

Physical and nutritional assessment of fruits of *Acrocomia aculeata* (Jacq.) Lodd ex Mart. (Arecaceae) based on pulp color

Evaluación física y nutricional de los frutos de *Acrocomia aculeata* (Jacq.) Lodd ex Mart. (Arecaceae) con base en el color de la pulpa

Suelen Alves Vianna¹, Priscila Aiko Hiane², Mariana Nalesso Jordão²,
Eduarda Carneiro da Costa², Arnildo Pott³

Abstract

Harverters select fruits of the palm *Acrocomia aculeata* according to pulp color in order to manufacture particular products being this one of the most important characteristics of this fruit in the market. We conducted a study on the physical and chemical characteristics of pulp of *A. aculeata* of different colors. Pulp color was visually determined including the following colors: yellow, orange, white, brown and pink for the species. We observed a higher proportion of plants (34.3%) with yellow pulp. We did not detect significant differences in physical characteristics of equatorial length (cm), fresh mass of fruits (g), fresh mass of pulp (g) and pulp yield (%) among different pulp colors. We determined the components (g.100 g⁻¹) moisture, total fats, proteins, fibers, fixed mineral residues and caloric value (kcal.100g⁻¹) of pulps with different colors. Fruits with yellow pulp presented higher fat content (17.5±2.9 g.100 g⁻¹) and, consequently, higher caloric value (249.4±30.3 kcal.100g⁻¹). Ash content was significantly higher in the white pulp (3.17 g.100g⁻¹), compared with other colors. Pulp color does not influence quality, but can be chosen to improve or make the final product more attractive. We confirm the nutritive potential of this native palm.

Keywords: Extractivism, Native fruit, Natural food, Nutrient source, Palm, Plant resource.

Resumen

Se recolectan los frutos de la palma *Acrocomia aculeata* de acuerdo con el color de la pulpa para fabricación de productos, siendo el color la característica más importante en su mercadeo; por esta razón se realizó un estudio de las características físicas y químicas de la pulpa con diferentes colores. Los colores se determinaron visualmente incluyendo los siguientes: amarillo, naranja, blanco, marrón y rosa para la pulpa de los frutos de la especie. Se observó una mayor proporción de plantas (34,3%) con la pulpa de color amarillo. Entre sus diferentes colores no se detectaron diferencias significativas en las características físicas de longitud ecuatorial (cm), la masa de las frutas frescas (g), masa fresca de la pulpa (g) y el rendimiento de la pulpa (%). Se determinaron los componentes (g.100 g⁻¹) de humedad, grasas totales, proteínas, fibras, residuo mineral fijo y valor calórico (kcal.100g⁻¹) de pulpas con diferentes colores. Las frutas con pulpa amarilla presentaron mayor contenido de grasa (17,5±2,9 g.100 g⁻¹) y en consecuencia, un mayor valor calórico (249,4±30,3 kcal.100g⁻¹). El contenido de cenizas fue significativamente mayor en la pulpa blanca (3,17 g.100g⁻¹), en comparación con otros colores. El color de la pulpa no influyó sobre la calidad, pero el color elegido puede hacer el producto final más atractivo. Se confirmó el potencial nutritivo de esta palmera nativa.

Palabras clave: Comida natural, Extractivismo, Fruta nativa, Fuente de nutrientes, Palma, Recurso vegetal.

¹ Programa de Pós-Graduação em Agricultura Tropical e Subtropical com ênfase em Genética, Melhoramento e Biotecnologia Vegetal, Instituto Agronômico (IAC), Campinas, São Paulo, Brasil. e-mail: suelen.loesch@gmail.com

² Departamento de Tecnologia de Alimentos e Saúde Pública, Universidade Federal do Mato Grosso do Sul, Campo Grande, Mato Grosso do Sul, Brasil.

³ Departamento de Biologia. Programa de Pós-Graduação em Biologia Vegetal, Universidade Federal do Mato Grosso do Sul, Campo Grande, Mato Grosso do Sul, Brasil.

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Figure 1. A. Natural population of *Acrocomia aculeata* in the região of Corumbá, MS, Brazil. B. Fruit bunches. C. Fruit in cross-section showing peel (epicarp), pulp (mesocarp), stone (endocarp) and nut (seed).

Photos: Arnildo Pott (A), Suelen Alves Vianna (B,C).

Introduction

Palms (Arecaceae) are among the plants which most serve to people due to their versatility and diversity of uses. Practically all parts of the palms are useful, ranging from food to medical uses, with great economic importance (Ellison 2001), providing abundant resources for several peoples (Balick and Beck 1990). They are the plants which best characterize landscapes, among species of tropical and subtropical regions. Palms have the highest morphologic diversity within the Monocotyledons (Uhl and Dransfield 1987), and nowadays they are represented by c. 2,700 species distributed in more than 240 genera (Lorenzi et al. 2010).

The palm *Acrocomia aculeata* (Jacq.) Lodd. ex Mart. has a wide distribution and can be found in the tropical and subtropical America, from southern Mexico to northern Argentina (Henderson et al. 1995). It is evergreen, heliophyte, monoecious, 4 to 15 m tall, being easily recognized for its stipe covered with spines. The fruit is a drupe, with stony endocarp (Henderson et al. 1995, Almeida et al. 1998, Moraes 2004, Lorenzi et al. 2010) (Figure 1). In general, it flowers and fructifies year round, with higher intensity in the rainy season, the first fruit set occurring around the fourth or fifth year after germination (Almeida et

al. 1998). Because of its wide geographical distribution, the phenology varies according to the region.

The common name of the species varies according to the region of occurrence, being known in Brazil mainly as «macaúba», country in which it is also called «mucajá», «coco-de-catarro», «chicle-te-de-baiano», «bocaiúva», among others. It is also called «mbocayá» in Argentina, «totaí» in Bolivia, «corozo» in Colombia and Venezuela, «tamaco» in Colombia, «corosse» in Haiti, «coyol» in Costa Rica, Honduras and in Mexico, in France «noz de coyol», in Spain «amankayo» and other names, and in Germany «coyoli Palme» (Almeida et al. 1998, Carvalho et al. 2011, Hernández et al. 2011).

Acrocomia aculeata is a palm of multiple uses, since all its parts can be utilized. In Brazil, the leaves are used as good forage (Santos et al. 1997), source of textile fiber for confection of hammocks and fishing lines, handicrafts and cover and/or to build houses (Nucci 2007). The stem can be utilized as poles and to build fences. The endocarp (stone) has been used to replace gravel in concrete or for production of good quality charcoal (Toledo 2010). The nut gives excellent oil, equivalent to olive oil, that can be utilized either as human food or to manufacture cosmetics, waxes and other products. In Central American countries it is common the fermentation of the sap from the

stem to produce an alcoholic drink known as «vino de coyol» (Balick and Beck 1990, Lentz 1990). In Mexico, a liqueur called «taberna» is made from it (Hernández *et al.* 2011). In addition, the whole fruit can be used in the preparation of a dessert, just peeled. There are reports of its use in Brazil for medicinal purposes, as strengthener (pulp), as painkiller (pulp oil), and as laxative (nut oil). In the same way it is used in Mexico against worms (nut) and diabetes (root infusion) (Hernández *et al.* 2011).

With regard to the pulp, it can be consumed fresh or processed as flour, ice cream, cakes and other food items (Vianna *et al.* 2012, Hernández *et al.* 2011, Ramos *et al.* 2008). There is a growing interest represented by an also higher number of studies regarding composition of its oil for application as biofuel.

A large variation in size, weight, color of the peel and color of the pulp have been reported by the harvesters of fruits of *A. aculeata* at the municipality of Corumbá, MS, Brazil, region of the Pantanal wetland. In this region, the fruits are collected by small rural

producers, who sell the pulp or the flour made out of this, a typical regional product (Figure 2). Harvest is mainly based on pulp color, since the final product is differentiated according to that. In general, fruits with pulp of orange tones look more attractive and, therefore, are sold as frozen or dehydrated pulp for consumption *in natura* and for ice cream, and those of yellow color are mainly used to prepare flour.

Although there are available reports on the nutrient composition of the *Acrocomia* species (Hernández *et al.* 2011, Ramos *et al.* 2008, UNICAMP 2011), very few studies relate the nutritional attributes of the fruits and the diversity of colors observed among them. Rural extractivist communities use to associate the highest oil contents to fruits of yellow or orange pulp color. Berton (2013) found values of oil concentration above 70% for fruits with orange pulp. Given the importance of pulp color for extractivist, we study the physical characteristics and of the centesimal composition of fruits of *A. aculeata* with different pulp colors, in order to verify the existence



Figure 2. A. Pulp of fruits of *Acrocomia aculeata* being sun dried by an extractivist of the region of Corumbá, MS, Brazil, B. Wooden mortar and pestle with the pulp being ground to flour, C. Commercial flour.

Photos: Arnildo Pott (A), Suelen Alves Vianna (B,C).

of chemical compounds or physical factors influencing the quality of the final products. We hope that our analysis will help to determine those characteristics associated with the most appropriate fruits for harvest and processing. Another relevant factor to keep in mind is that due to its wide geographic distribution and adaptability, the species is an alternative of economical exploration for low income people or also for large commercial crops, not only in Brazil.

Methodology

Sampling area. Considering the great economic potential of the species, our study was undertaken in three areas situated on the Western edge of the Pantanal wetland, at the municipality of Corumbá, Mato Grosso do Sul, Brazil. There are large natural populations of the species used by local people working on extracting and processing of the pulp. The study area is disturbed, with secondary vegetation, predominantly *Urochloa* spp. grasslands for cattle. Soils are mainly clayey and calcareous, fertile, but shallow (Cardoso *et al.* 2002), often unsuitable for crops. The climate of the region according to Köppen-Geiger classification is type Aw-tropical, megathermal, with seasonal annual rainfall of 1,070 mm (Cadavid-Garcia 1984; Soriano 1997)).

Sampling and characterization of fruits. We selected 70 plants with fruits showing differentiated pulp colors, at ripening stage, as indicated by fruit drop on the ground. We harvested two bunches per plant for the analyses.

We counted all fruits on each collected bunch, and then we removed 50 fruits at random from each bunch, weighed them on a precision scale and measured them for polar length (cm) and equatorial width (cm) using a caliper and visually determined pulp color.

Centesimal composition of the pulp. In addition to the fruits used for physical characterization, we removed 100 fruits from each bunch, then manually peeled and pulped them. The pulp was homogenized in a food processor, packed and stored at -20°C until the onset of the chemical analyses (Ramos *et al.* 2008). For analyses, the homogenized pulp of each fruit lot was dried in a forced air oven at 40°C and ground in Tecnal mill mod TE 631.

For analysis of centesimal composition of the

samples, we followed methods described in the analytic rules of Instituto Adolfo Lutz (Ministério da Saúde 2005). The determination of moisture was performed by desiccation in oven at 105°C (gravimetric method), the total fat content was determined by the method of direct extraction with organic solvent in Soxhlet extractor, ashes (fixed mineral residue) determined by burning in muffle oven at 550°C (gravimetric method), and carbohydrates evaluated by the method of Lane-Eynon (reduction method). The protein content was determined by total nitrogen content (%), after the method of microKjeldahl, using the factor 6.25 for conversion of nitrogen in protein, described by the Association of Official Analytical Chemists (AOAC) (1992). Fiber was obtained by difference between 100 g and the total grams (%) of moisture, protein, fats, ashes and carbohydrates (Ramos *et al.* 2008).

Total energy from nutrients was expressed in kilocalories (kcal), estimated by conversion factors of Atwater:

$$\text{kcal} = (4 \times \text{g protein}) + (4 \times \text{g carbohydrates}) + (9 \times \text{g fats}) \text{ (Ramos et al. 2008).}$$

Statistical analyses. The independent and nominal sampling data were submitted to qui-square (X^2) test aiming to verify the existence or not of association among the variables of quantity and pulp color (Zar 1999). The results of physical characteristics and nutritional composition were statistically analyzed using ANOVA with post-Tukey test at 5%, for detection of difference among groups of fruits with different color.

Results and discussion

Physical characteristics of the fruits. After observations and dialogue with extractivists, we determined five colors of pulp of *A. aculeata*: yellow, pink, brown, white and orange, observing (but not evaluated variation) tones within those colors, e.g., dark and light yellow (Figure 3). We point out that these colors were determined on fruits harvested from bunches which presented fruit dropping (sign of ripening), therefore the colors were not influenced by degree of ripeness.

We observed that 34.3% of the analyzed plants presented fruits with yellow pulp, followed by plants

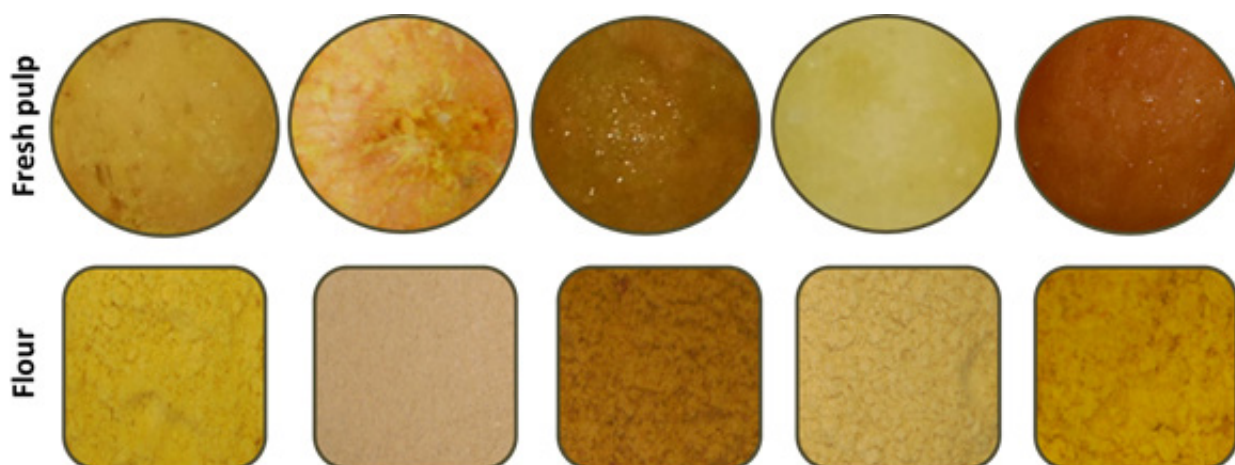


Figure 3. Colors of pulp of *Acrocomia aculeata* and its respective flours: yellow →pink →brown →white →orange (from left to right).

with orange pulp (30%), plants with fruits of brown pulp (17.1%), white pulp (10%) and pink pulp (8.6%). The herein observed diversity of the assessed pulp colors as well as the previously reported variation in pulp color demonstrates a high intra and inter population variability of this characteristic in this palm species. Besides pulp color, *A. aculeata* presents high variation in other parameters (plant height, absence of spines, etc.) that can be selected and used in breeding programs aiming to increase productivity and quality of the final product.

Reports made in other regions confirm the existence of a diversity of pulp colors within and among populations of *A. aculeata*. However, fewer colors, e.g., Silva (2009) qualified as whitish for the fruits sampled in the State of Minas Gerais. Azevedo Filho *et al.* (2009) described the mesocarp color, of fruits collected in the States of Minas Gerais and São Paulo, in three yellow tones (light, medium and dark) and white.

Regarding the evaluated physical parameters, we

did not find significant differences among fruits with different pulp colors (Table 1), suggesting that pulp color does not influence fruit biometry, consequently not altering pulp yield. The X^2 test demonstrates that there was no significant association between pulp color and quantity (pulp weight), ($p=0,179$).

Regardless color, the contribution of the pulp presents a good yield for culinary preparations and as well as a source of potentially nutritive food (53.4% in average), similar to the value determined by Ramos *et al.* (2008) (44.2%).

Centesimal composition. Although not statistically supported, we observed differences in lipid content and consequently total caloric value (TCV) among the different pulp colors. The highest lipid content (17.53 ± 2.89 g.100 g⁻¹) and TCV (249.38 ± 30.28 kcal.100g⁻¹) were found in yellow pulp fruits, and the lowest oil content (8.56 ± 2.33 g.100 g⁻¹) and TCV (167.19 ± 24.67 kcal.100g⁻¹) were associated with pink pulp fruits (Table 2).

Remarkably, the lowest TCV determined in our

Table 1. Physical characteristics of fruit and pulp of *Acrocomia aculeata* with different pulp colors

Pulp color	Equatorial width (cm)	Fresh mass (g) of fruit	Fresh mass (g) of pulp	Contribution of pulp (%)
Yellow	2.77±0.06	15.88±0.84	9.47±0.73	59.30±2.90
White	2.75±0.06	15.25±1.43	7.19±1.12	46.16±4.65
Orange	2.66±0.15	14.65±0.83	8.39± 0.79	55.20±2.83
Brown	2.73±0.10	14.95±1.2	8.37±0.88	54.34±2.61
Pink	2.77±0.07	15.03±1.92	7.93±1.34	51.98±3.00
Mean	2.74	15.15	8.27	53.40

Mean± Standard error of the mean. The evaluated data did not show significant difference among fruits with different pulp colors ($p>0.05$).

Table 2. Centesimal composition of pulp with different colors of *Acrocomia aculeata* expressed in g.100 g⁻¹ of fresh sample

Components	Yellow	Orange	Brown	White	Pink
Moisture	45.16 ^a ±5.94	48.17 ^a ±5.41	49.25 ^a ±5.20	45.01 ^a ±0.91	53.61 ^a ±3.05
Ashes	2.16 ^a ±0.17	2.04 ^a ±0.10	2.35 ^a ±0.24	3.17 ^b ±0.05	2.54±0.16
Total fats	17.53 ^a ±2.89	14.22 ^a ±2.14	13.98 ^a ±2.79	14.12 ^a ±2.60	8.56 ^a ±2.33
Proteins	2.92 ^a ±0.24	2.62 ^a ±0.21	2.61 ^a ±0.26	2.09 ^a ±0.06	2.45 ^a ±0.07
Carbohydrates	19.96 ^a ±1.82	19.98 ^a ±2.46	18.19 ^a ±2.23	20.28 ^a ±1.43	20.10 ^a ±0.86
Fiber*	12.65 ^a ±1.38	12.98 ^a ±1.18	13.62 ^a ±1.22	15.34 ^a ±0.28	12.76 ^a ±0.05
TCV** (kcal.100g ⁻¹)	249.38 ^a ±30.28	218.43 ^a ±28.28	207.64 ^a ±30.37	216.52 ^a ±17.98	167.19 ^a ±24.67

Mean± Standard error of the mean. ANOVA with post-Tukey test at 5%. Same letters in the line do not differ (p>0.05).

* Fiber by difference. ** Total calorific value.

work (167.19 kcal.100g⁻¹ – pink pulp), has an energetic potential value nearly three times higher than the one reported for the pulp of the «Açaí» (*Euterpe oleracea* Mart. 58 kcal.100g⁻¹), and twice as high as the one found in the pulp of the «Buriti» (*Mauritia flexuosa* L. f. 85.9 kcal.100 g⁻¹) (UNICAMP 2011, Ramos et al. 2008), two of the most consumed palms in Brazil.

Such energetic potential, which is estimated under cultivation as 4,966 L.ha.year⁻¹, besides being used as food, arouse interest for its utilization as biofuel, with much higher yield than other crops commonly utilized for such purpose, e.g., soybean (*Glycine max* (L.) Merr.), sunflower (*Helianthus annuus* L.) and castor oil (*Ricinus communis* L.), that produce 420, 890 and 1,320 L.ha.year⁻¹, respectively.

We only verified significant differences among different pulp colors for «fixed mineral residue» (ashes), with an ash content higher in fruits with white pulp (3.17 g.100g⁻¹) (Table 2).

The nutritional composition shown in our work for *A. aculeata* fruits (with pulp of all colors), agrees with the recommended daily ingestion of fiber and carbohydrates and is in pace with the acceptable range of daily fat intake in human diet (National Academies Press 2002/2005, Ministério da Saúde 1998).

Considering that the species is native in the region and can be easily found in large natural populations, our study shows the potential of *A. aculeata* as a promising source of for nutritional and technological products, that can make a difference for rural communities economy and quality of life of the people involved in extractivism or cultivation.

Conclusions

The fruit *A. aculeata* presents a good pulp yield, demonstrating to be a good candidate to be used for culinary preparations, technological uses, and as source of nutritive food, independently of its color. Although extractivists select *A. aculeata* fruits for pulp color, we show that there is no significant difference for the majority of the nutritional components among fruits with different pulp color; hence, any pulp color can be used for fabrication of flour or any other product without loss of the final quality. Nevertheless the colors can be chosen in order to improve the final product or to make its visual aspect more attractive.

In view of the diversity of existing carotenoids, and that they among other factors are responsible for fruit color, plus being important compounds for human health, we suggest research on composition of carotenoids considering different pulp colors of *A. aculeata*.

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