild food plants (all being fruit trees), which were selected and included in the second stage of the study (interviews). Two other species were added to the list after informal interviews in the two selected communities, resulting in a total of 17 species (Table 1).

The fieldwork was conducted between March and August 2019 through semi-structured interviews conducted only with community extractivists, who were identified using the snowball technique (Albuquerque et al. 2010). The 17 plants were presented to the interviewees so they could indicate which species they consume and which species they trade.

A Likert scale (from 1 to 5) was also employed for each interviewee so they assign scores to wild fruits in terms of local consumption intensity, commercial potential, taste, nutritional potential, absence of adverse effects, post-harvest durability, additional uses, temporal availability of the fruit, spatial availability of the fruit, spatial availability of the plant, ease of collection, and ease of cultivation. Therefore, instead of directly asking why each plant was used or traded, we opted to access people's perceptions concerning different potential drivers and then statistically relate them to our variables of domestic and commercial importance. Although similar approaches have been done for other use-categories (e.g., Gama et al. 2018), this is the first time this framework is applied to study local criteria for wild food plant selection.

The study material was identified by researchers from the MAC Herbarium of the Instituto do Meio Ambiente, in Alagoas. All botanical material was stored in the same herbarium. Table 1 shows the reference numbers.

Data analysis

For each factor evaluated using the Likert scale, mean values were calculated, corresponding to the sum of the scores

assigned to the plant divided by the total number of interviewees who provided scores. If the interviewee did not know the plant in question, assessment of taste, availability, etc., was not possible; therefore, only information from people who actually knew the plant was considered in the calculation of mean values.

To identify the selection criteria used by the population for wild plant for consumption, multiple regressions were performed using as the dependent variables (1) the number of people who mentioned to use the] species, and (2) the mean score of plants for consumption intensity. The independent variables were the mean scores of the attributes evaluated during the interviews (absence of adverse effects, post-harvest durability, additional uses, temporal availability of the fruit, spatial availability of the plant, spatial availability of the fruit, nutritional potential, ease of cultivation, and taste). The response variable 'consumption intensity' was transformed by means of an exponential function.

Multiple regressions were also performed to analyze the selection criteria for sale. The dependent variables were (1) the number of people who traded the species, and (2) the mean score of commercial potential, and the independent variables were the same as those in the previous models.

The stepwise approach was used to select the model with lower AIC values. Additionally, we searched for the most important predictor of each model by Identifying the independent variable that produces the most substantial R^2 increase when it is the last variable added to the model (ΔR^2). All the analyses were processed in RStudio, version 1.2.5001.

Legal aspects

This study was submitted to the Sistema Nacional de Gestão do Patrimônio Genético and submitted to and approved by the Ethics Committee of the Federal University of Alagoas (CAAE 09805618.1.0000.5013), in compliance with basis of article X, paragraph X.2, of Resolution no. 466/2012 of the National Health Council. The participants signed informed consent forms to authorize the use of participant information.

RESULTS

Perceived potential of fruit species

The snowball sampling technique led to a total of 52 extractivists (13 male and 39 female participants) aged 19–67 years. Most

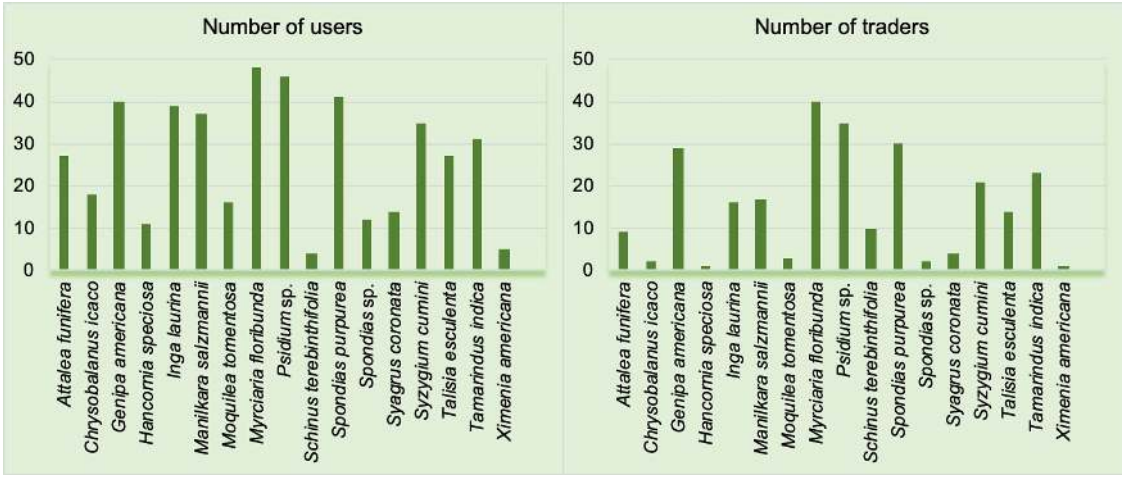

Figure 3. Native and woody fruit species classification according the number of users and traders in two rural communities of Piaçabuçu (Northeast region of Brazil).

of the extractivists belonged to the Retiro community (47), while only five lived in the Fazenda Paraíso settlement.

The wild food plants had a mean number of users of 26.5±14.5, while the mean number of traders was 15.1±12.8. The mean consumption intensity of edible wild plants was 3.20±0.49, while the mean for commercial potential was 4.24±0.39. The maximum possible value for the last two variables could be five, according to the Likert scale.

The species used by a higher number of interviewees was *Myrciaria floribunda* (H. West ex Willd.) O. Berg (Figure 3). *M. floribunda* also stood out in terms of number of traders, consumption intensity, commercial potential (Figure 4), and taste (Figure 5).

Spondias purpurea L was the species with the highest mean value for cultivation potential, and *Syagrus coronata* Becc. was relevant in terms of post-harvest durability.

According to the interviewees, the species with more additional uses was *Schinus terebinthifolia* Raddi because it is commonly used by the community for medicinal purposes. *Manilkara salzmannii* (A.DC.) H.J. Lam was the species with the highest scores for both spatial availability of the fruit and spatial availability of the plant. Regarding the absence of adverse effects, eight species presented the maximum score of 5, indicating absence of adverse effects associated with consumption. All species presented scores above 4.5 for this attribute. Finally, *Genipa americana* L. presented the best scores in terms of temporal availability, nutritional potential, and overall evaluation (mean of all evaluated factors). The species with the greatest overall scores are shown in Figure 6.

What criteria explain the selection of a plant for human consumption and sale?

The final model for number of users included the variables absence of adverse effects, other uses, and spatial availability of the individual, and all of them were significant (Table 2). The explanatory power of the model was relatively high (R^2=0.78), these variables can largely explain the variation in consumption. The variable that contributed to a higher increase in the explanatory power of the model was spatial availability of the individual (ΔR^2=0.22).

Concerning the number of traders, the final model included the variables other uses, spatial availability of the individual, cultivation potential, and absence of adverse

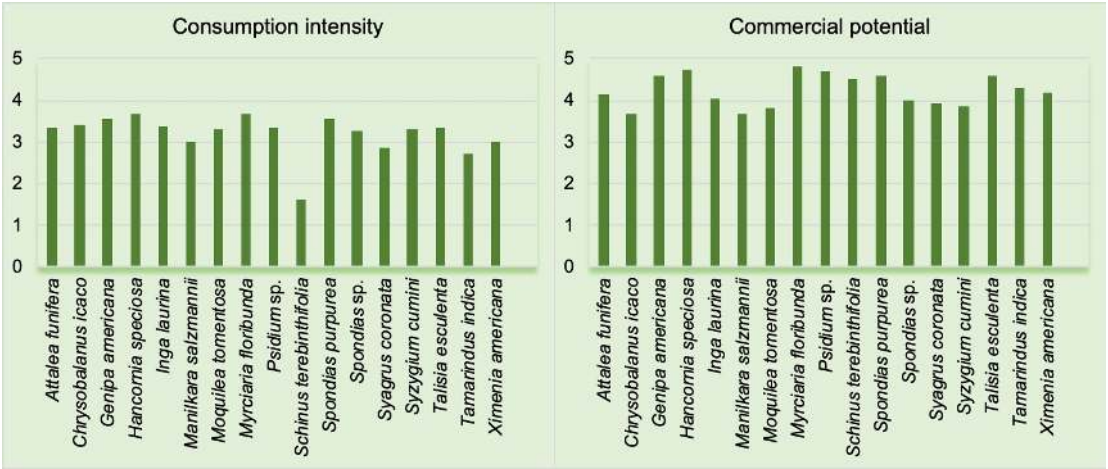

Figure 4. Native and woody fruit species classification according to the consumption intensity and commercial potential in two rural communities of Piaçabuçu (Northeast region of Brazil).

Table 2. Multiple regression models to explain the consumption and sale of wild fruits by extractivists from two rural communities in the municipality of Piaçabuçu, state of Alagoas, Northeast region of Brazil.

	Number of users	Consumption intensity	Number of traders	Commercia potential
Intercept	436.4	−60.4	372.8	8.7
Coefficients (b)/ ΔR^2				
Temporal availability	-	−3.3/0	-	0.1/0.1
Cultivation potential	-	-	9.1*/0.13	0.3/0.1
Nutritional potential	-	10.1*/0.13	-	-
Absence of adverse effects	-86.0*/0.1	-	-77.4/0.11	−1.6/0.1
Taste	-	16.6***/0.4	-	0.6*/0.3
Post-harvest durability	-	-	-	-
Other uses	-33.8**/0.19	-	-26.4*/0.15	-
Spatial availability (plant)	11.9**/0.22	-	9.3*/0.16	-
Spatial availability (fruit)	-	-	-	-
AIC	124.25	106.5974	126.36	17.05343
R^2	0.7811	0.7709	0.7329	0.4524

*<0.05; **<0.01; ***<0.001

effects, but the last was not significant. R^2 was 0.73, and ΔR^2 was also higher for spatial availability (0.16).

The variables that remained in the explanatory model of consumption intensity were taste, nutritional potential, and temporal availability (R^2=0.78). However, only the first two variables were significant. The variable with the greatest effect on the explanatory power of the model was taste (ΔR^2=0.4).

Finally, the model for commercial potential had the lowest explanatory power (R^2=0.45). The model kept temporal availability, cultivation potential, absence of adverse effects, and taste. However, only taste was significant, and it was also the variable with the greatest ΔR^2 (0.3).

DISCUSSION

Local consumption of wild food plants

In general, the wild food plants presented high mean scores for consumption intensity, and the mean number of users was higher than half the total of interviewees. The outstanding values for domestic consumption indicated that most plants remain widely consumed among the interviewees in the studied communities. This finding may be the result of the extraction activity at the site because extraction is the main economic activity of the interviewees and they have direct contact with these resources. Pieroni and Soukand (2018) argued that communities that have extraction as the main economic activity or additional source of income know and include in their diets a wide variety of edible wild plants.

Another factor that possibly influences the high diversity of species consumed in that area is the close distance to areas of native vegetation. The literature shows that populations living near forests have more contact with wild plants and tend to use forest resources more often than communities farther away (Pieroni and Soukand 2018).

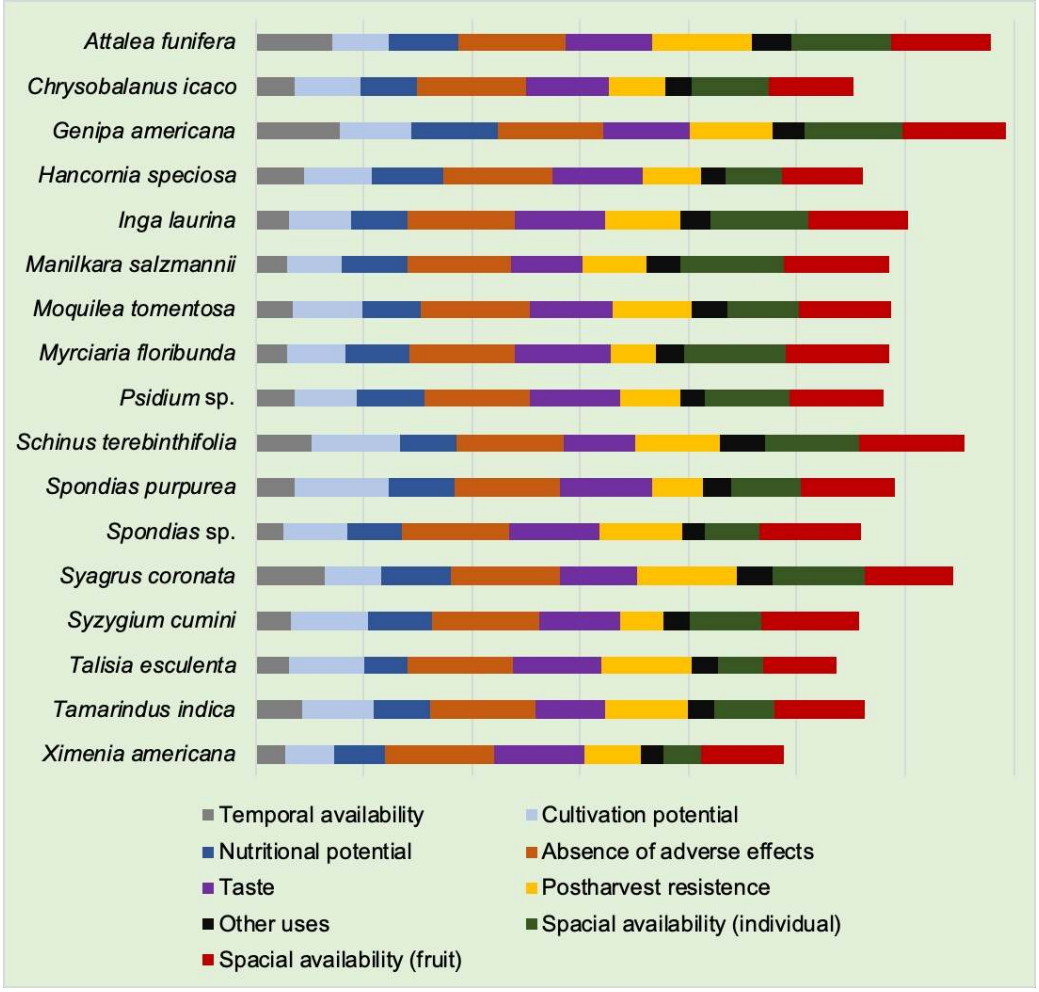

Figure 5. Native and woody fruit species classification according to perceived parameters in two rural communities of Piaçabuçu (Northeast region of Brazil).

Although the two communities in this study are connected to urban centers, the interviewees still consume many wild fruits. This scenario is different from findings in the literature, which suggest that living close to urban areas would reduce consumption of wild fruits (Bortolotto et al. 2015, Reyes-Garcia et al. 2005). However, the extractivist nature of Retiro and Paraíso areas and the close distance to areas with native vegetation seem to withstand the influence of urbanization, ensuring maintenance of wild food plant consumption.

The fact that the mean number of traders was lower than the mean number of users indicates that trade is more specialized than domestic consumption in the region. However, the mean score for commercial potential was higher than the mean score for consumption. Therefore, once a species is selected for trade, its primary destination is for income generation rather than for domestic purposes. This is because wild plants are not the main components of the local diet, that is, income from extraction, government support, and other professional activities allows people to buy products that are produced globally (rice, beans, wheat, etc.), which in turn form the base of their diet. The secondary role of these plants in the local diet may also influence local criteria for their consumption, a topic that will be discussed below.

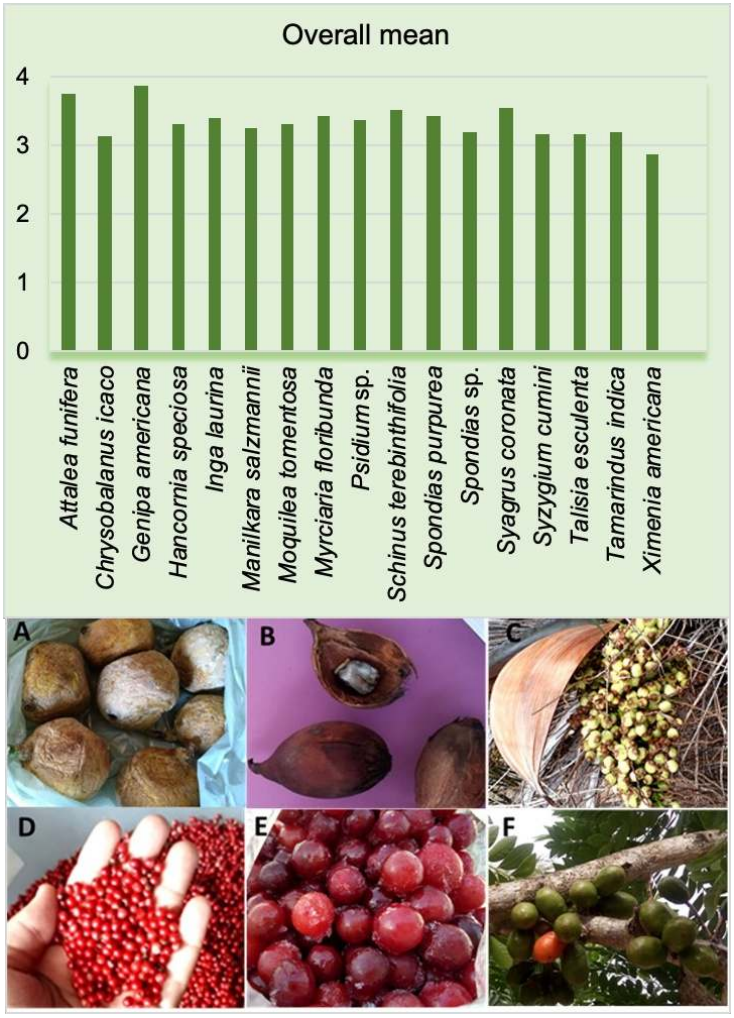

Figure 6. Native and woody fruit species used by rural communities of the municipality of Piaçabuçu (Northeast region of Brazil). Mean values of the evaluated attributes and graphic representations of the species with higher scores. A: *Genipa americana* L.; B: *Attalea funifera* Mart.; C: *Syagrus coronata* Becc.; D: *Schinus terebinthifolia* Raddi; E: *Myrciaria floribunda* (H. West ex Willd.) O. Berg; F: *Spondias purpurea* L.

Selection criteria for edible wild plants

Spatial availability of the individual was the most important variable to explain both the number of users and the number of traders and. Despite having a strong influence on the consumption of other plant resources (Gonçalves et al. 2016), availability was not suggested to significantly influence the knowledge or consumption of food plants among Brazilian rural communities, as evidenced in studies that used phytosociological indices as availability indicators (Ribeiro et al. 2014; Soldati et al. 2017). Therefore, our result diverges from ethnobotanical literature, and it may have to do with (1) local specificities of social-ecological systems, or (2) the different ways of assessing availability. Local perceptions of availability often consider aspects other than abundance, frequency, or dominance, as, for example, the accessibility. Therefore, despite their abundance, plants that occur in places far from people's houses or their routes may be perceived as unavailable (Gama et al. 2018).

We found an inverse relation between other uses and number of traders of wild food. We expected that, when a plant had

many uses, the chances for its collection would increase, and more people would employ them for different purposes. However, it is possible that the relevance for edible purposes may be protecting some plants from other uses, especially the most threatening (e.g., wood uses). People would avoid destining wild food plants for other purposes that could compromise the species' availability. In such a case, the number of users of the wild food plants would be determining the number of other uses and not the other way around. Nevertheless, this hypothesis needs to be tested with proper research designs.

The variables that explained the number of users/traders were utterly different from those that explained consumption intensity and commercial potential. It may seem unexpected, but these variables have distinct natures. If a plant is not readily available, fewer people will use or sell it. However, it seems that for those that trespass the availability barrier (e.g., people that often walk long distances or live close to areas were certain "unavailable" species occur), the main factor that drives consumption intensity and commercial potential is the plant's taste.

Taste was the variable with the strongest influence on consumption intensity and commercial potential. This variable was also highlighted as the most important reason for the consumption of edible wild plants in the Catalan Pyrenees and Balearic Islands (Serrasolses et al. 2016) and in the Western Himalayas (Thakur et al. 2017).

Nutritional potential was also a variable that helped explain the consumption of edible wild plants, but its influence was lower than that of taste. Nutritional value was also among the factors that strongly influenced consumption of edible wild plants in southeastern Benin (N'Danikou et al. 2011).

Studies analyzing hunter-gatherer societies, especially regarding the optimal foraging theory, often consider nutritional value (energy intake) and availability (energy expenditure) among the main variables that influence food selection (Hawkes et al. 1982). In particular, regarding the consumption of wild food plants among hunters and gatherers, Ong and Kim (2017) observed that the most important species for this purpose were groups of carbohydrate-rich plants, highlighting the importance of nutritional potential; they also reported that low availability resulted in reduced utilization of a species.

When comparing our findings to those in the literature, it is reasonable to assume that taste is more relevant in contexts in which wild food plants are not the base of the local diet; however, when these plants are essential for energy intake and nutrition, taste becomes a secondary component, highlighting aspects that are more clearly associated with energy expenditure. However, this hypothesis should be tested in future studies.

Another aspect supporting this notion is that while nutritional potential influenced consumption, this variable did not significantly influence commercial potential. Edible wild plants are sold in urban areas near the communities. For people in these areas, such species have an even lower contribution to daily energy intake because their consumption is only complementary (for example, juice during lunch). This fact would explain the lower importance of nutritional potential and absolute predominance of taste in the commercial context because the demand generated by consumers is for tasty fruits.

CONCLUSION

Criteria that influence people to select certain plants for consumption can be defined (1) by the purpose of the selection, e.g., for domestic consumption or sale, and (2) according to the importance of these species in the energy intake of the population. Future studies should test the hypothesis that taste is predominant in contexts in which the population is less dependent on wild food plants. However, low dependence does not imply low consumption. The communities studied here for instance consume a high number of native fruits although these fruits are not the base of their diet.

Remarkable differences between the drivers of the number of users and the drivers of consumption intensity indicate that they need to be treated in future ethnobotanical studies as different processes of the social-ecological systems. The same principle needs to be applied for the number of traders and the commercial potential.

Finally, the low explanatory power of the model for commercial potential when compared to the others suggests that aditional variables not considered in this study may be important for the definition of plants perceived as more important for sale. Then, other factors specifically related to the generation of market demand should be identified and tested. Studies analyzing production chains can help identify explanatory variables.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

CONTRIBUTION STATEMENT

Conceived of the presented idea: PMM.

Carried out the field work: DLG, RPSF, EMCS.

Carried out the data analysis: DLG, PMM.

Wrote the first draft of the manuscript: DLG.

Review and final write of the manuscript: DLG, PMM, RPSF, EMCS, RRVS.

Supervision: PMM, RRVS.

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