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Original Article

Biometric aspects of fruits and seeds and determination of the absorption curve of *Hymenaea martiana* Hayne seeds

Aspectos biométricos de frutos e sementes e determinação da curva de absorção em sementes de *Hymenaea martiana* Hayne

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Abstract

The biometric differences between fruits and seeds are useful characteristics that can provide important data for the investigation and preservation of the species and may be linked to environmental and genetic influences. In this sense, considering the importance of this species and the need for conservation, the objective was to carry out physical characterization of the fruits and seeds of *Hymenaea martiana* as well as to determine the seed imbibition curve. The experiment was conducted at the Seed Analysis Laboratory at the Agricultural Sciences Center at the Federal University of Paraíba in Areia, PB. The evaluations carried out were as follows: biometry of fruits and seeds, number of seeds per fruit, colorimetry of fruits and seeds, percentage of damaged seeds, weight of a thousand seeds, seed water content, mass and imbibition curve. The biometric data were subjected to descriptive analysis to determine the minimum, maximum, average value, standard deviation, asymmetry, and kurtosis of the fruits and seeds. In terms of the biometric characteristics of the fruits and seeds of *H. martiana,* there was a marked variation, with average fruit lengths of 90.28 mm, widths of 46.83 mm, thicknesses of 34.69 mm, weights of 65.86 g and four seeds per fruit. The average length, width, thickness and weight of the seeds were 23.75 mm, 18.34 mm, 12.71 g and 4.13 g, respectively. The fruits were darker than the seeds, and both the fruits and seeds had red tones. Compared with nonscarified seeds, scarified seeds absorb a greater amount of water.

Keywords: imbibition curve, jatobá, morphobiometry, forest seed.

Resumo

As diferenças biométricas entre frutos e sementes são características úteis que podem fornecer dados importantes para a investigação e preservação da espécie, podendo estar vinculadas a influências ambientais e genéticas. Neste sentido, considerando a importância dessa espécie e a necessidade de conservação, objetivou-se realizar a caracterização física dos frutos e sementes de *Hymenaea martiana*, bem como determinar a curva de embebição das sementes. O experimento foi conduzido no Laboratório de Análise de Sementes, do Centro de Ciências Agrárias, da Universidade Federal da Paraíba, em Areia - PB. As avaliações realizadas foram as seguintes: biometria de frutos e sementes, número de sementes por frutos, colorimetria dos frutos e sementes, porcentagem de sementes danificadas, peso de mil sementes, teor de água das sementes, massa e curva de embebição. Os dados biométricos foram submetidos à análise descritiva para determinação do valor mínimo, máximo, médio, desvio padrão, assimetria, curtose dos frutos e sementes. Nas características biométricas de frutos e sementes de *H. martiana* houve variação acentuada, cujos valores médios dos frutos foram de 90,28 mm para o comprimento, 46,83 mm de largura, 34,69 de espessura, peso de 65,86 g e quatro sementes por fruto. Quanto as sementes, os valores médios foram de 23,75 mm, 18,34 mm, 12,71 e 4,13 g para o comprimento, largura, espessura e peso, respectivamente. Em relação a coloração, foi observado que os frutos são mais escuros que as sementes, e que tanto os frutos quanto as sementes têm tonalidades voltadas para o vermelho. As sementes escarificadas absorvem maior quantidade de água se comparadas as sementes não escarificadas.

Palavras-chave: curva de embebição, jatobá, morfobiometria, semente florestal.

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1. Introduction

The genus *Hymenaea*, belonging to the Fabaceae family, occurs in practically all biomes in Brazil, with the exception of Pampa, and includes 18 species, 12 of which are endemic (Pinto et al., 2020a). The species *Hymenaea martiana* Hayne can be found in the Caatinga, Cerrado and Atlantic Forests. It has an arboreal size, with heights varying from 8 to 18 meters. It is considered a secondary, heliophytic, selective hogrophyte plant characteristic of Caatinga areas with humid floodplains and clayey soils (Lorenzi, 2009; Pinto et al., 2020b). This species is widely used in popular medicine and has antinociceptive and anti-inflammatory properties (Pacheco et al., 2022).

Wood from species of this genus has a high economic value and can be used in civil construction due to its resistance and high durability (Silva et al., 2017b), in addition to being important in afforestation procedures and recovery of degraded areas impacted by activities. anthropogenic (Motta et al., 2019). Farinaceous pulp that covers seeds can enrich products prepared with flour, such as cakes, breads and biscuits, and can contribute to disease prevention through its medicinal properties (Leite et al., 2017).

Knowledge about the physical characterization of fruits and seeds is useful for differentiating species belonging to the same genus (Santos et al., 2018), facilitating the discovery of genetic diversity in populations of the same genus and the relationship with environmental factors, as well as the development of environmental restoration operations (Souza et al., 2017).

In addition to helping to differentiate species within the same genus, biometrics can also be used to classify seeds by size and to understand ways to overcome dormancy, which can be very useful in exploring species and maximizing their economic benefits (Silva et al., 2017a; Araújo et al., 2014).

Some forest seeds, such as *H. martiana*, exhibit dormancy characterized by delays in germination; even in environments with adequate light, temperature, humidity and oxygen, the seeds cannot germinate normally, and this event is common in several species of trees. temperate, tropical and subtropical climates (Motta et al., 2020). Seed germination is one of the most important physiological processes for the perpetuation of species (Ribeiro, 2019), in which, from the beginning of water absorption, seeds reactivate their basal metabolism, use their stored energy reserves and carry out several metabolic processes during imbibition that together result in germination (Marcos-Filho, 2015; Torres et al., 2020).

The imbibition curve occurs through a three-phase pattern, in which during phase I, there is rapid reactivation of water absorption in viable and nonviable seeds; in phase II, there is an induction of growth, in which the osmotic potential and pressure potential increase; and in phase III, there is protrusion of the primary root, indicating the beginning of visible germination (Pimenta et al., 2014). Therefore, it is important to follow each stage of the seed imbibition curve because identifying physical dormancy due to integumentary water impermeability is enlightening (Guollo et al., 2016).

Considering the importance of this species and the need for conservation, the objective of this work was to carry out the physical characterization of the fruits and seeds of *H. martiana* as well as to determine the seed imbibition curve.

2. Materials and Methods

2.1. Fruit collection and experimental location

The fruits of *H. martiana* were collected ripe, characterized by a dark brown epicarp, from matrices located in the municipality of Areia, PB (6° 58'12'S and 35° 42' 15'W), at altitudes varying between 400 and 600 m, an average annual temperature of 22 °C, and a relative humidity of approximately 85% (Azevedo, 2017).

After collection, the fruits were packed in nylon bags and transported to the Seed Analysis Laboratory of the Federal University of Paraíba, Center for Agricultural Sciences, in the city of Areia-PB, where the experiment was conducted.

2.2. Evaluated characteristics

2.2.1. Fruit and seed biometrics

To determine the biometrics of the fruits, 400 units were used, and the length (measured from the base to the apex), width (from the largest horizontal end) and thickness (from the smallest horizontal end) were measured with the aid of a digital caliper with an accuracy of 0.01 mm. The fruits were subsequently weighed on an analytical balance with an accuracy of 0.001 g. After weighing, the fruits were broken with the aid of a wooden stick, and the number of seeds per fruit was counted.

Seed processing was carried out with the aid of a knife to remove excess pulp and subsequent immersion in water for 30 minutes to facilitate the extraction of the floury pulp, followed by washing and slight friction with damp sponges to completely remove the pulp from the seeds. and were placed on trays and left at room temperature to dry.

Seed biometry was performed based on length, width and thickness using a digital caliper, with results expressed in mm. In addition, the seeds were weighed on an analytical balance, and the values are expressed in grams. For these evaluations, 400 seeds were used.

2.2.2. Colorimetry of fruits and seeds

The color of the fruits and seeds was determined with a Konica Minolta colorimeter, model CR-10, which was pressed in such a way as to maintain firm contact with the surface of the fruit and seed. Color determination by the CIE system provides three coordinates, L^*, a^* and b^*, which allow the observer to accurately determine the color of the object under study. The L^* coordinate refers to the luminosity level, and from the relationship between the values of a^* and b^*, the chromaticity was obtained, which is represented by the hue angle (°h*) (Pinheiro, 2009).

2.2.3. Percentage of damaged seeds

The percentage of seeds damaged by insects was determined by manual counting of a sample of 100 fruits and an equal number of seeds. The seeds damaged by insects were those with holes, indicating the presence of adults or larvae inside.

2.2.4. Moisture content

The determination of water content was carried out in four repetitions of ten seeds, adopting the oven method at 105 ± 3 °C, for 24 hours, according to Brasil (2009), with seeds without scarification and scarified on the side opposite the hilum.

2.2.5. Weight of a thousand seeds

To determine the weight of a thousand seeds, eight repetitions of 100 seeds each were used, and the seeds were weighed on an analytical balance with a precision of 0.001 g (Brasil, 2009).

2.2.6. Determination of the water absorption curve

The curve was determined using four replications of 25 seeds, with and without scarification in the region opposite the hilum, which were immersed in a Becker with a capacity of 100 mL containing distilled water and subsequently placed in a biological chamber. The oxygen demand (B.O.D.) was regulated at 25 °C. The water absorption level was measured at the following intervals: 0, 2, 4, 6, and 8, 10, 12, 24, 48, 72, 96, 120, 144, 168, 192, 216, 240, 264, 288, 312, 336, 360, 384, 408 and 432 hours.

At the end of each period, the seeds were removed from the beaker, dried with a paper towel and weighed, and the wet weight was obtained. The water content absorbed at each time point was calculated by the following expression:

$$\% of\ water\ absorbed = \frac{Fw - Iw}{Iw} \quad (1)$$

where Iw corresponds to the initial weight and Fw to the final weight of the seeds at each time.

2.3. Statistical analysis

A descriptive analysis was carried out on the physical data to determine the minimum, maximum, average value, standard deviation, asymmetry and kurtosis of the fruits and seeds. The reference values adopted for the asymmetry coefficient were as follows: S < 0, asymmetric distribution to the left; and S > 0, asymmetric distribution to the right. The kurtosis coefficients were K > 3 (leptokurtic), a distribution that is more "tapered" than abnormal, and K < 3 (platykurtic), a distribution that is flatter than normal, according to Silva et al. (2007). The software used for the analyses was SISVAR (Ferreira, 2014).

3. Results

According to the descriptive analysis of the data, the average length of *H. martiana* fruits was 90.28 mm, with values varying from 45 to 160 mm, while their width varied from 19.70 to 73.80 mm, with an average value of 46.83 mm, while the average thickness value was 34.69 mm, with maximum and minimum values of 51.59 and 21.20 mm, respectively (Table 1).

Regarding fruit weight (Table 1), the average, minimum and maximum values obtained were 65.86, 16.68 and 204.18 g, respectively, and the number of seeds per fruit varied from 1 to 12 seeds, with an average value of 4 seeds.

The coefficients of variation (Table 1) indicate that for length (23.79%), width (17.94%) and thickness (15.32), the lowest values occurred and were considered more homogeneous, while for weight and number of seeds per fruit, the values were greater (49.24 and 60.42%, respectively), indicating heterogeneity in the data and highlighting the high genetic variability of these characteristics.

Analysis of the symmetry data (Table 1) revealed that the distribution in the fruits was asymmetrically positive, indicating that the fruits were separated, with values close to the maximum. The values of fruit kurtosis were close to or greater than three, indicating that the frequency distribution was platykurtic.

The majority of fruits (44.0%), in terms of length, belonged to the frequency class of 79.5 to 102.5 mm (Figure 1A); in terms of width, 47.75% belonged to the distribution class of 35.9 to 46.7 mm (Figure 1B); in terms of thickness, 35% were in the classes from 10.3 to 13.9 mm (Figure 1C); and for fruit mass, 21.75% were in the distribution class from 72.9 to 110.4 g (Figure 1D). For the distribution of the number of seeds per fruit, 41% of the fruits had 2 to 4 seeds (Figure 1E).

Table 1. Descriptive analysis of the physical data of the fruits of *Hymenaea martiana* collected in the city of Areia-PB.

Statistical parameters	Variables				
	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)	NS
Minimum	45.0	19.70	21.20	16.68	1.0
Maximum	160.0	73.80	51.59	204.18	12.0
Average	90.28	46.83	34.69	65.86	4.2
Standard deviation	21.48	8.41	5.31	32.43	2.5
CV(%)	23.79	17.94	15.32	49.24	60.4
Asymmetry	0.66	0.48	0.11	1.26	1.2
Kurtosis	3.36	3.52	2.92	4.57	3.8

Legend: coefficient of variation (CV); number of seeds per fruit (NS).

Regarding the evaluated characteristics of *H. martiana*, the average length was 23.75 mm, with values ranging from 13.10 to 32.80 mm for the minimum and maximum lengths, respectively. The width varied from 10.03 to 24.64 mm, with an average of 18.34 mm, while the thickness varied from 4.91 to 23.00, with an average of 12.71 mm. For the weight variable, the average value obtained was 4.13 g, with values of 0.45 and 7.68 g for the minimum and maximum values, respectively (Table 2).

When analyzing the seed symmetry data (Table 2), for most variables, the distribution was negatively skewed, meaning that the values were close to the minimum. The kurtosis values were close to or greater than three, indicating that the frequency distribution was platykurtic.

The frequency distribution of *H. martiana* seeds (Figure 2) revealed that 48.5% of the H. martiana seeds were 22.9 to 26.9 mm long (Figure 2A). In terms of width, 44.25% of the DEGs were distributed from 17.3 to 20.2 mm (Figure 2B); in terms of thickness, 35.0% were distributed from 10.3 to 13.9 mm (Figure 2C). For seed weight, 42.0% were concentrated in the distribution class of 4.1 to 5.5 g (Figure 2D).

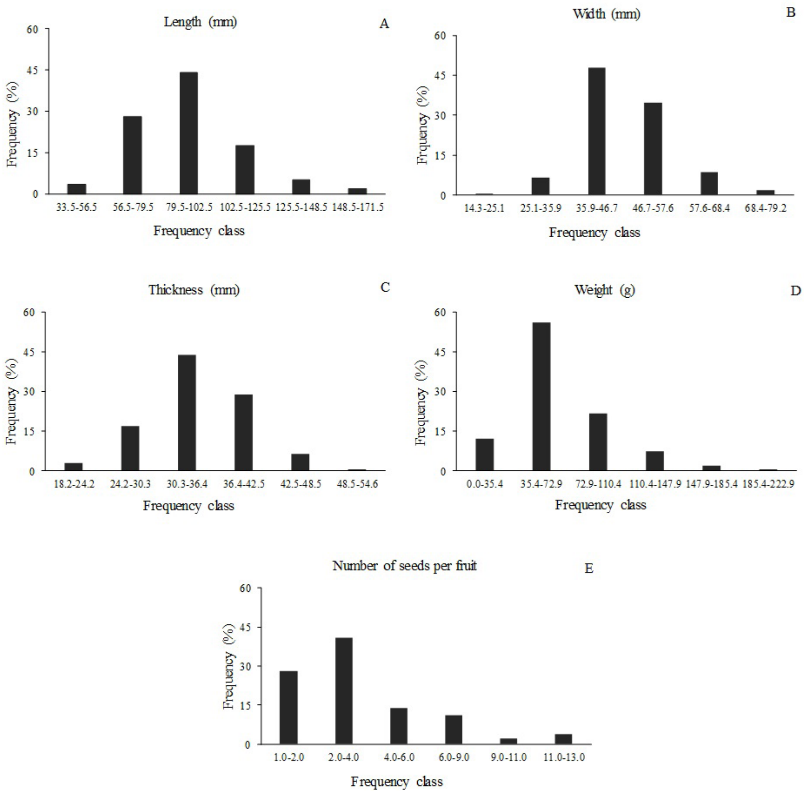

Figure 1. Frequency distribution classes for length (A), width (B), thickness (C), weight (D) and number of seeds per fruit (E) of *Hymenaea martiana*.

Table 2. Descriptive analysis of physical data from seeds of *Hymenaea martiana* collected in the city of Areia-PB.

Statistical parameters	Variables			
	Length (mm)	**Width (mm)**	**Thickness (mm)**	**Weight (g)**
Minimum	13.10	10.03	4.91	0.45
Maximum	32.80	24.64	23.00	7.68
Average	23.75	18.34	12.71	4.13
Standard deviation	3.03	2.74	3.72	1.38
CV(%)	12.77	14.95	29.27	33.45
Asymmetry	-0.21	-0.51	0.49	-0.21
Kurtosis	3.55	3.25	2.88	2.82

Legend: coefficient of variation (CV).

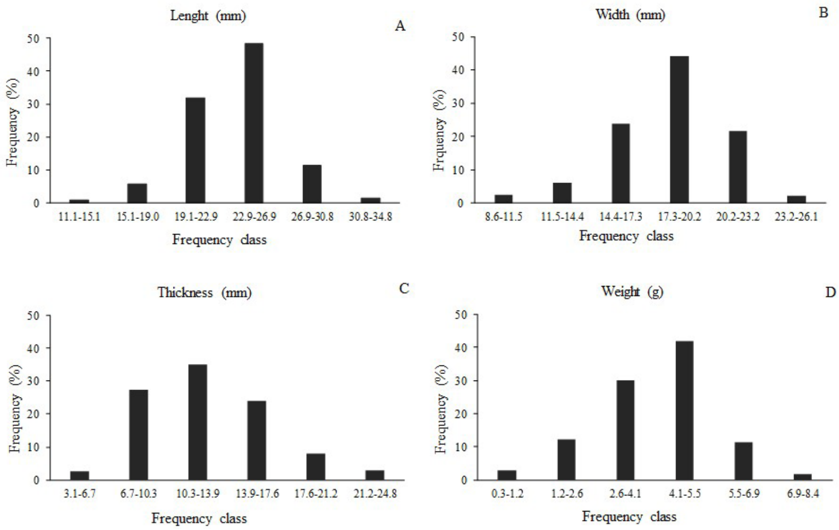

Figure 2. Frequency distribution classes for length (A), width (B), thickness (C) and weight (D) of *Hymenaea martiana* seeds.

Table 3. Colorimetry of fruits and seeds of *Hymenaea martiana* collected in the city of Areia-PB.

Variables	Fruits	Seeds
L	23.35	28.88
C	14.20	19.77
°h	36.75	41.64

Legend: luminosity (L), chromaticity (C), Hue angle (°h).

Table 4. Percentage of damaged seeds and weight per thousand of *Hymenaea martiana*.

Damaged seeds (%)	Weight of a thousand seeds (g)
10.48	422.65

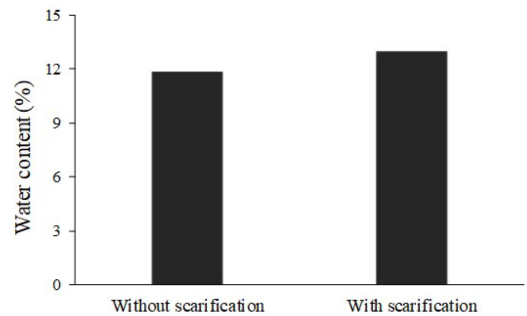

Figure 3. Water content of seeds of *Hymenaea martiana* with scarification and without scarification.

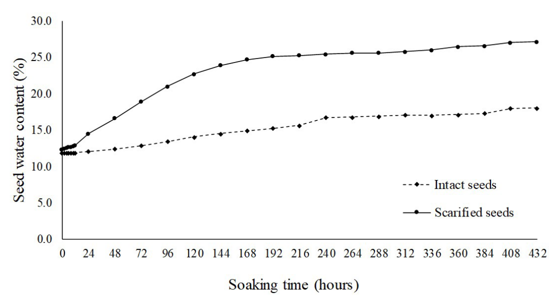

Figure 4. Water absorption curve by unscarified (A) and scarified (B) seeds of *Hymenaea martiana*.

In colorimetry (Table 3), the L value corresponds to luminosity, for fruits, the average luminosity was 23.35, while for seeds, it was 28.88. For chromaticity (C), the values obtained were 14.20 and 19.77 for fruits and seeds, respectively. The value obtained for the hue angle (°h) for the fruit was 36.75, while for the seeds, it was 41.64

Larvae and insects were observed in the fruits, which contributed to a damaged seed percentage of 10.48% (Table 4). The weight of a thousand seeds was 422.65 g.

The water content of *H. martiana* seeds (Figure 3) without scarification was 11.81%, while in scarified seeds, the value obtained was 12.95%,

The water absorption curve of *H. martiana* seeds without scarification demonstrated a small variation in water content as a function of soaking time, in which the initial water content increased from 11.8% to 18.4% after 432 hours of imbibition (Figure 4).

Analysis of the evolution of the water absorption process by the seeds of scarified *H. martiana* revealed an increase over the 432 h of evaluation, with an initial water content of 12.3%, reaching 24.7% after 168 h of soaking, the moment at which the seeds passed from phase I to phase II of the germination process (Figure 4).

4. Discussion

In tropical tree species, there is variability in relation to the size of fruits and seeds (Cruz and Carvalho, 2003), whose variations are influenced by biotic, abiotic, genetic factors of the species itself or regional factors (Gomes et al., 2016). Thus, the biometric characteristics of fruits and seeds represent an important tool for identifying morphological and genetic variability within populations of the same species, as well as in the study of dispersal and dispersing agents (Felippi et al., 2015; Acchile et al., 2017).

Just like the present study, Andrade et al. (2010) when evaluating the biometric characteristics of *H. courbaril* fruits, reported that the average length, width and thickness varied from 86 to 147 mm, 45.64 to 85.82 mm and 34.95 to 50.00 mm, respectively, while in research with *H. courbaril*, Santos et al. (2019) reported an average length of 111.38 mm, width of 47.09 mm and thickness of 30.18 mm.

The average fruit weight in this study was similar to that reported by Santos et al. (2019), who evaluated *H. courbaril*, whose average value was 62.30 g, while Silva et al. (2022) reported that for *H. martiana,* the number of seeds per fruit varied from 0 to 15.

The quantity of seeds in a fruit, in addition to being influenced by genetic factors specific to each species, can be affected by environmental conditions, particularly by microenvironmental variations. These elements have a direct impact on the total seed production per fruit and its weight (Macedo et al., 2009; Pereira, et al., 2017).

When analyzing the symmetry data, the fruits showed a positive asymmetric distribution, in relation to kurtosis, the frequency distribution was platykurtic. When studying the biometric aspects of *H. courbaril* fruits and seeds, Santos et al. (2019) reported a platykurtic distribution for the fruits; however, an asymmetry to the right occurred in the seeds. Variations resulting from the properties of fruits and seeds must be influenced by water flexibility during plant evolution (Marcos-Filho, 2015).

For the biometric characterization of *H. martiana* seeds, a wide variation was observed for all the studied characteristics (Table 2). Changes in the biometric characteristics of seeds are the result of the influence exerted by fruits, which are impacted by environmental changes, such as disparities in pollination between flowers, nutrient utilization strategies and availability of water resources. In addition to the genotypic variability of the stand, which leads to specific phenotypic characteristics, the environmental effects on the seed development process are mainly evidenced by changes in size, weight and physiological and health attributes (Barros et al., 2020).

When evaluating *H. courbaril* seeds, Duarte et al. (2016) reported average lengths, widths and thicknesses of 22.6, 17.7 and 12.0 mm, respectively, and an average weight of 3.4 g, while Santos et al. (2019) reported average values of 22.74 mm for length, 16.30 mm for width, 12.04 mm for thickness and 3.09 g for average weight. Separating the seeds into two classes, small and large, Smiderle and Souza (2021) obtained average length, width, thickness and weight values of 22.44 mm, 18.26 mm, 13.69 mm and 4.07 g, respectively, for the small seed classes, for large seeds the values obtained were 26.38 mm in length, 20.57 mm in width, 12.37 mm in thickness and weight of 5.17 g. All these works corroborate the present study, whose values were similar.

Similarly, when evaluating the seeds of the species *H. courbaril*, Santos et al. (2019) observed that there was a variation in the distribution of frequency classes, with a percentage of 59% with lengths between 20.7 and 22.8 mm, 47% with widths between 15.8 and 17.2 mm, 38% with thicknesses between 11.4 and 12.7 mm and 33% weighing between 3 and 3.2 g.

Seeds with greater length, width, thickness and weight are those that develop better and contain a well-structured embryo and a large volume of reserve substances; these seeds are considered viable and more vigorous for seedling production (Barroso et al., 2016).

In colorimetry, the L value corresponds to luminosity, which varies from 0 (completely black) to 100 (completely white); for fruits, the average luminosity was 23.35, while for seeds, it was 28.88, indicating that the fruits are darker than the seeds. For chromaticity (C), the values obtained were 14.20 and 19.77 for fruits and seeds, respectively; C values close to zero represent neutral colors (gray), while values close to 60 express vivid colors (Mendonça et al., 2003).

The value obtained for the hue angle (°h) for the fruit was 36.75, while for the seeds, it was 41.64 (Table 2). This variable is related to tone, assuming values of 0 (red), 90° (yellow), 180° (green), 270° (blue) and 360° (black) (Pinheiro, 2009); that is, both the fruits and seeds have shades closer to red.

There were 10.48% of damaged seeds, this was due to the presence of larvae and insects in the fruits, Carvalho et al. (2005) also observed attacks by insects and larvae on *H. stigonocarpa* seeds. Insects and larvae play an ecological role of fundamental importance for seeds, as they control the plant population, that is, in which abiotic conditions are not adequate (Peroni and Hernández, 2011).

The weight of a thousand seeds was 422.65 g (Table 4), which is important for differentiating and standardizing this species. This characteristic is important in seed analysis, as it helps in the base values that provide quality control for batch analyses (Brüning et al., 2011; Santos et al., 2014).

For water content, it was observed that seeds that were scarified had a higher water content than those that were not scarified, indicating that scarification of the seed coat impaired dehydration since the water content of the seeds was greater. In the seeds of Schizolobium parahyba (Vell) Blake, Araújo et al. (2016) also reported lower water content in those that were not subjected to scarification, which seems to indicate a tendency for seeds to have a water-impermeable seed coat.

Due to the integumentary dormancy of the seeds, opening the cavity by scarification on the opposite side of the hilum was not considered satisfactory for the total dehydration of the seeds since this method achieved superior results compared to the results obtained with seeds without scarification; thus, a blockage occurred in the integument due to the presence of tissues that block water flow, such as the oil and sugar glands (Andrade et al., 2010).

The water content of the seeds in the present work was close to that obtained by Andrade et al. (2010), who reported 12.46% water content in intact *H. coubaril* seeds. Silva and Cesarino (2016) obtained a water content of 9% in *H. parvifolia* seeds, a value much lower than that of the present study, while Ramalho et al. (2019) reported a water content of 10% in the seeds of *H. stigonocarpa*.

The water absorption curve of *H. martiana* seeds without scarification demonstrated a small variation in water content as a function of soaking time, in which the initial water content increased from 11.8% to 18.4% after 432 hours of imbibition. This result is related to the presence of physical dormancy (integumentary), which makes it difficult for water to pass through the seed's cell membranes. This dormancy is observed in the seeds of several species of the Fabaceae family, whose characteristic physical barrier mainly hinders the imbibition of water by the seeds (Matos et al., 2015).

Phase I of the germination process is characterized by the rapid absorption of water by the seeds (Figure 4), while phase II (168 to 432 hours) represents a reduction in the speed of water absorption throughout the imbibition time, characterized as a stationary phase or physiological rest. It was also noted that the seeds of *H. martiana* reached a water content of 25.5% after 432 hours of imbibition, probably due to the high respiratory activity of the seeds; however, phase III occurred throughout the 432 hours of imbibition, which may have been caused by the inadequate volume of water because it has been proven that this excessive humidity can prevent germination from occurring due to the lack of oxidation of the seeds (Moreira, 2018).

Analysis of the evolution of the water absorption process by the seeds of scarified *H. martiana* revealed an increase over the 432 h of evaluation, with an initial water content of 12.3%, reaching 24.7% after 168 h of soaking, the moment at which the seeds passed from phase I to phase II of the germination process.

Phase I of water absorption is represented by the accelerated increase in respiration and hydration of seed tissues due to the difference in water potential between the seeds and the environment. In phase II (the stationary phase), imbibition occurs slowly according to the balance between pressure and osmotic potential. In this phase, the embryonic axis is still unable to develop, while in phase III, there is an increase in the content of water, and the embryonic axis begins to develop through an increase in the speed of water entry during respiratory activity when there is greater oxygen availability (Bewley and Black, 1994).

The water absorption curve of *Mimosa scabrella* Benth seeds was evaluated. With and without scarification, Guollo et al. (2016) observed a three-phase pattern of imbibition in scarified seeds, with the seeds reaching phase I of twinning after up to four hours of imbibition and phase III close to 24 hours of imbibition, while a three-phase pattern was not observed in intact seeds. This is supposedly due to the slower imbibition speed due to physical dormancy.

5. Conclusions

The fruits of *H. martiana* have an average length of 90.28 mm, width of 46.83 mm, thickness of 34.69, average weight of 65.86 g and four seeds per fruit. The seeds have an average length, width, thickness and weight of 23.75 mm, 18.34 mm, 12.71 mm and 4.13 g, respectively.

The fruits are darker than the seeds, with shades towards red.

Scarified seeds absorb a greater amount of water compared to non-scarified seeds, confirming integumentary dormancy.

References

ACCHILE, S., COSTA, R.N., SILVA, L.K.S., SANTOS, J.C.C., SILVA, D.M.R. and SILVA, J.V., 2017. Biometria de frutos e sementes e determinação da curva de absorção de água de sementes de *Sesbania virgata* (Cav.) Pers. *Scientific Electronic Archives*, vol. 10, no. 5, pp. 26-34. http://doi.org/10.36560/1052017480.

ANDRADE, L.A.D., BRUNO, R.D.L.A., OLIVEIRA, L.S.B.D. and SILVA, H.T.F.D., 2010. Aspectos biométricos de frutos e sementes, grau de umidade e superação de dormência de jatobá. *Acta Scientiarum. Agronomy*, vol. 32, no. 2, pp. 293-299. http://doi.org/10.4025/actasciagron.v32i2.3681.

ARAÚJO, A.M.S., TORRES, S.B., NOGUEIRA, N.W., FREITAS, R.M.O. and CARVALHO, S.M.C., 2014. Caracterização morfométrica e germinação de sementes de *Macroptilium martii* Benth. (Fabaceae). *Revista Caatinga*, vol. 27, no. 3, pp. 124-131.

ARAÚJO, A.V., PINTO, M.A.D.S.C., FERRAZ, A.P.F. and BRITO, A.C.V., 2016. Comparação de métodos para avaliar o teor de água em sementes de paricá (*Schizolobium parahyba*). *Revista Biociências*, vol. 22, no. 2, pp. 71-77.

AZEVEDO, J.P.D.S., 2017. *Ecofisiologia de Erythroxylum pauferrense em uma floresta de brejo de altitude, Nordeste do Brasil*. Areia: Universidade Federal da Paraíba, 22 p. Graduação em Agronomia.

BARROS, H.S.D., CRUZ, E.D., PEREIRA, A.G. and SILVA, E.A.A., 2020. Fruit and seed morfometry, seed germination and seedling vigor of *Parkia gigantocarpa*. *Revista Floresta*, vol. 50, no. 1, pp. 877-886. http://doi.org/10.5380/rf.v50i1.56855.

BARROSO, R.F., SILVA, F.A., NÓBREGA, J.S., SILVA, L.J.S., NOVAIS, D.B. and FERREIRA, V.S., 2016. Biometria de frutos e sementes de *Luetzelburgia auriculata*, Allemão, Ducke. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*, vol. 11, no. 5, pp. 156-160. http://doi.org/10.18378/rvads.v11i5.4703.

BEWLEY, J.D. and BLACK, M., 1994. *Seeds: physiology of development and germination*. 2nd ed. New York: Plenum, 445 p. http://doi.org/10.1007/978-1-4899-1002-8.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Secretaria de Defesa Agropecuária, 2009. *Regras para análise de sementes*. Brasília: MAPA/ACS, 399 p.

BRÜNING, F.O., LÚCIO, A.D. and MUNIZ, M.F.B., 2011. Padrões para germinação, pureza, umidade e peso de mil sementes em análises de sementes de espécies florestais nativas do Rio Grande do Sul. *Ciência Florestal*, vol. 21, no. 2, pp. 193-202. http://doi.org/10.5902/198050983221.

CARVALHO, P.S., MIRANDA, S.C. and SANTOS, M.L., 2005. Germinação e dados biométricos de *Hymenaea stigonocarpa* Mart. Ex Hayne (Leguminosae- Caesalpinoideae) jatobá-do-cerrado. *Revista Anhangüera*, vol. 6, no. 1, pp. 101-116.

CRUZ, E.D. and CARVALHO, J.E.U., 2003. Biometria de frutos e sementes e germinação de curupixá (*Micropholis* cf. *venulosa* Mart. e Eichler - Sapotaceae). *Acta Amazonica*, vol. 33, no. 3, pp. 389-398. http://doi.org/10.1590/S0044-59672003000300005.

DUARTE, M.M., PAULA, S.R.P., FERREIRA, F.R.L. and NOGUEIRA, A.C., 2016. Morphological characterization of fruit, seed and seedling and germination of *Hymenaea courbaril* L. (Fabaceae) ('jatobá'). *Journal of Seed Science*, vol. 38, no. 3, pp. 204-211. http://doi.org/10.1590/2317-1545v38n3159734.

FELIPPI, M., ARAÚJO, M.M. and LONGHI, S.J., 2015. Morfologia da flor, fruto, semente, plântula e muda de *Cabralea canjerana* (Vell.) Mart. *Cerne*, vol. 21, no. 3, pp. 387-394. http://doi.org/10.1590/01047760201521031466.

FERREIRA, D.F., 2014. Sisvar: a guide for its bootstrap procedures in multiplecomparisons. *Ciência e Agrotecnologia*, vol. 38, no. 2, pp. 109-112. http://doi.org/10.1590/S1413-70542014000200001.

GOMES, D.R., ARAUJO, M.M., NUNES, U.R. and AIMI, S.C., 2016. Biometry and germination of *Balfourodendron riedelianum* Eng. *Journal of Seed Science*, vol. 38, no. 3, pp. 187-194. http://doi.org/10.1590/2317-1545v38n3159311.

GUOLLO, K., MENEGATTI, R.D., DEBASTIANI, A.B., POSSETI, J.C. and NAVROSKI, M.C., 2016. Biometria de frutos e sementes e determinação da curva de embebição em sementes de *Mimosa scabrella* Benth. *Revista Cultivando o Saber*, vol. 9, no. 1, pp. 1-10.

LEITE, B.N., FEITOSA, B.F. and ROCHA, E.M.F.F., 2017. Formulação e caracterização de biscoito amanteigado à base de farinha de jatobá, adoçado com farinha de rapadura. *Tecnologia & Ciências Agropecuárias*, vol. 11, no. 4, pp. 55-61.

LORENZI, H., 2009. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3rd ed. Nova Odessa: Instituto Plantarum, 368 p.

MACEDO, M.C.D., SCALON, S.D.P.Q., SARI, A.P., SCALON FILHO, H., ROSA, Y.B.C.J. and ROBAINA, A.D., 2009. Biometria de frutos e sementes e germinação de *Magonia pubescens* ST. Hil (Sapindaceae). *Revista Brasileira de Sementes*, vol. 31, no. 2, pp. 202-211. http://doi.org/10.1590/S0101-31222009000200024.

MARCOS-FILHO, J., 2015. *Fisiologia de sementes de plantas cultivadas*. 2nd ed. Londrina: ABRATES, 659 p.

MATOS, A.C.B., ATAÍDE, G.D.M. and BORGES, E.E.D.L., 2015. Physiological, physical, and morpho-anatomical changes in *Libidibia ferrea* ((Mart. exTul.) LP Queiroz) seeds after overcoming dormancy. *Journal of Seed Science*, vol. 37, no. 1, pp. 26-32. http://doi.org/10.1590/2317-1545v37n1140433.

MENDONÇA, K., JACOMINO, A.P., MELHEM, T.X. and KLUGE, R.A., 2003. Concentração de etileno e tempo de exposição para desverdecimento de limão "Siciliano". *Brazilian Journal of Food Technology*, vol. 6, no. 2, pp. 179-183.

MOREIRA, S.S., 2018. *Germinação e vigor de sementes de quiabo-de-metro (Trichosanthes cucumerina L.)*. Capanema: Universidade Federal Rural da Amazônia, 50 p. Graduação em Bacharelado em Ciências Biológicas.

MOTTA, V.H.M., MARQUES, M.H., MORAIS, J.F., ALVES, W.B., OLIVEIRA, T.A.F., ADÃO, B.G.F., GOMES, I.D., JESUS, N.V., PEREIRA, G.F., PORTO, B.S.M., ALVES, D.F.C., PENA, V.M.L., LIMA, L.M. and MORAIS, C.R., 2019. Superação de dormência de *Hymenaea courbaril*, por meio de diferentes métodos artificiais. *Revista GeTeC*, vol. 8, no. 22, pp. 81-95.

PACHECO, A.G.M., PACHECO, E.J., MACEDO, L.A.R.O., SILVA, J.C., LIMA-SARAIVA, S.R.G., BARROS, V.P., OLIVEIRA-JUNIOR, R.G., BRANCO, A., QUINTANS, J.S.S., QUINTANS-JUNIOR, L.J.H., COUTINHO, D.M., MENEZES, I.R.A. and ALMEIDA, J.R.G.S., 2022. Antinociceptive and anti-inflammatory activities of *Hymenaea martiana* Hayne (Fabaceae) in mice. *Brazilian Journal of Biology = Revista Brasileira de Biologia*, vol. 82, e240359. http://doi.org/10.1590/1519-6984.240359. PMid:34105646.

PEREIRA, M.O., NAVROSKI, M.C., HOFFMANN, P.M., GRABIAS, J., BLUM, C.T., NOGUEIRA, A.C. and ROSA, D.P., 2017. Qualidade de sementes e mudas de *Cedrela fissilis* Vell. em função da biometria de frutos e sementes em diferentes procedências. *Revista de Ciências Agroveterinárias*, vol. 16, no. 4, pp. 376-385. http://doi.org/10.5965/223811711642017376.

PERONI, N. and HERNÁNDEZ, M.I.M., 2011. *Ecologia de populações e comunidades*. Florianópolis: CCB/UFSC, 107 p.

PIMENTA, A.C., RIBAS, K.C.Z., LAVIOLA, B.G. and PANOBIANCO, M., 2014. Curva de absorção de água em sementes de pinhão-manso. *Comunicata Scientiae*, vol. 5, no. 3, pp. 295-301. http://doi.org/10.14295/cs.v5i3.480.

PINHEIRO, J.M.S., 2009. *Tecnologia pós-colheita para a conservação de bananas da cultivar tropical*. Montes Claros: Universidade Estadual de Montes Claros, 59 p. Dissertação de Mestrado em Produção Vegetal no Semiárido, Área de Concentração em Produção Vegetal.

PINTO, R.B., TOZZI, A.M.G.A. and MANSANO, V.F., 2020a [viewed 5 March 2024]. *Hymenaea* L. [online]. Flora do Brasil/Jardim Botânico do Rio de Janeiro. Available from: http://floradobrasil2020.jbrj.gov.br/reflora/floradobrasil/FB22971

PINTO, R.B., TOZZI, A.M.G.A. and MANSANO, V.F., 2020b [viewed 5 March 2024]. *Hymenaea* [online]. Flora do Brasil/Jardim Botânico do Rio de Janeiro. Available from: https://floradobrasil.jbrj.gov.br/FB83203

RAMALHO, C.I., CAMILO, F.L., PARANAGUÁ, L.A.M.N. and GOMES, G.S.L., 2019. Avaliação de diferentes tratamentos pré-germinativos para sementes de jatobá do cerrado (*Hymenaea stigonocarpa* L.). *Revista Brasileira de Meio Ambiente*, vol. 7, no. 2, pp. 2-9. http://doi.org/10.5281/zenodo.3524805.

RIBEIRO, M.I., 2019. *Curva de embebição, anatomia e mobilização de reservas em sementes de Mimosa flocculosa Burkart submetidas a superação de dormência*. Cascavel: Universidade Estadual do Oeste do Paraná, 37 p. Dissertação de Mestrado em Conservação e Manejo de Recursos Naturais.

SANTOS, J.C.C., SILVA, C.H., SANTOS, C.S., SILVA, C.S. and MELO, E.B., 2014. Grau de umidade, peso de mil sementes e germinação de catingueira. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*, vol. 9, no. 2, pp. 364-367.

SANTOS, J.C.C., SILVA, D.M.R., COSTA, R.N., SANTOS, S.A., SILVA, L.K.S. and SILVA, J.V., 2019. Biometria de frutos e sementes e tratamentos pré-germinativos em sementes de *Hymenaea courbaril*. *Revista em Agronegócio e Meio Ambiente*, vol. 12, no. 3, pp. 957-979. http://doi.org/10.17765/2176-9168.2019v12n3p957-979.

SANTOS, J.C.C., SILVA, D.M.R., COSTA, R.N., SILVA, C.H., SANTOS, W.S., MOURA, F.B.P. and SILVA, J.V., 2018. Aspectos biométricos e morfológicos de frutos e sementes de *Schinopsis brasiliensis*. *Nativa*, vol. 6, no. 3, pp. 219-224. http://doi.org/10.31413/nativa.v6i3.4709.

SILVA, B.M.S. and CESARINO, F., 2016. Germinação de sementes e emergência de plântulas de jutaí (*Hymenaea parvifolia* Huber.). *Revista Brasileira de Plantas Medicinais*, vol. 18, no. 1, suppl. 1, pp. 256-263. http://doi.org/10.1590/1983-084X/15_178.

SILVA, J.N., ALVES, E.U., MEDEIROS, M.L.S., PÁDUA, G.V.G., SILVA, M.J., RODRIGUES, M.H.B.S., BERNARDO, M.K.F., CRUZ, J.M.F.L., SOUZA, A.G. and ARAÚJO, L.D.A., 2022. Caracterização morfológica de frutos e sementes em uma população natural de *Hymenaea martiana* Hayne. *Scientia Forestalis*, vol. 50, no. 1, e3929. http://doi.org/10.18671/scifor.v50.44.

SILVA, M.S., VIEIRA, F.A. and CARVALHO, D., 2007. Biometria dos frutos e divergência genética em uma população de *Geonoma schottiana* Mart. *Revista Brasileira de Biociências*, vol. 5, no. 1, pp. 582-584.

SILVA, R.M., CARDOSO, A.D., DUTRA, F.V. and MORAIS, O.M., 2017a. Aspectos biométricos de frutos e sementes de *Caesalpinia ferrea* Mart. ex Tul. provenientes do semiárido baiano. *Journal of Neotropical Agriculture*, vol. 4, no. 3, pp. 85-91. http://doi.org/10.32404/rean.v4i3.1427.

SILVA, S.P.M., PINHEIRO, A., BOTELHO, R.A., SILVA, L., SOUZA, M.D. and OLIVEIRA, O.E., 2017b. Ocorrência de *Tricorynus* sp. (coleoptera: anobiidae) em frutos de jatobazeiro *Hymenaea courbaril* L. (Fabaceae) no município de Santo Antônio do Leverger, Mato Grosso. *Biodiversidade*, vol. 16, no. 1, pp. 128-134.

SMIDERLE, O.J. and SOUZA, A.G., 2021. Do scarification and seed soaking periods promote maximum vigor in seedlings of *Hymenaea courbaril? Journal of Seed Science*, vol. 43, e202143030. http://doi.org/10.1590/2317-1545v43254481.

SOUZA, O.M., SMIDERLE, O.J., SOUZA, A.G., CHAGAS, E.A., CHAGAS, P.C., BACELAR-LIMA, C.G. and MORAIS, B.S., 2017. Influência do tamanho da semente na germinação e vigor de plântulas de populações de camu-camu. *Scientia Agropecuaria*, vol. 8, no. 2, pp. 119-125. http://doi.org/10.17268/sci.agropecu.2017.02.04.

TORRES, M.F.O., DANTAS, S.J., SOUZA, J.L., NUNES, V.V., CALAZANS, C.C., FERREIRA, O.J.M. and FERREIRA, R.A., 2020. Curva de embebição e viabilidade de sementes de *Sapindus saponaria* L. *Global Science and Technology*, vol. 13, no. 1, pp. 211-218.