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Article

Physical and chemical characterization of sweet passion fruits genotypes in Sao Mateus, Espírito Santo State, Brazil

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Abstract

In Brazil 95% of the passion fruit marketed comes from the species *Passiflora edulis* f. *flavicarpa* (yellow passion fruit), the remainder are *Passiflora edulis* f. *edulis* (purple passion fruit) and *Passiflora alata* (sweet passion fruit), considered market niches. Because of the wide genetic variability the genus *Passiflora*, it is of fundamental importance to identify superior genotypes to improve the quality of fruit for the fresh market. The objective is to analyze the physical and chemical characteristics of the fruits of 33 genotypes *P. alata* Curtis, evaluated in a randomized complete block design with two replicates of four plants, from native matrices, located at the experimental farm of the University Center of the North of Espírito Santo, Federal University of Espírito Santo, in the Northern Region of the state of Espírito Santo, São Mateus -ES. Thirty-two mature fruits were collected in each replicate, eight per plant and the following characteristics were analyzed: fruit weight (g); equatorial and polar diameter of fruit (cm); peel thickness (mm); mass of the pulp (g); pulp volume (mL); pulp yield (%); number of seeds per fruit, pH; soluble solids (SS); titratable acidity (TA) and ratio (SS/TA). There is a wide genetic variability among *P. alata* genotypes as to the traits assessed. Genotypes 4, 6, 8, 11, 15, 18, 21, 25 and 26 stood out among the rest, and is therefore recommended for new plantings and future breeding programs.

Keywords: *Passiflora alata*, genetic diversity, descriptors.

Introduction

The genus *Passiflora* L. has about 80 species with edible fruits and desirable agronomic characteristics (Ocampo et al., 2016) and many of these are dispersed throughout the Brazilian territory characterizing the country as one of the main genetic diversity centers of the genus, with wide natural genetic variability (Matins et al., 2003; Gonçalves et al., 2007).

The high genetic variability found among and within passion fruit genotypes, confers the establishment of several selection strategies. Indirect gains in fruit mass can be obtained by selection of fruits with larger equatorial diameter and lower peel thickness, allowing the achievement of heavier fruits and higher pulp yield (Negreiros et al., 2007). Oliveira et al.,(2008) confirms that the use of direct selection provides positive genetic gains in relation to mass, length, width, shape and number of fruits per plant parameters.

The external characteristics of the fruit must achieve quality standards such as size and mass, which reach the quality desired for commercialization (Nascimento et al., 1999). The fruit mass is generally proportional to the number of seeds and, in passion fruit, to the yield of juice (Fortaleza et al., 2005).

The objectives were to analyze the physical and chemical characteristics of the fruits

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of 33 genotypes of *P. alata* Curtis and to select the best ones for a breeding program.

Material and Methods

The work was carried out in the Experimental Area and in the breeding plants Laboratory of the Centro Universitário Norte do Espírito Santo (CEUNES), Universidade Federal do Espírito Santo (UFES), São Mateus-ES (latitude 18 ° 42’50 “ and a West longitude of 39 ° 50 ‘53 “).

In the evaluations, 33 genotypes of *Passiflora alata* Curtis, obtained in the surroundings of CEUNES, were used in a radius of 500 m. These genotypes were propagated via seminiferous and arranged in a randomized block design with two replicates of four plants, grown at 2 m spacing between rows and 2.5 m between plants in the row in a soil classified as Cohesive Yellow Argisoil of sandy texture agreement with the Brazilian Agricultural Research Corporation (EMBRAPA, 2006). In the dry season, irrigation frequency was twice a week, using a water tank coupled to the tractor.

Ripe fruits, number of 32 per repetition, with pericarp presenting straw yellow color, were harvested with a pruning shears removing the fruit from the branches with a cut in the petiole. They were then identified and transported in Styrofoam boxes with a bottom of phenolic foam to the laboratory. In the laboratory the fruits were numbered and packed in open plastic boxes, in which they were identified by genotype and repetition, and immediately began the analysis of the following characteristics: fruit mass (g) - determined in an electronic scale (0.01 g); equatorial and polar diameter of fruits (cm) - determined using a digital caliper; peel thickness (mm) - measured in fruits sectioned in the middle, using the digital caliper; volume of pulp (mL); pulp yield (%) - determined by weighing the fruits and the crude pulp separately, obtaining the pulp yield by the ratio between the crude pulp mass and the total mean mass of the fruit, according to Equation, PY (%) = (MCP / TMF) x 100. Where: PY (%) = pulp yield ; MCP (g) = mass of the crude pulp; TMF (g) = total mass of the fruit; number of seeds per fruit; Soluble solids (SS / ° Brix) - determined by reading in an analog hand held refractometer, with temperature compensation; pH - evaluated with a benchtop pHmeter, with glass electrode; titratable acidity (TA, % citric acid) - determined from the juice of the pulp, using the phenolphthalein indicator. The titration was done with 0.1 N NaOH, expressed as a percentage of citric acid from the equation: % citric acid = (Vg x N x f x Eq. Ac.) / 10 xg, where: Vs (mL) = volume of spent NaOH; N = normality of the NaOH solution used; f = correction factor obtained for standardization of NaOH; Ac. = acid equivalent, which for passion fruit is 64; g = mass of the sample and the ratio (SS / TA).

Data were submitted to analysis of variance, and later Scott-Knott grouping test, at a 5% probability level. In the multivariate analysis, the genetic divergence between the accessions was estimated by the Tocher grouping method (Rao, 1952), using the generalized distance of Mahalanobis (D2), as a measure of dissimilarity. Based on the distance matrix, the cluster analysis was carried out by UPGMA (Unweighted Pair Grouped Method Average) hierarchical classification algorithm. The identification of the importance of the characteristics was made based on Singh’s method (Singh, 1981). Statistical-genetic analyzes were performed with the aid of the statistical program Genes (Cruz, 2016).

Results and Discussion

The physical characteristics with the greatest variability among the genotypes, in descending order, were: seed number, peel mass, pulp yield, fruit mass, pulp mass, peel thickness, equatorial diameter, longitudinal diameter with variation coefficients of 24.12; 23.44; 22.80; 22.25; 19.92; 13.01; 7.99 and 7.5%, respectively (Table 1). Negreiros et al. (2008) with the species *P. edulis* f. *flavicarpa* obtained for the characteristics, pulp mass, fruit mass, peel mass, pulp mass, peel thickness, equatorial diameter and longitudinal coefficients of variation of 22.66; 14.26, 13.20 and 11.48%, respectively. According to Soares et al. (2011) in the species *P. foetida* the characteristic that showed the greatest variation was the soluble solids content. These results suggest that in genotypes studied there is great genetic variability, and may be an advantage in the improvement of passion fruit *P. alata* in terms of genetic gain and genotype choice, according to the purpose of the fruits.

The fruits of *P. alta*, in general, presented a more elongated shape, usually pear-shaped, contrasting with those of *P. edulis f. flavicarpa*, which are oblong shaped. The highest means of the equatorial diameter were observed in fruits of genotypes 3, 4, 6-11, 15, 16, 18, 19, 21, 25 and 28 (mean of 55.56 mm) and the longitudinal diameter was obtained with genotype 6 with a mean of 85.2 mm (Table 1), identified as the most oblong of all genotypes. Alves et al. (2012b) found in fruits of *P. alata*, mean of 74.59 ± 5.07 and 85.35 ± 5.83 mm, for the equatorial and longitudinal diameter, respectively. However, among the 33 genotypes of the species *P. alata*, the number seven presented a more rounded shape, where the equatorial diameter was 56.4 mm and the longitudinal one was 56.2 mm (Table 1), which characterizes the fruits of this species. In the case of *P. edulis f. flavicarpa*, more oblong fruits are sought. This characteristic is important for those destined mainly to the industry, which prefers oblong fruits because they present about 10% more juice than the round ones (Fortaleza et al., 2005).The thickness of the passion fruit peel is an important characteristic, in which Nascimento et al. (1999) consider satisfactory for the infra-specific epithet "*flavicarpa*" the standard of less than 5 mm, in the fresh fruit and industry markets. Fruits of *P. edulis* f. *flavicarpa* are preferred when they have a thinner peel, as they have a higher amount of pulp, however, less mechanical

Table 1. Means of the fruits physical characteristics of genotypes (GEN) of *P. alata* as the longitudinal diameter (LD), equatorial diameter (ED), fruit mass (FM), peel mass (PC) , pulp mass (PM), pulp yield (PY) and number of seeds per fruit (NS)

GEN	ED (mm)	LD (mm)	FM (g)	BC (g)	PC (mm)	PM (g)	PY (%)	NS
1	50.3 b*	60.1 c	54.3 c	39.6 b	5.9 c	14.6 c	27.0 a	134.0 c
2	45.4 b	56.4 d	98.9 a	85.0 a	6.2 b	13.9 c	14.0 c	144.0 c
3	52.3 a	63.6 c	80.4 b	60.8 b	7.8 a	19.5 b	25.2 a	191.2 b
4	53.4 a	68.0 b	91.3 a	78.5 a	9.4 a	12.8 d	14.0 c	132.0 c
5	47.0 b	56.5 d	82.3 b	66.1 b	9.2 a	16.2 c	20.8 b	140.5 c
6	56.9 a	85.2 a	116.2 a	100.0 a	8.2 a	16.2 c	14.0 c	147.5 c
7	56.4 a	56.2 d	92.4 a	77.2 a	9.1 a	15.1 c	16.3 c	174.5 b
8	54.0 a	67.2 b	87.1 a	62.5 b	6.2 b	24.5 a	28.5 a	204.0 b
9	55.1 a	73.7 b	103.7 a	92.6 a	7.3 b	11.1 d	10.8 c	135.5 c
10	61.4 a	74.2 b	90.9 a	78.8 a	4.3 c	12.0 d	13.3 c	150.7 c
11	54.5 a	71.1 b	99.2 a	81.5 a	6.8 b	17.7 b	17.9 c	216.2 a
12	50.0 b	59.0 d	76.4 b	56.0 b	7.6 b	20.3 b	26.6 a	183.0 b
13	45.6 b	55.8 d	57.7 c	61.1 b	8.2 a	11.5 d	15.9 c	141.7 c
14	48.7 b	70.7 b	92.0 a	73.3 a	8.6 a	18.7 b	25.7 a	221.7 a
15	54.8 a	67.7 b	110.6 a	94.2 a	8.7 a	16.4 c	14.9 c	184.2 b
16	51.9 a	64.3 c	76.6 b	63.8 b	7.1 b	12.7 d	17.2 c	156.2 c
17	49.7 b	60.6 c	58.6 c	42.5 b	5.6 c	16.1 c	28.1 a	197.0 b
18	58.9 a	65.8 b	114.4 a	104.0 a	10.2 a	10.4 d	9.0 c	137.0 c
19	56.6 a	65.7 b	123.6 a	99.7 a	8.4 a	23.9 a	19.9 b	240.7 a
20	49.8 b	61.2 c	100.7 a	90.2 a	8.4 a	10.5 d	10.4 c	146.5 c
21	55.0 a	66.2 b	91.6 a	79.3 a	9.0 a	12.3 d	13.9 c	133.0 c
22	43.2 b	58.2 d	79.0 b	61.3 b	7.8 a	17.7 b	21.7 b	156.7 c
23	46.8 b	58.4 d	92.2 a	79.6 a	8.7 a	12.5 d	13.8 c	185.0 b
24	47.3 b	64.7 c	62.4 c	53.1 b	8.4 a	9.3 d	14.9 c	111.5 c
25	57.1 a	69.3 b	97.4 a	85.3 a	9.3 a	12.0 d	12.4 c	155.7 c
26	51.3 b	66.0 b	87.7 a	72.4 a	7.8 a	15.3 c	17.4 c	188.0 b
27	49.1 b	61.7 c	56.9 c	42.4 b	8.3 a	14.4 c	25.6 a	148.0 c
28	55.2 a	68.8 b	84.1 b	62.0 b	6.4 b	22.1 a	26.6 a	192.0 b
29	46.3 b	63.4 c	99.8 a	87.2 a	7.9 a	12.5 d	13.7 c	147.2 c
30	44.5 b	61.3 c	78.1 b	57.7 b	8.0 a	20.4 b	26.1 a	184.5 b
31	51.5 b	72.4 b	102.1 a	90.8 a	9.3 a	11.3 d	11.0 c	139.2 c
32	49.3 b	57.2 d	83.7 b	68.0 b	8.0 a	15.7 c	18.7 c	202.0 b
33	46.4 b	55.0 d	63.5 c	54.3 b	8.1 a	9.2 d	15.0 c	126.7 c
CV (%)	7.99	7.5	22.25	23.44	13.01	19.92	22.80	24.12

* Means followed by the same letter in the column, belong to the same grouping, by the Scott-Knott test, at 5% probability.

resistance to transport. In the present work, for the species *P. alata*, the thickness of the peel ranged from 4.3 to 5.9 mm for the grouping of smaller means (genotypes 1, 10 and 17) and from 7.8 to 10.2 mm (genotypes 3-7, 13-15, 18-27 and 29-33) (Table 1). Jung et al. (2007a, b), Alves et al. (2012a) and Alves et al. (2012b) found peel thickness of *P. alata* fruits of 10.41; 14.38 and 14.48 mm, respectively. Tissues of the peel of fruits of the species *P. edulis* f. *flavicarpa* are firmer compared to those of the *P. alata* species thicker, meanwhile, softer. Even perforations and damage to *P. alata* fruits can easily occur when they are very ripe, which makes them very sensitive to the transport and attack of microorganisms, as it is verified to the field in infestations by bacteria and also by ants. Heavy fruits of the species *P. alata* are very desirable, to be considered as consumed *in natura*. The fruit mass is usually proportional to the number of viable seeds and, to juice yield, mainly because each seed is surrounded by an aril (Fortaleza et al., 2005). In the present study, the mean fruit mass among the studied genotypes of *P. alata* was 87.45 g (Table 1). The grouping of the highest fruit mass means (mean of 99.56 g) was obtained with genotypes 2, 4, 6-11, 14, 15, 18-21, 23, 25, 26, 29 and 31 (Table 1). Jung et al. (2007a, b), studying the specific combining ability of 36 crosses, found means of *P. alata* fruits with a mass of 213.9 g. Nascimento et al. (2003) in 20 progenies of the species *P. edulis* f. *flavicarpa* observed a mean fruit mass of 161.6 g.

Regarding the number of seeds of the 33 genotypes of *P. alata*, there was a variation between 111.5 and 240.7 (Table 1), while Alves et al. (2012b) found mean values of seeds of 268.73 ± 50.68, with lower value of 110.0 and higher value of 379.0. The fruit peel mass, among the evaluated genotypes, was about 39.64 g (Table 1). According to Negreiros et al. (2008), the mass of the peel of passion fruit *P. edulis* f. *flavicarpa*, in 61% of the evaluated genotypes was inferior to 80,37 g, with variation of 56,58 g to 116,32 g. The mass value of the high peel is an undesirable characteristic because it does not contribute to the yield of the juice, especially for fruit destined for industrial processing.

The pulp yield was higher among genotypes 1, 3, 8, 12, 14, 17, 27, 28 and 30, with a mean of 26.6% (Table 1), close to those found by Jung et al. (2007a, b), in 36 crosses of *P. alata*, which was 30.26%; Alves et al. (2012a) in mature fruits of *P. alata* after 30.6 days of anthesis, the proportion of 74.10% of pericarp (peel), 24.46% of pulp and 3.14% of seeds, while in *P. edulis* f. *flavicarpa*, Negreiros et al. (2008) observed pulp yield between 27.65 and 45.83%. Like the physical characteristics, the chemicals are very important in a series of factors such as the conservation of the pulp and the amount of sugars to be added to the juice. The pH values of genotypes 15, 16 and 32 were the highest (3.74, 3.85, 3.73, respectively), while in genotype 31 it was 3.29 (Table 2). Freitas et al. (2006) in *P. alata* found pulp pH values of 3.53, lower than the mean value found in this study, which was 3.29 (Table 2). The acidity of the fruit is a very important characteristic for the industry, as it inhibits the proliferation of microorganisms and provides a longer shelf life (Negreiros et al., 2008). The total acidity of fruits of genotypes 2, 4, 7, 8, 11-13, 17-22, 25, 27 and 31 stands out in the cluster of higher means, with values ranging from 5.71 to 7.48% (Table 2). Freitas et al. (2006) working with the same species found 1.70 g of citric acid / 100 mL, and according to Alves et al. (2012a), from 63º to 91º days after the anthesis there is a decrease in titratable acidity of 2.3 to 1.5%.

For soluble solids, genotypes 26 and 32 were higher than 22 °Brix and genotypes 15, 17, 22 and 24 lower than 18.7 °Brix, which formed the group of lower levels. The lowest and the highest values found were 17.2 and 22.57 ° Brix, respectively, with a difference of 5.37 ° Brix (Table 2). Meletti et al. (2003) evaluated seven genotypes of *P. alata* and soluble solids (SS), ranging from 19.8 to 22.8º Brix. Freitas et al. (2006) found values of 20.8º Brix, while Alves et al. (2012b) found on mean 18.20 ± 1.43º Brix and Machado et al. (2015), in the access BGP 004, mean of 14.6 ° Brix.

For the species *P. edulis* f. *flavicarpa* Nascimento et al. (2003), Jung et al. (2007b, 2008) and Negreiros et al. (2008) founded mean values of 16.2; 18.06 and 15.72 ° Brix, respectively. According to Nascimento et al. (2003), the differences in soluble solids contents for *P. edulis* f. *flavicarpa* may be a consequence

Table 2. Means of the chemical characteristics of fruits of genotypes (GEN) of *P. alata* as pH, titratable acidity (TA), soluble solids (SS) and SS / TA ratio

GEN	pH	TA (%)	SS (°Brix)	SS/TA
1	3.46 c*	5.53 b	20.32 b	3.80 c
2	3.49 c	6.04 a	19.42 c	3.25 c
3	3.53 b	5.20 b	19.37 c	3.77 c
4	3.38 c	5.71 a	19.70 c	3.50 c
5	3.59 b	4.57 c	20.10 b	4.47 b
6	3.46 c	5.24 b	18.37 c	3.57 c
7	3.52 b	5.76 a	20.55 b	3.66 c
8	3.38 c	6.01 a	20.52 b	3.46 c
9	3.54 b	5.00 b	20.95 b	4.22 b
10	3.48 c	5.37 b	19.05 c	3.54 c
11	3.32 c	5.87 a	20.62 b	3.60 c
12	3.45 c	6.09 a	19.57 c	3.27 c
13	3.43 c	6.38 a	18.82 c	2.97 c
14	3.51 b	5.23 b	20.52 b	4.10 b
15	3.60 b	3.84 c	17.20 d	5.11 a
16	3.74 a	4.24 c	21.20 b	5.13 a
17	3.85 a	3.80 c	17.77 d	5.01 a
18	3.38 c	7.48 a	19.30 c	2.57 c
19	3.36 c	7.00 a	19.75 c	2.84 c
20	3.32 c	5.95 a	19.10 c	3.46 c
21	3.29 c	6.84 a	20.95 b	3.06 c
22	3.29 c	6.32 a	17.85 d	2.91 c
23	3.58 b	5.42 b	18.60 c	3.43 c
24	3.42 c	4.86 b	16.15 d	3.44 c
25	3.31 c	6.36 a	19.35 c	3.07 c
26	3.48 c	5.21 b	22.10 a	4.28 b
27	3.34 c	5.80 a	21.82 a	3.80 c
28	3.40 c	5.28 b	18.95 c	3.61 c
29	3.45 c	5.32 b	19.85 b	3.77 c
30	3.60 b	4.81 b	20.35 b	4.37 b
31	3.29 c	6.12 a	19.00 c	3.18 c
32	3.73 a	4.00 c	22.57 a	5.64 a
33	3.51 b	5.28 b	20.50 b	3.88 c
CV (%)	4.56	16.62	5.92	19.45

* Means followed by the same letter in the column, belong to the same grouping, by the Scott-Knott test, at 5% probability

of the variability inherent in the *flavicarpa* form. The same can be observed for *P. alata* species. Cavichioli et al. (2012) when grafting *P. edulis* f. *flavicarpa* in *P. alata* did not verify changes in the contents if SS, TA and ratio. This indicates that the species *P. alata* is a good rootstock for *P. edulis* f. *flavicarpa*. Zucareli et al. (2014) observed that *P. alata* grafted on *P. cincinnata* did not undergo alterations in the mineral contents of the plants. However, Hurtado-Salazar et al. (2015) when grafting *P. edulis* on *P. gibertii* and *P. mucronata* verified reductions in TA, SS, ratio and vitamin C.

For both the industry and the fruit market *in natura*, the soluble solids (SS) content must be high, and the higher the SS content the lower the quantity of fruits required for the juice concentration (Negreiros et al., 2008). The genotypes 15; 17; 22 and 24 presented the lowest levels of SS, 17,20; 17.77; 17.85 and 16.15 °Brix, respectively, whose values are below the mean that was 19.67 ° Brix (Table 2). Nascimento et al. (1999) consider that the varieties of *P. edulis* f. *flavicarpa* destined to the industrialization must have, besides high yield of juice, soluble solids around 16 °Brix.

The ratio (SS / TA) indicates the degree of equilibrium between the sugars and organic acids content of the fruit. According to Freitas et al. (2011) the value ratio is considered one of the most practical ways of evaluating the fruit flavor. The acidity is decisive in this point, because if it is very high, it reduces this relation. The results suggest that there were significant differences in flavor among the groups, with the largest groupings observed in genotypes 15, 16, 17 and 32 (Table 5), respectively (5.11, 5.13, 5.01 and 5.64), values below those found by Freitas et al. (2006) with the same species, which was 12.2, that is, 2.33 times greater. However, the sugar content and acidity of the fruits may vary according to environmental factors, cultivation practices, quality of sunlight, temperature, as well as fertilizer type and dosages (Nascimento et al., 2003). The genotypes 4, 6, 8, 11, 15, 18, 21, 25 and 26 presented better results, between 5 and 7 physical and chemical characteristics of the fruits (Tables 1 and 2), being therefore classified as superior genotypes and could be selected for subsequent crops.

The Singh method (1981), based on D² of Mahalanobis considers of lesser importance, characteristics that express less variability. According to Loss et al. (2006), the values of genetic divergence among *P. alata* populations ranged from 0.09 to 0.15 and the analysis of molecular variance indicated a greater intra-population (57.44%) than inter-population genetic variation (42.56%). In these genotypes, the yield of pulp (12.66%) was the characteristic that most contributed to the genetic diversity (Table 3). Jung et al. (2008), verified among the 36 different crosses a wide variation in the estimates of heritability and genetic gain in different characters of the fruits of the *P. alata* species. For example, for pulp yield, the heritability value ranged from zero to 49.30%. According to these authors, the heritability is dependent on the cross, to consider that a particular parent has different genes controlling the character in question. The genetic diversity in Passifloraceae family can also be evaluated by means of vegetative morphological characters, as in the study of Lawinscky et al. (2014) between accessions of *P. alata*, in which they verified that the length of bracts, and the height of the plant were those that presented greater variation, and that of Paiva et al. (2014), where the characters related to the flowers that most contributed the most to the genetic diversity of the accessions.

The use of the Tocher optimization method, based on the dissimilarity expressed by the distances of Mahalanobis (D2), allowed the formation of ten distinct groups (Table 4): group I, with genotypes 2, 3, 4, 5, 7, 9 , 11, 12, 13, 14, 20, 21, 22, 23, 25, 26, 29, 31 and 33; group II, with genotypes 1, 8, 27, 28 and 30; group III, with genotypes 16 and 32; group IV, with genotype 17; group V, with genotype 15; group VI, with genotype 10; group VII, with genotype 24; group VIII, with genotype 6; group IX, with genotype 19 and group X, with genotype 18. However, by the UPGMA method that uses the generalized distance of Mahalanobis (D2) where the cut-off point in the dendogram determines the optimal number of groups by the Mojena method (1977), we obtained three groups: group I, formed by genotypes 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32 and 33; group II by genotype 19 and group III, by genotype 17 (Figure 1). Bellon et al. (2009), when studying the clustering analysis performed on the basis of genetic distances allowed to subdivide the 17 accessions of *P. alata* in at least five groups of genetic similarity. The wild accesses

Table 3. Estimates of the relative contribution of each trait (S.j) to the genetic divergence among genotypes of *P. alata*, by the Singh method (1981) generalized distance of Mahalanobis (D2).

Variables	S.j	Values in %
Equatorial diameter (mm)	66.10	8.53
Diameter in mm (mm)	51.43	6.63
Fruit mass (g)	69.63	8.98
Peel mass (g)	76.77	9.90
Peel thickness (mm)	48.65	6.28
Pulp mass (g)	74.74	9.64
Pulp yield (%, citric acid)	98.12	12.66
Number of seeds	63.23	8.16
pH	62.19	8.02
Titratable acidity - TA (%)	58.29	7.52
Soluble solids - SS (° Brix)	48.42	6.25
SS / TA	57.11	7.37

contributed the most to the genetic base of the studied materials, opening perspectives for the use of these materials in breeding programs.

Table 4. Representation of the cluster generated by the Tocher optimization method based on the generalized distance of Mahalanobis among genotypes of *P. alata*, through the use of 12 characteristics of the fruits

Groups	Genotypes
I	2. 3. 4. 5. 7. 9. 11. 12. 13. 14. 20. 21. 22. 23. 25. 26. 29. 31. 33
II	1. 8. 27. 28. 30
III	16. 32
IV	17
V	15
VI	10
VII	24
VIII	6
IX	19
X	18

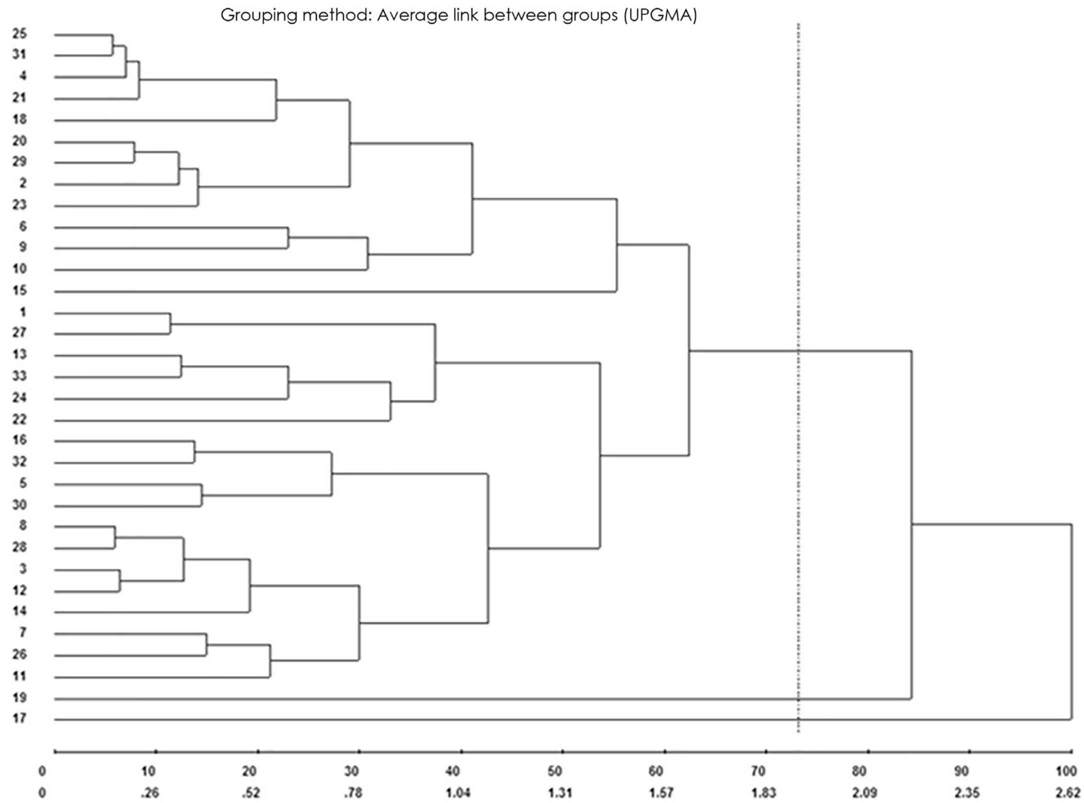

Figure 1. Representative dendogram of genetic dissimilarity among genotypes of *P. alata*, obtained by the UPGMA method, using the generalized distance of Mahalanobis (D2).

Conclusions

There is a great genetic variability among the genotypes of P. alata regarding the characteristics evaluated, with plants showing high and low genetic potential. Genotypes 4, 6, 8, 11, 15, 18, 21, 25 and 26 are recommended for future breeding programs.

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