Essay

Challenges and controversies of the Ataulfo mango

Claudia Mendoza-Hernández
Raymundo Rosas-Quijano
Alfredo Vázquez-Ovando
Didiana Gálvez-López[§]

Institute of Biosciences-Autonomous University of Chiapas. Blvd. Príncipe Akishino s/n, Col. Solidaridad 2000, Tapachula, Chiapas, Mexico. CP. 30798. Tel. 962 6427972. (claudia1mendoza8@gmail.com; raymundo.rosas@unach.mx; jose.vazquez@unach.mx).

[§]Corresponding author: didiana.galvez@unach.mx.

Abstract

The Ataulfo mango (*Mangifera indica* L. var Ataulfo) is a tropical fruit native to the Soconusco region, Chiapas, Mexico. This represents a pillar of the economic-social development of the state and specifically of the region. Over the years, the production of this fruit has experienced significant increases that benefit its commercial chain, due to the tropical soils and environmental conditions typical of the area. Another aspect that has benefited development is the implementation of appropriate technologies for cultivation, such as integrated management of orchards, high planting densities, among others. In recent years, the Ataulfo variety has become the most important Mexican variety in the international market due to the high demand for exports to North America and Japan, making Mexico the main mango exporting country. The high international demand derives from the desirable organoleptic characteristics of the variety, such as sweet flavor, fleshy pulp and little fibrous, among other aroma and texture properties. However, in the Ataulfo mango production chain there are some problems that must be addressed in order to improve its profitability, as well as its commercialization and its correct valuation. Therefore, the objective of this work is to show the current situation of the production chain and the challenges to be faced in order to sustain it.

Keywords: denomination of origin, NOM-188-SCFI-2012, production chain.

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Brief history and propagation of the Ataulfo mango

The Ataulfo mango is a tropical variety native to Mexico that stands out for its sensory properties, mainly taste, smell and texture. This fruit is succulent, fleshy, oval in shape, with thin seed and abundant pulp, it also contains a high amount of vitamins A and C, it is rich in minerals, fibers and antioxidants such as ascorbic acid, carotenoids and phenolic compounds, while its content of calories, fat and sodium is low (Ma *et al*., 2011).

Since this fruit was made known, it presented a growing commercial exploitation due to its high consumption both in the national and international markets (SIAP, 2018). Starting from a broader perspective and regarding the total of Mexican mangoes, it was registered in 2019 that 90% of the production is exported to the United States of America; while the rest goes to Canada (FAO, 2020). These consumption levels have made Mexico the main mango exporter in the world (Esponda, 2016).

This fruit is grown in 22 states of the country, of which the state of Chiapas ranks fourth nationally as a mango producer with 237 thousand 530 tons per year (SIAP, 2017a). As for the Ataulfo variety, this entity is the center of origin of it but it is not the main producer. Despite this, the Ataulfo mango has established itself as one of the most important fruit crops in the state, becoming a pillar of the economic and social development of Chiapas and specifically of the Soconusco region, located in the southern part of the country on the border with Guatemala (Figure 1).

Figure 1. Ataulfo Mango trees del Soconusco, Chiapas.

The genealogy of the Ataulfo mango is uncertain, since its true parents are unknown. According to local reports and documentaries, there were eight Ataulfo mango 'mother-father' trees located on the property that in 2000 was owned by the heirs of Don José Ataulfo Morales Gordillo, but due to the outstanding economic importance of the crop, the state government decided to buy said land.

In this way, it was acquired for its conservation and subsequent research from the Produce Chiapas Foundation, AC, with the aim of preserving the father trees and providing them with the care they require. In order to preserve and improve the quality of production, it was decided to install specific research laboratories for Ataulfo mango on the same site (De la Torre, 2013). As of 2020, there are only five parent trees on the property.

Without considering the morpho-genetic variations between these 'sister' trees, the varetas that gave rise to the first Ataulfo mango plantations were propagated and dispersed following the vareta grafting process, until reaching the thousands of trees now established in Chiapas and in the rest of the Mexican Republic and that have even spread to Guatemala and Brazil.

Said propagation of vegetative material was transferred from the Mexican Institute of Coffee (IMC, by its acronym in Spanish) to the National Commission for Fruit Growing (CONAFRUT) for its massive propagation. Years later, the fruit tree was known as 'Ataulfo'. It is estimated that the trees were born in 1943 (Infante *et al*., 2011).

The Ataulfo variety stands out for having a greater amount of pulp than other mango varieties, as well as a long shelf life, which brings with it great opportunities for its packaging and transport to export markets. Over the years and to safeguard the sensory quality of the fruit of this variety, the Ataulfo Mango Regulatory Council was founded, which is a public body that authorizes the display of a badge to those producers in the Soconusco area who comply with the rules and the quality standards that the denomination of origin establishes for this crop.

The declaration of protection of the denomination of origin of the 'mango Ataulfo del Soconusco Chiapas' was published in the Official Gazette of the Federation on August 27, 2003, being the municipalities of: Suchiate, Frontera Hidalgo, Metapa, Tuxtla Chico, Tapachula, Mazatan, Huehuetan, Tuzantan, Huixtla, Villa Comaltitlan, Escuintla, Acacoyagua and Acapetahua, declared the places of extraction (production) of this variety (Secretaría de Economía, 2016).

Production transition in the appellation of origin protection zone

According to the data contained in the Agrifood and Fisheries Information Service (SIAP), the production of the Ataulfo mango in the state of Chiapas dates from 1980 (Figure 2). In 1980 the annual production was 84 366 t, which increased to 196 166.05 t in 2014. In the same way, the sown area (hectares) increased. It can be observed that in the years 1982-1984 production remained in a range of 54 572 and 52 900 t, which indicates little variation and that from 1994 there was a significant increase in it, being in 1998 when the highest production is obtained with 207 761 t.

This increase in production is due to the implementation of technological packages that INIFAP developed and the high response of producers. Said technological innovation was due to the description that implies different specific cares such as: pruning, irrigation and fertilization in specific phenological stages to promote or inhibit physiological processes and the application to the soil of Paclobutrazol (PBZ) in doses of (0.5 g ai. m^{-1} of cup diameter). This allowed to control the size of the tree, to obtain an abundant and early flowering and to increase production. The potential impact of these technologies is reflected in the 75% increase in yield compared to orchards with traditional management and tree density.

Following the above, it is important to mention that before the technological implementation, the yield per tree in the orchards with ordinary management was 25.2 kg per tree (10 t ha^{-1}), while the increase was evidenced with 45 kg of fruit per tree (18 t ha^{-1}).

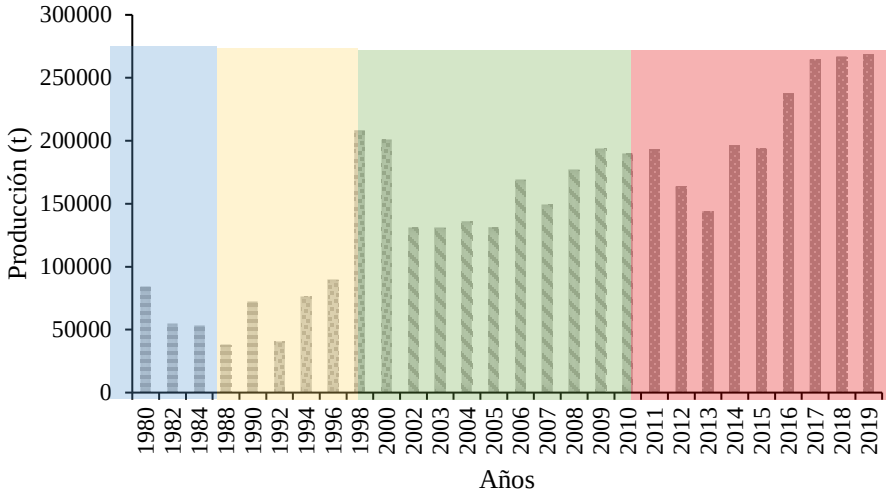

Figure 2. Annual production (1980-2019) of *Mangifera indica* L. var. Ataulfo in Chiapas, Mexico (SIAP, 2019).

Similarly, the improvement in the price was highlighted when obtaining the harvest outside the normal season, since the value rises up to 2.5 times compared to traditionally managed orchards, causing a highly positive effect on the profitability of this fruit (INIFAP, 2012; Shinde *et al*., 2015).

Fruit production was significantly high between the years 1998 and 2000, after those dates, fluctuations took place without reaching such production levels; the apparent cause of the decrease in production is due to a decrease in the presence and diversity of pollinating insects, such as bees, flies and ants, in addition to the use of some pesticides. The absence of these pollinators is a consequence of the use of some substances that stimulate the flowering of trees when there is a delay in the natural cycle. However, for 2017, production again reached a significant increase (264 507 t) that still prevails, without considering that several producers by 2020 have demolished their orchards to exchange their crops for other non-mangoes.

Although the protection of the Ataulfo mango appellation of origin applies to the Soconusco region, Chiapas, there are figures that show that this entity contributes 34% of the harvest volume in the country (SIAP, 2015). But also in other states of the Mexican Republic such as Colima, Guerrero, Jalisco, Michoacan, Nayarit and Oaxaca, the other two-thirds of the national volume generated is produced (Figure 3a) (SIAP, 2017 b).

When contrasting the production of Ataulfo mango in the Soconusco region with the rest of the Mexican Republic, it can be seen that the yield in the Soconusco area is represented by 30.8%, with the municipality of Tapachula showing a higher production of the fruit, providing a 12.37% of the same in said region, while for Suchiate and Mazatan the figures are 5.41% and 7.35% respectively. Such municipalities confer a significant contribution from this mango (SIAP, 2010).

Data that appear in the list of Ataulfo mango orchards registered for export to the United States of America for the years 2017 and 2018 reaffirm the aforementioned since, it is pointed out that Tapachula maintains a higher production of Ataulfo mango, which is due to that said municipality has an area of 2 421.03 ha.

Likewise, municipalities that also have hectares of registered orchards are: Mazatan (822.04 ha), Huehuetan (500.09 ha), Villa Comaltitlan (373 ha), Frontera Hidalgo (133.5 ha), Suchiate (120.52 ha), Mapstepec (93.5 ha), Escuintla (57 ha), Acacoyagua (37 ha) and Acapetahua (5.94 ha) (SAGARPA-SENASICA, 2017-2018). However, there is no record for the towns of Huixtla, Metapa and Tuzantan, which also constitute the area with a designation of origin (Figure 3b).

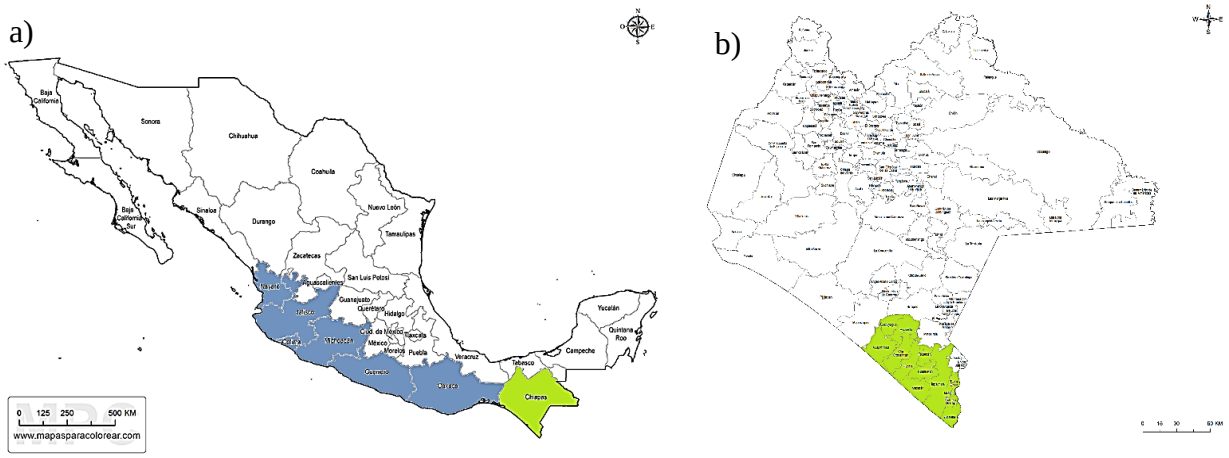

Figure 3. a) federal entities of Mexico producing Ataulfo mango (SIAP, 2017b); and b) municipalities that constitute the zone with the denomination of origin of Soconusco, Chiapas.

The significant production by the Soconuso, Chiapas area is due to the fact that this region has appropriate soils that allow Ataulfo mango of excellent quality to be obtained, this has been verified in some investigations that show that in the region of the coast in the Ocean Pacific, south of Chiapas, meets the ideal agroecological conditions for high soil productivity and excellent fruit quality (De la Torre, 2013). The aforementioned is due to the four types of soil that occur in the area: eutric fluvisols, chromic luvisols, molic andosol and eutric gleysols (Bertolini *et al*., 2018). The first of them represents 37% of the surface of the Soconusco region and its lands are of medium texture with materials rich in clay, have good fertility and drainage, as well as a slightly acidic pH. Chromic luvisol soils are highly capable of retaining nutrients, which benefits in obtaining high fruit yields.

While the soils of the mollic andosol type are found to a lesser extent and have medium texture, as well as a layer rich in organic matter and nutrients. The fourth type of soils that also make up the Soconusco region are eutric gleysols, characterized by being close to the sea, presenting a slow drainage and being swampy lands (FAO, 2008). In them, planting is not recommended, however there are reports of mango orchards in production in them (De la Torre, 2013).

Successes and modifications of NOM-188-SCFI-2012

The denomination of origin of the Ataulfo mango del Soconusco, Chiapas is highly significant, since it marks a distinction as an original product for this fruit from the state of Chiapas, Mexico. This denomination aims to develop the producers who grow this fruit in the Chiapas state, which allows them to carry out projects aimed at training, production, industrialization and marketing, with the intention of enhancing the quality of said fruit internationally (Esponda, 2016). With the above, legal security would be granted to the Chiapas producer and benefits such as raising the profitability of the crop and granting the distinctive seal to Chiapas as the original producing state of said mango would be achieved.

In order to provide and grant legal security to the producers and consumers of Ataulfo mango in Chiapas and to make the appellation of origin effective, the Quality Regulatory Council of Mango Ataulfo del Soconusco, Chiapas AC was established, which is responsible for certifying the origin and the compliance with the provisions of the Official Mexican Standard NOM-188-SCFI-2012 (SEGOB, 2012). The regulatory council is a public body whose function is to authorize the display of a badge to producers in the area who are complying with the rules and quality standards established by the denomination of origin (Molina, 2016). A designation of origin (DO) is a type of geographical indication applied to an agricultural or food product whose quality or characteristics are fundamentally and exclusively due to the geographical environment in which it is produced, transformed and elaborated (Landi and Stefani, 2015).

Either by the very nature of the environment as by the human factors involved. In other words, it can be said that it is a qualification that is used to legally protect certain foods that are produced in a certain area, against producers in other areas who would like to take advantage of the good name that the originals have created in a long time of manufacture or cultivation.

The designation of origin granted in 2003 to the Mango Ataulfo del Soconusco, Chiapas is applied to the mango with an average weight of 350 g (Secretaria de Economia, 2016), characterized by an average composition of 69% of pulp (presenting a low value in fiber content), 19% husk and 8.5% bone or seed. It is also resistant to post harvest handling.

When the Mexican State acquired the denomination of origin of the 'Ataulfo Mango del Soconusco, Chiapas', it was established that this name can only be used under the written authorization of the Mexican Institute of Industrial Property, but provided that the fruit is produced in the municipalities that make up the Soconusco protected area: Suchiate, Frontera Hidalgo, Metapa, Tuxtla Chico, Tapachula, Mazatan, Huehuetan, Tuzantan, Huixtla, Villa Comaltitlan, Escuintla, Acacoyagua and Acapetahua (Esponda, 2016). On April 30, 2004, the World Intellectual Property Organization granted Registry No. 850 to 'Ataulfo Mango del Soconusco, Chiapas'.

In this registry it is established that the Mexican State is the owner of the denomination of origin, but there is the possibility of authorizing the use of it to any person who is directly engaged in activities related to the 'Mango Ataulfo del Soconusco, Chiapas' and must comply with the official standard issued by the country.

On September 28, 2012, the national advisory committee for the standardization of user safety, commercial information and business practices, unanimously approved the Official Mexican Standard NOM-188-SCFI-2012, 'Mango Ataulfo del Soconusco, Chiapas (*Mangifera caesia* Jack ex Wall) specifications and test methods'. Said regulation establishes that it is the responsibility of the Federal Government to procure the necessary measures to guarantee that the products that are marketed in national territory contain the necessary requirements, in order to guarantee the security aspects and commercial information to achieve effective consumer protection.

It is worth mentioning that, in principle, the scientific name of the Ataulfo mango (*Mangifera indica* L. var Ataulfo) was incorrectly written in this registry and to date this error has not been corrected or updated in the Official Gazette of the Federation, therefore, the name of the appellation of origin is still *Mangifera caesia* Jack ex Wall (DOF, 2012).

However, this Official Mexican Standard gives technical support to the denomination of origin 'Mango Ataulfo del Soconusco, Chiapas', whose ownership corresponds to the Mexican State in the terms of the Industrial Property Law. The issuance of this Norm is necessary, in accordance with point 2 of the general declaration of protection to the denomination of origin 'Mango Ataulfo del Soconusco, Chiapas', published in the Official Gazette of the Federation on August 27, 2003 and established in section XV of article 40 of the Federal Law on Metrology and Standardization.

In the research work entitled: genetic variability between parent trees of *Mangifera indica* var. Ataulfo (Salvador *et al*., 2008), the importance of the Ataulfo Mango denomination of origin is highlighted since when introducing a boat containing mango that presents similar characteristics to the Ataulfo mango, tests are required so that the authenticity of the product can be certified. For the above, morphological and biochemical characterization studies have been carried out (Galvez-López *et al*., 2007; Galvez-López *et al*., 2010; Arellano-Durán *et al*., 2017), requiring molecular studies; however, studies have been carried out with RAPD (Random amplified polymorphic DNA) molecular markers at the intra-varietal level.

In the aforementioned scientific article, it is reported that there is a 95.7% similarity between the mango trees *Mangifera indica* L. var. Ataulfo, which make up the Father Garden of this variety. With the above, it can be affirmed that the scientific name with which the Ataulfo mango has been called in the DOF: '*Mangifera caesia* Jack ex Wall' is totally incorrect. Therefore, the denomination of origin presented by the Ataulfo mango needs to be updated for the correct protection of this variety, of agricultural and commercial importance for Mexico.

From the hands of the producer to the cooperatives

The national committee of the product-mango system is made up of five main links that include producers, packers, industrialists, researchers, recently a new link in this production chain has been added to the list, which is represented by the Supply Centrals and work is currently being done so that self-service stores also appear within this system (Mazariegos *et al*., 2017).

In Mexico, there is no exclusive marketing chain that is fulfilled for mangos in general, this chain varies according to the actors that make it up in each federative entity (Astudillo-Miller *et al*., 2020); However, there are cooperative societies of producers and wholesale suppliers of mango located in: San Blas, Nayarit; Monterrey, Nuevo Leon; Zapopan, Jalisco; Campeche, Campeche; El Rosario, Sinaloa; etc. These companies commercialize the Ataulfo variety and face variations in the characteristics of the fruit with respect to size and color (Table 1), as well as due to physical and chemical properties, which are governed and stipulated by the official Mexican standards for mango exports. (Table 2).

Table 1. Average size and weight of the product according to NOM-188-SCFI-2012.

Size	Weight
Extra big	324 to 606 g or more
Big	269 to 323 g
Medium	239 to 268 g
Small	119 to 238 g
Ataulfo Mango child	Less than 118 g

Elaboration: NOM-188-SCFI-2012.

Table 2. Physicochemical specifications of the product according to NOM-188-SCFI-2012.

Parameter	Specifications	Testing method
Soluble solids, °Brix	8 °B minimum	NMX-FF-058-SCFI-2006
Texture	Even	NMX-FF-058-SCFI-2006
Mango presentation	Whole	Visual
Appearance	Shock free	Visual
Peduncle	None	Visual

Elaboration: NOM-188-SCFI-2012.

It is important to highlight that at the wholesale level the price behavior shows an increase year after year and as a result higher prices are paid for the Ataulfo variety compared to the Haden and Tommy varieties. The Ataulfo mango presents a classic behavior of supply and demand, where the price is high when there are smaller volumes of the fruit, on the other hand in the months in which there is greater availability of the same: May, June and July, the price experiences a considerable decrease, this is evidenced in the prices paid to the producer (CONASPROMANGO, 2012).

Although it is of little knowledge for the country, but not for Chiapas producers, in Soconusco, Chiapas, cooperatives mount the temporary reception of the Ataulfo mango fruit with apparently experienced people, who are mostly intermediaries, colloquially called ‘coyotes’. In this reception, the selection of the fruit is based on the color or pigmentation of the fruit’s skin and on the size. This last selection separates the fruits into four ‘qualities’: the first (extra large or large range), second (medium and small), lacra (mango stained from the skin, as long as it complies with extra-large, large or medium size) and child mango.

There are several aspects where the small producer is affected, on the one hand, the receptionist cooperatives buy fully filled mango bars, but when they sell them they are completed at the weight requested by the wholesale cooperatives, the amount being always lower than that originally acquired by hands. from the producer, meanwhile, the excess mango in said bars remains as profit for the coyote. On the other hand, the producer is also affected when the value of the fruit per grid is determined by agreement between said coyotes.

After this first reception of the fresh fruit, the coyotes transport it to the wholesale cooperatives, and where it is separated according to the rules of NOM-188-SCFI-2012, if it does not comply with these requirements, it is not possible to export the fruit. mango and the product remains for local or national consumption.

Therefore, the first and second quality product chosen by the coyote passes to the cooperatives as a product for sale, while the raw mango remains for local consumption. It is worth mentioning that the mango child also already has a national and international market, under presentations that the same carriers have designed.

The main destination of the Ataulfo mango that is exported is: United States of America, Canada, Japan, United Kingdom, Belgium, Spain, France, Germany, Netherlands, Guatemala, Austria, Switzerland, Australia, Costa Rica, Israel, Italy, Luxembourg, New Zealand, Brazil, South Korea, Colombia and Sweden. These 22 destinations indicate that the commercial breadth favors Mexico in the distribution of this fruit. For the year 2015, the inventory of Mexico's export volume was obtained for four of the listed countries: Germany (270 952 t), Canada (33 511 666 t), France (789 283 t), United Kingdom (415 465 t) (Sistema de Información Arancelaria, 2015; Trademap, 2016).

Said exports require conditions that define the fair quality standard for marketing, which are established in regulation 543/2011, the objective of such standard is to guarantee safe food to consumers. The Ataulfo mango complies with the general marketing standard of the aforementioned regulation, which consists of the following indications: the product must be whole, healthy, products that show rottenness or other alterations, clean, free of visible foreign matter, are excluded, free from pests, free from damage caused by pests that affect the pulp, free from abnormal external humidity, free from foreign odors and/or flavors (NMX-FF-058-SCFI-2006).

The development and the state of ripeness must allow the fruit to continue with its ripening process and reach a satisfactory degree of maturity, which will be assessed by the standard. Another important aspect in the quality of the Ataulfo mango fruit is the aroma, which consists of its own volatile components that characterize the variety (Salazar-Sandoval *et al*., 2007).

Likewise, the sensory profile of Ataulfo could be a useful indicative descriptor of the quality of the fruit, since it contributes to the correct classification and identification of a variety (Zhang *et al*., 2020), and has an impact on the acceptability and preference of the consumer. (Liguori *et al*., 2018); however, for Ataulfo this sensory profile has not yet been described. Regarding the origin marking of the product, the full name of the country of origin is required, this indication must appear in the language understandable by consumers of the country of destination (Regulation 543/2011, 2011).

Challenges for the Ataulfo mango product system

There are various challenges to be faced in the productive chain of the Ataulfo mango product-system in Chiapas. The first challenge to be solved corresponds to establishing a marketing chain of the federative entity (Astudillo-Miller *et al*., 2020), which avoids triangulations between the different actors, is objective, maintains the value of the product and the producer is the most benefited. Another is the need to reduce labor and input costs, making production more technical. Likewise, the need to update the correct denomination of origin of the Ataulfo mango is observed, to give the value that corresponds to the variety produced in the area protected by the DO.

Another important challenge is to regulate the local mango receptionist cooperatives in the region, so that the producer receives a fair payment for his work, and prevent the coyote from keeping the highest profits, this could be analyzed by expert economists in the area (Mazariegos *et al*., 2017). Some researchers have found that there could be greater profitability and competitiveness if there were a strategic organization that would allow the joining of efforts among all those involved in the product system, marketers, packers, transporters and others, to achieve order and as a consequence greater socio-economic impact for Chiapas and for Mexico (Ruiz-Díaz and Muñoz-Rodríguez, 2016).

Likewise, it is important to work on developing and implementing a program for the rejuvenation of the orchards that until now the majority reach more than 50 years of age, said rejuvenation could be achieved with the certification of the varetas that are used for the clonal propagation of this culture; to date, at the regional level, there is no adequate control regarding their quality and they do not have a defined origin, which prevents preserving the quality of the original fruit (Burondkar *et al*., 2000; Wali *et al*., 2013).

On this last point, molecular markers represent a highly supportive technology to define the identity of the twigs when renovating in orchards (Koc *et al*., 2009; Fazio *et al*., 2011; Jahnke *et al*., 2011), the use of this technology would approve the identity of said rods and the Ataulfo mango would present the necessary homogeneity to comply with the requirements stipulated by NOM-188-SCFI-2012; therefore, the development of research works that meet this need is required.

Another important aspect is the homogeneous control of pests and diseases, for example, the control of the fruit fly does not reach all the producing orchards in the Sonocusco region, Chiapas, either due to lack of information on the part of the producer or due to lack of outreach in the MOSCAFRUT program (Montoya *et al*., 2000; Hernández *et al*., 2012). To achieve this requires the sum of effort and agreements of various actors in the production chain. If the aforementioned challenges were met, the Soconusco area would be given notoriety as a highly producing region of said fruit tree, enhancing the quality of this mango and boosting profits for the benefit of Chiapas producers and there would be a greater socio-economic impact in the region, state and country.

Finally, despite the multiple needs in the production chain, the Ataulfo mango is seen as an economically promising variety in the international market, due to its high demand that has been maintained in the last decade.

Conclusions

The Ataulfo mango is the fruit tree of greatest economic and social importance in the Soconusco region, Chiapas, due to its high value in the agricultural production chain. The production and export of the fruit could improve, as long as agreements are established that define the directions of production. The Ataulfo mango production chain could face the challenges posed with an adequate organization among the different actors in the production chain: producers, Mango Regulatory Council, marketers, exporters, scientific researchers, academics, students, etc. Likewise, it is necessary to develop new studies that lead to the correct protection of the product, for example, the production of varetas with a defined origin for homogeneity of the crop and the fruit to be marketed, reduce the illegal trade chains, increase the quality of the fruit in export, conquer other export markets in other countries, etc.

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