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Scientific article

Physical and chemical attributes of feijoa fruit in Veracruz, Mexico

Atributos físicos y químicos del fruto de feijoa en Veracruz, México

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Abstract: The feijoa is a fruit tree recently grown in the highlands of Veracruz, Mexico. The objectives of this study were to determine some physicochemical and nutritional characteristics of feijoa fruits harvested in Veracruz and to show that some of these attributes are comparable to those of fruits from other producing areas. Commercial-sized fruits were obtained from eight-year-old trees with a single compost application per year. The total soluble solids, pH and acidity of the pulp, in fruits stored at 4, 12 and 25 °C, were similar to those reported in feijoas cultivated in temperate zones. The carbohydrate, fat, fiber, ash, moisture and protein contents in the pulp differ slightly from those reported in the literature. On the other hand, the concentration of vitamin C was higher in the shell than in the pulp. This is the first information on quality parameters of feijoa grown in Mexico. This crop was appropriately adapted to the environment of a high tropical zone.

Keywords: *Acca sellowiana*, vitamin C, pineapple guava, postharvest.

Resumen: La feijoa es un frutal cultivado recientemente en las montañas altas de Veracruz, México. Los objetivos del presente estudio fueron determinar algunas características fisicoquímicas y nutricionales de frutos de feijoa cosechados en Veracruz y mostrar que algunos de estos atributos son equiparables a los de frutos de otras zonas productoras. Se obtuvieron frutos de tamaño comercial de árboles de ocho años con una sola aplicación de composta al año. Los sólidos solubles totales, pH y acidez de la pulpa, en frutos almacenados a 4, 12 y 25 °C, fueron similares a los reportados en feijoas cultivadas en zonas templadas. Los resultados de contenido de carbohidratos, grasa, fibra, cenizas, humedad y proteína en la pulpa difieren ligeramente a los reportados en la literatura. Por otro lado, la concentración de vitamina C fue mayor en la cáscara que en la pulpa. Esta es la primera información sobre parámetros de calidad de la feijoa cultivada en México. Este cultivo se adaptó adecuadamente al ambiente de una zona tropical de altura.

Palabras clave: Acca sellowiana, vitamina C, guayaba piña, poscosecha.

Introduction

In the mountainous regions of Veracruz, Mexico, above 1,300 m, there is little horticultural production with high added value for marketing

(Cruz, Torres, Rodríguez, & Martínez, 2001). The feijoa (*Acca sellowiana* (O. Berg) Burret or *Acca sellowiana* Berg) is a fruit tree of the family Myrtaceae. Its center of origin is located in the highlands of Paraguay, southern Brazil and Uruguay, and northeastern Argentina (Keller & Tressens, 2007).

In New Zealand and Australia, feijoa cultivation has been very popular and the fruits are exported as fresh fruit or industrialized products such as wines, jellies, jams and sweets, among others (Cruz, Torres, & Sánchez, 2002). Its cultivation has increased in Italy (Pasquariello et al., 2015), China (Zhang, Wang, Shao-Xiong, & Li-Zhang, 2011) and Turkey (Beyhan, Bozkurt, & Boysal, 2011) due to its high market sales potential and its medicinal anticancer, anti-inflammatory, antiviral, antimicrobial, hepatoprotective, anti-osteoporosis, antihyperthyoid, antioxidant and immunomodulatory properties (Lim, 2012); it is also used as a preventive treatment for gastritis and ulcers (Monforte et al., 2014). It grows in soils with pH between 6.0 and 6.5 (Fischer, Miranda-Lasprilla, Cayón-Salinas, & Mazorra-Agudelo, 2003), but in Turkey it has adapted to pH levels of up to 8.66 (Beyhan et al., 2011). It is propagated by grafting, cutting and layering (Zhang et al., 2011).

This is the first paper published in a peer-reviewed journal on the cultivation of feijoa in a high tropical region in Mexico. The objectives of this study were to determine some physicochemical and nutritional characteristics of feijoa fruits harvested in Veracruz and to show that some of these attributes are comparable to those of fruits from other producing areas.

Materials and methods

Plant material

Feijoa fruits were collected at physiological maturity in July 2015 in Huatusco, municipality of Veracruz, Mexico. The fruits came from eight-year-old trees propagated by seed; they were kept under rain-fed conditions and fertilized once a year with 400 g of compost made with sheep manure. The trees were established in a 4 x 4 m planting arrangement in a tropical zone at 2,000 masl, with average annual rainfall of 1,825 mm (Cruz et al., 2002) and soil with pH 6.1 at 30 cm deep.

Physical characterization of fruits

A total of 30 fruits were randomly selected from one out of every four similar-sized (2.5 m) trees in an orchard with 350 feijoa trees. Their length (mm) and diameter (mm) were determined with a digital vernier caliper (Mitutoyo model CD-6"CSX). The pulp and shell were separated and weighed (g) on a digital scale (OHAUS CS 2000).

Bromatological analysis

Total moisture, ash, crude protein, fat, crude fiber and carbohydrate percentages (Hall, 2003) were determined in 10 ripened feijoa fruits (Harman, 1987), harvested at random from a tree. The analyses were done in triplicate and expressed on a wet basis. The determinations were carried out in accordance with the following Mexican standards for the bromatological analysis of food: NMX-F-83-1986 (Secretaría de Economía [SE], 1986), NMX-F-089-S-1978 (SE, 1978a), NMX-F-068-S-1980 (SE, 1980), NMX-F-090-S-1978 (SE, 1978b) and NMX-F-066-S-1978 (SE, 1978c).

Physicochemical analysis

From three trees, fruits of 70 to 80 g at physiological maturity (with little resistance to harvesting; Harman, 1987) were randomly collected. Subsequently, three samples of 35 fruits each were subjected to 4, 12 and 25 °C and total soluble solids (TSS, °Brix), pH and titratable acidity (%) were evaluated at 0, 4, 8, 12, 16 , 20 and 24 days of storage.

To measure TSS, a few drops of fruit juice were placed in an ABBE® digital refractometer (Leica Mark II), previously calibrated with distilled water. The pH of the previously-ground pulp was determined with a potentiometer. The titratable acidity was determined according to Mexican standard NMX-F-102-S-1978 (SE, 1978d), titrating with 0.1 N NaOH. Results were expressed as percent acidity based on citric acid (Famiani, Battistelli, Moscatello, Cruz-Castillo, & Walker, 2015). Weight loss (g) was assessed by the Harman method (1987). Firmness and resistance to pressure were determined in three parts of the fruit: distal, proximal and middle, for which a 0-10 $kg \cdot cm^{-2}$ Wagner® penetrometer was used.

Determination of vitamin C

The fruits were lyophilized (LABCONCO® 4.5) for 9 h at 332 $Mbar \cdot 10^{-3}$ and -41 °C, or dehydrated (Sedona Combo-SD-P9150-F) by convection at 60 °C, 8 h and 40 °C, 24 h. For each type of drying, the vitamin C content was determined by the volumetric method (Association of Official Analytical Chemists [AOAC], 1990). To do this, an extractive solution was prepared by mixing 7.5 g of metaphosphoric acid, 200 mL of distilled water and 20 mL of acetic acid. The mixture was brought to 250 mL with distilled water. Subsequently, from a standard solution of ascorbic acid (1 $mg \cdot mL^{-1}$), a 2-mL aliquot was taken and brought to 50 mL with the extractive solution. The feijoa pulp or shell sample (0.1 g) was mixed with 5 mL of the extractive solution, vortexed (5 min) and centrifuged (3,000 rpm, 15 min). The supernatant was brought to 5 mL. The sample and the vitamin C standard (2 mL) were titrated with 2,6-dichlorophenolindophenol concentrated at 10 $\mu g \cdot mL^{-1}$. The extractive

solution was used as a blank. The determinations were done in triplicate and the results were expressed in milligrams of vitamin C per gram of dry basis sample.

Data analysis

A completely randomized design was used to evaluate the physical characteristics of the fruits. The variables were evaluated with an analysis of variance and significant differences among means were determined using the Tukey test ($P \leq 0.05$). The standard error was determined to evaluate parameters of the bromatological analysis and vitamin C content. Data analysis was done with the InfoStat statistical package (Di Rienzo et al., 2016).

Results and discussion

Physical characterization of fruits

The weight and diameter of the fruits were statistically different ($P \leq 0.05$) among the four evaluated trees. Average fresh weight ranged from 29.47 to 50.25 g (Table 1). Talamini-do Amarante and Louise-dos Santos (2011) indicate that feijoa fresh weight ranges from 20 to 250 g, and the values determined in the present study are within this range. However, they were lower than those determined in feijoa cultivars planted in Italy (Pasquariello et al., 2015), which were mainly selected for their size and weight (Sharpe, Sherman, & Miller, 1993). In the present study, data are shown for seed-propagated trees, which in orchards generally have smaller fruits (Fischer et al., 2003). In terms of diameter and length, the fruits are within the ranges indicated in the literature (Talamini-do Amarante & Louise-dos Santos, 2011).

Table 1
Physical characteristics of feijoa fruits grown in Huatusco, Veracruz, at 2000 masl.

	Tree 1/Árbol 1	Tree 2 /Árbol 2	Tree 3/Árbol 3	Tree 4/Árbol 4
Fresh weight (g) /Peso fresco (g)	50.25 ± 13.34 a[z]	45.34 ± 15.01 a	35.97 ± 14.30 b	29.47 ± 10.84 b
Length (mm)/Longitud (mm)	52.22 ± 7.78 a	55.65 ± 5.84 a	51.13 ± 7.80 a	52.39 ± 7.98 b
Diameter (mm)/Diámetro (mm)	39.66 ± 3.76 a	37.96 ± 4.31 c	33.87 ± 4.98 c	31.28 ± 4.64 b

Bromatological analysis

The feijoa grown in Veracruz is similar to that produced in Colombia in terms of carbohydrates and fiber (Table 2). The ash, moisture and protein values were higher in the Colombian fruits (1.6, 1.0 and 3.5 times, respectively). In fats, the feijoa pulp analyzed in this study had values 1.5 times higher than those reported in Colombian fruits (Fischer et al., 2003).

Table 2
Bromatological analysis of feijoa fruit pulp in 100 g fresh weight.

Component / Componente	Amount (%) / Cantidad (%)
Ash / Cenizas	0.32
Moisture / Humedad	80.42
Protein / Proteína	0.23
Fat / Grasa	0.38
Crude fiber / Fibra cruda	3.75
Carbohydrates / Carbohidratos	15

Physicochemical analysis

The fruits at 25 °C and 24 days of storage reached TSS concentrations of 12 to 14 °Brix. At 12 °C, fruit metabolism was slower and with few changes until 20 days of storage. By contrast, at 4 °C there was no significant variation ($P \leq 0.05$) in TSS (10 °Brix) after 24 days of storage. In postharvest, the values of this parameter in the feijoa range from 10 to 13.3 °Brix (Pasquariello et al., 2015).

In the first four days of storage there were no statistically significant ($P \leq 0.05$) changes in the pH of the fruit pulp at 4 °C (2.8) and 12 °C (2.9). However, at 25 °C the pH was higher (3.6). Parra and Fischer (2013) mention that feijoa postharvest pH ranges between 3.1 and 3.5. The pH may fluctuate depending on the cultivar, agroecological factors in the orchard and storage conditions. The maximum titratable acidity value in this study was 5 % in fruits stored at 25 °C for 24 days. Fruits stored at 12 °C had 2.05 % acidity. At 4 °C, the 1 % acidity at 25 days of storage was twice as high as that reported by Velho, do Amarante, Argenta, and Steffens (2011).

In feijoa pulp, the predominant organic acids are the malic and citric ones throughout development and maturation, and their increase is continuous from two months after anthesis. Quinic acid is also present at maturity, but in small amounts (Harman, 1987). Fruit firmness values at 16 days of storage were 1.5, 2.2 and 2.9 $kg{\cdot}cm^{-2}$ at 25, 12 and 4 °C, respectively. Parra and Fischer (2013) indicate similar values.

On the other hand, fruits stored at 4 °C for 24 days had 3.5 % weight loss, while at 25 °C for 20 days they had a 30 % loss. In postharvest, this phenomenon is related to increased transpiration and respiration (Parra & Fischer, 2013).

Vitamin C

The vitamin C concentration was higher in the shell than in the pulp in both lyophilized and dehydrated fruits (Table 3), with more than twice as much vitamin C in lyophilized fruits (0.59 and 0.32 mg·g-1, respectively) (Valente, Gonçalves-Albuquerque, Sanches-Silva, & Costa, 2011). Considering that the dry weight of a feijoa produced in Veracruz is

18 to 20 % of the total weight of the fruit (data not shown), a lyophilized fruit of 50.25 g (Table 1) can reach 3.22 mg of vitamin C in the pulp.

Table 3
Vitamin C content (mg·g^{-1} dry basis) of feijoa fruits cultivated in Veracruz, Mexico, which were lyophilized or dehydrated.

Part of the fruit / Parte del fruto	Vitamin C/Vitamina C	
	Lyophilized/Liofilizado	Dehydrated/Deshidratado
Shell/Cáscara	0.59 ± 0.11	0.16 ± 0.02
Pulp/Pulpa	0.32 ± 0.05	0.10 ± 0.01

Information on vitamin C in feijoa has generally been expressed in fresh weight (Weston, 2010), for example 2.64 mg·100 g^{-1} (Valente et al., 2011). Human require from 60 to 120 mg of this vitamin per day (Carr & Frei, 1999). This requirement can be met by consuming the fresh pulp of approximately six to eight feijoas per day. Vitamin C values in pulp and shell in dehydrated fruits were lower compared to lyophilized ones (Table 3). According to Ratti (2001), the final composition of a conventionally-dried food changes drastically. This should be considered when preparing feijoa food products with conventional drying.

Conclusions

Fruit size and some chemical characteristics such as protein, carbohydrates, fats, ash and fiber of feijoas harvested in Veracruz, Mexico, were comparable with values reported in other countries. In storage, the fruits had titratable acidity, total soluble solids and pH values similar to those reported in the literature.

The size of the fruit and its vitamin C content can be increased, since the trees used in this study were propagated by seed and only had one application of compost per year. This is the first information on quality parameters of feijoa grown in Mexico. This crop was adequately adapted to the environment of a high tropical zone in Veracruz, Mexico. However, further studies are needed in different locations to expand the production of this fruit.

References

Association of Official Analytical Chemists (AOAC). (1990). *Official methods of analysis of AOAC international*. Washington, D. C. USA: Author. Retrieved from http://www.fao.org/3/a-y4705e/y4705e24.htm

Beyhan, O., Bozkurt, M. A., & Boysal, S. C. (2011). Determination of macro-micro nutrient contents in dried fruit and leaves and some pomological characteristics of selected feijoa genotypes (*Feijoa sellowiana* Berg.) from Sakarya provinces in Turkey. *The Journal of Animal & Plant Sciences*, *21*(2), 251-255. Retrieved from http://www.thejaps.org.pk/docs/21-2/10-126-RevisedFormated.pdf

Carr, A. C., & Frei, B. (1999). Toward a new recommended dietary allowance for vitamin C based on antioxidant and health effects in humans. *The American Journal of Clinical Nutrition*, *69*(6), 1086-107. Retrieved from http://www.beauty-review.nl/wp-content/uploads/2015/07/Toward-a-new-recommended-dietary-allowance-for-vitamin-C-based-on-antioxidant-and-health-effects-in-humans.pdf

Cruz, C. J. G., Torres, L. P. A., & Sánchez, J. O. (2002). La Feijoa (*Acca sellowiana* Berg.). In: Cruz-Castillo, J. G., Torres-Lima, P. A. (Compiladores), *Frutales para México* (pp. 205-212). México: Contribuciones del Caribe y Sudamérica, Universidad Autónoma Metropolitana - Universidad Autónoma Chapingo -Fundación Salvador Sánchez Colín.

Cruz, C. J. G., Torres, L. P. A., Rodríguez, B. F., & Martínez, P. D. (2001). Adaptación de frutales caducifolios. Revisión comparativa de Guatemala y Veracruz, México. *Sociedades Rurales, Producción y Medio Ambiente*, 2(1), 63-74. Retrieved from https://publicaciones.xoc.uam.mx/Recurso.php

Di Rienzo, J. A., Casanoves, F., Balzarini, M. G., González, L., Tablada, M., & Robledo, C. W. (2016). *Statistical analysis InfoStat versión 2016*. Argentina: Grupo InfoStat, FCA, Universidad Nacional de Córdoba.

Famiani, F., Battistelli, A., Stefano-Moscatello, S., Cruz-Castillo, J. G., & Walker, R. P. (2015). The organic acids that are accumulated in the flesh of fruits: occurrence, metabolism and factors affecting their contents - a review. *Revista Chapingo Serie Horticultura*, *21*(2), 97-128. doi: 10.5154/r.rchsh.2015.01.004

Fischer, G., Miranda-Lasprilla, D., Cayón-Salinas, G., & Mazorra-Agudelo, M. (2003). *Cultivo, poscosecha y exportación de la feijoa (Acca sellowiana Berg.)*. Colombia: Universidad Nacional de Colombia. Retrieved from https://www.researchgate.net/publication/258211952_Cultivo_poscosecha_y_exportacion_de_la_feijoa_Acca_sellowiana_Berg

Hall, M. B. (2003). Challenges with nonfiber carbohydrate methods. *Journal of Animal Science*, *81*(12), 3226-3232. Retrieved from https://dl.sciencesocieties.org/publications/jas/pdfs/81/12/0813226

Harman, J. E. (1987). Feijoa fruit: growth and chemical composition during development. *New Zealand Journal of Experimental Agriculture*, *15*(2), 209-215. doi: 10.1080/03015521.1987.10425561

Keller, H. A. & Tressens S. G. (2007). Presencia en Argentina de dos epecies de uso múltiple: *Aca sellowiana* (Myrtaceae) y *Casearia lasiophylla* (Flacourtiaceae). *Darwiniana*, *45*(2), 204-212. Retrieved from http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S0011-67932007000200007

Lim, T. K. (2012). *Edible medicinal and non-medicinal plants*. India: Springer Science Business Media. doi: 10.1007/978-90-481-8661-7

Monforte, M. T., Lanuzza, F., Mondello, F., Naccari, C., Pergolizzi, S., & Galati, E. M. (2014). Phytochemical composition and gastroprotective effect of *Feijoa sellowiana* Berg fruits from Sicily. *Journal of Coastal Life Medicine*, 2(1), 14-21. doi: 10.12980/JCLM.2.2014J12

Parra, C. A., & Fischer, G. (2013). Maduración y comportamiento poscosecha de la feijoa (*Acca sellowiana* (O. Berg) Burret). Una revisión. *Revista Colombiana de Ciencias Hortícolas*, 7(1), 98-110. Retrieved from http://www.scielo.org.co/pdf/rcch/v7n1/v7n1a10.pdf

Pasquariello, M. S., Mastrobuoni, F., di Patre, D., Zampella, L., Capuano, L. R., Scortichini, M., & Petriccione, M. (2015). Agronomic, nutraceutical and molecular variability of feijoa (*Acca sellowiana* (O. Berg) Burret) germplasm. *Scientia Horticulturae*, *191*(6), 1-9. doi: 10.1016/j.scienta.2015.04.036

Ratti, C. (2001). Hot air and freeze-drying of a high value foods: a review. *Journal of Food Engineering*, *49*(4), 311-319. doi: 10.1016/S0260-8774(00)00228-4

Secretaría de Economía. (1986). *NMX-F-83-1986: Productos alimenticios para uso humano. Ingenios azucareros. Materias primas, materiales en proceso, productos terminados y subproductos*. Mexico: Author.

Secretaría de Economía. (1980). *NMX-F-068-S-1980: Alimentos. Determinación de proteínas*. Mexico: Author .

Secretaría de Economía. (1978a). *NMX-F-089-S-1978: Determinación de extracto etéreo (método Soxhlet) en alimentos*. Mexico: Author.

Secretaría de Economía. (1978b). *NMX-F-090-S-1978: Determinación de fibra cruda en alimentos*. Mexico: Author .

Secretaría de Economía. (1978c). *NMX-F-066-S-1978: Determinación de cenizas en alimentos*. Mexico: Author .

Secretaría de Economía. (1978d). *NMX-F-102-S-1978: Determinación de la acidez titulable en productos elaborados a partir de frutas y hortalizas*. Mexico: Author .

Sharpe, R. H., Sherman, W. B., & Miller, E. P. (1993). Feijoa history and improvement. *Proceedings of the Florida State Horticultural Society*, *106*, 134-139. Retrieved from http://fshs.org/proceedings-o/1993-vol-106/134-139%20(SHARPE).pdf

Talamini-do Amarante, C. V., & Louise-dos Santos, K. (2011). Feijoa (*Acca sellowiana*). *Revista Brasilera de Fruticultura*, *33*(1), 001-334. Retrieved from http://www.scielo.br/pdf/rbf/v33n1/en_42.pdf

Valente, A., Gonçalves-Albuquerque, T., Sanches-Silva, A., & Costa, H. S. (2011). Ascorbic acid content in exotic fruits: A contribution to produce quality data for food composition databases. *Food Research International*, *44*(7), 2237-2242. doi: 10.1016/j.foodres.2011.02.012

Velho, A. C., do Amarante, C. V. T., Argenta, L. C., & Steffens, C. A. (2011). Influência da temperatura de armazenamento na qualidade pós-colheita de goiabas serranas. *Revista Brasileira de Fruticultura*, *33*(1), 14-20. Retrieved from http://www.scielo.br/pdf/rbf/v33n1/aop00111.pdf

Weston, R. J. (2010). Bioactive products from fruit of the feijoa (*Feijoa sellowiana*, Myrtaceae): A review. *Food Chemistry*, *121*(4), 923-926. doi: 10.1016/j.foodchem.2010.01.047

Zhang, M., Wang, D., Shao-Xiong, R., & Li-Zhang, F. (2011). Study on growth characteristics of young feijoa trees in different propagation methods. *Botany Research Journal*, 4(3), 26-28. Retrieved from http://docsdrive.com/pdfs/medwelljournals/brj/2011/26-28.pdf

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