Article

Characterization of guava grown in Mexico

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Abstract

Guava (*Psidium guajava*) can be characterized by its genetic diversity and its morphological, physicochemical and biological attributes, which depend on exogenous factors such as: agronomic cultivation, harvest season and maturity. Characterized by its content of carbohydrates (13.2%), fats (0.53%), proteins (0.88%) and high moisture content (84.9%). It is important to characterize the 'media china' guava grown in the municipality of Juárez, Michoacán, with the aim of improving morphological, physicochemical, biological and nutritional characteristics and statistical variables in quality control to correlate them to the possibility of industrializing it and international trade. For this purpose, the systemic methodology of 'reliability block diagrams' was used, which included random sampling of guava for study, in which the following are determined: weight, longitudinal diameter, transverse diameter, pulp, thickness and pH. The following were obtained: arithmetic mean, variance and standard deviation, variables to graph and compare with established standards for national and international trade. As a result, it was found that guava from the municipality of Juárez, Michoacán showed the best results in its characterization. The guava grown in the orchard of the municipality of Calvillo in the state of Aguascalientes presented lower results, it was observed that the quality was exceeded by the fruit of Juárez, Michoacán. The characteristics in size, visual appearance, seed content of the fruit, observed in the samples compete with those of commercial varieties. The analysis of this research infers the following conclusions: the productive system of the crop in the state of Michoacán and Aguascalientes is in a position to offer guava of good quality for national and international trade, due to the good agricultural practices applied and its registration in the National Service of Health, Safety and Agrifood Quality of the General Directorate of Plant Health of the Secretariat of Agriculture and Rural Development.

Keywords: agronomic cultivation, commercialization standards, genetic diversity, morphological characteristics, reliability block method.

Reception date: April 2022
Acceptance date: July 2022

Introduction

Current food production presents a wide variety of sustainable crops with great demand due to the nutrient content (Brklacich *et al*., 1991; Gerbens *et al*., 2003). Cultivated foods are indispensable in the daily diet of the population. Globalization has generated a large number of changes in the economic, social aspects and means of food production that have contributed to their increase, access and availability (Burlingame, 2012).

The United Nations (UN) states the international agreement to promote sustainable communities as a sustainable development goal (UNDP, 2019). The main problem in food is due to the high demand for foods and food services, it forces the ability to pressure markets that promote better forms of production in more environmentally friendly and socially just foods, which can encourage a healthier diet (Muchnik *et al*., 1996). For this reason, several countries develop nutritional criteria regulations, stimulate and incorporate sustainability criteria in public food purchases and public procurement of food services.

It is estimated that by 2030 there will be more than eight billion people in the world, according to a report by the Global Outlook Studies unit of FAO (2015), global trends in foods, nutrition and agriculture for the next 30 years are anticipated and with that scenario we will need to produce more foods, with an increase of up to 70% to feed the entire population. A serious public health problem in Mexico is obesity and chronic noncommunicable diseases (Barquera, 2013).

The National Survey of Health and Nutrition ENSANUT (2016) reported that more than 70% of the Mexican population suffers from obesity due to poor diet. It is suggested that these conditions can be prevented with healthy lifestyles and a good diet (Barquera *et al*. 2012; Dary, 2015). There are records that physical activity and dietary consumption in the population influence the nutritional status and health status of people (Rouhani *et al*., 2016).

Diet and good nutrition have been recognized as an excellent tool worldwide to reduce the epidemic of obesity and noncommunicable diseases in the world (Cecchini *et al*., 2010; OECD, 2010; Cecchini, 2016). There are foods such as guava (*Psidium guajava*) which has healing and nutritional properties. This fruit is grown in tropical and subtropical countries (Dakappa, 2011; Laily, 2014; Rojas, 2016). It has great acceptance for its good flavor, nutritional and medicinal properties and great commercial value.

In addition, it is an excellent source of vitamins A, C, thiamine, riboflavin, nicotinic acid and minerals such as calcium, iron, phosphorus and carbohydrates (Yusof, 1987). Due to its potential properties, it has effects on health (Flores, 2014; Chen, 2006). Lozano *et al*. (2002) mentioned that the vitamin C content in guava is five times higher than that of citrus fruits, there are records of 16 vitamins, it contains amino acids: tryptophan, lysine and methionine. The main objective of the study was to determine the physical, chemical and nutritional characteristics of guava (*Psidium guajava*).

Studies of researchers found that it contains important medicinal phytoconstituents, metabolites of good yield which contain various biological activities of great utility belonging to phenolics, flavonoids, carotenoids, terpenoids tannins, quercetin, triterpenoids, pentacyclic, guajanoic acid, saponins, lectins, leucocyanidin, ellagic acid, amritoside, beta-sitosterol, uvaol, oleanolic acid, ursolic acid and triterpenes (Rakmai, 2004; Jiao, 2017). The characterization of a species means the variability that exists between the population of the individuals that make it up (Franco, 2003).

Guava crop is characterized by having great genetic variability and by its great diversity in the morphological, physical, chemical and biological characteristics of its fruits. The result of this crop also depends on exogenous factors such as agronomic management in the plantation, harvest season and state of maturity of the fruit. In studies, it was found that metabolite extracts of leaves and fruits have important pharmacological properties of great utility for humans (Arias, 2019). In recent studies of the literature, it is stated that guava is known mainly for having antispasmodic and antimicrobial properties for the treatment of diarrhea and dysentery (Montenegro, 2019).

It is also attributed the use as a hypoglycemic agent (Rosario, 2017). Pharmacological studies demonstrate that guava and its leaves contain antioxidants, hepatoprotective, antiallergic, antimicrobial, antigenotoxic, antispasmodic, cytotoxic, antispasmodic, cardioactive, antitussive, antidiabetic, anti-inflammatory and antinociceptive properties that support their traditional treatments (Martínez, 2021). An important characteristic of the 'media china' guava, variety that is most commercially grown in Mexico, is the high content of carotenoids, particularly lycopene, it has been shown to prevent diseases such as prostate cancer (Giovannucci, 2002).

In addition, studies conducted on nutraceutical properties of guava have focused on vitamin C and carotenoids (Pal *et al*., 2004; Sanjinez, 2005). They are suggested by specialists for its wide range of medicinal applications in the treatment of enteritis due to infantile rotavirus, diarrhea, diabetes and mainly in this time of pandemic against COVID 19 because it strengthens the immune system (Pérez *et al*., 2017). Guava has one of the highest vitamin C contents (Mondragón, 2009).

Due to the good acceptance, high fresh commercialization and products derived from guava, information is needed on the characteristics of guava and pulp that establish the required attributes of quality based on commercialization. The main objective of this research work was to characterize morphological and physical attributes, using measures of central tendency and dispersion such as the arithmetic mean, variance and standard deviation of the 'media china' guava as a contribution to the knowledge and updated record of fruits grown and processed in the country.

Materials and methods

The guava fruit was collected in three different places, Mr. José Ramón Suárez Toledo's 'La parota' orchard in the municipality of Juárez, Michoacán, Mr. Sergio Martínez Santana's orchard in Juárez, Michoacán and an orchard in the municipality of Calvillo, Aguascalientes. Ten trees were randomly chosen from a batch of 300 to collect their fruits suitable for harvest, visibly healthy,

from the three orchards. The raw material was weighed, washed with pressurized water jet to remove foreign materials. The fruits were distributed on a smooth and clean surface at room temperature (25 °C ±2 °C). The following samples were selected, batches of 16 guavas from each of the indicated orchards.

Chemical composition of guava

Below is a sample of 100 g of guava pulp that showed an average of the following results. Table 1 shows the high content of vitamins, minerals and fiber that guava has, demonstrating that it is a fruit with a large amount of essential nutrients in the diet.

Table 1. Analysis of the guava of the 'media China' variety and 'criolla' variety.

Nutrients	'Media China' guava	'Criolla' guava
Calories	52	55
Proteins	1.1 g	1 g
Fat	0.6 g	0.4 g
Carbohydrate	12 g	13.5 g
Calcium	33 mg	33 mg
Phosphorus	39 mg	29 mg
Iron	0.74 mg	1.32 mg
Thiamine	0.05 mg	0.04 mg
Riboflavin	0.04 mg	0.04 mg
Niacin	1.2 mg	1.3 mg
Ascorbic acid	150 mg	100 mg

Physical dimensions and weight

The physical dimensions were recorded with a vernier caliper (Surtek Shook-Proof and Velab VE-1000 balance). Twelve-megapixel digital camera, and kitchen knife.

Techniques applied in characterization

Weight measurement (g), the weight of each fruit was recorded, a digital image was recorded for its collection with an identification number of each of the batches. Records were made in the longitudinal and transverse diameters of each of the guava samples from the three batches. The thickness of the peel and the pulp was measured, for this exercise it was split in half with a kitchen knife, to make the measurement of peel and pulp, a digital image of each half of guava was also recorded. The pH was obtained by a test with a ribbon and a standard sample.

From the measurements obtained, a table was made to order and calculate the variables to be obtained, such as arithmetic mean, variance and standard deviation. These parameters will allow making the graphs and quickly obtaining important information that will allow us to have control of the statistical analysis of the batches.

Statistical analysis

The experimental design was using the methodology of reliability blocks, integrating the batch of 'media china' variety separately, four samples of each block and four repetitions were considered, obtaining a total of 48 samples. The variables evaluated were: weight, volume, longitudinal diameter, polar diameter, pulp diameter, peel thickness and pH.

The pH is a measure in the intensity of the acid flavor of a product, very important in the control of the development of populations of microorganisms and the activity of enzymatic systems, in the process of clarification of juices and beverages, in the stability of these and products made from fruits; also, in the production of jelly, jam, whose firmness and color are determined by the concentration with hydrogen ions.

Design

Randomized design, complete blocks that depend on the choice and time to make the measurements, labeling was carried out. The product was placed in its respective bag (Figure 1).

Figure 1. Photographs of the instruments used.

Method

The reliability block diagram is shown in Figure 2.

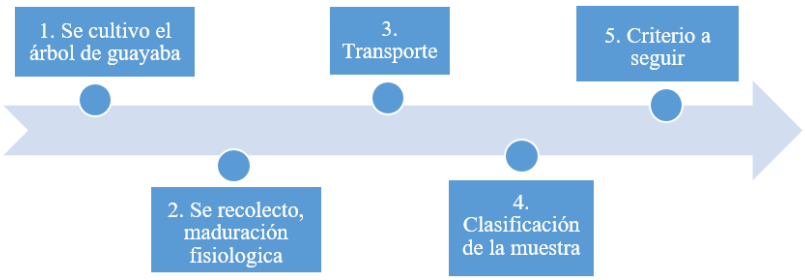

Figure 2. Block diagram of the activities carried out.

Figure 2 shows the reliability block diagram as the method applied for being the most suitable. Figure 3 shows the block diagram of the method applied in expanded form.

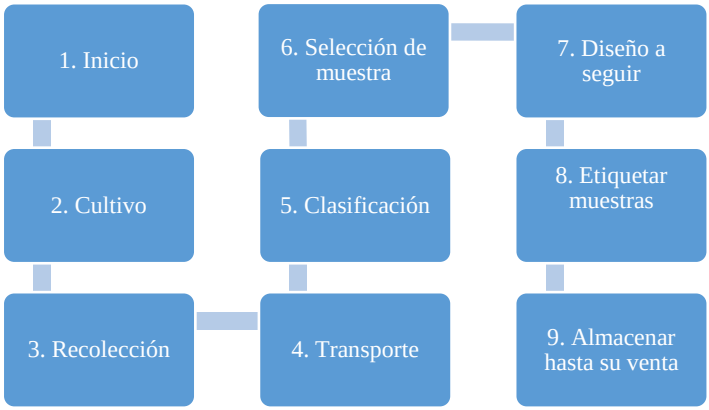

Figure 3. Block diagram of the applied transdisciplinary method.

Figure 3 shows the block diagram in extended form, showing the procedure developed in this research.

Measurements

First exercise

Study material extracted from the guava orchard belonging to Mr. Sergio Martínez Santana from Juárez, Michoacán. It was classified based on its state of physiological maturation based on the color from green to yellow, four classifications were made, with four repetitions, shown in (Table 2).

Table 2. Experimental design, randomized blocks for guava characterization.

Blocks	R1	R2	R3	R4
1 M1	3	6	10	15
2 M2	1	5	9	13
3 M3	2	8	11	16
4 M4	4	7	12	14

Table 2 shows how the order of the repetitions was randomly classified. The results of the characterization can be seen in Table 3. Where the total sum of the 16 elements of the guava sample selected for study.

Table 3. Characterization results.

Samples	Weight (g)	Major d. (cm)	Minor d. (cm)	Pulp d. (cm)	Peel t. (cm)	pH
1	140	7.3	6	3.5	1.5	4
2	120	6	6	3.5	1.3	4
3	115	6.5	6.2	3.6	1.2	4
4	100	6.3	5	3	1.2	4

Samples	Weight (g)	Major d. (cm)	Minor d. (cm)	Pulp d. (cm)	Peel t. (cm)	pH
5	100	7	5.2	3	1.4	4
6	98	7	5.5	3.5	1.5	4
7	95	6.3	5.6	3.6	1.6	4
8	90	6.2	5.4	4	1.5	4
9	90	6.1	5.5	4	1.5	4
10	84	6.4	5.4	3.5	1.6	4
11	85	6.5	6	4	1.5	4
12	75	6	5.2	4	1.2	4
13	80	6.3	5.4	4.1	1.2	4
14	75	6	5	3.5	1.5	4
15	60	5.5	4.5	3	1.5	4
16	60	5.3	4.3	3	1.3	4
	Ɛ= 1467	Ɛ= 100.7	Ɛ= 86.2	Ɛ= 56.8	Ɛ= 22.5	pH= 4
Mean	91.7	6.29	5.38	3.55	1.4	
Variance	445	0.26	0.27	0.15	0.02	
St. deviation	21.1	0.51	0.52	0.39	0.14	

Second exercise

In the second exercise, material extracted was collected from a batch of 300 trees from the orchard belonging to Mr. José Ramón Suárez Toledo in the municipality of Juárez, Michoacán. Based on the material obtained (guava) *Psidium Guajava*. It was classified based on its state of physiological maturation, four classifications were made with four repetitions, as observed in Tables 4 and 5. Table 4 shows the experimental design of the randomized blocks and Table 5 shows the results of the characterization of the 16 guava samples for study. With this information, we can know the arithmetic mean, variance, standard deviation, which serve to find the real parameters and know, through good agricultural practices, how to achieve the desired parameters to be evaluated.

Table 4. Experimental design, randomized blocks.

Blocks	R1	R2	R3	R4
1 M1	2	7	10	15
2 M2	3	5	11	13
3 M3	4	6	9	16
4 M4	1	8	12	14

Table 5. Characterization results.

Samples	Weight (g)	Major d. cm	Minor d. cm	Pulp d. cm	Peel t. cm	PH
1	149	7.6	6.4	3.5	1.6	4
2	112	6.3	6	3.5	1.4	4
3	112	6.8	6	3.6	1.5	4
4	105	6.5	5.6	3.5	1.2	4
5	94	7.4	5.3	3	1.4	4
6	96	7	5.8	3.6	1.4	4
7	97	6.5	5.5	3.6	1.1	4
8	91	6.2	5.5	4	1.2	4
9	89	5.8	5.5	3.8	1.2	4
10	83	6.5	5	3.8	1	4
11	82	6.3	5.1	3.5	1.2	4
12	73	5.8	5	3.5	1	4
13	82	6.4	5.2	3.5	1.1	4
14	78	6	5	3.6	1	4
15	56	5.2	4.8	3.5	1	4
16	54	5	4.8	3.4	1	4
	Ɛ= 1 453	Ɛ= 101.3	Ɛ= 86.5	Ɛ= 56.9	Ɛ= 19.3	pH= 4
Mean	90.8	6.33	5.4	3.55	1.2	
Variance	489	0.45	0.2	0.13	0.03	
St. Deviation	22.1	0.67	0.45	0.37	0.19	

Exercise three

Material extracted from an orchard located in the municipality of Calvillo in the state of Aguascalientes. Based on the material obtained (guava) *Psidium guajava*. It was classified based on its state of physiological maturation, four classifications were made, with four repetitions (Table 6).

Table 6. Experimental design, randomized blocks of fruits suitable for cutting.

Blocks	R1	R2	R3	R4
1 M1	3	7	11	15
2 M2	1	5	10	13
3 M3	4	8	9	16
4 M4	2	6	12	14

Results and discussion

The guava from Juárez, Michoacán provided the best results in morphological and physical characterization according to the measures obtained of the variables to be evaluated and because its cultivation has professional advice provided by agronomists, chemists. They are monitored, supervised and endorsed by the Local Board of Plant Health based in the town of Benito Juárez, Michoacán. It has the necessary conditions for good development, such as the following demographic characteristics, altitude above sea level, humidity, temperature, type of soil, enough water for irrigation, flat surfaces for cultivation, this characterization met the objectives and exceeded the standards established for its commercialization in the country and abroad.

The guava characterized in Aguascalientes ranked second, with very good quality and acceptance, it is also grown with professional advice by agronomists and has the services of the Local Board of Plant Health for approval, this characterization met the objectives and standards established for its commercialization in the country and abroad. The guava characterized from a tree that is not representative of a producing area of Mexico City ranked last since it does not have the attentions of a certified cultivation orchard, did not meet the objectives and standards for its commercialization and consumption at national and international level.

It is recommended as suitable for agribusiness and in this way, it is not discarded as garbage. Table 4 shows the mean of each of the parameters, variance and standard deviation, the pH was 4 in all the fruits, measured with a special tape to measure pH and a reference standard, with these data one has the necessary elements to make the evaluation and comparison of the three sampling sites and give a diagnosis based on experience and the results obtained. Finally in the Table 7 presents a summary of the parameters found on the guava characterization of the three sites studied.

Table 7. Summary of the parameters found in the characterization of guava.

Color	Weight (g)	Major d. (cm)	Minor d. (cm)	Image	Pulp d. (cm)	Peel t. (cm)	pH
Sample of guava: Sergio Martínez of Juárez, Michoacán, Mexico							
							
Mean	91.7	6.29	5.38		3.55	1.4	
Variance	445	0.26	0.27		0.15	0.02	
St. deviation	21.1	0.51	0.52		0.39	0.14	
Sample of guava: Joseph R. Suarez T. de Juárez, Michoacán, Mexico							
							
Mean	90.8	6.33	5.4		3.55	1.2	
Variance	489	0.45	0.2		0.13	0.03	
St. deviation	22.1	0.67	0.45		0.37	0.19	

Color	Weight (g)	Major d. (cm)	Minor d. (cm)	Image	Pulp d. (cm)	Peel t. (cm)	pH
Sample of guava: Calvillo, Aguascalientes, Mexico							
							
Mean	55	5.23	4.48		3.05	0.85	
Variance	40.8	0.17	0.03		0.03	0.01	
St. deviation	6.39	0.41	0.18		0.18	0.1	

The information obtained by other authors, standard requirements, standards for trade and export, finding the following results; Cañizares *et al*. (2003) affirm that for the good cultivation and the best characteristics of the guava, it is important the professional assistance in the field, to apply good agricultural practices, to carry out studies and laboratory analysis of soil and leaves of the tree, excellent fertilization, control of pests, diseases, to keep a record of harvests, indicating which ways produced the best results.

Authors such as Marquina *et al*. (2008) state that the following factors must be considered in order to be successful in the cultivation of guava, good selection of the land, the best vegetative material, use of appropriate planting methods, best use of the irrigation system, fertilizer formulas, good guidance at official institutions, make the producer understand the importance of pruning. Similarities in the pH values recorded and contrasts with the information obtained through the own preparation of the results tables and what was published by Cañizares (2003) were found.

The 'Media China' variety showed high vitamin C content, compared to the values observed by Pal *et al*. (2004), who reported 140 mg 100 g^{-1} of fruit in guava. Vitamin C variations have been recorded in guava varieties as a result of differences in maturation, due to vitamin C decreasing during maturation (Carvalho *et al*., 2008).

The minimum requirement of vitamin C for an adult is 60 mg daily, having an availability of 30% for several factors, a portion of 100 g of guava will cover between 20 and 35% of this requirement (Carvalho *et al*., 2008) state that, if a person consumes a guava of 90 g, average weight of the fruit, it will cover between 30 and 50% of the daily requirement of vitamin C. The authors' suggestions found in this scientific research of guava characterization are considered for future studies.

Conclusions

Mr. Sergio Martínez Santana's and Mr. José Ramón Suárez Toledo's guavas from the municipality of Juárez Michoacán showed the best results in their characterization. They were satisfactory and exceeded the expectations, they have very good acceptance in the market, excellent sale price, easy to market, high quantity and quality of nutrients, this because all the necessary elements for their cultivation were applied.

The guava grown in the orchard of the municipality of Calvillo in the state of Aguascalientes presented lower results, it is observed that the quality was exceeded by the fruit of Juárez Michoacán. The fruit shows good acceptance in the market, but a lower economic value than the fruit from the state of Michoacán, because the measured parameters are lower than that of the guava from the state of Michoacán. The characteristics in size, visual appearance, seed content of the fruit, observed in the samples compete with those of commercial varieties.

The productive systems of guava crop in the state of Michoacán and Aguascalientes are in a position to grow guava of good quality for national and international commercialization, due to the good agricultural practices applied and their registration in the National Service of Health, Safety and Agrifood Quality of the General Directorate of Plant Health of SAGARPA.

Cited literature

Arias, J. N. M. 2019. Evaluación de la actividad antioxidante, según la farmacogeografía, en extractos hidroalcohólicos obtenidos de las hojas de *Psidium guajava* L. (guayaba) (Bachelor's thesis, Quito: UCE). 1-4 pp. http://www.dspace.uce.edu.ec/bitstream/25000/20370/1/T-UCE0008-CQU-208.pdf.

Barquera, S. C.; Rivera, D. J. y Gasca, G. A. 2012. Políticas y programas de alimentación y nutrición en México. Salud Pública de México. 43(5):464-477.

Barquera, S. C.; Campos, N. I.; Hernández, B. L.; Pedroza, A. S. y Rivera, D. J. A. 2013. Prevalencia de obesidad en adultos mexicanos. Salud Pública de México. 55(2):S151-S160.

Brklacich, M.; Bryant, C. R. y Smit, B. A. 1991. Revisión y evaluación del concepto de sistemas sostenibles de producción de alimentos. Gestión Ambiental. 15(1):1-14.

Burlingame, B.; Charrondiere, U. R.; Dernini, S.; Stadlmayr, B. and Mondovì, S. 2012. Food biodiversity and sustainable diets: implications of applications for food production and processing. *In*: green technologies in food production and processing. Springer, Boston, MA. 643-657 pp.

Cañizares, D. L. y Puesme, R. 2003. Crecimiento y desarrollo del fruto de guayaba (*Psidium guajava* L.) en Santa Bárbara, Estado Monagas, Venezuela. Rev. Científica UDO Agrícola. 3(1):34-38.

Carvalho, S. R. 2008. Promoción de la Salud, "empowerment" y educación: una reflexión crítica como contribución a la reforma sanitaria. Salud Colectiva. 4(3):335-347.

Cecchini, M.; Sassi, F.; Lauer, J. A.; Lee, Y. Y.; Guajardo, B. V. and Chisholm, D. J. 2010. Tackling of unhealthy diets, physical inactivity, and obesity: health effects and cost effectiveness. The Lancet. 376(9754):1775-1784.

Cecchini, M. and Warin, L. 2016. Impact of food labelling systems on food choices and eating behaviours: a systematic review and meta-analysis of randomized studies. Obesity reviews. 17(3):201-210.

Chen, H. M.; Liu, Z. H.; Zeng, C. H.; Li, S. J.; Wang, Q. W. y Li, L. S. 2006. Lesiones podocitarias en pacientes con glomerulopatía relacionada con la obesidad. Rev. Am. Enfermed. Renal. 48(5):772-779.

Dakappa, S. S; Sajjekhan, S. and Jha, P. K. 2011. Pharmacognostic evaluation of *Psidium guajava* L. leaves (Mrytaceae). Med. Aromat. Plant sci. Biotechnol. 5(2):156-159.

Dary, O.; Dwyer, J. T.; Wiemer, K. L.; Keen, C. L.; King, J. C.; Miller, K. B. and Bailey, R. L. 2015. Fortification and health: challenges and opportunities. Advances in nutrition. 6(1):124-131.

Dey, R. K. K. P.; Pal, K. K.; Bhatt, D. M. and Chauhan, S. M. 2004. Growth promotion and yield enhancement of peanut (*Arachis hypogaea* L.) by application of plant growth promoting rhizobacteria. Microbiological Research. 159(4):371-394.

Flores, C. C y Sarandón, S. J. 2014. Agroecología. Editorial de la Universidad Nacional de La Plata (EDULP). 342-373 pp. http://sedici.unlp.edu.ar/handle/10915/37280.

Franco, T. L. 2003. Análisis estadístico de datos de caracterización morfológica de recursos fitogenéticos boletín técnico IPGRI. 8(8):80-100.

Gerbens, L. P. W.; Moll, H. C. and Uiterkamp, A. S. 2003. Design and development of a measuring method for environmental sustainability in food production systems. Ecological economics. 46(2):231-248.

Giovannucci, E. L.; Rimm, E. B.; Liu, Y.; Stampfer, M. J. y Willett, W. C. 2002. Un estudio prospectivo de productos de tomate, licopeno y riesgo de cáncer de próstata. Rev. Instit. Nac. Cánc. 94(5):391-398.

Jiao, Y.; Zhang, M. Wang, S. y Yan, C. 2017. El consumo de guayaba puede tener efectos beneficiosos en la diabetes tipo 2: una perspectiva bioactiva. Rev. Internac. Macromol. Biológic. 101:543-552.

Laily, N. B.; Kusumaningtyas, R. W.; Sukarti, I. and Rini, M. R. D. K. 2014. The potency of guava (*Psidium guajava* L.) leaves as a functional immunostimulatory ingredient. Procedia chemistry. 14:301-307.

Lozano, J. C.; Toro, J. C.; García, R. y Táfur, R. R. 2002. Manual sobre el cultivo del guayabo en Colombia (No. Doc. 22526) CO-BAC, Bogotá). 270-300 pp.

Marquina, V.; Araujo, L.; Ruíz, J.; Rodríguez, M. A. y Vit, P. 2008. Composición química y capacidad antioxidante en fruta, pulpa y mermelada de guayaba (*Psidium guajava* L.). Archivos latinoamericanos de nutrición. 58(1):98-102.

Martínez, L.; Martínez, K. y Noguera, M. N. 2021. Usos medicinales de las hojas de *Psidium guajava* "guayaba". Rev. Mangifera. 3:95-101.

Mondragón, J. C.; Toriz, A. L. M. y Guzmán, M. S. H. 2009. Caracterización de selecciones de guayaba para el Bajío de Guanajuato, México. Agricultura Técnica en México. 35(3):315-322.

Montenegro, P. D. D. 2019. Efectividad antibacteriana de la hoja de la guayaba y clorhexidina sobre el *Streptococcus mutans*. La libertad, Trujillo. 20 p.

Muchnik, S. L. F. E. 1996. Visión crítica de la agricultura chilena y sus políticas. Estudios Públicos núm. 61. 142-150 pp.

Pérez, C. M. D.; León, Á. J. L.; Dueñas, H. A.; Alfonzo, G. J. P.; Navarro, D. D. A.; Noval, G. R. y Morales, S. A. 2017. Guía cubana de diagnóstico, evaluación y tratamiento de la hipertensión arterial. Rev. Cubana de medicina. 56(4):242-321.

Rojas, G. C.; Pérez, A. M.; Vaillant, F. y Pineda, C. M. L. 2016. Composición fisicoquímica y antioxidante de frutos frescos de chontaduro (*Bactris gasipaes* Kunth) en Costa Rica. Rev. Brasileña de tecnología de alimentos.

Rakmai, J.; Cheirsilp, B.; Mejuto, J. C.; Simal, G. J. and Torrado, A. A. 2004. Antioxidant and antimicrobial properties of encapsulated guava leaf oil in hydroxypropyl beta cyclodextrin. Industrial crops and products. 111:219-225.

Rosario, M. and Delgado, R. M. 2017. Análisis del efecto de la temperatura de cocción en la calidad nutritiva del jugo natural de guayaba (*Psidium guajava* L.) utilizando el fruto maduro sin piel. Revista de Investigación. 41(90):102-119.

Rouhani, M. H; Haghighatdoost, F.; Surkan, P. J. y Azadbakht, L. 2016. Asociaciones entre la densidad de energía dietética y la obesidad: una revisión sistemática y un metanálisis de estudios observacionales. Nutrición. 32(10):1037-1047.

Sanjinez, A. E. J.; Cunha, R. L.; Menegalli, F. C. y Hubinger, M. D. 2005. Evaluación de carotenoides totales y ácido ascórbico en guayabas pretratadas osmóticas durante el secado convectivo. Rev. Italiana de Ciencia de los Alimentos. 17(3):305-314.

Yusof, S. and Mohamed, S. 1987. Physico chemical changes in guava (*Psidium guajava* L.) during development and maturation. Journal of the science of food and agriculture. 38(1):31-39.