Genotype characterization of pomegranate trees grown in Tabuleiro de Russas–CE

Caracterização de genótipos de romãzeira produzidos em Tabuleiro de Russas-CE

DOI:10.34117/bjdv7n4-267

Recebimento dos originais: 10/03/2021
Aceitação para publicação: 12/04/2021

Elny Alves Onias
Doutoranda em Agronomia
Instituição: Universidade Federal da Paraíba (UFPB)
Endereço: Rodovia BR 079 – Km 12, CEP 58.397-000 Areia, Paraíba, Brasil
E-mail: elnyonias@hotmail.com

Railene Hérica Carlos Rocha Araújo
Doutora em Fitotecnia, docente da Universidade Federal de Campina Grande (UFCG)
Instituição: Universidade Federal de Campina Grande (UFCG)
Endereço: Rua Jairo Vieira Feitosa, 1770 - Pereiros, CEP 58840-000 Pombal, Paraíba, Brasil
E-mail: raileneherica.ufcg@gmail.com

Ana Paula Nunes Ferreira
Mestranda em Horticultura Tropical
Instituição: Universidade Federal de Campina Grande (UFCG)
Endereço: Rua Jairo Vieira Feitosa, 1770 - Pereiros, CEP 58840-000 Pombal, Paraíba, Brasil
E-mail: paula-nf@hotmail.com

Agda Malany Forte de Oliveira
Doutoranda em Fitotecnia
Instituição: Universidade Federal Rural do Semi-árido (UFERSA)
Endereço: Rua Francisco Mota Bairro, 572 - Pres. Costa e Silva, CEP 59625-900, Mossoró, Rio Grande do Norte, Brasil
E-mail: agdamalany@hotmail.com

Albert Einstein Mathias Medeiros Teodosio
Doutorando em Agronomia
Instituição: Universidade Federal da Paraíba (UFPB)
Endereço: Rodovia BR 079 – Km 12, CEP 58.397-000 Areia, Paraíba, Brasil
E-mail: albertemmt@gmail.com

Diogenes Henrique Abrantes Sarmento
Doutor em Fitotecnia
Instituição: Universidade Federal Rural do Semi-árido (UFERSA)
Endereço: Rua Francisco Mota Bairro, 572 - Pres. Costa e Silva, CEP 59625-900, Mossoró, Rio Grande do Norte, Brasil
E-mail: dabrantes01@yahoo.com.br

Kalinny Araújo Alves
Graduanda em Engenharia de Alimentos
Instituição: Universidade Federal de Campina Grande (UFCG)
Endereço: Rua Jairo Vieira Feitosa, 1770 - Pereiros, CEP 58840-000 Pombal, Paraíba, Brasil
E-mail: kalialves2015@outlook.com

Thais Batista de Queiroga
Doutoranda em Agronomia
Instituição: Universidade Federal da Paraíba (UFPB)
Endereço: Rodovia BR 079 – Km 12, CEP 58.397-000 Areia, Paraíba, Brasil
E-mail: thaisqueirogah@gmail.com

ABSTRACT
The pomegranate (*Punica granatum* L.) is one of the most ancient fruits there is, characterized by its great variability of genotypes that differ between themselves in their physical and biochemical properties. Studying these characteristics allows us to evaluate these genotypes' variability, as to identify those with features that are fit for use in commercial orchards. In this sense, the purpose hereof was to evaluate the variability in terms of physical-chemical properties of three pomegranate tree genotypes (CV8, CV12, and CVW) grown in the semiarid region to gather more knowledge about these fruits' potential. The fruits employed were collected from an experimental orchard, located at Tabuleiro de Russas–CE, and transported to the lab, where they were selected, washed, and sanitized. An 18-fruit sampling of each genotype was employed for the characterization thereof as their quality physical-chemical features. The genotypes CV8 and CVW presented greater potential of peel and aril color in comparison with CV12; as for the external and internal appearance, the genotypes met the *in natura* pomegranate commercialization quality. The juice yield was greater in the genotypes CVW (28.3%) and CV8 (26.9%), which also presented the greatest levels of soluble solids—CVW, 13.2%, and CV8, 12.9%. As for the titratable acidity, all three genotypes presented levels under 1% of citric acid. The ascorbic acid and phenolic compounds were greater in the CV8 and CV12 genotypes. The pomegranate tree genotypes CV8 and CV12, produced in Tabuleiro de Russas–CE, presented the best physical-chemical features that meet the quality standard for the commercialization of *in natura* fruits.

Keywords: *Punica granatum* L, physical-chemical characterization, quality.

RESUMO
A romã (*Punica granatum* L.) é um dos frutos mais antigos, caracterizados por apresentar grande variabilidade de genótipos que diferem entre si em suas propriedades físicas, químicas e bioquímicas. Estudar estas características permite avaliar a variabilidade destes genótipos, de modo a identificar aqueles com características adequadas para serem usados em pomares comerciais. Neste sentido, objetivou-se com este trabalho avaliar a variabilidade em termos de propriedades físico-químicas de três genótipos de romãzeira (CV8, CV12 e CVW) cultivados no semiárido, a fim de obter maior conhecimento sobre o potencial desses frutos. Os frutos utilizados foram obtidos de um pomar experimental, localizado em Tabuleiro de Russas, CE e transportados para o laboratório, onde foram selecionados, lavados e sanitizados. Utilizou-se uma amostragem de 18 frutos de cada genótipo para realização da caracterização dos mesmos quanto aos aspectos físico-químicos de qualidade**.** Os genótipos CV8 e CVW apresentaram maior potencial de cor

da casca e do arilo, quando comparados com o CV12, quanto à aparência externa e interna os genótipos atenderam a qualidade para comercialização da romã *in natura*. O rendimento de suco foi maior nos genótipos CVW 28,3% e CV8 26,9%, sendo que estes também apresentaram os maiores teores de sólidos solúveis CVW 13,2% e CV8 12,9%. Quanto à acidez titulável, os três genótipos apresentaram teores inferiores a 1% de ácido cítrico. O ácido ascórbico e os compostos fenólicos foram maiores nos genótipos CV8 e CV12. Os genótipos de romãzeira CV8 e CV12, produzido no Tabuleiro de Russas, CE reuniram as melhores características físico-químicas que atendem ao padrão de qualidade para a comercialização dos frutos na forma in natura.

Palavras-chave: *Punica granatum.*L, qualidade, caracterização físico-química.

1 INTRODUCTION

Pomegranates (*Punica granatum* L.) originate from Central Asia, from where they reached the Mediterranean basin, Southern Asia, and several countries of North and South America. It is a species of temperate climate that also requires high temperatures for its proper ripening, but it is easily spread in arid and semiarid regions of the world, due to its salinity and water shortage tolerance (ZAOUAY et al., 2012; MARTÍNEZ et al., 2016).

It is characterized by its great variability in terms of domestic, wild, and ornamental genotypes, which present differences in features such as peel and aril color, succulence, sugar/acid ratio, fatty acid content, anthocyanins, phenols, and antioxidant activity. To select genotypes of interest for growth in commercial orchards, studies have been performed around the morphological, chemical, and biochemical features of different genotypes located in several regions of the world (ZAOUAY et al., 2012; FERRARA et al., 2014, KARIMI, 2017; ALCARAZ-MÁRMOL et al., 2017; KYRIACOU et al., 2020; SOUZA et al., 2020).

In Brazil, although the pomegranate production has been growing since 2009, with commercial cultivation performed in the Northeastern states of Bahia, Paraíba, and Ceará, whose commercial orchards have as goal the insertion thereof in the national market for the extraction of nutraceutical compounds and the development of new products of elevated antioxidant activity, as well the reemployment of its inedible parts, due to its nutritional and functional characteristics (SILVA, 2013; SUZUKI, 2016; ATAÍDE et al., 2018), the scientific knowledge about its physical-chemical properties and its modulation by genotype remains limited.

In this sense, it is required the development of research into the morphological, physical-chemical, and biochemical characteristics of different genotypes with the purpose of evaluating the variability thereof and selecting new cultivars of promising characteristics for use in commercial orchards, as well as to decide its suitability for *in natura* consumption, industrialization, or exportation (FERRARA et al., 2014; ALCARAZ - MÁRMOL et al., 2017).

Therefore, the purpose hereof was to evaluate pomegranate tree genotypes with potential for *in natura* commercialization, through the fruits' physical and physical-chemical characteristics.

2 MATERIAL AND METHODS

The research was developed at the Federal University of Campina Grande (UFCG), Center of Sciences and Agri-food Technology (CCTA), at the laboratory of Fruit and Vegetable Postharvest Technology. The pomegranate genotypes (CV8, CV12, and CVW) were collected from an experimental orchard located at Tabuleiro de Russas–CE, which is 292.8 km from the city of Pombal. The harvest was performed in the first hours of the morning, and the fruits were collected during the commercial ripening stage, establishing the harvesting point according to the fruits' color and size. The transportation was performed in cardboard boxes (640 x 480 cm), whose internal part was duly covered to minimize physical damages. At the laboratory, the selection was performed as to size uniformity, color, and absence of flaws; cracked or ill fruits were thrown away. Nevertheless, some fruits presented the incidence of spots during the harvest. Then, the fruits were washed with a solution of neutral detergent at 1% and, after rinsing, they were sanitized with a solution of sodium hypochlorite 100 ppm of chlorine. After outdoor drying, an 18-fruit sampling of each genotype was selected for the characterization thereof. The following characteristics were evaluated: **Peel and aril color**: Determined though the L*, a*, and b* system, by reflectometry, employing a refractometer of the brand Konica Minolta, model Chroma meter CR-400. The values of "a" and "b" were converted into a Hue angle "h" (h = tan-1 (b/a)), which represents color intensity, and chroma (C = (a2 + b2) 1/2), color purity. **External and internal appearance:** It was obtained through the mean of the results of three trained evaluators, considering subjective scales of scores varying from 5 to 0, quantified by defect percentages, as established by Silva (2013). **Peel yielding:** Determined though the ratio between the fruit's peel mass and fresh mass, individually quantified for each fruit, and whose results were expressed in percentages. **Juice yielding:** Determined through the ratio between the juice volume and fruit volume, individually quantified in a volumetric beaker, and whose results were expressed in percentages. **Seed yielding:** Determined through the ratio between the fruit's seed mass and fresh mass individually quantified for each fruit, and whose results were expressed in percentages. **Power of hydrogen (pH)**: It was measured through a digital bench pH meter by direct reading, according to IAL (2008). **Soluble solids (SS) (%):** Determined by direct reading with digital refractometer (model PR – 100, Palette, Atago Co., LTD., Japan), whose results were expressed in °Brix (AOAC, 2006). **Titratable acidity – TA (% of citric acid/100 mL of juice):** Determined by titrimetry employing a solution of NaOH 0.1M with phenolphthalein indicator, until a permanent light pink color was obtained, according to the methodology described by IAL (2008). The results were expressed in g of citric acid by 100 g^{-1} of the sample. **Soluble solid and Titratable acidity ratio (SS/TA):** Performed by the ratio between the values of soluble solids and titratable acidity. **Ascorbic acid ($mg.100mL^{-1}$ of ascorbic acid):** Determined according to AOAC (2006), through titration with 2.6 dichlorophenolindophenol (DCPIP), employing 1.0 mL of juice diluted in 49.0 mL of oxalic acid 0.5% (AOAC, 2006). **Total phenolic compounds ($mg.100mL^{-1}$):** Were determined through the method described by Waterhouse (2006). **Data analysis and presentation***:* A descriptive analysis of the results was performed, obtaining a mean and the standard deviation (SD), which were expressed in bar charts, designed with the program Microsoft Excel 2010.

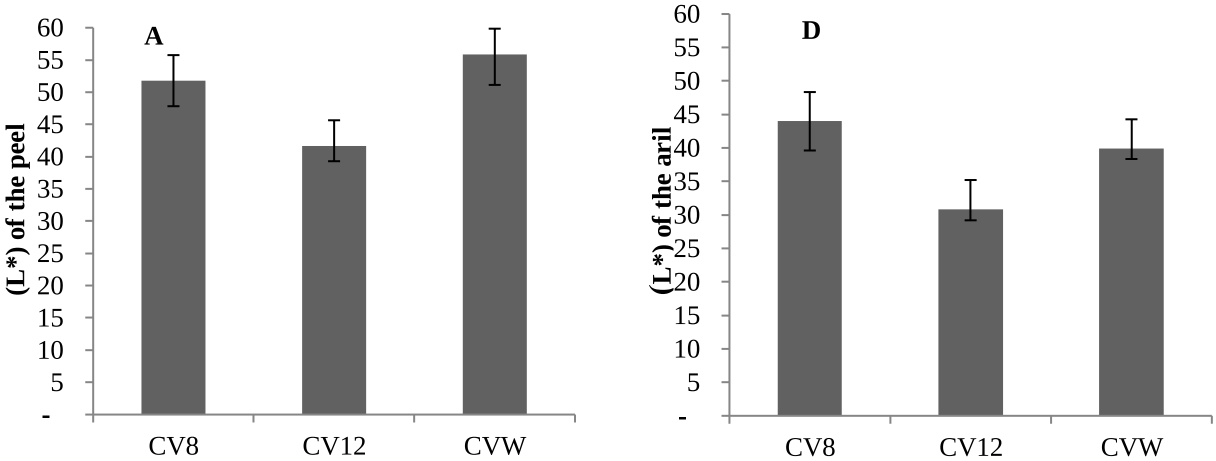
3 RESULTS AND DISCUSSION

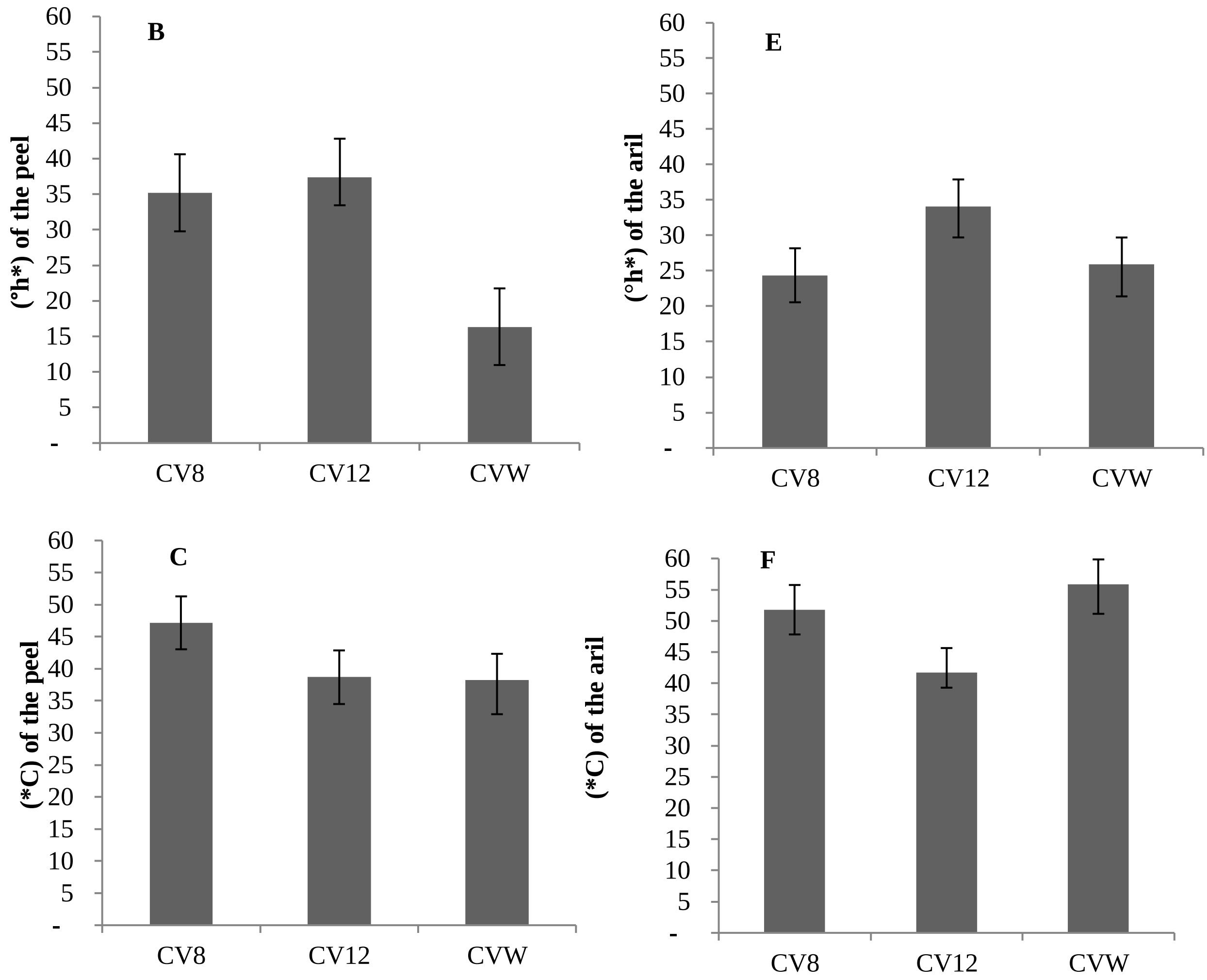
Regarding peel luminosity (L*), the greatest values were seen in fruits of the genotypes CVW and CV8, with means of L*55.89 and L*51.79, respectively, which means shinier fruits. The fruits of the genotype CV12 were characterized by a lower luminosity value in comparison with the other genotypes, with a mean of L*41.68, which implies in more opaque fruits (Figure 1A). Regarding the behavior of the peel color angle °h*, the greater mean values were seen in the fruits of the genotypes CV12 (°h*37.39) and CV8 (°h*35.39), corresponding to an orange-red color of the fruits' peel, as reported as well by Kyriacou et al. (2020) for the genotypes Kouklial, Emba3, Dymes, and Geri, which presented values of 30 < °h* < 50. The fruits of the genotype CVW presented the lower values for the color angle, with a mean of °h*22.41, which corresponds to fruits with much darker red peel color (Figure 1B). These results are in harmony with the ones of Kyriacou et al. (2020) for the genotypes Mazotos1, Mazotos2, and Wonderful, which present a variation of °h*<30°. As for color saturation (*C), the fruits of the genotypes

CV8 and CVW presented greater peel color intensity, with means of *C 47.16 and *C 42.57, and the fruits of the genotype CV12 presented a less saturated peel pigmentation (Figure 1C). Results similar to the ones found herein for CV8 and CVW were reported for Spanish and Italian pomegranates (FERRARA et al., 2014, ALCARAZ-MÁRMOL et al., 2017).

Just as with the peel, the aril luminosity was greater for the fruits of the genotypes CV8 and CVW, with means of L*43.98 and L*39.91, and lower in fruits of the genotype CV12 (Figure 1D). The results hereof are in harmony with the study of Kyriacou et al. (2020) for Cypriot accesses, which had L* ranging from 34.82 to 50.61. Regarding the color angle *h°, the fruits of the genotypes CV8 and CVW presented arils with more reddish color and means of °h* 24.37 and °h* 25.89, and the fruits of the genotype CV12 with mean of °h* 34.09 presented orange-red arils (Figure 1E). The aril's color intensity, expressed by chromaticity, was greater in the fruits of the genotypes CVW (*C 55.89) and CV8 (*C 51.79). A similar behavior of reported by Beaulieu et al. (2015) for the aril coloration of Californian pomegranate cultivars (Haku, Nusa). The genotype CV12 presented a lower value for this characteristic, with a mean of *C 41.68 (Figure 1F). With the lower value results for hue angle and chromaticity, a redder peel and aril color is highlighted in the fruits of the genotypes CV8 and CVW in comparison with those of the genotype CV12. This result is in harmony with the study performed with Italian- and Israeli-originated pomegranates (FERRARA et al., 2014).

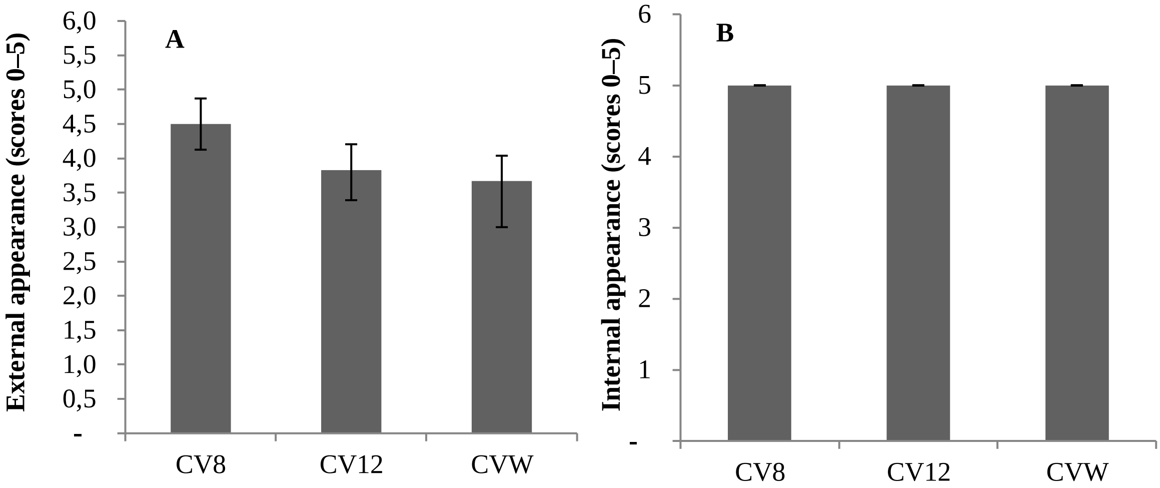
Figure 1: Peel and aril Luminosity (L*), Hue angle (°h*), and Chromaticity (C*) of pomegranate genotypes grown in Tabuleiro de Russas–CE, n=18





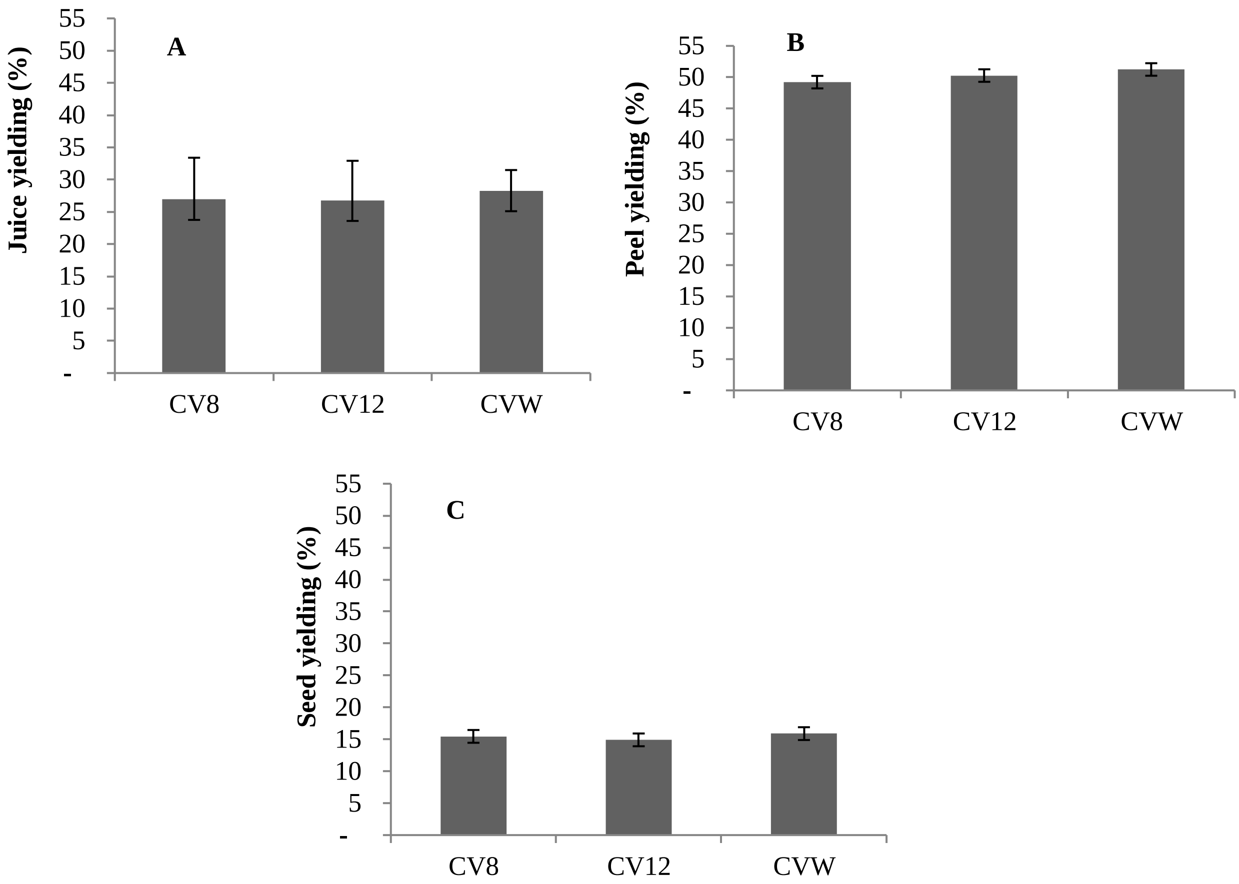
Regarding the fruits' external appearance, the three genotypes presented spot traces, which are presented in lower proportion in the fruits of the genotype CV8, with score means of 4.5; as for the fruits of the genotypes CV12 and CVW, they achieved score means of 4.0. This result represents 1% to 10% of the fruit affected with spots; nonetheless, the characterized genotypes did not present incidence of withering (Figure 2A). The internal appearance of the fruits was satisfactory, and all three genotypes had a score mean of 5.0, which corresponds to an internally healthy fruit, without changes in color, absence of loose seeds and/or presence of microorganisms (Figure 2B). The fruits' appearance was similar to the 'Molar' pomegranate grown on the organic system of the Paraiban semiarid region, meeting the quality for *in natura* pomegranate commercialization (SILVA et al., 2015; MOREIRA et al., 2015).

Figure 2: External and internal appearance of pomegranate genotypes grown in Tabuleiro de Russas–CE, n = 18.



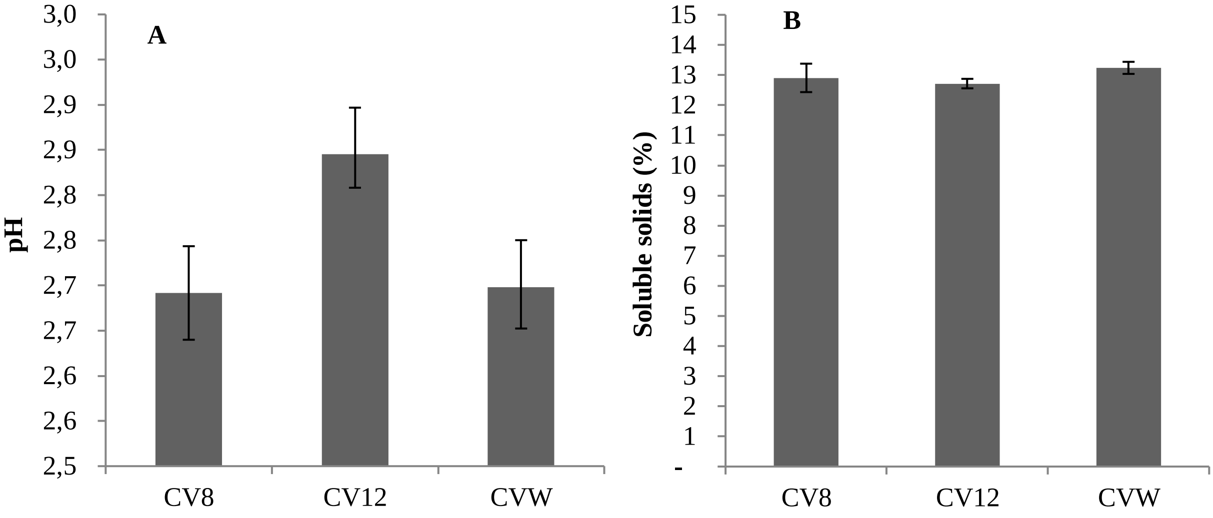
Regarding juice yielding, small variations between genotypes were observed. Nevertheless, the CVW fruits presented the greatest mean percentages, corresponding to 28.3%, while the fruits of the genotypes CV8 and CV12 presented yields under 26.9% and 26.8%, respectively (Figure 3A). Generally, the juice yields of the studied genotypes were inferior to the ones reported by Kyriacou et al. (2020) for the "Cypriot" genotypes. Regarding peel yielding, all three genotypes presented very similar yields, representing 51.2% for the CVW genotype, while the fruits of the genotypes CV12 and CV8 presented 50.3% and 49.2% of peels, respectively (Figure 3B). Something similar happened for seed yielding, which was of 15.9% and 15.5% for the CVW and CV8 genotypes, respectively, and 14.9% of seeds for CV12 (Figure 3C). Despite small differences, it is noticeable that the genotypes with greater percentages of seeds per fruit resulted in greater juice yielding, a feature that must be considered for the juice industry and for *in natura* commercialization as well (KYRIACOU et al., 2020). Cultivars of greater seed yielding can also represent a great potential for the industry because their seeds have several compounds, such as proteins and lipids, from which one can extract pomegranate oil, which is particularly rich in polyunsaturated fatty acids (PUFA), including isomers of conjugated linolenic acid (CLnA) (KÝRALAN et al., 2013), as well as the genotypes of greater peel yielding, since this part of the fruit has been currently studied due to the interest in the search of good phytochemicals present therein for use in the food, pharmaceutical, and cosmetic industries (SINGH et al., 2017).

Figure 3**:** Juice yielding (A), peel yielding (B), and seed yielding (C) of pomegranate genotypes grown in Tabuleiro de Russas–CE, n = 18.



Generally, the pH values were similar between the genotypes, with means of 2.9 for the fruits of CV12 and of 2.7 for the fruits of the genotypes CV8 and CVW, values that match with the ones of Silva et al. (2015) for the Molar pomegranate and for the ones reported by Alcaraz-Mármol et al. (2017) for cultivars of Italian (2.9) and Israeli (3.6) pomegranates (Figure 4A). All three pomegranate genotypes presented very similar soluble solid levels, with means of 13.2% for CVW, 12.9% for CV8, and 12.7% for CV12 (Figure 4B). The genotypes' soluble solids were similar to the ones reported for the Molar pomegranates grown in the Paraiban (13.8%; Silva et al., 2015), Pernambucan (13.9%; Oliveira, 2018), and Spanish (12.6% to 15.3%; Martinez-Nicolas et al., 2016) semiarid regions, and lower than the ones reported for the Italian (15.7%; Ferrara et al., 2014) and Californian pomegranates (16.0%; Beaulieu et al., 2015). Soluble solid variations can be attributed to differences between the genotypes but also to environmental conditions and harvest periods (KHADIVI-KHUB et al., 2015).

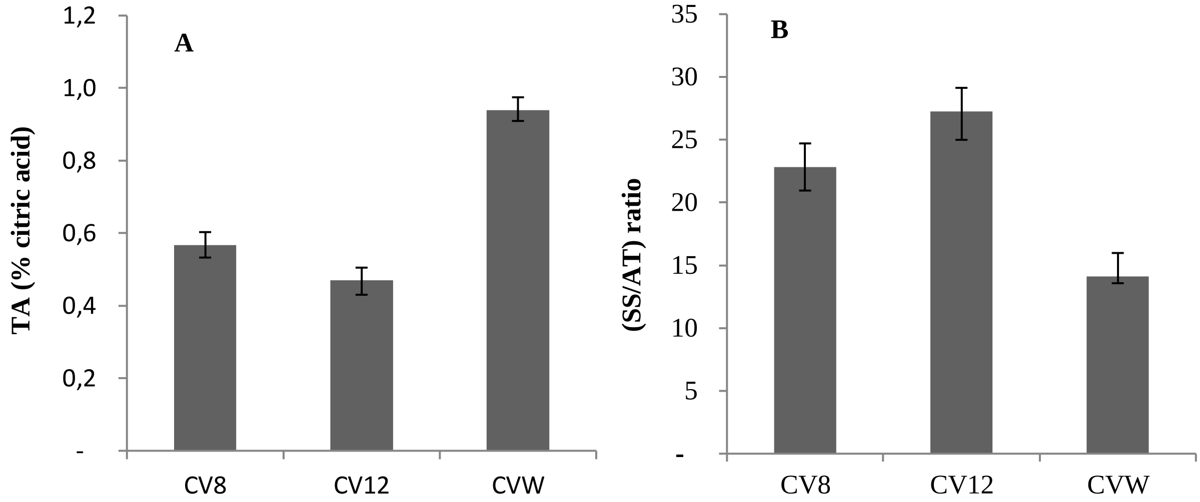
Figure 4: pH (A), Soluble solids (B) of pomegranate genotypes grown in Tabuleiro de Russas–CE, n= 18.



The fruits of the genotypes CV8 and CV12 were characterized by presenting a lower level of titratable acidity, with means of 0.6% and 0,5% of citric acid.100mL^{-1}, respectively, in comparison with the ones of the genotype CVW, which presented greater values (0.9%) of citric acid.100mL^{-1} (Figure 5A). The genotypes presented greater acidity than some Californian, Fleischman, Nusai, and Sin Pepe cultivars (0.2% of citric acid) (ALCARAZ-MÁRMOL et al., 2017). In pomegranate fruits, the organic acids composition differs according to the variety. Varieties of acidity under 1% are classified as sweet, 1.2% as bittersweet, and varieties of elevated acidity—above 2%—are deemed bitter (PAREEK et al., 2015; ALCARAZ- MÁRMOL et al., 2017). Therefore, all three genotypes grown in Tabuleiro de Russas–CE fall into the sweet group, with acidity under 1%, exhibiting a satisfactory quality as for acidity for the *in natura* consumption of the fruit, a behavior also observed for the Molar variety, grown in the Paraiban semiarid region (Silva et al., 2015) and for the Cypriot genotypes (KYRIACOU et al., 2020).

The SS/TA ratio was greater for the CV12 genotype, with a mean of 27.1, justified by the greater acidity seen in this genotype, whose value was greater than the one reported for the germplasm selected from the USDA (22.3; CHATER et al., 2018). The CV8 and CV12 genotypes presented lower values for the SS/TA ratio, with means of 22.6 and 14.1, respectively. Generally, the SS/TA ratio of the genotypes was greater than those of the pomegranates grown in California Selavatski (12.9), Myaggkosemyannyi, and Ovadam (12.5) (Alcaraz-Mármol et al., 2017). The SS/TA ratio is usually employed as a tool to evaluate the pomegranate's taste. This variable expresses the balance between the fruit's sweetness and acidity. In other words, the greatest its value, the better is the fruit's sweetness level (DIAS et al., 2011; RAMOS et al., 2011; MARTÍNEZ et al., 2012). In this sense, the CV12 and CV8 genotypes are characterized by presenting fruits with more pleasant taste to the palate in comparison with the CVW genotype (Figure 5B).

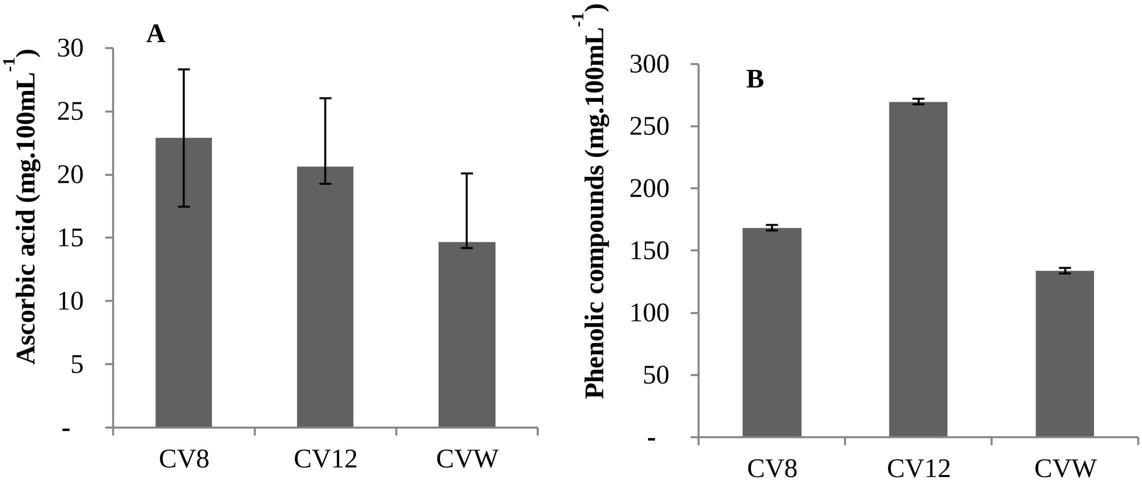
Figure 5**:** Titratable acidity and SS/TA ratio (A) of pomegranate genotypes grown in Tabuleiro de Russas–CE, n = 18.



The fruits of the genotypes CV8 and CV12 exhibited more elevated contents of ascorbic acid, with means of 22.9 and 20.6 mg.100mL^{-1}, in comparison with the CVW genotype (14.7 mg.100mL^{-1} (Figure 6A). Generally, the ascorbic acid contents of the characterized genotypes are similar to the ones found by Sayyari et al. (2010), who reported variations between 10 and 36 mg.100mL^{-1} g of ascorbic acid in the pomegranate juice, and greater than the ones reported by Silva et al. (2015) for the 'Molar' pomegranate. According to Tehranifar et al. (2010), the level of vitamin C in pomegranates can range from 10 to 36 mg.100g^{-1}. Therefore, the studied genotypes can be classified as rich in vitamin C, a relevant feature for the fruit's consumption *in natura* (TEHRANIFAR et al., 2010).

The genotypes of greater values for phenolic compounds were CV12 (269.7 mg.100mL^{-1}) and CV8 (168.2 mg.100mL^{-1}); on the other hand, it was lower in the fruits of the CVW genotype (133.7 mg.100mL^{-1}) (Figure 6B). The values for phenolic compounds of the characterized genotypes are within the range observed by Tehranifar et al. (2010), who reported variations of 295.8 to 985.4 mg.100g^{-1}, and with the 'Molar' pomegranate grown in the Pernambucan semiarid region (271.0 mg.100mL^{-1}) (Oliveira, 2018). According to Alcaraz-Mármol et al. (2017), phenolic compounds affect the fruits' quality because they are responsible for the main organoleptic characteristics thereof, especially the color and astringency properties. The concentrations of phenolic compounds reported in the literature show that the levels in pomegranate fruits are varied because they depend on factors such as the type of cultivar, weather, ripening, and fruit part (MENA et al., 2011; LI et al., 2015). However, the pomegranate genotypes grown in Tabuleiro de Russas can be characterized as a good source of phenolic compounds.

Figure 6. Ascorbic acid (A) and phenolic compounds (B) of pomegranate genotypes grown in Tabuleiro de Russas–CE, n = 18.



4 CONCLUSIONS

The fruits of the CV8 and CV12 genotypes exhibited the best physical-chemical quality characteristics, with the lower acidity levels, greater SS/TA ratio, and greater ascorbic acid and phenolic compounds levels, with potential for the commercialization of the fruits *in natura*.

ACKNOWLEDGMENTS

To Capes, CNPq, FAPESQ, the Cearian Foundation for the Support of Scientific and Technological Development–FUNCAP, and the Department of Economic and Labor Development–SEDET–CE.

REFERENCES

ALCARAZ-MÁRMOL, N.; NUNCIO-JÁUREGUI, F.; GARCÍA-SÁNCHEZ, J.; MARTÍNEZ-NICOLÁS and HERNÁNDEZ, F. Characterization of twenty pomegranate (*Punica granatum* L.) cultivars grown in Spain: Aptitudes for fresh consumption and processing. Scientia Horticulturae. 219:152-160, 2017. https://doi.org/10.1016/j.scienta.2017.03.008.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS – AOAC. Official Methods of Analysis of the Association of Official Analytical Chemists.18 ed, Gaithersburg, Maryland, 2006.

ATAÍDE, E. M.; SILVA, M.S. de.; BASTOS, D.C and SOUZA, J.M.A. Qualidade pós-colheita de romã comercializada no semiárido pernambucano. Agrarian Academy, 5: 429-436, 2018.

BEAULIEU, J.C.; LLOYD, S.W.; PREECE, J.E.; MOERSFELDERA, J.W.; STEIN-CHISHOLM, R.E and OBANDO-ULLOA, J.M. Physicochemical properties and aroma volatile profiles in a diverse collection of California-grown pomegranate (*Punica granatum* L.) germplasm. Food Chemistry, 181:354-364, 2015. https//doi: 10.1016 / j.foodchem.2015.02.026

CHATER, J.M.; MERHAUT, D.J.; JIA, Z.; MAUK, P.A and PREECE, J.E. Fruit quality traits of ten California-grown pomegranate cultivars harvested over three months. Scientia Horticulturae. 237:11-19, 2018. https://doi.org/10.1016/j.scienta.2018.03.048

DIAS, T. C.; MOTA, W.F.; OTONI, B.S.; MIZOBUTSI, G.P and SANTOS, M.G.P. 2. Post-harvest conservation of formosa papaya with pvc film and refrigeration. Revista Brasileira de Fruticultura. 33: 666-670, 2011. https://doi.org/10.1590/S0100-29452011000200040.

FERRARA, G.; GIANCASPRO, A.; MAZZEO, A.; GIOVE, S.L.; MATARRESE, A.M.S.; PACUCCI, C.; PUNZI, R.; TRANI, A.; GAMBACORTA, G.; BLANCO, A and GADALETA, A. Characterization of pomegranate (Punica granatum L.) genotypes collected in Puglia region, Southeastern Italy. Scientia Horticulturae.178:70–78, 2014.

INSTITUTO ADOLFO LUTZ (IAL). 2008. Métodos Físico-Químicos para Análise de Alimentos. 4 ed. São Paulo. Available at: < http://www.ial.sp.gov.br> Accessed in June 17, 2018.

KARIMI, M.; SADEGHI, R and KOKINI, J. Pomegranate as a promising opportunity in medicine and nanotechnology. Trends in Food Science & Technology, 69:59–73, 2017. https://doi.org/10.1016/j.tifs.2017.08.019.

KHADIVI-KHUB, A.; KAMELI, M.; MOSHFEGHI, N and EBRAHIMI, A. Phenotypic characterization and relatedness among some Iranian pomegranate (*Punica granatum* L.) accessions. Trees, 29:893–901, 2015. https//doi 10.1007/s00468-015-1172-9

KYRALAN, M.; GOLUKCU, M and TOKGOZ, H. Oil and conjugated linolenic acid contents of seeds from important pomegranate cultivars (Punica granatum L.) grown in

Turkey. Journal of the American Oil Chemists' Society, 86:985–990, 2013. https//doi 10.1007/s11746-009-1436-x.

KYRIACOU, M.C.; IOANNIDOU, S.; NIKOLOUDAKIS, N.; SERAPHIDES, N.; PAPAYIANNIS, L.C and KYRATZIS, A.C. Physicochemical characterization and trait stability in a genetically diverse *ex situ* collection of pomegranate (*Punica granatum* L.) germplasm from Cyprus. Scientia Horticulturae, 263, 2020.

LI, X.; WASILA, H.; LIU, L.; YUAN, T.; GAO, Z.; ZHÁO, B and AHMAD, I. Physicochemical cháracteristics, polyphenol compositions and antioxidant potential of pomegranate juices from 10 Chinese cultivars and the environmental factors analysis. Food chemistry, 175:575-584, 2015.

MARTÍNEZ, J.J.; HERNÁNDEZ, F.; ABDELMAJID, H.; LEGUA, P.; MARTÍNEZ, R.; EL-AMINE, A and MELGAREJO, P. Physico-chemical characterization of six pomegranate cultivars from Morocco: processing and fresh market aptitudes. Scientia Horticulturae, 140:100-106, 2012.

MARTINEZ-NICOLAS, J.J.; MELGAREJO, P.; LEGUA, P.; GARCIA-SANCHEZ, F and HERNÁNDEZ, F. Genetic diversity of pomegranate germplasm collection from Spain determined by fruit, seed, leaf and flower characteristics, PeerJ 4:e2214, 2016.
MARTÍNEZ, P.; MELGAREJO, P.; LEGUA and GARCIA-SANCHEZ, F. Hernández. Genetic diversity of pomegranate germplasm collection from Spain determined by fruit, seed, leaf and flower characteristics. Peer J. 19, 2016.

MENA P.; GARCÍA-VIGUERA, C.; NAVARRO-RICO, J.; MORENO, A.D.; BARTUAL, J and SAURA, D. Phytochemical characterisation for industrial use of pomegranate (*Punica granatum* L.) cultivars grown in Spain. Journal of the Science of Food and Agriculture, 91: 1893-1906, 2011.

MOREIRA, I. S.; ROCHA, R.H.C.; PAIVA, E.P.; SILVA H.S.; and SOUSA, F.A. Biometria e componentes físico-químicos de romã armazenada sob refrigeração. Pesquisa Agropecuaria Tropical, 45: 209-215, 2015.

OLIVEIRA, L.M.de. Uso de *Spirulina platensis* sob a qualidade pós-colheita de romã em duas condições de armazenamento. (Master's Dissertation), Federal University of Campina Grande, Pombal, 2018.

PAREEK, S.; VALERO, D and SERRANO, M. Postharvest biology and technology of pomegranate. Journal of the Science of Food and Agriculture, 95: 2360-2379, 2015.

PINHEIRO, J.M.S. Tecnologia pós-colheita para a conservação de bananas da cultivar tropical. 59f. Dissertation (Master's Degree), State University of Montes Claros, 2009.

RAMOS, D.P.; LEONEL, S.; SILVA, A.C.; SOUZA, M.E.; SOUZA, AP and FRAGOSO, A. M. Épocas de poda na sazonalidade, produção e qualidade dos frutos da goiabeira 'Paluma'. Semina: Ciências Agrárias, 32: 909-918, 2011.

SAYYARI, M.; CASTILLO, S.; VALER, D.; DIAZ-MULA, H.M and SERRANO, M. Acetyl salicylic acid alleviates chilling injury and maintains nutritive and bioactive compounds and antioxidant activity during postharvest storage of pomegranates. Postharvest Biology and Technology, 60:136-142, 2010.

SILVA, I.M.B.R. Biometria e qualidade da romã orgânica durante o armazenamento. (Master's Dissertation), Federal University of Campina Grande, Pombal, 2013.

SILVA, I. M. B. R.; ROCHA, R.H.C.; SILVA, H.S.; MOREIRA, I.S.; SOUSA, F. A and PAIVA, E.P. Quality and post-hárvest life organic pomegranate 'Molar' produced in Paraiba semiarid. Semina: Ciências Agrárias. 36: 2555-2564, 2015.

SINGH, B.; SINGH, J.P.; KAUR, A and SINGH, N. Phenolic composition and antioxidant potential of grain legume seeds: A review. Food Research International, 101:1–16, 2017.

SOUZA, J.F.de; AMARAL,V.A; ALVES, T.F.R; BATAIN, F; CRESCENCIO, K.M.M.de; BARROS, C.T. de; RIOS, A.C; CHAUD, M.V. Polyphenolsisolatedfrom pomegranate juice (Punica granatum L.):Evaluationof physical-chemical propertiesby FTIRand quantificationof total polyphenols and anthocyaninscontente. Brazilian Journal of Development., Curitiba, v. 6, n. 7, p. 45355-45372,jul. 2020.

SUZUKI, E.T. Avaliação fenológica, análise econômica e estudo da cadeia produtiva da romã (*Punica granatum*). (Doctoral Thesis), Faculty of Sciences Agronomic, Botucatu, 2016.

TEHRANIFAR, A.; ZAREI, M.; NEMATI, Z.; ESFANDIYARI, B and VAZIFESHENAS, M.R. Investigation of physico-chemical properties and antioxidant activity of twenty Iranian pomegranate (Punica granatum L.) cultivars. Scientia Horticulturae, 126: 180–185, 2010.

WATERHOUSE, A. Folin-ciocalteau micro method for total phenol in wine. American Journal of Enology and Viticulture, p.3-5, 2006. Available at: <http:// waterhouse.ucdavis.edu/faqs/folin-ciocalteau-micromethod- for-total-phenol-in-wine>. Accessed in June 17, 2018.

ZAOUAY, F.; MENA, P.; GARCIA-VIGUERA, C and MARS, M. Antioxidant activity and physico-chemical properties of Tunisian grown pomegranate (*Punica granatum* L.) cultivars. Industrial Crops and Products, 40: 81-89, 2012.