REVISTA BRASILEIRA DE ENERGIAS RENOVÁVEIS

USE OF THE INAJÁ STIPE (*Attalea maripa* (AUBL.) MART.) FOR THE GENERATION OF BIOENERGY[1]

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Abstract

The objective of this study was to evaluate the bioenergetics aptitude of Inaja stipe. The samples were collected in five sites in the northeast of Pará State: Cametá, Abaetetuba, São João de Pirabas, São Caetano de Odivelas and Capitão Poço. In each area, 25 matrices were identified and evaluated. The breast circumference (CAP) and the stipe length (AE) were collected for physical, chemical and energetic analysis, and a composite sample was collected from three random stipes from each zone. The analyzes were in accordance with the recommended Brazilian standards: ABNT 11940 (1983) for the physical analysis, ABNT 8112 (1986) for chemical analysis, and ABNT 8633 (1983) for energetic analysis. Regarding CAP, an average of 132.43 cm was obtained (CV = 27.81%), and AE had an average of 314.89 cm (CV = 30.67%). These variations may be explained by the different bioclimatic conditions in each region where the populations are located, as well as the different ages of each palm tree. The average values of the physical variables, moisture content and basic density were 50.09% and 0.34 g.cm-³, respectively. Therefore, it is recommended to perform a drying process, and it may be outdoors for the equilibrium moisture content with the region. The chemical tests indicated an average volatile matter of 82.46%, with an ash content of 0.83% and a fixed carbon of 16.76%. The higher calorific value was, on average, 4586.25 kcal.kg^{-1}. The results indicate that Inaja stipe can be suitable for energetic uses, such as heat generation.

Keywords: biomass energy, calorific power, renewable source.

USO DO ESTIPE DE INAJÁ (*Attalea maripa* (Aubl.) Mart.) PARA GERAÇÃO DE BIOENERGIA

Resumo

O objetivo deste estudo foi avaliar a aptidão bioenergética do estipe de inajá. As amostras foram coletadas em cinco locais no nordeste do estado do Pará: Cametá, Abaetetuba, São João de Pirabas, São Caetano de Odivelas e Capitão Poço. Em cada área, 25 matrizes foram identificadas e avaliadas. Foi levantada a circunferência à altura do peito (CAP) e a altura do estipe (AE). Para análise física, química e energética foram coletadas amostras compostas a partir de três estipes de cada município. As análises foram feitas de acordo com as normas recomendadas: ABNT 8112 (1986) para análise química, ABNT 11940 (1983) para a física e ABNT 8633 (1983) para a energética. Em relação ao CAP, obtivemos uma média de 132,43 cm (CV = 27,81%), e o AE apresentou uma média de 314,89 cm (CV = 30,67%). Essas variações podem ser explicadas pelas diferentes condições bioclimáticas em cada região onde as populações estão localizadas, bem como as diferentes idades de cada palmeira. Os valores médios das variáveis físicas, umidade e densidade básica foram de 50,09% e 0,34 g.cm^{-3}, respectivamente. Desta forma, recomenda-se realizar um processo de secagem ao ar livre para atingir o teor de umidade de equilíbrio com a região. Os testes químicos indicaram teores médios de materiais voláteis de 82,46%, cinzas de 0,83% e carbono fixo de 16,76%. Quanto o valor calórico superior foi, em média, 4.586,25 kcal.kg^{-1}. Os resultados indicaram que o estipe de inajá pode ser adequado para usos energéticos.

Palavras-chave: energia de biomassa, poder calorífico, fonte renovável.

INTRODUCTION

Biofuel theme has been widely discussed worldwide; the environmental, economic and political issues surrounding energy sources based on fossil fuels compromise the supply of the current energy, and these circumstances imply new alternative sources of energy, while they have positive impacts in both environmental and social terms.

Management palm trees may have a great potential to merge the sustainable resource uses as well as to improve the community quality of life. Some studies demonstrate that some palm trees can achieve economic viability, i.e. for energy service, due to the large relative abundance distribution, and high rate of reproduction, thus emphasizing their role in the regeneration of degraded areas and forest succession. Rural communities use palm trees for food, thatched roofs, handicrafts, etc. However, in the Amazon region there is large number of palm trees that have not been economically used yet or have been underutilized. Among them, *Attalea Maripa* (Aubl.) Mart., known as Inaja, that occurs all over the Brazilian North Region.

According to Rabelo (2012), this palm tree occurs throughout the Amazonian biome mainly in the states of Acre, Amazonas, Western Maranhão, Northern Mato Grosso, Pará, Roraima, Rondônia and Northern Tocantins, with great frequency and abundance, especially in brush forests, road margins, degraded pastures, and some fragments of forest remnants located within urban centers. This same author reports that Inaja in addition to tolerating clayey or sandy, well drained, wet or dry soils, after establishment in degraded forests, it also produces fruits in great abundance. Moreover, it is a tolerant palm to pests and diseases, as well as to withstand prolonged droughts, compacted, degraded soils and with low fertility.

Due to Inaja being very frequent and abundant, the goal of this work was to evaluate the bioenergetics aptitude of the Inaja stipe.

MATERIALS AND METHODS

The samples were collected in five sites in the northeast of Pará State: Cametá (CA), Abaetetuba (AB), São João de Pirabas (SJP), São Caetano de Odivelas (SCO) and Capitão Poço (CP). In each area, 25 matrices were identified and evaluated (Fig. 1A). The breast circumference (CAP) and the stipe length (AE) were collected for physical, chemical and energetic analysis, and a composite sample was collected from three random stipes from each zone. The analyzes were in accordance with the recommended Brazilian recommended: ABNT 11940 (1983) for physical analysis, ABNT 8112 (1986) for chemical analysis, and ABNT 8633 (1983) for energetic analysis.

The samples were taken to the Forest Products Technological Laboratory - LTPF / UFRA, where they underwent the proper identification and after that, the material was collected and mixed for the composite sampling, and were subjected to physical, chemical and energy tests.

In the studied city a participatory diagnosis was performed of the livelihoods in rural communities (FIGURE 1 - A) of their productive activities, and relevant information was identified about the Inaja (FIGURE 1 - B). The analysis was based in 2016, through semi-structured questionnaires to the rural producers, and for each municipality five rural properties were interviewed.

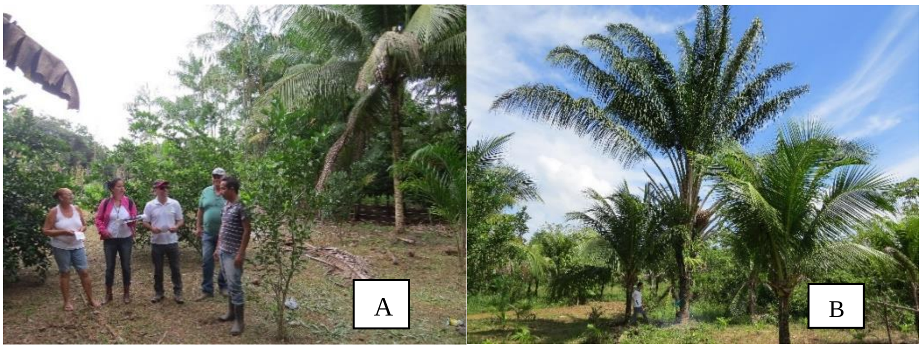

Figure 1 – (A): Interviews with the traditional population about the Inaja and their productivities; **(**B): Inaja

A considerable amount of Inaja were collected from 25 properties. The specimen botanical identification was performed in the field, and the samples were collected for confirmation at UFRA and EMBRAPA herbarium.

RESULTS AND DISCUSSION

An average of five people were found living in the same residence (FIGURE 2).

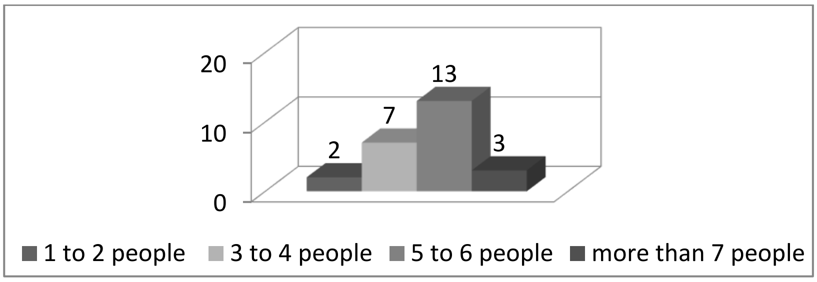

Figure 2 – Number of people residing in the residences from each family.

The interviewees were characterized as family farmers, who have an average of 98.84 acres, but the size of the area varied greatly (coefficient of variation, CV = 60%). The monthly incomes of these families are low (FIGURE 3). It was found that 52% earns incomes of up to $ 275.00; 16% has income between $ 275 to $ 550; 24% between $ 550 to $ 825; and only 8% higher incomes than $ 875.

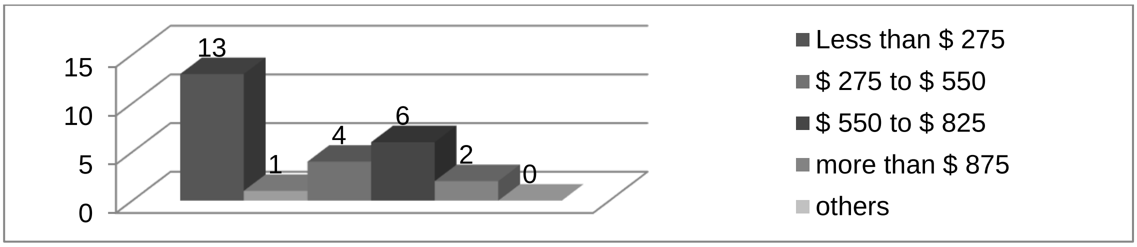

Figure 3: Estimated monthly family income.

The productive activities developed by the families vary greatly among the properties and among the cities, as well as throughout the year. It is observed that there is a predominance by Agroforestry Systems (SAF) and Annual Agriculture. It is worth mentioning that in the same property more than one activity may occur (FIGURE 4).

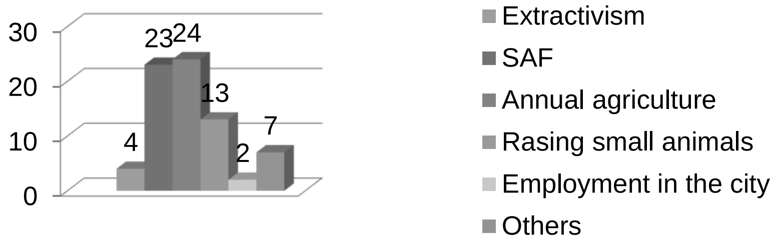

Figure 4: Economic activity base of the family income.

Inaja is a palm tree that is very frequent with natural occurrence in the studied plots. Despite it can be observed along the roads and highways, only those allowed by the owners were collected.

It was noticed that most of the interviewees do not consider Inaja as a productive resource, and for that reason, they do not know its characteristics, as well as its fruiting time or the quantity of Inaja numbers in their property. Only 5 to 7 of the interviewees make use of some Inaja structure, either the leaf as cover or the fruit as fertilizer or feed.

Most of them preserve the Inaja in their own properties, excepting when they need to increase their production (i.e. cassava, beans and corn) (FIGURE 5).

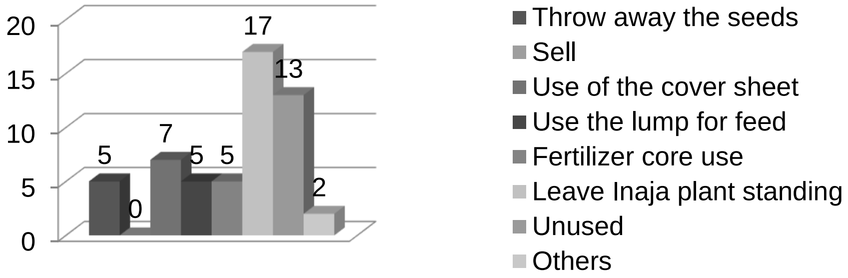

Figure 5: Inaja main uses by the farmers.

The stipe circumference at the breast height was on average 132.43 cm (CV = 27.81%), and the stipe length was 314.89 cm on average (CV = 30.67%). These variations may be explained by the different bioclimatic conditions in each region where the populations are located, as well as the different ages of each palm tree.

The moisture (W) content affects directly in the energy properties although it is not an intrinsic attribute due to the energy that it is required to evaporate the moisture contained in the biomass, and consequently there will be a reduction in the availability of combustion heat. According to Garstang et al. (2002), the biomass for the energy generation must have a moisture content equal to or less than 30%. However, none of the Inaja components (Table 1) collected directly from the field could obtain this recommended value.

In the study carried out by Brand et all. (2014) who evaluated the crowns, needles and branches of a newly collected *Pinus taeda*, he related that the W values found were 54 and 62%. These values are higher than those obtained in the collected biomass in our case studies. This demonstrates that the variable needs to be controlled for energy efficiency; it is recommended to carry out a study to verify the ideal weather and conditions to perform an outdoor drying in the region, before being intended for energetic use.

It is well known that wood density is a relevant characteristic since that it is a quality index that correlates directly with the dry mass production and with the physical-mechanical properties, besides being easily determined (PALERMO et al., 2004). For biomass in general this same premise remains. In the case of energy potential, the high density indicates that there is more matter to be consumed, therefore, the burning time of the material tends to be higher.

The average for the basic stocking density was 0.37 g, cm^{-3} in all cities, except for São Caetano de Odivelas, which presented a lower value of 0.2 $g.cm^{-3}$. This difference may occur due to the phenotype, site and age difference of the lnajá populations of that locality.

Table 1: Average physical characteristics of *Attalea maripa* (Aubl.) Mart. collected in five cities in the Northeastern of Pará.

Cities	Stipe	
	W (%)	Db (g cm-³)
São Caetano de Odivelas	53.39 ab	0.20 b
São João de Pirabas	46.56 b	0.37 a
Abaetetuba	55.77 a	0.37 a
Cametá	47.93 ab	0.37 a
Capitão Poço	46.80 b	0.37 a
CVexp (%)	9.92	9.76

CVexp, coefficient of experimental variation; W, moisture content; D, basic density. Average values followed by the same letter are not differentiated by the Tukey test ($p > 0.05$).

The higher the Volatile content (V) is the easier it is to ignite and to burn, but also the highest values conditioners a fast and inefficient burning. In the Inaja stipe chemical analysis (TABLE 2) the results obtained are within the expected range between 65 to 83% (CORTEZ; LORA, 2008 APUD PEREIRA; BRITO, 2016).

The Ash content (A) correspond to the mineral composition in the vegetative structures of the plant, and the Inaja leaves had a higher ash content due to the vegetative organs of high metabolic activity. Carré and Shenkel (1994) and Garstang et al. (2000) recommend that biomass for energy purposes should have an ash content less than 2% and our results found a rate between 0.35% and 1.51%.

The Fixed carbon (F) is very used as a parameter, although it cannot be analyzed in isolation to characterize the palm energy properties. Brito and Barrichello (1982) emphasized that the fixed carbon should be between 15% and 25%, and in our test an average of 17% F was obtained.

The High Calorific Power (PCS) found in the Inaja stipe (TABLE 2) was higher than 4,586 kcal/kg. It is worth pointing out that the agricultural waste already applied as energy production in Brazil has a higher average calorific value than the Inaja fruits.

The sugarcane bagasse, which accounts for 11.6% of the Brazilian energy matrix (MINISTRY OF MINES AND ENERGY, 2016) has PCS of only 2,276.75 kcal / kg according to Clemente et al. (2016), and 4268,65 kcal/kg affording to Santos (2014).

Eucalyptus grandis, the current species most used for charcoal production in Brazil has a PCS of 4,274 Kcal / kg (MÜZEL, et al., 2014), and it is a value lower than those obtained in Inaja stipes. The same occurred for five other genera Eucalyptus species, whose PCS ranged from 4,538 to 4,669 Kcal / kg (JESUS et al., 2017).

Table 2: Average chemical analysis of the strain of *Attalea maripa* (Aubl.) Mart.

Cities	W (%)	D (g.cm-³)	F (%)	V (%)	A (%)	PCS (Kg/Kcal)
São Caetano de Odivelas	53.39 ab	0.20 b	16.68 b	81.64 c	1.51 a	4620.33 a
São João de Pirabas	46.56 b	0.37 a	16.39 b	82.63 b	0.94 b	4526.67 b
Abaetetuba	55.77 a	0.37 a	18.91 a	80.58 d	0.80 b	4668.67 a
Cametá	47.93 ab	0.37 a	16.94 b	82.78 b	0.35 c	4582.33 ab
Capitão Poço	46.80 b	0.37 a	14.89 c	84.68 a	0.54 c	4529.33 b
CVexp (%)	9.92	9.76	2.03	0.43	8.98	0.7

CONCLUSION

Regarading the chemical, physical and energetic analyses *Attalea maripa* (Aubl.) Mart., Inaja, presented considerable and suitable characteristics for the use as energy product.

The use of Inaja as raw material for energy use will have greater energy efficiency if it, at least, dried outdoes, in order to increase its net calorific value.

It is advisable to carry out studies that monitor the Inaja productivity, under different conditions, to verify which may contribute to the increase of its potential.

In addition, the use of Inaja for energy purposes in a sustainable way is also important to propose the alternative use of this palm, which is not used as an alternative source of energy, and also offers a socioeconomic improvement in small properties, since this use can generate an economic return with low cost, generating income for the small farmer.

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