

ORIGINAL ARTICLE

Quality aspects of pepino dulce fruits in distinct ripening stages, packaging forms and storage conditions

Qualidade de frutos de muricato em diferentes estágios de maturação, formas de embalagem e condições de armazenamento

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Abstract

Pepino dulce (*Solanum muricatum* Aiton) or *Pepino* has been growing to produce edible, juicy and attractive fruits. The imported fruits and national small scale of *Pepino dulce* production are currently stored and commercialized under the absence of postharvest handling recommendations. Therefore, this work aimed to evaluate the quality aspects of *Pepino dulce* fruits in distinct ripening stages, forms of packaging and conditions of storage. The trial was conducted in a 2x2x2 factorial scheme - 2 ripening stages (ripe and immature) x 2 forms of packaging (with and without wrapping in plastic film) x 2 conditions of storage (room: 25 °C ± 2 °C and 57% ± 5% of relative humidity (RH); cold: under refrigeration 10 °C ± 2 °C and 85% ± 5% of RH) – in a complete randomized block design. Fruit quality attributes, such as vitamin C, chemical and phenolic content, fruit color (mesocarp), firmness, dry matter content, total titratable acidity (TA), total soluble solids and pH, were evaluated. Fruits showed a centesimal composition with low calories and a significant content of potassium (K), phosphorus (P) and magnesium (Mg), which can contribute to the daily supply of these elements. For commercialization purposes, the association of packaging (plastic wrapping film) and refrigerated storage (cold: 10 °C ± 2 °C and 85% ± 5% of RH) to maintain the characteristics of fruit quality after a 15 days period is more important than its individual use.

Keywords: *Solanum muricatum* Aiton; Fruits; Composition; Minerals; Maturity; Preservation.

Resumo

O muricato (*Solanum muricatum* Aiton) é cultivado para produção de frutos suculentos e atraentes. Frutos importados e os produzidos nacionalmente em pequena escala são armazenados e comercializados sem recomendações de manuseio pós-colheita. Dessa forma, o presente trabalho teve o objetivo de avaliar aspectos de qualidade de frutos de muricato em diferentes estágios de maturação, formas de embalagem e condições de armazenamento. O experimento foi conduzido em esquema fatorial 2 × 2 × 2 – dois estágios de maturação



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(maduros e imaturos) × duas formas de embalagem (com e sem envoltório em filme plástico) × duas condições de armazenamento (temperatura ambiente: 25 °C ± 2 °C e 57% ± 5% de umidade relativa; sob refrigeração: 10 °C ± 2 °C e 85% ± 5% de umidade relativa) – em delineamento de blocos ao acaso. Atributos de qualidade dos frutos foram avaliados – vitamina C, conteúdo químico e fenólico, cor do fruto (mesocarpo), firmeza, teor de matéria seca, acidez total titulável, sólidos solúveis totais e pH. Esses frutos apresentaram composição centesimal com baixas calorias e uma quantidade significativa de potássio (K), fósforo (P) e magnésio (Mg), que podem contribuir no suprimento diário desses elementos. Para fins de comercialização, associar embalagem e armazenamento refrigerado visando manter suas características após um período de 15 dias é mais importante do que o emprego dessas técnicas de forma individual.

Palavras-chave: *Solanum muricatum* Aiton; Frutos; Composição; Minerais; Maturidade conservação.

1 Introduction

Pepino dulce (*Solanum muricatum* Aiton) is a species that was considered important in the Andean region, even before the arrival of European colonizers. This species has been growing to produce edible, juicy and attractive fruits (Mateos, 2015). There are varieties with good aromatic characteristics used as a fresh fruit, while others are consumed as salads, varying according to the ripening stage of the fruits in different harvesting periods (Viñals & Martinez, 1996). Latin American countries, such as Peru, Ecuador, Bolivia, and Colombia, plant this crop in small areas, and in Chile there has been a substantial increase in the harvested area and exportation. New Zealand, Australia, Israel, the Netherlands, Spain, and others countries in Europe also have had experiences with the introduction and cultivation of this species, including greenhouse production (Prohens et al., 1996). In Brazil, this species is also named *muricato* or *Andean melon*, and this plant can be found mainly in home orchards located in the south and southwest region, being consumed and offered in street/farmers markets as an unconventional or traditional vegetable (Melo et al., 2017; Globo Rural, 2017). This worldwide interest in this species generated a considerable amount of technical and scientific data on phenology, fruit composition (Herraiz et al., 2015, 2016; Mateos, 2015), among other important characteristics. In the national territory, this species has not, until now, reached the status of an established medium or large scale field for commercial production, although imported fruits are found in the supermarkets placed on exotic fruits, achieving high prices (Melo et al., 2017; Globo Rural, 2017). Efforts in terms of cultivation practices in the country were initiated (Melo et al., 2017) and could be linked to the capacity for growing in high altitude areas, in other words, having an increasing interest in its consumption (Bellon et al., 2015) or being an alternative cash crop for growing markets (Globo Rural, 2017). In contrast, there is still little interest in the implementation of production guidelines suited to local conditions (Melo et al., 2017) and more important, to establish quality and market standards (Bellon et al., 2015). Fruits storage capacity and shelf-life provide flexibility allows plant to be commercialized in a specific marketing period (Mateos, 2015); however, imported fruits and national small scale production are currently stored and commercialized under the absence of postharvest handling recommendations. Therefore, this work had the objective of evaluating quality aspects of *Pepino dulce* fruits in distinct ripening stages, forms of packaging and conditions of storage.

2 Material and methods

Plants of a *Pepino dulce* access (CNPH 1) were grown from June 2016 to April, 2017 using agroecological and cultural practices at “Embrapa Vegetables” situated in Brasília-DF, Brazil (15°56’00” S and 48°08’00” W) in Cerrado conditions (Melo et al., 2017). Four rows of 30 plants were harvested randomly in the experimental plots all at the same time in April 2017. Fruit quality attributes were assessed and analyzed immediately at the time of harvest and after 15 days of storage treatments. After harvest, fruits were then classified in two following categories: Stage (1) immature: with light green flesh and having ≥ 60 mm of

diameter and weighting ≥ 150 g; Stage (2) ripe: fruits were completely yellow and having ≥ 60 mm of diameter and weighting ≥ 150 g. Six fruits at each development stage were designated into five replications. The trial was conducted in a $2 \times 2 \times 2$ factorial scheme - 2 ripening stages (ripe and immature) \times 2 forms of packaging (with and without wrapping in plastic film) \times 2 conditions of storage (room: $25 \text{ }^\circ\text{C} \pm 2 \text{ }^\circ\text{C}$ and $57\% \pm 5\%$ of RH; cold: under refrigeration $10 \text{ }^\circ\text{C} \pm 2 \text{ }^\circ\text{C}$ and $85\% \pm 5\%$ of RH) – in a complete randomized block design, thus using 60 fruits as plot per factor. Recently harvested fruits were analyzed for their vitamin C, chemical and phenolic contents. At the end of the storage period, 15 days after harvest (DAH), a period of fruit weight loss was compared to 30 DAH according to Huyskens-Keil et al. (2000) and Mateos (2015), even as the external (flesh/exocarp) and internal fruit color (mesocarp) (C), firmness (F), dry matter content (DM), total titratable acidity (TA), total soluble solids (TSS) and pH, were analyzed and the evaluations were done comparing the two storage forms (room and cold). Fruits were placed in styrofoam trays and evaluated for shriveling, pitting and decay by hedonic scores (HS) where 1 equals none, 2 equals slight, 3 equals moderate, 4 equals moderately severe and 5 equals severe (Cantwell et al., 1992). Firmness was evaluated by a texture analyzer model TA.XT Plus, Surrey, England, with the following operating conditions: cylindrical probe of 2 mm/second, 10 mm of distance for fruit penetration and 5 g of trigger force. Colors were evaluated by measuring green and ripe fruits colorimetric parameters L^* , a^* , b^* C^* and Hue angle (H°) using a Minolta Model CR-400 colorimeter (McGuire, 1992). TA content, soluble solids and pH were analyzed by AOAC Official Methods (Association of Official Analytical Chemists, 2010). The content of vitamin C was determined by spectrophotometry, and the analysis was performed according to the methodology described by Strohecker & Henning (1967) using 2,4 dinitrophenylhydrazine. The results were expressed as mg of ascorbic acid per 100 g of pulp. The determination of the total phenolic compounds was performed according to Nuutila et al. (2003).

Preliminary analysis indicated that TA presented a skew and overdispersed distributions, and it was required a particular use of data transformation for normalization. Thus, means were evaluated after square root transformation. Normality of residuals was tested using Shapiro-Wilk test and the distribution presented as normal subsequently. Assumptions of one-way analysis of variance (ANOVA) were violated for TSS and hedonic scores, even after mathematical transformation of data, thus a non-parametric data analysis was carried out using Kruskal-Wallis test and significant mean differences for congregated treatments were found ($\alpha = 5\%$). All computations were performed with Assisat[®] software (Silva & Azevedo, 2016) and ANOVA means were compared by Tukey's test (5%).

3 Results and discussion

For the centesimal composition, fruits presented a high content of water (92%) and low calories (24.50 kcal/100 g). These results are in accordance to Viñals & Martinez (1996) containing 92.4% of water content, 0.4% of protein and 25 kcal 100 g^{-1} (Table 1), this way, classifying *Pepino dulce* as a low-calorie fruit with a high hydric content. The calories in *Pepino dulce* are originated from carbohydrates that are broken down into glucose during digestion, being used as a body source of fuel. The aqueous extract of its fruits can attenuate the progression of diabetes due to its anti-inflammatory, antiglycative and antioxidative effects (Maheshwari et al., 2014). Fresh fruits also contain a significant amount of potassium (K) ($318.73 \text{ mg } 100 \text{ g}^{-1}$) (Table 2). Magnesium (Mg) and phosphorus (P) contents were also prominent, with mean values of $11.18 \text{ mg } 100 \text{ g}^{-1}$ and $22.65 \text{ mg } 100 \text{ g}^{-1}$ in fresh fruit, respectively. It is worth mentioning the importance of these minerals for health, which participate in various chemical and biochemical reactions in the human body. Phosphorus is a fundamental element, whose functions are related to bone mineralization and teeth, and participates in energy metabolism, absorption and transport of nutrients, regulation of protein activity and acid-base balance (United Nations University et al., 2001). The daily recommendation is $3,510 \text{ mg day}^{-1}$ of K, 700 mg day^{-1} of P and 260 mg day^{-1} of Mg. Hence, the consumption of 0.14 g of fresh *Pepino dulce* fruits for K, 23.08 g for P and 30.76 g for Mg would meet the aforementioned Food and

Agriculture Organization/World Health Organization (FAO/WHO) established daily requirements. Microelements, also known as trace elements, are considered as essential as vitamins. In this study, *Pepino dulce* had a content of 0.12 mg of zinc (Zn) 100 g⁻¹ and 0.39 mg. of iron (Fe) 100 g⁻¹ of fresh fruit (Table 2). The average dietary Zn recommendation for adults is 7 mg per day and 14 mg Fe per day for adults (United Nations University et al., 2001). Thus, this vegetable can contribute to the daily supply of these microelements with the consumption of 58.4 g and 35.9 g of fresh fruit, for Zn and Fe, respectively.

Table 1. *Pepino* fruits centesimal composition (CP) (%).

Humidity	Dry matter	Protein	Lipid	Carbohydrate	Fiber	Ash	Calories
92.27	7.73	0.40	ND	5.73	ND	1.60	24.52

ND – not detectable.

Table 2. Minerals of fresh *Pepino dulce* fruits (mg 100 g⁻¹).

Na	K	Mg	Ca	Mn	Fe	Zn	Cu	P
2.05	318.73	11.18	6.04	0.08	0.39	0.12	0.10	22.65

In addition, the flesh (exocarp) of ripe fruits presented an L* value of 73.62 and in the inner part of the fruits (mesocarp) a lower L* value of 57.43, meaning a golden yellow color for the flesh and a pale yellow color for the pulp. In the flesh of the green fruit, L* value was 72.89 and for the inner part, L* value was 62.15, an analogous obtained result for ripe fruits, with a light green and pale green colors for flesh and pulp fruits, respectively. For the hue angle (H°) measurement, higher values were observed in the green fruits, with 112.64 for flesh and 108.56 for the inner parts of the fruit. As expected, ripe fruits presented H° values ranging from 95.71 to 96.46, for the flesh and inner parts of the fruit, respectively, indicating values close to the angle of 90° that represents different shades of yellow color. Chromaticity showed values ranging from 17.10 to 32.72, for the flesh and inner parts of the fruit, respectively, indicating a green/gray color and an intense yellow color of the fruits, respectively. Color is the most obvious change that occurs in most fruits and is often the main criterion used by consumers to determine whether the fruit is ripe or green. It was observed, comparing green and mature fruits, that there was a change in color from light green to light yellow; and regarding the maturation of the fruits, an increase of almost twice in the value of Chroma occurred. These results are in agreement with those obtained by Huyskens-Keil et al. (2006), with mean Chroma values ranging from 25 to 30, but they also verified that there was a decrease at the end of the storage by 21 days when the senescence stage began.

Vitamin C content of these fruits ranged from 24.91 to 147.63 mg 100 g⁻¹ in the fresh fruits, and the content of total phenolic compounds ranged from 286.95 to 445.66 mg EAG 100 g⁻¹. That suggests a high antioxidant capacity. The interest in natural antioxidants is increasing in the last years, due to its prevention properties on human diseases and the reduction of associated risks (Siger et al., 2012). Faller & Fialho (2009) presented a value of 13.7 (±1.2) mg EAG 100 g⁻¹ for fresh tomato fruits, an analogous Solanaceae species to *Pepino dulce*, and other fruits and vegetables with values ranging from 15.3 mg EAG 100 g⁻¹ of fresh papaya fruits to 215.7 mg EAG 100 g⁻¹ of fresh banana fruits, as the average content of total polyphenols in Brazil using data from the literature. Therefore, the highest value achieved for *Pepino dulce* phenolic content surpasses the aforementioned values.

After harvest, fruits did not present any damage, considering that all of them at this stage would have received a score equal 1 by the HS. However, after storage, the appearance was superior for wrapped fruits compared to unwrapped ones, thus being a recommended procedure in order to proportionate a modified atmosphere inside the package(s), prolonging its shelf-life and being possible to conduct long distance commercialization (Table 3). The use of controlled atmosphere slows the plant aging process by reducing the respiratory rate by about 50% when compared to the respiratory rate of a product exposed to air, due to the

decrease in the gas exchange of the product inside the package (Chitarra & Chitarra, 2005). Increased respiratory rates in the presence of oxygen (O₂), results in a faster ripening and formation of ethylene (C₂H₄). So, decreasing the respiratory rate is crucial to use the minimum O₂ concentration possible without triggering anaerobic fermentation (Kader et al., 1989; Kirtil et al., 2016), being attributed to the fruits appearance results. The TSS mean value in the ripe fruits after harvest was 7.1°, and for the green fruits the mean value was 6.7°. After TSS storage values, these values varied from 5.38° to 6.52° in the respective treatments (Table 4). Fruits kept under cold temperatures presented lower values compared to the room storage, except for fruits without plastic wrapping film, indicating that even though *Pepino dulce* fruits are considered non-climacteric, a slight increase in their sugar content occurred. This increase can be attributed to insoluble polysaccharides hydrolysis. Reduction of TSS values on the 15th day of storage resulted from soluble sugars degradation at the beginning of senescence stage, being utilized as a substrate during the respiratory process (Gonzalez et al., 2000). Gonzalez et al. (2000) achieved TSS values above 7° brix, being a superior result to the aforementioned, originated from greenhouse production fruits. Heys et al. (1994) described that *Pepino dulce* produces autocatalytic ethylene in response to propylene, elevating its respiratory rate, and little production is detected when stored under 20 °C. After storage, acidity (AC) values were higher in the cold stored fruits, a response analogous to TSS (Table 5). This is due to the use of acids in the respiratory process of the fruit that was most intense in the fruits stored under environmental conditions. The acidity of a fruit is related to the organic acids present, whose content tend to decrease during the process of maturation and senescence, due to their oxidation to tricarboxylic acids and also to respiration (Chitarra & Chitarra, 2005). The TSS/AC ratio was also higher in this storage form, indicating a balanced fruit flavor (Table 6). However, it is important to mention that these results are above the values obtained by Mateos (2015) in Spain with 32.4 and 36.2 using clones named 806-PV and 821-PV, respectively. The mean pH values were 5.4 and 6.3, for the green and ripe fruits, respectively. After storage, the values in the mature fruits were higher, indicating a slight decrease in the pH of the green fruits (Table 7). Gonzalez et al. (2000) also observed an increase in pH values with ripe fruits corroborating the results obtained in the present work. Consequently, the importance of the use of refrigeration and modified atmosphere techniques in the maintenance of the quality of this fruit is more important than its individual use. Fruits stored under refrigeration (cold) also presented significant firmness value (21.40 N), considering that higher temperatures are one of the main factors that potentiate the activity of the enzymes related to the degradation of the firmness of the fruit. The green fruits maintained more firmness compared to the mature fruits with 24.33 N (Table 8). Softening properties of *Pepino dulce* fruits are reported to be associated with the breakdown of carbohydrates from the structural cell wall, i.e., insoluble pectin, xyloglucan and hemicelluloses located in the middle lamella as well as with an increase in soluble pectin. These changes in pectin result in weakening the cell walls and reduction of the cohesive forces binding cells together (Heys et al., 1994). Huyskens-Keil et al. (2006) demonstrated that the metabolic activity of *Pepino* fruits at a progressed ripening stage could not be suppressed by the treatments and that ripe fruits should be distributed only to local markets.

Table 3. Hedonic scores (HS) of *Pepino dulce* fruits at different ripening stages and forms of storage.

Factors (treatments)	HS
RP	1.0 b
GP	1.0 b
RN	2.0 a
GN	1.3 ab

RP = ripe with wrapping; GP = green with wrapping; RN = ripe without wrapping; GN = green without wrapping. Means followed by the same letters in the columns and capital letters in the lines do not differ by Kruskal-Wallis non-parametric test ($\alpha = 5\%$).

Table 4. Total soluble solids (TSS) of *Pepino dulce* fruits.

Factors (treatments)	TSS (°Brix)
RNC	5.96 c
GNC	5.38 c
RPC	6.20 b
GPC	5.35 c
RNRo	6.50 a
GNRo	6.52 a
RPRo	6.36 ab
GPRo	6.30 ab

R = ripe; G = green; N = without wrapping; P = with wrapping; C = cold; Ro = room. The combination of letters (RNC, GNC, RPC, GPC, RNRo, GNRo, RPRo and GPRo) is the congregation of factors - maturity stages, forms of storage and packaging. Means followed by the same letters in the columns and capital letters in the lines do not differ by Kruskal-Wallis non-parametric test ($\alpha = 5\%$).

Table 5. Acidity (AC) of *Pepino dulce* fruits.

Factors (treatments)	AC
Cold	0.12 a
Room	0.10 b

Means followed by the same letters in the columns and capital letters in the lines do not differ by Tukey's test at 5% probability. CV%: 13.23.

Table 6. Packaging and forms of storage interaction - TSS/AC ratio (Total Soluble Solids/Acidity ratio).

Factors (treatments)	Unwrapped	Wrapped
Cold	58.92 aA	62.64 aA
Room	39.22 bB	55.31 bA

Means followed by the same letters in the columns and capital letters in the lines do not differ by Tukey's test at 5% probability. CV%: 12.11.

Table 7. pH values of *Pepino dulce* fruits.

Factors (treatments)	pH
Ripe	6.3 a
Green	5.75 b

Means followed by the same letters in the columns and capital letters in the lines do not differ by Tukey's test at 5% probability. CV%: 2.81.

Table 8. Firmness – F (N) values of *Pepino dulce* fruits.

F (N)	
Cold 21.40 a	Green 24.33 a
Room 21.34 b	Ripe 15.87 b

Means followed by the same letters in the columns and capital letters in the lines do not differ by Tukey's test at 5% probability. CV%: 12.82.

4 Conclusion

Pepino dulce presented a centesimal composition with low calories and a substantial mineral content of K, P and Mg, which can contribute to the daily supply of these elements.

For commercialization purposes, the association of packaging (plastic wrapping film) and refrigerated storage (cold: $10\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ and $85\% \pm 5\%$ of RH) is more important than its individual use, in order to maintain the characteristics of fruit quality after a 15 days period.

References

- Association of Official Analytical Chemists – AOAC. (2010). *Official methods of analysis* (18th ed., 1094 p.). Washington: AOAC.
- Bellon, A. A., Guimarães, L. A. O. P. G., Souza, J. L., Favarato, L. F., Dias, M. A., & Balbino, J. M. S. (2015). Características pós-colheita de melão-andino em função do tempo de armazenamento. In *Anais do 19º Encontro Latino-Americano de*

- Iniciação Científica, Anais do 15º Encontro Latino Americano de Pós-graduação, Anais do 9º Encontro Latino Americano de Iniciação Científica Júnior, Anais do 5º Encontro Nacional de Iniciação à Docência*. São José dos Campos: UNIVAP.
- Cantwell, M., Flores-Minutti, A., & Trejo-Gonzalez, A. (1992). Developmental changes and postharvest physiology of tomatillo fruits (*Physalis ixocarpa* Brot.). *Scientia Horticulturae*, 50(1-2), 59-70.
- Chitarra, M. I. F., & Chitarra, A. B. (2005). *Pós-colheita de frutos e hortaliças: Fisiologia e manuseio* (2. ed., 785 p.). Lavras: UFLA.
- Faller, A. L. K., & Fialho, E. (2009). Disponibilidade de polifenóis em frutas e hortaliças consumidas no Brasil. *Revista de Saude Publica*, 43(2), 211-218. PMID:19225692. <http://dx.doi.org/10.1590/S0034-89102009005000010>
- Globo Rural. (2017). *Como plantar muricato*. Retrieved in 2019, June 18, from <https://revistagloborural.globo.com/vida-na-fazenda/como-plantar/noticia/2017/03/como-plantar-muricato.html>
- Gonzalez, M., Cámara, M., Prohens, J., Ruiz, J. J., Torija, E., & Nuez, F. (2000). Colour and composition of improved Pepino cultivars at three ripening stages. *Gartenbauwissenschaft*, 65(2), 83-87.
- Herraiz, F. J., Raigón, M. D., Vilanova, S., García-Martínez, M. D., Gramazio, P., Plazas, M., Rodríguez-Burruezo, A., & Prohens, J. (2016). Fruit composition diversity in landraces and modern Pepino (*Solanum muricatum*) varieties and wild related species. *Food Chemistry*, 203, 49-58. PMID:26948588. <http://dx.doi.org/10.1016/j.foodchem.2016.02.035>
- Herraiz, F. J., Vilanova, S., Plazas, M., Gramazio, P., Andújar, I., Rodríguez-Burruezo, A., Fita, A., Anderson, G. J., & Prohens, J. (2015). Phenological growth stages of Pepino (*Solanum muricatum*) according to the BBCH scale. *Scientia Horticulturae*, 183, 1-7. <http://dx.doi.org/10.1016/j.scienta.2014.12.008>
- Heys, J. A., Blaikie, F. H., Downs, C. G., & Sealey, D. F. (1994). Textural and physiological changes during Pepino (*Solanum muricatum* Ait.) ripening. *Scientia Horticulturae*, 58, 1-15.
- Huyskens-Keil, S. H., Prono-Widayat, P., Ludders, M., & Schreiner, M. (2006). Postharvest quality of Pepino (*Solanum muricatum* Ait.) fruit in controlled atmosphere storage. *Journal of Food Engineering*, 77(3), 628-634. <http://dx.doi.org/10.1016/j.jfoodeng.2005.07.028>
- Huyskens-Keil, S. H., Widayat, H. P., Lüdders, P., Schreiner, M., & Peters, P. (2000). Physiological changes of pepino (*Solanum muricatum* Ait.) during maturation and ripening. *Acta Horticulturae*, (531), 251-256. <http://dx.doi.org/10.17660/ActaHortic.2000.531.41>
- Kader, A. A., Zagory, D., Kerbel, E. L., & Wang, C. Y. (1989). Modified atmosphere packaging of fruits and vegetables. *Critical Reviews in Food Science and Nutrition*, 28(1), 1-30. PMID:2647417. <http://dx.doi.org/10.1080/10408398909527490>
- Kirtil, E., Kilercioglu, M., & Oztop, M. H. Modified atmosphere packaging of foods. *Reference Module in Food Science*, 2016. <http://dx.doi.org/10.1016/B978-0-08-100596-5.03218-2>.
- Maheshwari, R., Malhotra, J., Mohan, L., & Upadhyay, B. (2014). Exotic pepino: a shrub for prophylactic consequence & nutritional regime. *International Journal of Pharma Research and Health Sciences*, 2(1), 42-48.
- Mateos, M. G. S. (2015). *Evolución de los parámetros de calidad en frutos de pepino dulce (Solanum muricatum Ait.) durante las fases de crecimiento, maduración y post-cosecha* (Tesis doctoral). Universidad Politécnica de Valencia, España.
- McGuire, R. G. (1992). Reporting of objective color measurements. *HortScience*, 27(12), 1254-1255. <http://dx.doi.org/10.21273/HORTSCI.27.12.1254>
- Melo, R. A. C., Botrel, N., Madeira, N. R., Amaro, G. B., & Freitas, K. A. (2017). *Avaliação da produção de muricato (Solanum muricatum Aiton) sob espaçamentos e formas de condução de plantas em sistema agroecológico nas condições do Cerrado* (Boletim de Pesquisa e Desenvolvimento, Vol. 150). Brasília: Embrapa Hortaliças.
- Nuutila, A. M., Puupponen-Pimiä, R., Aarni, M., & Oksman-Caldentey, K.-M. (2003). Comparison of antioxidant activities of onion and garlic extracts by inhibition of lipid peroxidation and radical scavenging activity. *Food Chemistry*, 81(4), 485-493. [http://dx.doi.org/10.1016/S0308-8146\(02\)00476-4](http://dx.doi.org/10.1016/S0308-8146(02)00476-4)
- Prohens, J., Ruiz, J. J., & Nuez, F. (1996). The Pepino (*Solanum muricatum* - Solanaceae): A "new" crop with a history. *Economic Botany*, 50(4), 355-368. <http://dx.doi.org/10.1007/BF02866518>
- Siger, A., Czubinski, J., Kachlicki, P., Dwiecki, K., Lampart-Szczapa, E., & Nogala-Kalucka, M. (2012). Antioxidant activity and phenolic content in three lupin species. *Journal of Food Composition and Analysis*, 25(2), 190-197. <http://dx.doi.org/10.1016/j.jfca.2011.10.002>
- Silva, F. A. S., & Azevedo, C. A. V. (2016). The Assstat Software Version 7.7 and its use in the analysis of experimental data. *African Journal of Agricultural Research*, 11(39), 3733-3740. <http://dx.doi.org/10.5897/AJAR2016.11522>
- Strohecker, R., & Henning, H. M. (1967). *Análises de vitaminas: métodos comprovados*. Madrid: Paz Montolvo.
- United Nations University – UNU, World Health Organization – WHO, & Food and Agriculture Organization of the United Nations – FAO. (2001). *Human energy requirements: Report of a joint FAO/WHO/ONU Expert Consultation* (FAO Food and Nutrition Technical Report Series, Vol. 1). Rome: FAO. Retrieved in 2017, May 10, from <http://www.fao.org/docrep/007/y5686e/y5686e00.htm>
- Viñals, F. N., & Martínez, J. J. R. (1996). *El pepino dulce y su cultivo*. Roma: Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO).

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