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Physiological quality of castor seeds (*Ricinus communis* L.) after processing[1]

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ABSTRACT – Castor bean seeds are the raw material used for extracting oil destined to pharmaceutical and industrial ends. The appropriate application of post-harvest technologies, such as processing, is required to ensure the production of top quality seeds. Thus, this study aimed at assessing the physiological quality of seeds from two castor bean genotypes, classified according to their specific mass and size. Castor seeds of the genotypes EVF102 and EVF103 were mechanically harvested and then classified with the aid of cylindrical sieves and a densimetric table. This procedure was conducted at the processing unit of the company *Sementes Goiás LTDA* [*Goiás* Seeds Co.]. Evaluations of seed physiological quality were carried out in the Seed Laboratory of *Instituto Federal Goiano*, following a completely randomized design. The testing was conducted in four replicates, in a 2 x 2 x 5 factorial scheme (two genotypes x two sizes x five specific masses). The following parameters were appraised: (a) mass of one thousand seeds; (b) germination; (c) germination speed index; (d) emergence test; (e) emergence speed index; (f) electrical conductivity; and (g) accelerated aging. Genotype EVF102 seeds sized 8 mm, as classified by the densimetric table, showed the highest physiological quality, considering the germination, germination speed index, and emergence. Seeds of the genotype EVF103, sorted by size, exhibited no difference in physiological quality.

Index terms: *Ricinus communis* L., size, specific mass, densimetric table.

Qualidade fisiológica de sementes de mamona (*Ricinus communis* L.) após o beneficiamento

RESUMO – Sementes de mamona são a matéria-prima para extração de óleo utilizado para diversos fins farmacêuticos e industriais. Para assegurar a produção de sementes com qualidade, é necessário aplicar apropriadamente tecnologias de pós-colheita, como o beneficiamento. Assim, objetivou-se avaliar a qualidade fisiológica de sementes de dois genótipos de mamona, classificadas por massa específica e tamanho. Sementes de mamona dos genótipos EVF102 e EVF103 foram colhidas mecanicamente e classificadas por meio de peneiras de crivos cilíndricos e mesa densimétrica, na Unidade de Beneficiamento das Sementes Goiás Ltda. As avaliações da qualidade fisiológica foram conduzidas no Laboratório de Sementes do Instituto Federal Goiano, em um delineamento experimental inteiramente casualizado, com quatro repetições, em esquema fatorial 2 x 2 x 5 (2 genótipos x 2 tamanhos x 5 massas específicas). Foram avaliados os parâmetros massa de mil sementes, teste de germinação, índice de velocidade de germinação, teste de emergência, índice de velocidade de emergência, condutividade elétrica e envelhecimento acelerado. Sementes do genótipo EVF102 de tamanho 8 mm, conforme classificadas pela mesa densimétrica, apresentaram maior qualidade fisiológica considerando-se a germinação, índice de velocidade de germinação e emergência. Sementes do genótipo EVF103 separadas por tamanho não apresentaram diferença na qualidade fisiológica.

Termos para indexação: *Ricinus communis* L., tamanho, massa específica, mesa densimétrica.

Introduction

Ricinus communis L. (Euphorbiaceae) is a culture of importance, cultivated mostly in tropical and subtropical regions (Ribeiro et al., 2015). The oil extracted from the seeds is largely used for pharmaceutical and industrial purposes, due to its chemical

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composition high in ricinoleic acid (Severino et al., 2012).

The Brazilian state of Bahia is the primary national producer of castor beans. In the 2017/18 crop, the cultivated area was expected to achieve 31.6 million hectares, which represents an addition of 12.9% over the previous year. Such a trend can be attributed to both favorable local climatic conditions and also to the product pricing in the market, especially in the last three years (CONAB, 2018).

Obtaining castor seeds with high physiological, physical, and sanitary properties, capable of generating vigorous plants that can establish an adequate stand, is one of the hindrances for large-scale production (Neto et al., 2012). Besides, Machado et al. (2010) linked the seed supply shortage and low quality of the beans to the fact that the cultivation still occurs with the farmer's matrices, which generally are highly heterogeneous and include a broad diversity of cultivars.

Castor seed lots are subjected to general processing to remove impurities coming from the field, and also to improve the quality of the product. The processing comprises a set of operations carried out by specialized machinery, with the purpose of enhancing the physical, physiological, and in some cases, the sanitary aspects of a lot (Marcos-Filho, 2015).

Air machines and sieves separate different materials within a lot, based on physical differences, such as size and specific mass (Carvalho and Nakagawa, 2012). The air device removes the large particles, whereas those smaller than the seeds are sorted out by mesh size, sieve vibration, and ventilation (Nery et al., 2012; Melo et al., 2016a; Melo et al., 2016b).

The functioning of a densimetric table relies on the specific mass, as separation occurs by stratification (Hessel et al., 2012). During the operation, the airflow keeps lighter particles in the top part, from where they are directed to the nether half, only to be unloaded at the bottom extremity of the device. Meanwhile, the denser materials are conveyed to the upper border, from where they discharged, and the intermediate ones are collected in the middle section of the table (Hessel et al., 2012; Melo et al., 2016a; Melo et al., 2016b).

Even though classification by size and specific mass are essential tools to improve the quality of lots, there is still not enough information on how this processing influences physical and physiological attributes of the seeds, nor about its effectiveness in enhancing the final quality of the lots. On account of that, this work aimed at evaluating the physiological quality of two genotypes of castor beans after they were processed and sorted by size and specific mass via air machine, sieves, and densimetric table.

Material and Methods

The trials were conducted in the Seed Laboratory of *Instituto Federal Goiano – campus Rio Verde, Goiás* - Brazil. Castor seed of the genotypes EVF102 and EVF103 were used in the study. They had been grown in the production fields of the company *Sementes Goiás Ltda.*

The fruits were mechanically harvested (Platform PLM 08L, specific for castor beans) and then processed at the seed processing unit (SPU) of the company. The operation included the following steps: shelling, precleaning, cleaning (air and sieves), and classification. The seeds were withal sampled during the procedure.

Seeds were sorted with round-perforated sieves, with diameters of 8 and 9 mm. Then, the lots of each size were individually classified into four categories, according to the specific mass, given by which outlet of the table the grains had coursed through. So, the classes obtained were the following: D1 (seeds collected at the upper part of the table), D2 (middle part of the table), D3 (lower part of the table), and D4 (waste). A fifth category, named SD, was created to designate the samples not processed by the densimetric table.

The experiments were carried out following a completely randomized design (CRD), with four replications, in a factorial scheme 2 x 2 x 5 (two genotypes x two sizes x five specific masses).

The following treatments were formed within each genotype:

- Seeds unclassified as for their specific mass (SD), sieve ≥ 9 mm;
- D1 seeds (densest), sieve ≥ 9 mm;
- D2 seeds (intermediate mass), sieve ≥ 9 mm;
- D3 seeds (least dense), sieve ≥ 9 mm;
- Waste of the 9 mm sieve (D4);
- Seeds unclassified as for their specific mass (SD), sieve between 8 and 9 mm;
- D1 seeds (densest), sieve between 8 and 9 mm;
- D2 seeds (intermediate mass), sieve between 8 and 9 mm;
- D3 seeds (least dense), sieve between 8 and 9 mm;
- Waste of the 8 mm sieve (D4)

The water content of castor seeds was determined via the gravimetric method, by placing two replications of 12 grams inside an oven at 105 ± 3 ºC, for 24 hours (Brasil, 2009).

The mass of one thousand seeds was determined in eight replications of 100 seeds (mechanical counters were employed to separate them). Subsequently, the seeds of each replication were weighed in a four-decimal precision scale. The mean of each replication was calculated and used to attain a value corresponding to one thousand seeds (Brasil, 2009).

After separating and tagging the seed lots, the physiological quality was assessed according to the following tests:

Germination test and germination speed index: the sowing was conducted on germitest paper sheets that had been moistened with distilled water, in the proportion of 2.5 times the mass of the dry substrate. Four replications, with 50 seeds each, were analyzed. The paper rolls were kept inside a BOD chamber, set at an alternate temperature of 20–30 ºC, and a photoperiod of 12/12 hours (Brasil, 2009). The percentage of germination was evaluated 7 and 14 days afterward, when the total number of normal seedlings was accounted. The result was expressed in percentage of normal seedlings (Brasil, 2009). The germination speed index (GSI) was calculated from the sum of germinated seeds - that is, those with radicle equal to or larger than 1 cm. The values were recorded daily, and divided by the number of days between sowing and the start of the daily counts (Maguire, 1962)

Emergence and emergence speed index: 200 seeds were divided into four replications of 50 units. They were sown in a sand bed, at 3 cm depth, and kept inside a greenhouse with an automated sprinkler system, to maintain the substrate moistened at 60% of its field capacity. The emergence of seedlings was evaluated until stabilization, taking into account only the normal ones. Then, the results were expressed in final emergence percentage. The emergence speed index (ESI) of the seedlings was assessed daily, starting from the setup of the test, by counting the number of seedlings emerged that is, those with both cotyledons exposed above the sand level. Next, the obtained figure was divided by the number of days since the sowing, as proposed by Maguire (1962).

Accelerated aging: it was conducted according to the gerbox method and the methodology proposed by Marcos-Filho (2015). In each gerbox, 50 seeds were distributed over the internal screen, and 40 mL of distilled water was poured at the bottom of the box. This procedure was done in four replications. In the following step, the boxes were incubated in a BOD chamber set at 42 ºC, for 72 hours. After that period, the seeds from each replication were sown, and the normal seedling emerged 7 days afterward were counted (Brasil, 2009).

Electrical conductivity: to assess the electrical conductivity of the imbibition solution, the mass conductivity method was used. Four samples with 25 seeds each, previously weighed with a two-decimal precision analytical scale. The seeds were left soaked in plastic cups containing 75 mL of deionized water, inside a BOD chamber at 25 ºC, for 24 hours. After this time, the electrical conductivity of the imbibition solution was read with a conductivity meter Tecnal TEC-4MP. The results were expressed in $\mu S.cm^{-1}.g^{-1}$ of seeds (Vieira and Krzyzanowski, 1999).

All data were subjected to analysis of variance, and the means were compared through the Tukey's test at a 5% significance level. The statistical analysis was handled by the software SISVAR (Ferreira, 2011).

Results and Discussion

The water content of the seeds ranged from 5.03 to 6.56% having the waste presenting the highest values (Table 1). The uniformity among different treatments regarding this feature tends to ease the evaluation of seed quality, therefore providing more consistent results (Vieira et al., 2002). In this study, the values obtained prior to testing were considered even and adequate, once the variations did not exceed the tolerance limits, remaining within 2 or 3 percentage points (Marcos-Filho, 1999).

Seed processing procedures are undeniably relevant to the productive chain, as one of its primary goals is to perfect the quality of the lots, so that the minimum standards for commercialization are met (Baudet et al., 1999; Neves et al., 2016). In this sense, the

Table 1. Water content of castor seeds of the genotypes EVF102 and EVF103, sized 8 and 9 mm, as assessed for each level of specific mass (D1, D2, D3, D4).

Genotype	Processing class	Water content (% dry basis)
102	8	5.82
	9	5.61
	D1 8	5.49
	D1 9	5.43
	D2 8	5.39
	D2 9	5.56
	D3 8	5.35
	D3 9	5.73
	D4 8	7.03
	D4 9	6.49
103	8	5.30
	9	5.45
	D1 8	5.35
	D1 9	5.37
	D2 8	5.34
	D2 9	5.36
	D3 8	5.68
	D3 9	5.50
	D4 8	6.68
	D4 9	6.65

necessity of keeping the uniformity in water content at safe levels is crucial to prevent seed deterioration, and therefore to assure their storage potential (Antonello et al., 2009; Silva et al., 2010; Silva et al., 2011; Juvino et al., 2014).

The interaction among the three factors analyzed was significant for almost all variables considered. The electrical conductivity (CE) and the mass of one thousand seeds were the exceptions (Table 2).

The densimetric table uniformized the specific mass of the seeds. This fact became evident, as the values of mass of one thousand seeds sorted by the outlets D1 and D2 were higher than that of the unprocessed seeds. Also, the waste presented the lowest specific mass in both genotypes EVF102 and EVF103 (Table 3).

The seeds sized 9 mm of the genotype EVF 103 presented the highest specific mass after processing (Table 3). Neto et al. (2012) verified that castor seeds from two lots, expressly those which had been recovered at the upper outlet of the densimetric table, exhibited greater mass of one thousand seeds, in contrast to those sorted by the remaining outlets. Conrad et al. (2017) reported that this variable diverged among the collection points as well, and attributed the fact to the influence of sieve size. Eventually, they also found that seeds classified by the densimetric table had higher mass of one thousand seeds rates. Endorsing these observations, Gadotti et al. (2012) declared that it was possible to obtain high-quality seeds from those distributed at the top parts of the table.

Castor plants do not produce all seeds at the same time (Carvalho and Nakagawa, 2012). So, new racemes and seeds are formed as the ideal conditions gradually diminish, and the last grains are generally smaller or less dense, which results in less vigor (Marcos-Filho, 2015).

Seeds sized 8 mm of the genotype EVF102 exhibited more substantial germination when categorized by specific mass (D1, D2, and D3). Conversely, seeds sized 9 mm of the genotype EVF103 presented no significant difference in germination among themselves, except for class D3 (Table 4).

Table 2. Summary of the analysis of variance, with the respective F values of the variables mass of one thousand seeds (M_{1000}), germination (G), germination speed index (GSI), emergence (E), emergence speed index (ESI), electrical conductivity (EC), and accelerated aging (AA) of castor seeds of two genotypes, two sizes, and five specific mass classes.

SV	DF	F Values						
		M_{1000}	G	GSI	E	ESI	EC	AA
G	1	52.356*	27.358*	46.041*	9.357*	4.306*	50.625*	12.257*
S	1	484.604*	0.051ns	36.544*	0.068ns	3.816ns	22.428*	29.231*
M	4	388.838*	40.069*	24.254*	66.062*	6.425*	51.288*	42.863*
G *vs* S	1	2.246ns	23.816*	16.575*	7.121*	20.708*	0.322ns	25.972*
G *vs* M	4	3.057*	7.457*	24.847*	8.550*	19.347*	1.471ns	13.591*
S *vs* M	4	11.845*	2.020ns	15.197*	10.634*	7.068*	11.773*	10.906*
G *vs* S *vs* M	4	2.329ns	8.505*	19.505*	7.531*	2.719*	1.741ns	7.447*
CV (%)	-		29.03	25.99	8.83	24.06	19.12	17.05

*: significant at 5% by the Tukey's test; ns: non-significant; CV: coefficient of variation; SV: source of variation; DF: degrees of freedom; G: genotype; S: size; M: specific mass.

Table 3. Mass of one thousand castor seeds of the genotypes EVF102 and EVF103, processed by size (8 and 9 mm) and specific mass (D1, D2, D3, and D4).

Genotype	Specific mass				
	SD	D1	D2	D3	D4
EVF102	37.72 Bb	42.10 Ab	41.25 Ab	37.86 Bb	23.89 Cc
EVF103	40.75 Ba	45.64 Aa	44.50 Aa	41.14 Ba	23.99 Cc
Size (mm)	SD	D1	D2	D3	D4
8	35.13 Bb	40.41 Ab	39.55 Ab	36.67 Bb	17.54 Cb
9	43.33 Ba	47.33 Aa	46.20 Aa	42.32 Ba	30.34 Ca

Values followed by a lowercase letter, in the column, and an uppercase letter, in the line, do not differ by the Tukey's test at 5%. SD: unsorted by specific mass; D1, D2, and D3: classes sorted as for their specific mass (densest, intermediate, and least dense, respectively); D4: waste.

The studies of Faria et al. (2013) counter these observations, as these authors verified that large seeds of *Brosimum gaudichaudii* Trecul. are potentially more vigorous than the smaller, less dense ones. Thus, they are capable of originating more robust plants. Similar findings were obtained by Silva (2015) in his work with *Sideroxylon obtusifolium* (Roem. & Schult.) Penn.

Considering the seeds of the genotype EFV102, those belonging to the specific mass classes D2 and D3 presented the highest germination rate, whereas those of the waste group had the lowest values. When it comes to the 9 mm seeds, those of class D1 (the densest ones) germinate similarly to those categorized as waste (Table 4).

It is worth mentioning that setting the machinery correctly is imperative to avoid losses, and to enhance both physical and physiological qualities of seeds produced for commercialization (Gadotti et al., 2011; Melo et al., 2016a; Melo et al., 2016b).

As for 8 mm seeds of the genotype EFV103, there was more germination when no sorting by specific mass was performed (SD). The same was noticed in the 9 mm seeds, in which the germination of the waste group (D4) did not differ from that of the D1 class (Table 4). Still regarding 8 mm seeds, those of the genotype EFV102 categorized by the densimetric table in D2 and D3, had more prominent germination. Furthermore, 8 mm seeds of the genotype EFV102 sorted as D1, D2, and D3 rated higher in germination as opposed to its counterparts of the genotype EFV103 (Table 4).

The most pronounced germination speed index (GSI) of seeds sized 9 mm, genotype EFV102, was obtained in the classes SD, D3, and D4. This result evidences that the separation by specific mass did not enhance the vigor of the seeds (Table 5). As for the 8 mm seeds, both genotypes expressed their highest GSI in class D1. After classification by densimetric table, the groups D1, D2, and D3 of the genotype EFV102 performed better as for this feature (Table 5). Considering the 8 mm seeds from the categories SD, D2, D3, and D4, the genotype EVF102 exhibited higher GSI values than the EVF103 seeds (Table 5).

The emergence rates of 8 mm castor seeds of all the classes sorted by the densimetric table were superior to the waste (D4), in both genotypes studied. Also, the same result was obtained from 9 mm seeds of the genotype EVF103 (Table 6).

The emergence speed index (ESI) of seeds sized 8 mm, genotype EFV102, was higher in classes SD and D2. With regards to the 9 mm seeds of both genotypes, and 8 mm seeds of the genotype EFV103, the densimetric table was not

Table 4. Mean germination percentage of castor seeds, genotypes EVF102 and EVF103, as sorted by size (8 and 9 mm) and five specific mass classes (SD, D1, D2, D3, and D4).

Genotype	Size	Specific mass				
		SD	D1	D2	D3	D4
EVF102	8	28 BCb*B*	34 Ba**A*	66 Aa**A*	65 Aa**A*	13 Ca*A*
	9	43 Aa*A*	11 Bb*A*	38 Ab*A*	48 Ab*A*	16 Ba*A*
EVF103	8	42 Aa**A*	8 Ca*B*	27 ABa*B*	21 BCb*B*	7 C*a*A
	9	35 ABa*A*	20 Ba*A*	39 Aa*A*	40 Aa*A*	18 Ba*A*

Values followed by a lowercase letter, in the column, and an uppercase letter, in the line, do not differ by the Tukey's test at 5%. Similar uppercase letter in italics, considering the genotypes, do not differ, by the Tukey's test at 5%. *: difference between genotypes, considering the same seed size; SD: unsorted by specific mass; D1, D2, and D3: classes sorted as for their specific mass (densest, intermediate, and least dense, respectively); D4: waste.

Table 5. Mean values of germination speed index of castor seeds, genotypes EVF102 and EVF103, as sorted by size (8 and 9 mm) and five specific mass classes (SD, D1, D2, D3, and D4).

Genotype	Size	Specific mass				
		SD	D1	D2	D3	D4
EVF102	8	3.50 Ba**A*	3.50 Ba*B*	7.75 Aa**A*	7.75 Aa**A*	3.50 Ba*A
	9	4.25 Aa**A*	1.50 Bb*A*	1.75 Bb*A*	4.50 Ab*A*	3.75 Aa*A*
EVF103	8	1.25 Ca*B*	7.25 Aa**A*	0.25 Ca*B*	4.25 Ba*B*	2.00 Ca*B*
	9	1.75 Ba*B*	2.25 Bb*A*	1.50 Ba*A*	5.00 Aa*A*	2.50 Ba*A*

Values followed by a lowercase letter, in the column, and an uppercase letter, in the line, do not differ by the Tukey's test at 5%. Similar uppercase letter in italics, considering the genotypes, do not differ, by the Tukey's test at 5%. *: difference between genotypes, considering the same seed size; SD: unsorted by specific mass; D1, D2, and D3: classes sorted as for their specific mass (densest, intermediate, and least dense, respectively); D4: waste.

effective in separating those with the best ESI, as there was no significant difference among the groups D1, D2, D3, and the waste (D4) (Table 7).

Seeds sized 8 mm, genotype EVF102, of the classes SD and D2 exhibited higher ESI than those of genotype ETV103 (Table 5). This genotype, in its turn, presented more expressive values of ESI in seeds sized 9 mm of the groups D3 and D4 (Table 7).

Bispo et al. (2017) reported that seed size directly interfered on the growth of *angico* plants, under both controlled and greenhouse conditions. Likewise, Faria et al. (2013), Flores et al. (2014), and Silva (2015) also found a strict relation between seed size and vigor when studying *Brosimum gaudichaudii* Trecul., *Melanoxylon brauna* Schott., and *Sideroxylon obtusifolium* (Roem. & Schult.) Penn., respectively.

Table 6. Mean emergence values of castor seeds, genotypes EVF102 and EVF103, as sorted by size (8 and 9 mm) and five specific mass classes (SD, D1, D2, D3, and D4).

Genotype	Size	Specific mass				
		SD	D1	D2	D3	D4
EVF102	8	84 Aa*A*	81 Aa*A*	94 Aa*A*	93 Aa*A	38 Bb*B*
	9	84 Aa*A*	54 Bb*B*	80 Ab*B*	86 Aa*A*	63 Ba*A*
EVF103	8	87 Aa*A*	89 Aa*A*	86 Aa*A*	76 Ab*B*	54 Ba*A
	9	83 Aa*A*	87 Aa*A	92 Aa*A	89 Aa*A*	61 Ba*A*

Values followed by a lowercase letter, in the column, and an uppercase letter, in the line, do not differ among themselves, by the Tukey's test at 5%. Similar uppercase letter in italics, considering the genotypes, do not differ, by the Tukey's test at 5%. *: difference between genotypes, considering the same seed size; SD: unsorted by specific mass; D1, D2, and D3: classes sorted as for their specific mass (densest, intermediate, and least dense, respectively); D4: waste.

Table 7. Mean values of emergence speed index of castor seeds, genotypes EVF102 and EVF103, as sorted by size (8 and 9 mm) and five specific mass classes (SD, D1, D2, D3, and D4).

Genotype	Size	Specific mass				
		SD	D1	D2	D3	D4
EVF102	8	26.0 Aa*A	14.4 Ba*A*	26.4 Aa*A	14.2 Ba*A*	3.70 Ca
	9	12.5 Ab	13.2 Aa*A*	13.4 Ab*A*	12.0 Aa	7.10 Aa
EVF103	8	13.0 Aa	13.3 Aa*A*	15.3 Aa	16.8 Aa*A*	16.2 Aa*A
	9	10.8 Ba*A*	14.8 ABa*A*	18.2 Aa*A*	20.1 Aa*A	21.4 Aa*A

Values followed by a lowercase letter, in the column, and an uppercase letter, in the line, do not differ among themselves, by the Tukey's test at 5%. Similar uppercase letter in italics, considering the genotypes, do not differ, by the Tukey's test at 5%. *: difference between genotypes, considering the same seed size; SD: unsorted by specific mass; D1, D2, and D3: classes sorted as for their specific mass (densest, intermediate, and least dense, respectively); D4: waste.

Table 8. Mean electrical conductivity values ($\mu S.cm^{-1}.g^{-1}$) of castor seeds sorted by size (8 and 9 mm) and five specific mass classes (SD, D1, D2, D3, and D4).

Size	Specific mass				
	SD	D1	D2	D3	D4
8	95.2 Ab	72.6 Aa	75.8 Aa	81.2 Aa	183.0 Bb
9	74.8 Aa	75.4 Aa	80.2 Aa	70.7 Aa	113.4 Ba

Values followed by a lowercase letter, in the column, and an uppercase letter, in the line, do not differ among themselves, according to the Tukey's test at a 5% significance level. SD: unsorted by specific mass; D1, D2, and D3: classes sorted as for their specific mass (densest, intermediate, and least dense, respectively); D4: waste.

Regarding the electrical conductivity (EC), the unprocessed seeds (SD) sized 9 mm showed lower values. Also, these seeds did not differ from those categorized as D1, D2, and D3 (Table 8). Lopes et al. (2011) remarked that the electrical conductivity could be affected by mechanical damages resulting from an incorrect setting of the machines and equipment used for harvesting and processing the grains.

When assessing the electrical conductivity of soybean seeds, Neves at al. (2016) verified more substantial solute leaching due to mechanical injuries caused during drying and processing. However, the vigor of the seeds improved after being sorted by the gravimetric table. The same did not occur in castor seeds, since no difference was noticeable among the EC values of processed grains.

Table 9. Mean values of accelerated aging (%) of castor seeds, genotypes EVF102 and EVF103, as sorted by size (8 and 9 mm) and five specific mass classes (SD, D1, D2, D3, and D4).

Genotype	Size	Specific mass				
		SD	D1	D2	D3	D4
EVF102	8	84 Aa*A*	70 Aa*A*	74 Aa*A*	64 ABa*A*	45 Ba*A*
	9	58 Ab*B*	71 Aa*A*	57 Ab*B*	70 Aa*A*	32 Ba*A*
EVF103	8	85 Aa*A*	74 ABa*A*	67 ABa*A*	58 Ba*A*	35 Ca*A*
	9	74 Aa**A*	73 Aa*A*	77 Aa**A*	71 Aa*A*	20 Bb*A*

Values followed by a lowercase letter, in the column, and an uppercase letter, in the line, do not differ among themselves, by the Tukey's test at 5%. Similar uppercase letter in italics, considering the genotypes, do not differ, by the Tukey's test at 5%. *: difference between genotypes, considering the same seed size; SD: unsorted by specific mass; D1, D2, and D3: classes sorted as for their specific mass (densest, intermediate, and least dense, respectively); D4: waste.

Castor seeds sized 8 mm, of the genotype EFV102, and not processed via the densimetric table (SD), displayed the best vigor performance, as appraised by the accelerated aging test. The germination after accelerated aging of 8 mm seeds, genotype EFV103, was similar among the classes SD, D1, and D2. Nevertheless, the values registered in SD seeds were higher than those of the D3 and waste groups (Table 9).

Seeds sized 9 mm of the genotype EFV103, classes SD and D2, were more vigorous than their EFV102 equivalents, as analyzed by accelerated aging test (Table 9).

The accelerated aging test of soybean seeds showed that, after being categorized by the gravimetric table, there was an increase in the percentage of normal seedlings emerged. Such outcome attests the positive effect of the method on the physiological quality of those seeds (Neves et al., 2016). The same, however, did not occur in castor seeds of both genotypes EFV102 and EFV103, as their physiological quality was merely maintained after processing (groups D1 and D2).

In other cultivate species, processing generally brings numerous advantages. In rice seeds, for example, Pereira et al. (2012) noticed a gradual increase in the physical quality of the lot, since after their weighing, and throughout the processing as well. Ferreira and Sá (2010) also verified an enhancement in the quality of corn seeds subjected to processing.

Zuchi et al. (2010) observed that the size of castor seeds influenced their physiological performance. In cultivars IAC 226 and BRS 188 *Paraguaçu*, the small ones exhibited the highest values of germination speed and final germination percentage. Conversely, the same did not happen in the cultivars IAC 80 and Al *Guarany* 2002.

Neves et al. (2016) concluded that processing improves some quality attributes of soybean seeds during different phases. They realized the densimetric table had a vital role in enhancing the physiological and sanitary aspects of a lot, thus favoring the vigor of the seeds.

It is worth mentioning that setting the machinery correctly is imperative to avoid losses, and to enhance both physical and physiological qualities of seeds produced for commercialization (Gadotti et al., 2011; Melo et al., 2016a; Melo et al., 2016b).

Conclusions

Castor seeds sized 8 mm, genotype EVF102, and subjected to classification by a densimetric table, present the highest physiological quality, regarding germination, germination speed index, and emergence.

Seeds of the genotype EVF103, classified by size, do not show significant differences in physiological quality.

Seeds of both genotypes EVF102 and EVF103, sorted as D4 (waste), display the lowest physiological quality, based on the emergence, electrical conductivity, and accelerated aging test results.

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