Ethnobotany of *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. in two ecoregions of Colombia

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Ethnobotany Research and Applications 31:16 (2025) - http://dx.doi.org/10.32859/era.31.16.1-24
Manuscript received: 23/03/2025 – Revised manuscript received: 06/06/2025 - Published: 07/06/2025

Research

Abstract

Background: *Acrocomia aculeata* is a multipurpose neotropical palm, widely distributed in Colombia with a large potential in the oil and food sector. However, its management and uses in the country are largely unknown. Therefore, the current study involves an ethnobotanical study on the use, management, and commercialization of *Acrocomia aculeata* in two regions of Colombia, where wild populations are found.

Materials and Methods: Participant and non-participant observation sessions were conducted, along with semi-structured interviews with traders, processors, and consumers of palm, in 10 municipalities of Santander and Casanare, exploring harvesting methods, market characteristics, and uses of the palm.

Results: In Casanare, nine categories were identified, while seven were noted in Santander, with human and animal food being the most prominent in both regions. In Casanare, buds and fruits are harvested, whereas in Santander, only the fruits are collected. Processing is done using traditional artisanal methods, and the market is incipient and seasonal across the two regions. In Casanare, the market is characterized by the offer of handicrafts and utilitarian objects (rings, fans, brooms, and hats), while in Santander, comprises food products derived from the fruit (fruits, chicha, and ice cream). However, a decline in usage was attributed to the depletion of the resource.

Conclusions: The study outlines the use and commercialization of *Acrocomia aculeata* in Casanare and Santander, highlighting its cultural, social, and economic significance. Despite its considerable commercial potential, it is crucial to address the challenges related to use decline and resource depletion.

Keywords: Corozo, commerce, management, traditional uses, local knowledge

Background

Palms are widely known for the multiple uses and ecosystem services they provide to people in tropical areas (Balslev *et al.* 2011). For example, about 63% of palm species in Northwestern South America are used (Macia *et al.* 2011) and mainly harvested from wild populations (Bernal *et al.* 2013). From the grand pool of resources that palms offer, those multipurpose species, especially those used as fodder and oils, have the biggest potential to develop new mass-consumption products (Lorenzi 2006). One species that is both multipurpose and is a high oil producer is *Acrocomia aculeata*, the neotropical palm species that is highly valued in the oil industry because it naturally produces high quality oil with high yields up to 25 tons of oil per hectare, similar to those achieved by the African palm (*Elaeis guineensis* Jacq.) (Poetsch *et al.* 2012, Motoike & Kuki 2009, Borges *et al.* 2021). In Paraguay and Brazil, it is considered a multipurpose species with around 10 documented categories of use (Ambrocio-Ríos *et al.* 2021, Benítez *et al.* 2011, Lorenzi 2006), among which the most important are food for humans and animals, materials for construction and handicrafts, medicine, among others for which the entire palm is used (Benítez *et al.* 2011). Although *Acrocomia aculeata* has not been fully domesticated and its traditional and industrial uses still depend on wild collections (Vargas-Carpintero *et al.* 2021, Pires *et al.* 2013), its domestication process is accelerating (Carreño-Barrera *et al.* 2021). All these reasons highlight the importance of developing a comprehensive study to unlock its full potential.

The other factor that makes *A. aculeata* a valuable resource is its adaptability to different climatic and soil conditions. For example, it grows in exposed, degraded environments, with high luminosity, low rainfall and tolerance to high temperatures, it is also resistant to fire, allowing it to be exploited in areas of lower agricultural aptitude, such as cattle ranching areas and dry zones, something that is already observed in some parts of Colombia and Brazil (Benítez *et al.* 2011, de Lima *et al.* 2018). Its environmental requirements allow oil production areas to be expanded, as these are different from the requirements of **African palm**, for which a very humid environment is an essential condition (Lorenzi 2006). Its contribution to the regeneration of degraded areas stands out, thanks to its pioneering and heliophilous nature (Benítez *et al.* 2011), as well as the potential to use its endocarp as a biosorbent to decontaminate water (Giraldo-Bareño *et al.* 2023). The cultivation of *A. aculeata* presents itself as an opportunity to take advantage of disturbed habitats with demanding climatic conditions where large-scale cultivation is difficult. The increasing global demand for vegetable oils, driven by population growth and mainly supplied from the **African palm** (*Elaeis guineensis*) (Poetsh *et al.* 2012), has encouraged the expansion of *E. guineensis* cultivated areas in Colombia, becoming the world's third-largest producer of **African palm** (Santa Coloma 2011), resulting in negative environmental impacts (Pardo & Ocampo-Peña 2019). Colombia ranks third in the world for palm species richness; this situation underscores the need to explore and promote the sustainable use of native palms to secure the supply of essential oleaginous products without compromising the ecological balance.

In Colombia, *A. aculeata* is known as **corozo** or **tamaco** and is distributed in dry and savanna forests (Pedraza 2019). In the country, it is a resource historically used by various communities, but which has been surprisingly little studied in terms of its local and traditional use. In some compilations about the palms in the country it is mentioned that the fruits are used to extract oil for cooking and to feed pigs, either provided or by foraging on the land where the plant is present (Galeano & Bernal 2010, Santacoloma 2011). On the other hand, in Casanare, the mesocarp is used to feed poultry and in Santa Fe de Antioquia the roasted fruits are sold as a snack. As reported in Brazil and Mexico, in certain areas of the Caribbean region the stems are cut to obtain the sap and prepare wine (Galeano & Bernal 2010). However, details of these uses and management practices are still unknown. For these reasons, this study aims to offer a first approach to understanding the uses, management and market of the plant in two ecoregions of Colombia.

Casanare and Santander departments were selected as strategic study areas due to their contrasting ecological, economic, and cultural traditions and the prominent presence and use of *A. aculeata*, which allowed for a broader understanding of regional variation in the knowledge and practices associated with this palm. Casanare, situated in the low-urbanized Eastern Plains, is dominated by extensive livestock farming, where the palm grows abundantly in undisturbed areas. In contrast, Santander, located in the densely populated dry tropical Andean zone, has small-scale horticultural production and a strong market-oriented peasant tradition.

Materials and Methods

Species description

Acrocomia aculeata is a spiny palm that grows up to 10 to 15 m tall, with a trunk diameter of 20 to 30 cm (Fig. 1-A) (Teles 2009). Its bark is dark, with hard spines up to 15 cm long in the node region (Fig. 1-B). The leaves are covered with spines (Díaz-Fuentes *et al.* 2019) and are grouped at the top of the trunk (Azevedo et al. 2018, Rubio et al. 2012), where the old

leaves are easily detached (Benítez *et al.* 2011). This palm produces yellow panicle inflorescence, which reaches a length of up to 1.20 m (Fig. 1-C) (Díaz-Fuentes *et al.* 2019). Each individual can produce between 5 and 7 bunches, with a total of up to 700 fruits, depending on the conditions of its habitat (Fig. 1-D) (Benítez *et al.* 2011). The fruits are drupes between 2.5 and 5 cm, which change color from yellow to brown as they mature. They have a leathery epicarp, a fibrous and mucilaginous yellow mesocarp, and a rigid black endocarp (Díaz-Fuentes *et al.* 2019).

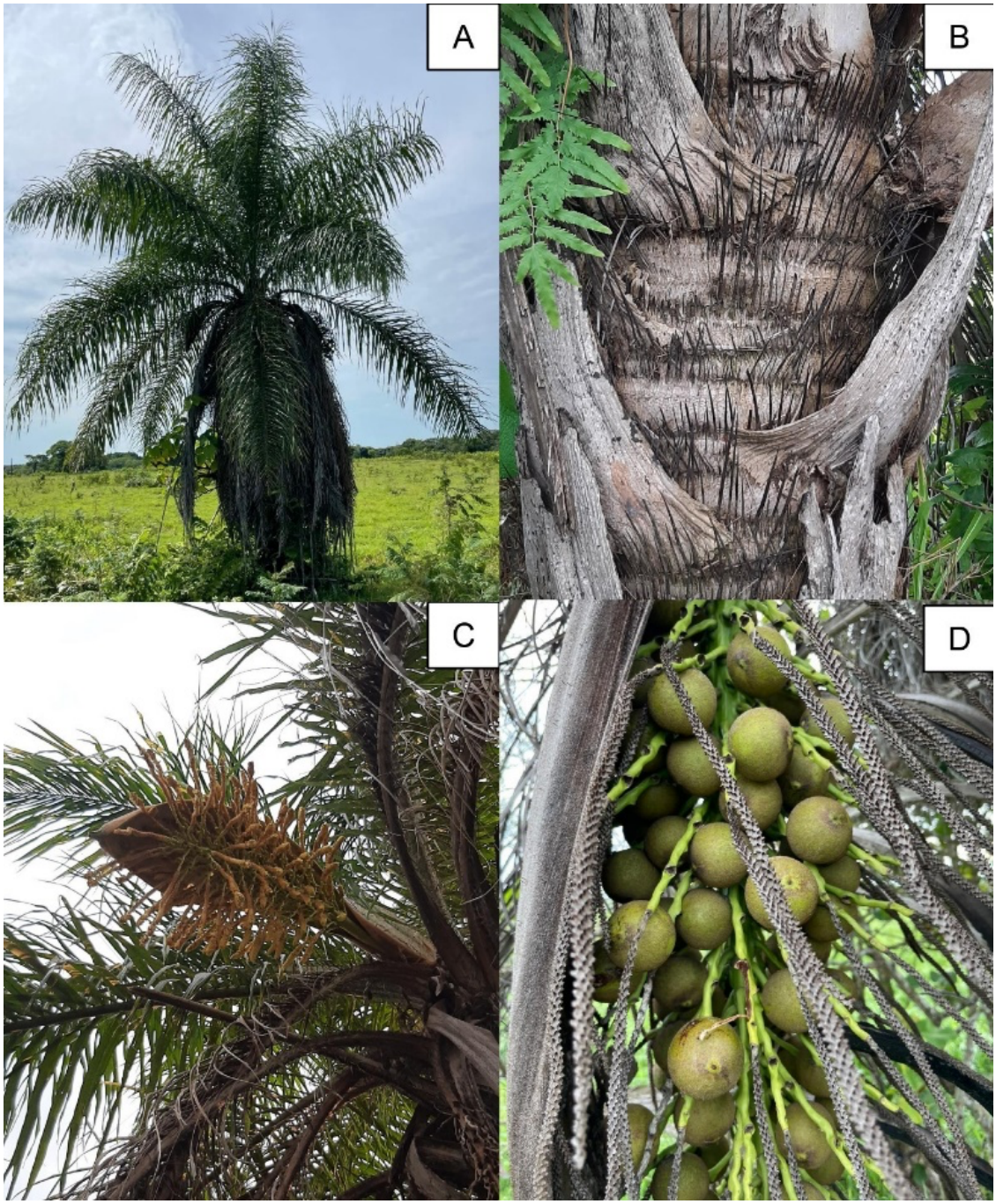

Figure 1. *Acrocomia aculeata*. **A)** General view, **B)** Trunk, **C)** Inflorescence, **D)** Fruit bunch

Study area

This study was carried out in South America, Colombia, in 10 municipalities of the departments of Santander and Casanare (Figure 2) between August 2023 and April 2024.

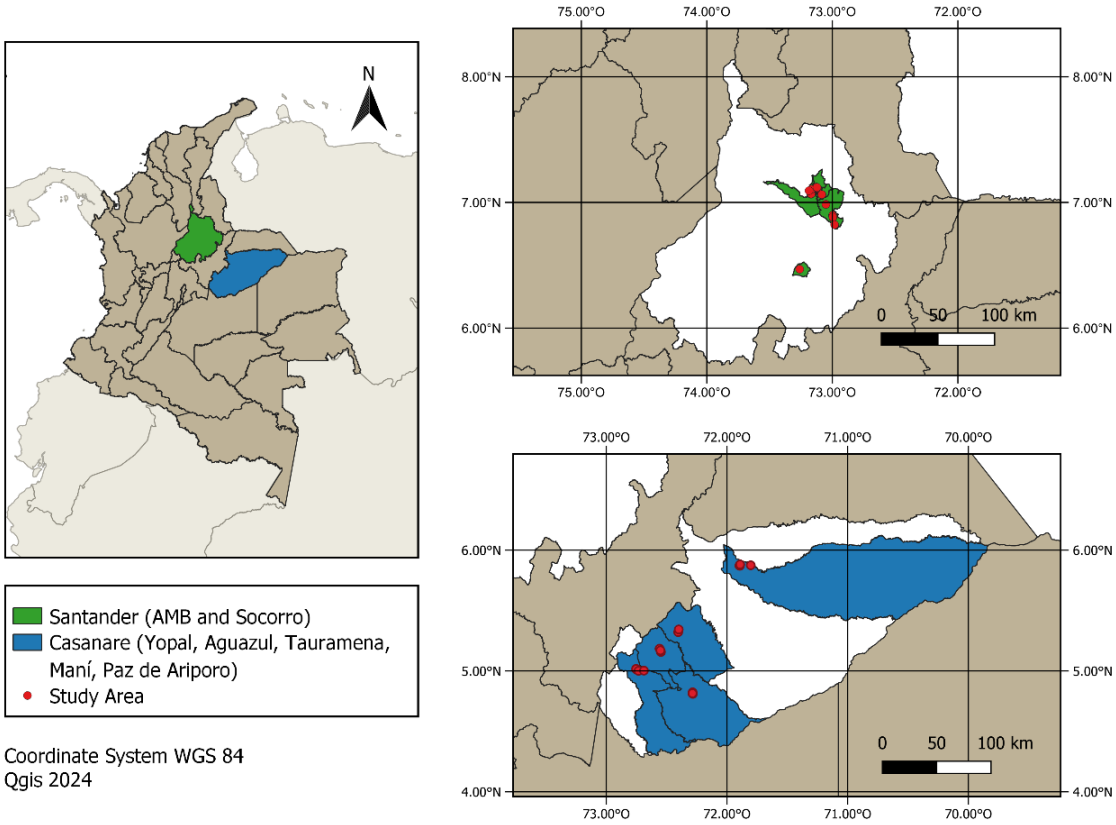

Figure 2. Map of the study area of the departments of Santander and Casanare.

Department of Santander

Santander is located in the central-eastern region of Colombia. Its cultural identity comes from a fusion of diverse cultures such as mestizos, afro-descendants, indigenous, and Roma communities (ProColombia 2021). Since the 1950s, this department has experienced a rapid rural-to-urban change, with a migration of the population to cities (Ruizorduz 2019). Despite these changes, the region maintains a rich cultural heritage, and agriculture remains an important economic activity. In this department, information was collected in the municipalities of Socorro, and the metropolitan area of Bucaramanga (AMB), that comprise Girón, Floridablanca, Piedecuesta, and Bucaramanga.

Department of Casanare

Casanare is located in eastern Colombia and is part of the Orinoquia region. Its economy is based mainly on cattle farming, agriculture, and in recent decades, on petroleum exploitation (Sánchez *et al.* 2005). This department has a *llanero* cultural identity shaped around cattle farming and holds knowledge about plants and animals of the region (Martínez 2015). This knowledge is applied for different purposes, especially in traditional medicine, food, cattle farming and agricultural practices. In Casanare, the information was collected in the municipalities of Yopal, Aguazul, Tauramena, Paz de Ariporo, and Maní.

Data collection

To collect information about the uses *of Acrocomia aculeata*, non-participant observations and semi-structured interviews (Annex 1) were conducted with individuals identified as consumers of the palm. These individuals were selected based on their knowledge of the palm and willingness to share their experiences. Interviews took place in common meeting spaces such as public markets, parks and fairs, focusing on the purposes and frequency of use of palm-derived products. In Casanare, 57 people were interviewed (37 men and 20 women), ranging in age from 35 to 82 years, and in Santander, 45 individuals participated (31 men and 14 women), aged between 40 and 82 years. This represents a small sample from each region, aimed at providing a general overview of the uses of the palm in these areas.

On the other hand, sellers were approached at public markets, street stalls, and handicraft shops to collect information about the harvesting techniques, the management, and the market of *Acrocomia aculeata*. These individuals participated directly in the harvesting or processing of palm products and those who did not refer us to those responsible. All identified actors (sellers, harvesters, and processors) were interviewed using semi-structured interviews (Annex 2). Interviews with sellers focused on product prices, sales locations, and the specific parts of the palm used. Harvesters were asked about collection techniques, frequency, and seasonality, while processors described the duration and sequence of processing steps. In each department, 15 individuals were interviewed, including: 11 women and four men between the ages of 40 and 64. In Casanare; 10 men and five women between the ages of 50 and 80 in the department of Santander.

In addition, in Casanare a participant observation session was carried out to document the harvesting and processing of palm leaves, recording the time taken at each stage of the process and the description of these stages. During data collection, the recommendations of Brokamp *et al.* 2010, were considered. This study was developed in accordance with the Code of Ethics of the International Society of Ethnobiology (ISE), obtaining the informed consent from all participants.

Data analysis

To analyze the data of the uses of Acrocomia aculeata, a categorization of the types of use reported for the palm in the two departments was carried out, based on the classification of palm use proposed by Paniagua-Zambrana et al. (2010). To identify the main uses and causes of loss of use of the palm free list and the prominence index (Smith's S) was applied, defined as:

$$S = \frac{1}{N}\sum_{j=1}^{N}\left(\frac{L_j - R_j + 1}{L_j}\right)$$

where Lj represents the length of each list, Rj is the rank of item j in the list, and N is the total number of lists in the sample (Smith 1993).

We also performed a cluster analysis to explore sociodemographic differences in usage patterns, such as age, gender, occupation, and region. Finally, descriptive statistics were employed to analyze data related to the management, harvest, and commercialization of the palm in each site.

Results

Use

In the department of Casanare, farmers, housewives, artisans, carpenters, merchants, drivers, employees, and retired people were interviewed. These participants identified 45 uses of the palm, categorized into nine categories of use (Table 1), in which human food, animal feed, and utensils and tools were the most reported. Regarding human food, the most common uses were the consumption of the fruit kernel, with 61.4% of the reports, and the consumption of wine (which also has medicinal uses) with 50.8%. The consumption of *chicha* was also registered, with 26.3% of the participants mentioning it. However, this practice is considered historical, as it was noted that *chicha* is no longer prepared or marketed. The consumption of pulp, palm heart, infusions, and juices were reported by less than 10% of the interviewees.

On the other hand, within the animal feed category, the primary use of the palm was cow fodder using the kernel and pulp of the fruit, accounting for 66.7% of the reports. This feed was described as nutritious and has the property to improve the taste of the milk produced. However, it was reported that there is no process of harvesting and distributing the fruits to ease the feeding for the cattle; instead, they left the fruits to naturally fall to the ground, where they are directly consumed. Furthermore, the use of fruits for the nutrition of poultry and pig was reported by 49.1% and 31.6% of the participants, respectively. In these cases, the process of harvesting and disposing of the fruits is carried out, in which the pigs receive the whole fruit, and the hens receive the residual kernel that remains after the consumption of the fruit by the pigs or cows. Although fruits and kernels are not the main food source, they are effective for fattening hens and increasing egg production. Finally, for the utensils and tools category, the most reported subcategory was household utensils, in which 63.1% of the participants reported making brooms with the leaf fiber. Other products in this category, such as strings and cordage, baskets, hammocks and clubs, were reported by less than 10% of the participants.

In the other locality, the department of Santander, farmers, housewives, merchants, employees, and retired people were interviewed. The participants reported 23 uses categorized into seven categories (Table 1), in which human food was the

main use, reported by 100% of the interviewees. Within this category, the beverages subcategory was cited in all cases, highlighting the use of fruits to prepare chicha, considered by some participants as "*The most traditional beverage in Colombia*". Juice consumption was the second most common use, with 53.3% of reports. Regarding processed and unprocessed food, pulp and ice cream consumption were the most representative uses, being reported by 48.9% of the participants. Another frequent use was kernel consumption at 35.5%, while the other preparations such as *masato* beverages, fruit pulp sweets, wine and compotes, had percentages of use below 10%.

The other six categories were reported by less than 12% of participants, and are considered historical uses, with low or no current frequency of use. Within these categories, animal feed reached the highest number of reports, in which pig feed was mentioned by 11.1% of participants, followed by chicken feed at 6.7%, cattle feed at 4.4%, and horse feed at 2.2%. In this department, animal feed differs from the pattern observed in the department of Casanare, since the source is based on the use of chicha residue (residual cake), which can be supplied directly, or through its processing for the manufacture of forage flour.

In total, 23 uses, or final products, were reported in Santander, of which only the consumption of chicha and juice exceeded 50% of the reports. The parts of the palm used were the fruits and leaves, where the fruits have 22 different types of use, and the leaves have a single use.

Table 1. Categories of use of the *Acrocomia aculeata* in Casanare and Santander departments.
**Note: The full version of this table is available in Annex 3.*

Department	Category	Frequency	Proportion of use reports	S Smith
Casanare	Animal feed (Forage)	46	0.209	0.607
Santander	Animal feed (Forage)	5	0.081	0.061
Casanare	Combustible (Biomass)	1	0.005	0.006
Casanare	Construction (House, fences, other)	22	0.100	0.163
Santander	Construction (Fences)	1	0.016	0.015
Casanare	Cultural (Accessories, religious, decoration, recreative)	38	0.168	0.338
Santander	Cultural (Accessories)	3	0.048	0.023
Casanare	Environmental (Fertilization, other)	5	0.023	0.024
Santander	Environmental (Fertilization)	1	0.016	0.022
Casanare	Human food (Beverages, unprocessed food)	50	0.227	0.638
Santander	Human food (Beverages, processed food, unprocessed food)	45	0.726	0.994
Casanare	Medicinal (Circulatory and digestive system, postpartum, reproductive and sexual health	9	0.041	0.081
Santander	Medicinal (Anti-cancer activity, circulatory and digestive system, reproductive and sexual health	4	0.065	0.037
Casanare	Oils (Cosmetic, cooking)	9	0.041	0.056
Santander	Oils (Cosmetic, cooking)	3	0.049	0.036
Casanare	Utensils and tools (Cordage, household utensils)	41	0.186	0.511

Despite the diversity of uses of this palm, the participants reported a significant decrease in its handling frequency, which has led to the disappearance of a large part of these uses. It should be noted that most of the participants reported this decrease spontaneously, without having asked any related questions. In Casanare, this decrease in use was cited by 72% of the participants, specifically five categories of causes for the loss of use were identified (Table 2). The most reported category, with also the highest Smith's salience index value, was resource depletion, followed by modernization, and the loss of traditions and knowledge. In the category of loss of use due to resource depletion, most reports indicated that this decline is primarily driven by anthropogenic factors, particularly the felling of the palm because of the presence of large thorns along the trunk and leaves of the palm, which accounts for 26.3% of the reports, as they cause frequent accidents involving people and cattle. Land clearings for land-use changes, including the establishment of pastures, crops such as rice, and oil extraction, accounted for 15.8% of the reports. Finally, the felling of plants because they were considered weeds and attract lightning strikes was reported by 3.5%. In the modernization category, the decrease in use of the palm was attributed to the replacement of traditional products by industrialized products. The most cited examples included substituting fruit-based animal feed with commercial concentrates, the use of plastic brooms, and the increase in the use of metals in jewelry. Finally,

in the loss of traditions and knowledge category, it was noted that the transmission of traditional knowledge has been interrupted due to the lack of interest of the younger generation in this type of knowledge. As a result, this knowledge is gradually disappearing with the aging and passing of its custodians.

Table 2. Categories of causes for the loss of use of *Acrocomia aculeata* in Casanare department.

Category	Frequency	Proportion of loss of use reports	S Smith
Management difficulty (Processing, harvest)	3	0.053	0.005
Modernization (Substitution by industrialized products)	15	0.263	0.307
Lack of commercialization (Low demand, lack of government support)	9	0.158	0.179
Loss of traditions and knowledge (Generational change)	12	0.219	0.221
Resource depletion (Anthropogenic factors, natural factors)	24	0.421	0.495

In Santander, 51% of the participants considered that there is currently a lower frequency and diversity of palm use. According to the participants' reports, four categories of causes for the loss of use were identified in this region (Table 2). Among these, the more frequently reported cause was resource depletion. This decrease was attributed to natural factors, with natural palm senescence being the most predominant cause, with 33.3% of the reports. In addition, 17.8% of the interviewees attributed the decrease to anthropogenic factors, specifically the land-use changes for building and crop establishment, while 11.1% of the participants cited the felling of palms due to their thorns. On the other hand, 4.4% of the participants indicated that the reduction in palms is caused by beetles (Coleoptera) that feed on the meristem, leading to wilting. Finally, a smaller percentage of participants, 2.2%, reported palm death due to direct lightning strikes and wilting caused by frost.

Table 3. Categories of causes for the loss of use of *Acrocomia aculeata* in Santander department.

Category	Frequency	Proportion of loss of use reports	S Smith
Modernization (Substitution by industrialized products)	1	0.045	0.023
Lack of commercialization (Supply chain constraints)	7	0.318	0.197
Loss of traditions and knowledge (Generational change)	7	0.318	0.212
Resource depletion (Anthropogenic factors, natural factors)	21	0.954	0.886

Analyzing and comparing the proportions among the seven categories of use shared by the departments of Casanare and Santander, the department of Casanare shows higher proportions of reports in the categories of animal feed, and cultural uses, while Santander shows higher reporting proportions in the human food category (Figure 3). In Santander, human food was the predominant use of the palm, so the reports are concentrated in this category. On the contrary, in Casanare, where palm has a wide variety of current uses, the reports´ distribution is distributed into several categories.

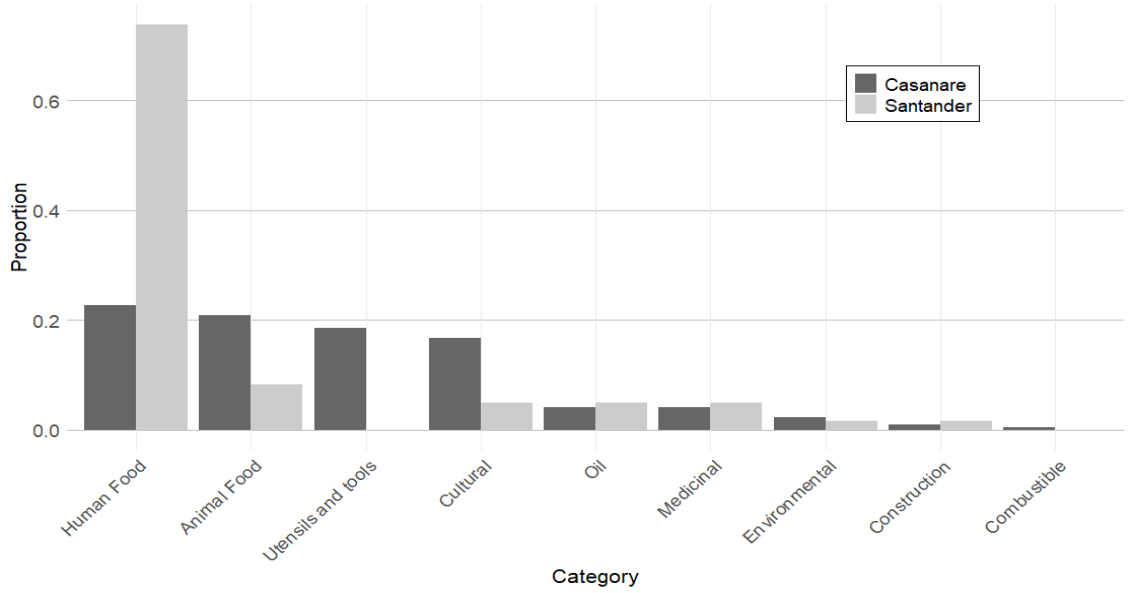

Figure 3. Proportion of use reports by use categories of *Acrocomia aculeata* in Santander and Casanare

The cluster analysis revealed that sociodemographic factors, including age, gender, and occupation, did not show variations in usage patterns. Instead, it highlighted a clear geographical differentiation between participants from Santander and Casanare (Figure 4). Group A is predominantly composed of interviewees from Santander (88.9%), while group B includes mainly interviewees from Casanare (78.9%), indicating regional variations in the utilization of *Acrocomia aculeata*. These results suggest that individuals from each region tend to share similar patterns of use, indicating regionally structured differences in the knowledge and utilization of the species.

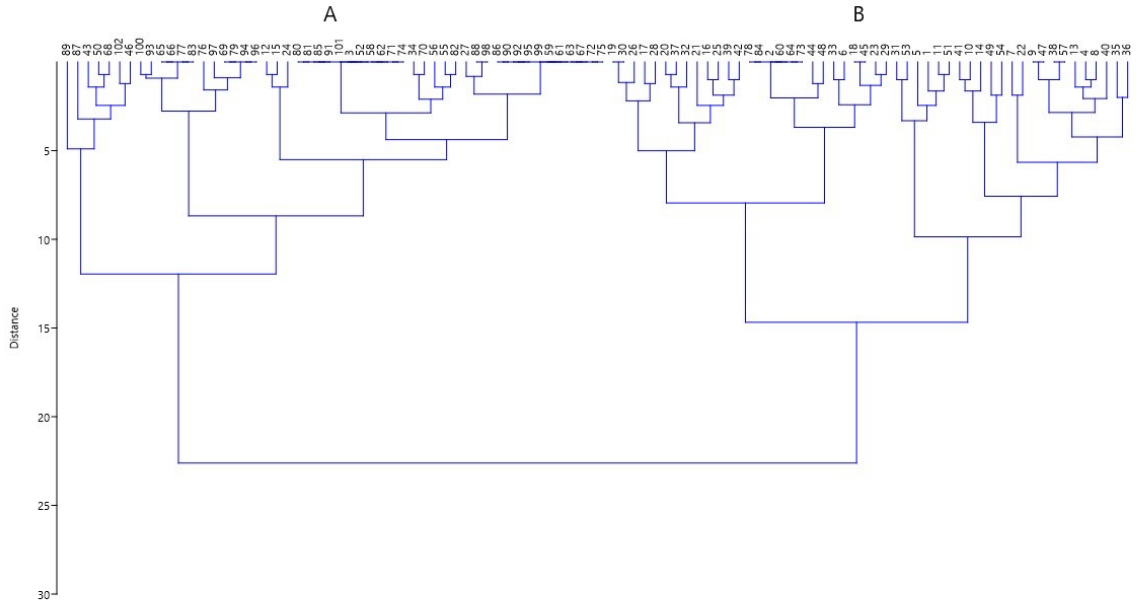

Figure 4. Similarity tree of the 102 interviewees according to the cluster analysis carried out in Past 4.03 using the Ward´s method and Euclidean distance (Cophen. corr.= 0.5696).

Harvest

In the department of Casanare, harvesting of *Acrocomia aculeat*a fruit and spear leaves was reported, while in the department of Santander, only fruit harvesting was reported.

In the first place, the harvesting of the spear leaves to make brooms, hats, hand fans and other textiles is carried out by men and is carried out in rural areas or on their farms. Harvesting is selective, using low-growing palms collecting spear leaves closed, using a machete (Figure 5-A,B). In taller palms, a ladder is used to reach the spear leaves. After cutting the buds, all surface thorns are removed (Figure 5-C), to avoid accidents during transport. The frequency of harvesting depends on the demand for the products and is carried out any month of the year; however, the preferred harvesting time is during the waning moon, because it gives greater durability to the products produced.

On the other hand, fruit harvesting is an activity carried out in family groups, in which men and women participate. Depending on the purpose of use, the fruits can be harvested dry or fresh. Dried fruits are harvested from the ground in Casanare to make handicrafts, as this facilitates the extraction of the seeds, which is the part used.

The fresh fruits are harvested in Casanare and Santander for pulp consumption. These fruits are harvested once they are mature since they do not ripen post-harvest. Three methods of harvesting fresh fruit were reported. The first is cutting the fruit bunch after the first fruit has fallen, which is a ripening indicator. To cut the fruit raceme, people use machetes, axes, or branch-cutting hooks. The second method involves moving the fruit bunch to make the fruits fall to collect them from the ground or collect the fruits already on the ground by their natural fall. Harvesting is performed throughout the year, with peak activity between December and February, and from August to September, when fruit availability is highest.

Figure 5. Harvesting process of *Acrocomia aculeata* buds. A) Selection of the bud, B) cutting of the bud, and C), removal of the thorns.

Processing

Bud processing

Bud processing is carried out in the department of Casanare, mainly by women, whose knowledge has been passed down over generations. The processing occurs in the artisans' homes. They first separate and extract the pinnae, selecting the longest pinnae, from which different woven artifacts are made.

One of the most common products derived from the spear leaves are brooms, made as a secondary activity to the artisans for domestic use and occasionally for commercial purposes. For their manufacture, the fresh pinnae are woven on a rope until they reach the desired length, which can vary from 1 to 3 meters depending on the needs and preferences of the artisan (Figure 6-A, B). Typically, 2 to 3 brooms can be produced from each spear leave. After the weaving is completed, the brooms are left to dry in the sun for 1 to 2 days (Figure 6-C); however, the drying time is extended if the weather is more humid. For this reason, artisans prefer to make these brooms during the dry seasons. Once the woven pinnae are dry, they are wrapped around a wooden stick and secured with the rope that protrudes from the weaving (Figure 6-D).

Fruit processing

Fruit processing to produce food

In the department of Santander, corozo fruits are mainly used to make chicha, juices, and ice cream, and is one of the main economic activities of the processors. This process is carried out by men and women, in family groups, with defined roles for each processing stage. Corozo juice, on the other hand, is made at home for self-consumption and not for commercial purposes.

To produce these products, the fruit must be peeled and then they remove the pulp. Experienced people can daily remove the pulp of up to 100 fruits, making this step the most time-consuming process (Figure 7-A, B). To simplify this process, there are some techniques such as cooking or sun-drying fruits which help to separate the exocarp from the mesocarp. Once the pulp has been removed, it is rationed into bags and stored in a freezer (4° to 5°C) (Figure 7-C). This practice arises from the irregular fruit supply, which drives the purchase of massive quantities during harvest to ensure supply for long periods.

To make chicha, the pulp is liquefied with water and cooked for at least two hours using firewood, stirring continuously to prevent the chicha from burning or curdling. After this, the mixture is allowed to cool and is liquefied again. The resulting juice is filtered through two sieves (rags or strainers) of different sizes. To sweeten the chicha, 250 grams of *panela* (similar to jaggery) are added for each liter of chicha during cooking or after filtering the mixture. The chicha is left to ferment for at least 24 hours. However, the fermentation time depends on the desired alcohol content. The chicha is stored in refrigerators and can be consumed up to 15 days after processing.

Figure 6. Processing of *Acrocomia aculeata* bud for broom production.

Figure 7. Preprocessing of Acrocomia aculeata fruits for the preparation of beverages and ice cream. A-B) fruit peeling and pulping process, C) pulp storage.

To make corozo juice, the pulp is cooked for one hour on a conventional stove and liquefied with water or milk according to preference. The juice can also be prepared without cooking; however, the flavor intensity is reduced when uncooked. Ice cream production follows a similar procedure as juice production, except that milk is added during blending and the mixture is frozen. To make a liter of ice cream, one pound of corozo is needed.

Fruit processing to produce handicrafts

One of the most popular handicrafts made with corozo fruits are the rings manufactured by men and women. There are traditional and modernized methods of production of these rings. In the traditional method, the ends of the corozo seed are cut off and shaped using stone tools. Once the desired shape is obtained, the surface is polished with ground porcelain or a

leaf from the **chaparro** tree (*Curatella americana*), and a soft cloth is used to apply a glossy finish. On the other hand, with modern methods, the ends of the seed are softened with sandpaper, and the shape is molded using a drill until the desired shape and thickness are achieved. Once the ring is shaped, it can be polished with sandpaper, white cement, and a mixture of ash and baking soda, or leather. Additional decorations such as inlaying stones or designing carvings can be done.

Using the traditional method, producing these rings takes an entire day, whereas modern techniques allow experts to manufacture them in about 30 minutes. In the department of Casanare these rings are used as an amulet to avoid the "evil eye" and are one of the most important symbols of engagement. For this reason, they are a common gift between couples that can be used as wedding rings. Despite this, nowadays, most artisans use corozo seeds only under specific orders or as a last resource, when they do not have materials from other species, such as **ojo de buey** (*Mucuna sp*.), due to the difficulty of its handling, attributed to the hardness of the fruit and the presence of spines.

Commercialization

In the department of Casanare, the market of the products included rings, hats, hand fans, and brooms (Figure 8). These products are sold in local stores, on the street, and on social media platforms, and have a small market due to low demand. The ring sales have peak sales during the holiday seasons at the end and middle of the year, as well as during fairs held in various municipalities. However, sales typically do not exceed five rings per month. In contrast, hats are in high demand during dry seasons, with most points of sale reporting monthly sales of six to eight hats. Despite this, a medium-sized company was identified in the region that sells customized hats at the national level (Figure 8-B), which has a significantly higher sales volume. Finally, the marketing of hand fans and brooms is not continuous; their sales are occasional due to the low production.

Figure 8. Products made from *Acrocomia aculeata* traded in the department of Casanare. A) Rings, B) Hat, C) Hand fan, D) Broom.

The prices of some products such as rings and hats have large fluctuations (Table 4), due to the level of personalization and additional work required. For example, rings without inlaid stones (Figure 8-A), tend to be cheaper and are produced in larger quantities compared to rings decorated with stones, which price is higher due to the additional work and materials used. Likewise, personalized hats (Figure 8-B), which require more work and detail, have a higher cost than plain hats. In contrast, other products such as brooms and hand fans do not have significant variations in their design or manufacture, so they do not have large fluctuations in price.

Table 4. Price of *Acrocomia aculeata* products traded in Casanare for the years 2023 and 2024.

Product	Quantity	Price Range (COP)
Ring	Unit	8.000 - 60.000
Hand fan	Unit	10.000
Broom	Unit	12.000 -15.000
Hat	Unit	15.000 - 110.000

In Casanare, most of the producers of these products carry out their harvesting process or receive help from members of their families, to whom they are not required to make any payment. Therefore, the sales values of the products reflect their gross profit. Only certain items, such as hats, are sold by resellers who purchase them wholesale at a lower market price and mark up the price to achieve a profit margin of at least 100%.

In the department of Santander, three products were sold: unprocessed fruits, chicha, and ice cream (Figure 9). These products are marketed in local stores and on the street. The peak sales season for fresh fruits coincide with the harvest season with major traders selling between 100 and 200 kilograms a week. The sellers of *Acrocomia aculeata* fresh fruits also sell other products not derived from this palm.

For chicha and ice cream, the peak sales seasons are during municipal fairs and Holy Week (which typically occurs in March or April). It is important to note that some chicha and ice cream traders only sell chicha and ice cream during these periods of high demand or fruit harvest. The traders reported that chicha and ice cream are in high demand by locals and tourists interested in regional cuisine. In high season, ten liters of chicha are sold daily, with sales reaching up to 20 liters per day.

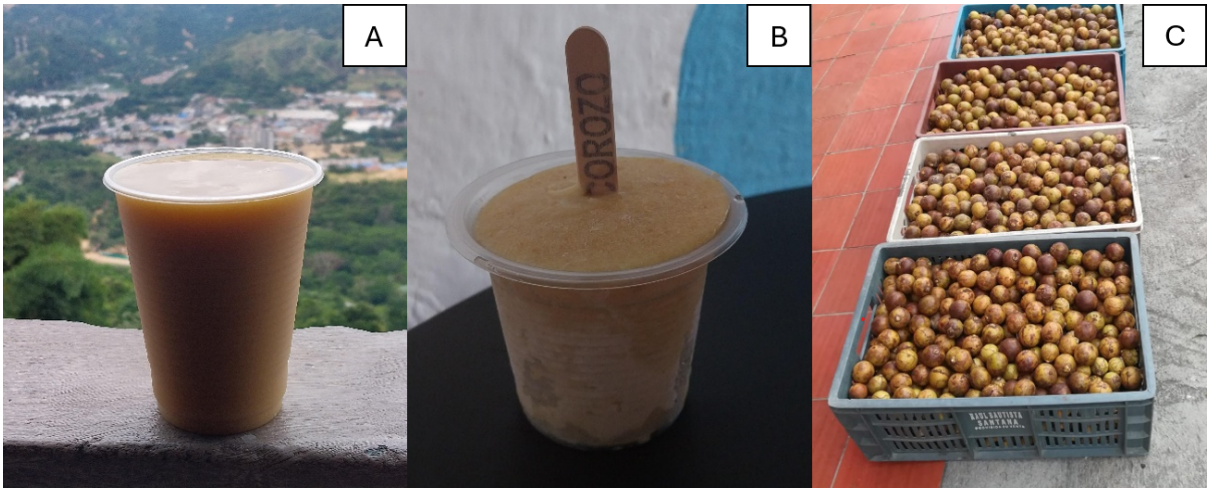

Figure 9. Products made from *Acrocomia aculeata* traded in the department of Santander. A) Chicha, B) ice cream, C) fresh fruits.

The prices of fresh fruits fluctuate depending on the availability of fruits in the market, which doubles in times of lower supply. In contrast, chicha and ice cream maintain a constant price throughout the year (Table 5), which varies according to the establishment or point of sale.

Table 5. Price of *Acrocomia aculeata* products traded in Santander for the year 2023 and 2024.

Product	Quantity	Price Range (COP)
Chicha	Cup	2.000 - 4.000
	Bottle	12.000 - 20.000
Ice cream	Unit	3.000 - 4.000
Fresh fruits	kg	2.500 - 5.000

The cost of processing an ice cream is estimated to be COP 1.000, so the gross profit for each unit of ice cream sold is between COP 2.000 and COP 3.000 (Table 6). In the case of chicha, production costs per liter vary among producers due to the different

amounts of fruit used. However, it is estimated that the production cost of a liter of chicha is around COP 4.000, generating a gross profit of approximately COP 8.000 per liter sold. Considering this, the main producers selling 10 liters of chicha per day could achieve a profit of approximately $2.400.000 COP per month, in a regular season.

Discussion

We found that *Acrocomia aculeata* is a multipurpose species in the two localities we covered, as observed in other countries, whose main use was human food. Its fruits' high nutritional quality could explain why they are mainly used as food since they are rich in β-carotenes, proteins, zinc, potassium, calcium, phosphorus, and manganese (Azevedo *et al.* 2018, Lorenzi 2006, Vianna *et al.* 2017). In Santander, the food use is especially relevant for its cultural value in traditional products such as chicha and ice cream, which strengthen the regional economy through gastronomic tourism (Castellón & Fontecha 2018, Pérez *et al.* 2016). Currently, its market is limited; however, the high demand for these products highlights the economic potential of the species, justifying the expansion of its supply and the development of new products derived from this palm that are not yet commercialized, such as juice.

On the other hand, in Casanare, animal feed was also reported as one of the most relevant uses, due to the region's economic dependence on livestock and again, the elevated nutritional value of fruits. This palm is considered a high-quality forage for its fiber, energy, and crude protein content, which supplies the dietary needs of animals (Corrales *et al.* 2015, Rubio *et al.* 2012, Rufino *et al.* 2011). However, its current use is limited due to the laborious process of harvesting and distribution of fruits. Nevertheless, the expansion of animal production, according to OCDE/FAO (2023) projections, will require greater availability of feed resources, which could make the commercialization of *Acrocomia aculeata*-based forages a key economic activity. To increase the economic revenue and shelving time of *A, aculeata* fruits, we propose transforming the pulp into processed foods, such as dry food or kibbles and fodder meals, which could also simplify its handling and transport.

The observed differences between Santander and Casanare in the use of *A. aculeata*, as revealed by the cluster analysis, underscore how regional socioeconomic and cultural contexts shape the management and valuation of this species. Although both regions acknowledge their multipurpose character, the prominence of food use in Santander reflects entrenched cultural traditions and local economic drivers like gastronomic tourism. In contrast, the greater relevance of animal feed use in Casanare aligns with the livestock-centered economy, demonstrating how livelihood strategies influence resource utilization.

The loss of use and knowledge of this palm was a topic of high relevance in the research, and the main categories of cause of loss of use reported here such as resource depletion, modernization and loss of traditions and knowledge, have also been documented in other studies on native palm species in Colombia (Ospina 2013). Although according to the Red List (2022), the palm is classified as Least Concern, in studies conducted in Casanare showed a differentiated population structure based on forest disturbance levels. In less disturbed forests, a higher density of individuals and an inverted "J" population structure were found, indicating constant natural regeneration; and in disturbed forests, the density was low, with no seedlings and few juveniles, suggesting a potential local extinction of *A. aculeata* (Lozano 2018). These findings, along with reports of declining numbers of individuals in areas where the species is predominantly used, raise concerns.

It is important to note that the degree and nature of these challenges vary across regions. In Casanare, the prominence of agriculture, crop cultivation, and petroleum oil extraction has driven significant land-use changes, increasing pressure on resources and contributing to the decline in palm population regeneration. In contrast, the cultural value of traditional products in Santander helps conserve knowledge about the use of these species. However, modernization and proximity to urban areas also drive the generational loss of traditional knowledge, as seen with other palm species in Colombia (Reyes-García et al. 2013).

One such potential application is oil extraction. Although this use had a low relevance in the current study, in countries such as Brazil, the oils extracted from the pulp and kernel of these fruits have great economic relevance, being highly valued by the cosmetics, food and fuel industries (Machado *et al.* 2015, Poetsh *et al.* 2012, Silva *et al.* 2020, Vianna *et al.* 2017). In Santander, oil production might compete with the preparation of chicha, as both rely on the same raw material. However, in Casanare, where fruit commercialization is minimal, the fruits could support oil extraction and animal feed production from residual cake, diversifying the uses of the palm and optimizing its economic exploitation.

It is important to note that participants recognized the potential of *Acrocomia aculeata* fruits for oil extraction but

highlighted the lack of efficient extraction methods as a limitation. Therefore, it is crucial to develop research to standardize these processes. Additionally, Casanare's position as one of the main producers of **African palm** in Colombia (López 2024) presents a significant challenge for the development of the *Acrocomia aculeata* oil market. However, given that the sustainable cultivation of **African palm** in Colombia and other neighboring countries is threatened by the bud rot disease caused by the fungus *Phytophthora palmivora* (Maizatul-Suriza *et al.* 2019, Gil *et al.* 2020), and that global vegetable oil production is projected to increase by 14% by 2050 (Meijaard *et al.* 2024), *Acrocomia aculeata* could hold a piece of this market. To achieve this, it is necessary to implement incentive programs that promote the use of native palms, giving *Acrocomia aculeata* a competitive advantage over **African palm** cultivation.

In addition to the economic importance of the fruits, other parts of the palm can be used without affecting fruit production and its derived products, maximizing their economic potential. For example, the buds of *A. aculeata* are used as brooms and hats, having commercial potential due to their fiber's biodegradability, quality and durability. However, the market for these products is currently low due to the preference for synthetic products. Despite this, trends are changeable, and can be influenced by several factors, such as sustainability movements (Bernal *et al.* 2010).

The commerce of wines made from stem sap extraction is also considered a potential market, since it is also used to treat gastrointestinal diseases as it contains probiotics, that improve the balance of the intestinal flora (Ambrocio-Ríos *et al.* 2021). Currently, due to the lack of technologies and protocols for its extraction, destructive extraction techniques are used. However, it has been documented that in other regions of the world, such as Asia, techniques have been developed to obtain the sap through the inflorescences (Bernal & Galeano 2015), which could allow obtaining the sap without compromising the other uses of the palm, thus preserving its integral economic value.

The multipurpose nature of *Acrocomia aculeata* and its promising market growth, reduces the risks associated with dependence on a single market. Consequently, this palm is considered a promising species for Colombia, reinforcing the importance of promoting its commercial development. However, it should be kept in mind that the market for these products is conditioned by the availability of resources. Therefore, to expand the market for existing products and promote new sectors, it might be necessary to migrate from wild harvesting systems to crops and agroforestry systems that allow for greater fruit production. The first step to achieving this goal is to conduct population studies, particularly in regions like Santander, where there is currently a lack of information. While Casanare has some studies on the species' population structure, much more research is needed to evaluate the viability of cultivation and sustainable management practices.

Conclusion

This study provides undocumented information on the use, management and marketing of *Acrocomia aculeata* in two Colombian regions where it is found in natural populations. In these regions*, A. aculeata* was described as a multipurpose species, with nine use categories identified in Casanare and seven in Santander, showing a cultural, social and economic importance that differs according to the region.

In Casanare, the palm is mainly used for domestic purposes, especially for human and animal nutrition. In contrast, in Santander, its use holds greater local economic significance, mainly in human food production. Despite its versatility, a decrease in the frequency and diversity of uses of this palm has been reported, due to diminishing resources, modernization and the loss of traditional knowledge. It is therefore important to address the challenges associated with the loss of use and to develop conservation strategies adapted to each region.

Although the palm exhibits significant economic potential, its market remains in an early stage of development. However, products such as chicha, animal feed, oils, fibers and wine have remarkable economic potential, positioning *Acrocomia aculeata* as a promising species. To promote market growth and integrate the palm into the national economy, programs for the selection, reproduction and cultivation of the species must be established. These initiatives would enhance and optimize fruit production, preserving its traditional and emerging applications. We recommend extending the study to other regions of the country, like the Caribbean and Antioquia, where the palm is also found in natural populations.

Declarations

List of Abbreviations: Not applicable.

Ethics approval and consent to participate: This study was developed in accordance with the Code of Ethics of the International Society of Ethnobiology (ISE), obtaining the informed consent of informed consent from all participants.

Consent for publication: Not applicable.
Originality: The submission has not been previously published, nor is it before another journal for consideration (or an explanation has been provided in Comments to the Editor). This document is not similar in content or details to any other articles the author(s) has already published or has under consideration. This document is not a review article but represents original creative thought.
Availability of data and materials: Data will be available from the corresponding author upon request.
Competing interests: The authors declare that there are no conflicts of interest.
Funding: This study was funded through Labex AGRO 2011-LABX-002, project number 2204-028, in the I-Site Muse framework, coordinated by Agropolis Fondation, the Institut de Recherche pour le Développement (IRD), and Vicerrectoría de investigación of the Universidad Militar Nueva Granada, project EXT-CIAS-3994.
Authors' contributions: Study design – TJT, CI. Information collection – DCG. Data analysis – DCG, CI. Paper writing – DCG, TJT, CI

Acknowledgements

We thank familia Alvarez and familia Plazas, particularly Daniel Plazas for their generous collaboration in Casanare. In Santander we thank Felipe Castaño at UIS and familia Parra Mojica, especially Margarita Mojica for their help. This work was funded by Labex AGRO 2011-LABX-002, project number 2204-028, in the I-Site Muse framework, coordinated by Agropolis Fondation. The Institut de Recherche pour le Développement (IRD) and the Vicerrectoría de investigación of the Universidad Militar Nueva Granada, project EXT-CIAS-3994 supported researchers' participation.

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Annex 1. Interview on the use of *Acrocomia aculeata* in two ecoregions of Colombia.

I authorize the researchers from the Universidad Militar Nueva Granada's Faculty of Basic and Applied Sciences, who are associated with the project " Ethnobotany of *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. in two ecoregions of Colombia" to interview me about the uses of the corozo palm (Acrocomia aculeata). I also authorize them to carry out the protocol of prior informed consent and anonymity of information.

Name: _____

ID: _____

Initial information

Date _____ GPS _____ N. _____

Municipality _____ Location _____

Name _____ Sex _____ Age _____

Time of residence in the municipality _____ Educational level _____

Occupation _____

Consumers

Common names of palm _____

What is palm used for? _____

_____

_____

Which part of the palm do the products come from? _____

_____

_____

Is its use current or past? _____

- If its use is in the past

What are the causes behind the loss of use? _____

_____

_____

- If its use is present

Where are these products sourced from? _____

Purchase quantity _____ Purchase frequency _____ Price _____

Do they carry out any type of processing? _____

What is this product used for? _____

_____

_____

At what frequency is it used? _____

Additional notes

Annex 2. Interview on the management and market of *Acrocomia aculeata* in two ecoregions of Colombia.

I authorize the researchers from the Universidad Militar Nueva Granada's Faculty of Basic and Applied Sciences, who are associated with the project " Ethnobotany of *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. in two ecoregions of Colombia" to interview me about the uses of the corozo palm (Acrocomia aculeata). I also authorize them to carry out the protocol of prior informed consent and anonymity of information.

Name: _____

ID: _____

Initial information

Date _____ GPS _____ N. _____

Municipality _____ Location _____

Name _____ Sex _____ Age _____

Time of residence in the municipality _____ Educational level _____

Palm activity ○ Harvester ○ Processor ○ Merchant

Working with this palm is your main occupation ○ Yes No, other occupations: _____

How much time do you spend working with this palm? _____

Years working with the palm _____

Range of total income _____

Income derived from the palm _____

Are you affiliated with any company, association, or community? _____

Marketing

What kind of products are sold? _____

Are these products in raw or processed form? ○ Raw ○ Processed

¿ From which part of the palm are the products derived? _____

Common names of palm _____

Where do you source the products? (homegrown/purchased) _____

* Where are the products purchased? _____

* Purchase price _____ Weekly purchase quantity _____

* What factors determine the amount purchased? _____

* Are there different quality classifications? Which category do you buy? _____

*What factor determines quality? _____

Maximum selling price _____ Minimum selling price _____

How are sales prices determined? _____

Where is the product sell? _____

What are regular buyers like? _____

What is the weekly sales quantity? _____

What is the peak selling season? _____

How are the products store? _____

Do you have to transport the products? How does it do it? _____

What are the uses of the products sold? _____

_____

_____

Is there a specific permit needed to conduct this activity? Which one? _____

How is the permit acquired? _____

Harvest

Source of plant material (location) _____

What parts of the palm are harvested? _____

Is a permit required to conduct this activity? Which one? _____

How is the permit acquired? _____

How is plant material harvested? – Methods and tools _____

_____

_____

_____

Why is this methodology employed? _____

Harvest time _____

Number of people involved in the harvest _____

Who are the individuals involved (workers, family members, etc.)? _____

What criteria do you use to decide the appropriate time for harvesting the palm? _____

_____

_____

_____

What are the harvest periods for the palm? _____

How frequently is a single palm harvested? _____

How many fruits are harvested each season? _____

Is there a selection method applied to the palms? Which one? _____

_____

_____

_____

Size of the harvest area _____

Number of individuals of *Acrocomia aculeata* in the area _____

Do you own the land at harvest? ○ Yes ○ No _____ Rental price _____

Are you involved in the cultivation of this palm? _____

Processing

Used part of the plant _____

Quantity of resource required for product manufacturing _____

What product is produced? How is the production process conducted? Description by step _____

_____

_____

_____

Production time _____

Quantity produced _____ Why? _____

Number of people participating in this stage _____

Who are the individuals involved (workers, family members, etc.)? _____

Is there a system for recording lots or batches? _____

Is a permit required to conduct this activity? Which one? _____

How is the permit acquired? _____

Additional notes