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Current situation of the guava agrifood chain in Zacatecas, Mexico

Situación actual de la cadena agroalimentaria de guayaba en Zacatecas, México

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Abstract

Guava is one of the most important fruit crops in Zacatecas, Mexico. However, its permanence as an agrifood chain could be at risk. This research evaluated the current positioning of the guava chain. The information supporting these results was collected using the International Service for National Agricultural Research (ISNAR) methodology. The results indicated that guava is in a retraction status due to low socioeconomic importance and competitiveness. This situation is due to a significant decrease in the established area with guava, induced by various climatic, productive, and economic factors that growers have been experiencing. Therefore, it is necessary to improve crop productivity through the dissemination and adoption of technological innovations to improve yield.

***Psidium guajava* L., Positioning, Socioeconomic importance, Competitiveness**

Resumen

La guayaba es uno de los frutales más importantes en Zacatecas, México. Sin embargo, su permanencia como cadena agroalimentaria podría estar en riesgo. Esta investigación evaluó el posicionamiento actual de la cadena de guayaba. La información que sustenta los resultados se recabó utilizando la metodología del International Service for National Agricultural Research (ISNAR). Los resultados indicaron que la guayaba se ubica en una posición de retracción, donde su importancia socioeconómica y competitividad son bajas. Esta situación obedece a una disminución significativa de la superficie plantada con guayabo, inducida por diversos factores climáticos, productivos y económicos que los productores han estado experimentando. Por ende, es necesario mejorar la productividad del cultivo a través de la difusión y adopción de innovaciones tecnológicas para mejorar el rendimiento.

***Psidium guajava* L., Posicionamiento, Importancia socioeconómica, Competitividad**

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Introduction

Guava has a high nutraceutical potential due to its vitamin C, E, and D12 content, in addition to minerals such as iron, copper, calcium, magnesium, potassium, manganese, and phosphorus (Padilla *et al.*, 2014). It also contains high levels of essential amino acids such as tryptophan, lysine, methionine, and tannins (Chauca & Chávez, 2020; Rojas & Narváez, 2009; Marquina *et al.*, 2008). These characteristics make it one of the most appreciated fruits by consumers, in the face of a growing trend for nutraceutical and functional products (Coronado *et al.*, 2015; Sauceda *et al.*, 2011).

World guava production amounted to almost 261 million t in 2022. India was the leading producer with 51 % of total world production, followed by Indonesia (7.5 %), Mexico (4.9 %), and China (4.9 %) (Trigde, 2023). In 2022, Mexico had an established area of 22,546 ha that produced 321 thousand t of this fruit (SIAP, 2023a). This fruit is cultivated in tropical and subtropical regions of the country as a crop, in the wild, or in backyard orchards. However, the economically important producing areas are located in the states of Aguascalientes and Zacatecas, particularly in the region known as Calvillo-Cañones (Padilla *et al.*, 2007; Padilla *et al.*, 2014), which in 2022 had an established area of 7,450 ha and a yield of 115.7 thousand t (SIAP, 2023a).

Zacatecas is the third largest producer of this fruit (31 thousand t), which is grown in the municipalities of Apozol, Huanusco, Jalpa, Juchipila, Moyahua de Estrada, Nochistlán de Mejía, Tabasco and Villanueva. From 2017 to 2022, guava yield in this region had an average growth rate of -9.3%. However, the importance of this fruit chain was emphasized in the number of producers engaged in this activity (≈ 348) and the number of field man workers generated annually around this crop (≈ 309 thousand) (Ramos *et al.*, 2017; SIAP, 2023a).

However, research must anticipate the challenges and needs projected by a world immersed in constant change processes. The challenge of this activity is not only to modernize and make agricultural activity more efficient but also to improve income, welfare, and life quality in the rural sector. In the same way, a balance must be established in research activities oriented to productivity (sufficiency and efficiency) in close relation to nutritional quality, health, and food safety for the benefit of the consumers (Kaimowitz, 2019, Carrasco & Sapera, 2016).

In this regard, it is necessary to analyze the agrifood chains of a region or state, to direct efforts toward technological innovation in a coordinated manner with a high probability of economic, social, and environmental impact (Urquía, 2014). Therefore, this research aimed to determine the socioeconomic and competitive importance of the guava chain in the state of Zacatecas, México.

Materials and methods

The methodology consisted in ranking the guava chain in Zacatecas based on weighted criteria so that this agrifood chain could be positioned and compared with other agrifood chains through a dimensionless numerical matrix. Two dimensions were considered: a) The socioeconomic dimension (SED). This included those characteristics of the agrifood chains that make them essential attributes for considering them a justifiable productive activity. The competitiveness dimension (CD). This explains the ability of those involved in a productive chain to face the challenges of change and the ability to adapt and overcome them. Both dimensions are key aspects of the motivations, opportunities, weaknesses, and strengths that agricultural activities manage and explain the socio-economic activities of the primary production sector (Rincón *et al.*, 2004).

Both dimensions are made up of criteria logically integrated into standardized numerical values. The criteria for the SED were: size, dynamism, and specialization. The CD was made up of the criteria: productivity, sustainability, and commercial performance. In turn, each criterion was explained by quantitative parameters and thus explain, numerically, the advantages and/or opportunities implicit in each agrifood chain. A total of fourteen parameters were used, as described below (Rincón *et al.*, 2004).

The yield value was used as the first indicator of economic and social magnitude for the size parameter. The second indicator was the cultivated area used by each crop in the state. This indicator can show the social importance of each agrifood chain. Another indicator associated with the size criterion was the number of jobs generated, which has a strong social and economic weight.

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The dynamism criterion was represented by three variables: yield value trend, real price evolution, and employment evolution. The three parameters can explain the socioeconomic impact of agrifood chains; because the dynamism criterion is an indicator of the ability to adapt to a continuous environment, but also of the agrifood chain's importance in providing jobs and maintaining competitive prices.

The specialization and concentration coefficients were used to refer to the level of specialization of an agrifood chain within the state (among agrifood chains) and national context. Both indicated the relative importance of the agrifood chains at the state and national levels.

The productivity criterion was represented by the return on capital (benefit/cost ratio) and labor productivity (total cost of wages/income). These indicators are an important part in defining the efficiency of each agrifood chain in making use of economic resources.

The sustainability generated by each agrifood chain was represented by the soil erosion levels, water use efficiency, and contamination levels by fertilizers, particularly due to high nitrogen applications, understanding nitrates as a source of soil and aquifers contamination.

The commercial performance criterion was represented by the trend of the real prices of the products.

The values of the variables of each criterion by dimension were added, and later, standardized to zero mean and standard deviation. With the latter, a dimensionless matrix for SCD and CD was generated. This was used to order each agrifood chain and position them in a two-dimensional plane to compare the guava chain with other agrifood chains.

Results and discussion

The integration of the agrifood chains information in a dimensionless matrix, for the period 2010-2021, allowed the formation of four agrifood chain groups according to the socioeconomic and competitive relevance of each one in the state of Zacatecas (Figure 1). The bean and apple chains were placed in Quadrant I of sustainability status. While the chains of peaches, carrots, and grapes were placed in Quadrant II of vulnerability status.

In contrast, tomato, green chili, cactus pear, lettuce, green tomato, guava, nopalitos, and onion were placed in a retraction status (Quadrant III); while in Quadrant IV, the garlic chain was positioned in a critical situation due to its great socioeconomic relevance but low competitiveness (Figure 1).

The guava chain was positioned in a retraction status (Figure 1, Quadrant III) due to its low competitiveness and socioeconomic relevance for Zacatecas state.

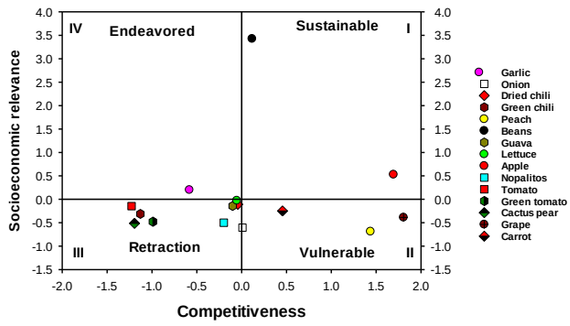

Figure 1 Positioning of agrifood chains in the State of Zacatecas for 2010-2021 period

This crop is transcendental on one hand, because it represents an alternative to using agroecological resources and, on the other hand, it is a source of savings and extraordinary capitalization for growers. The negative sign in the socioeconomic axis was due to a 58.6% reduction in the established area during the 2010-2021 period. In part, this has been due to the gradual depletion of aquifers and, therefore, to the increase in the costs of water extraction and irrigation supply. Besides, the orchards' devastation was due to recurrent temperature drops (Medina *et al.*, 2005) associated with other natural phenomena such as hailstorms and droughts, pests and diseases (Padilla *et al.*, 2007), the increase in production costs, as well as the poor planning in the public and private resources allocation (Borja *et al.*, 2019). The low real fruit prices have had an impact on crop profitability (Sangerman *et al.*, 2013), as these grew at an average annual rate of 4.2% between 2010 and 2022 (SIAP, 2023a). In 2022, the guava price in the Calvillo-Cañones region was 17% lower than the price received by the guava growers of Jalisco, Mexico (SIAP, 2023a). This was attributed to the volatility of prices, whose effect which hurt the income and profits of guava growers (Ramos *et al.*, 2017). The latter, in part, was because Zacatecas and Aguascalientes coincide with the production seasonality between August and December (SIAP, 2023b).

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Regarding the dynamism and specialization index average, the values were low, 0.009 and 0.1265, respectively. However, Aguascalientes had high values in these indexes (0.36 and 22.2, respectively), because growers oriented their efforts to exports, mainly to the USA, and to specialization in the domestic marketing of guava (Borja *et al.,* 2016).

The direct (≈ 309 thousand annual day laborers) and indirect jobs around the crop in Zacatecas enhance the importance and the search for opportunities to maintain or encourage the productive activity of this crop.

The guava agrifood chain competitiveness was affected by the increase in production costs, associated with the increase in the cost of fertilizers and inputs to pest and disease control as well as the increase in costs associated with irrigation. All these factors negatively influenced the profitability of the orchards and fruit quality. Therefore, the current situation of guava production is a quite favorable opportunity to adopt adequate cultural practices (e.g., irrigation systems, pest and disease control, pruning and fruit thinning alternatives, and plant nutrition, mainly) (Padilla *et al*., 2022). However, the most important element for increasing fruit crop productivity is the use of improved guava varieties (Khan *et al*., 2020)

The competitiveness of the guava agrifood chain has been affected by the increase in production costs associated with fertilizers cost, pests and diseases control, and irrigation costs. All these factors negatively influenced the guava orchards' profitability and fruit quality.

In Zacatecas, post-harvest handling of guava is insipient: guava is harvested by hand and transported in bulk or unprotected boxes. This generates a high percentage of damaged fruit cosmetically that is eventually discarded (Medina *et al.,* 2016). Growers are undercapitalized and therefore, infrastructure investment for harvesting, transportation, selection, packaging, transformation, and storage has been low or nonexistent. However, trends in guava consumption have changed. In developed markets, consumers consider aspects such as safety, preference in purchase places, convenience, environmentally responsible packaging, new value-added products, and benefits to human health (Nguyen *et al.,* 2020).

Conclusions

In the state of Zacatecas, the guava agrifood chain is currently in a retraction status due to its low socioeconomic importance and competitiveness. This situation is a result of a significant decrease in the established area with this fruit crop, caused by various climatic, productive, and economic factors that growers have been acing. Therefore, the diffusion, adoption of technological innovations, and the use of improved guava varieties are imperative to enhance crop productivity. Besides, to recover the socioeconomic and competitive importance towards the sustainability of this agrifood chain for both regions the "Cañones" and “Calvillo” together make up a compact production zone called "Calvillo-Cañones".

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