Article

Current status of litchi cultivation in producing municipalities of Veracruz and Oaxaca, Mexico

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Abstract

The litchi (*Litchi chinensis* Sonn.) Is an exotic fruit of growing productive interest in the states of Veracruz and Oaxaca, Mexico, has good supply in the external market and represents an alternative to generate economic income to producers; however, it has some limitations that prevent it from being potentialized as a profitable crop in some states of Mexico. The objective was to analyze the current situation of litchi cultivation and producers in three municipalities of Veracruz and Oaxaca and identify the limiting factors for their development. A survey was prepared and applied in March and April 2017 to 18 producers from the selected municipalities, integrating the information into a database. The results reveal that in the municipalities of Veracruz each producer has an average of 2.16 ha of planted area, with an average yield of 5.2 t ha^{-1}, while in Oaxaca they have an average extension of 30 ha with average yields of 4.6 t ha^{-1} one. The majority of production is organic. According to the perception of the producers, the main constraints of the crop are the low yields of production, the ignorance of the crop and the few marketing channels in both states. It is considered that litchi has great potential to be promoted with support programs, infrastructure and commercialization, which would allow the crop to increase its profitability and productivity.

Keywords: *Litchi chinensis* Sonn., commercialization, management, production.

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Introduction

The trends of global trade are directing the look to agricultural products that had not previously been considered in the food schemes, opening new marketing opportunities for novel and exotic crops, as is the case of litchi. The litchi is a fruit native to Asia with attractive appearance and a pleasant taste (sweet and slightly acidic), as well as a high nutritional value, which makes it very accepted by consumers (Jiang *et al*., 2004; Hajare *et al*., 2010) and turns it into a fruit with high commercial value (Cabral *et al*., 2014), with a high content of vitamins (B_1, C) and bioactive compounds (antioxidants), in addition to good pharmacological functionality, since it is used as a remedy to cure diseases (Bhoopat *et al*., 2011).

According to data reported in 2014, litchi production was 2.6 million tons worldwide (Vietnam's Lychee Export, 2014), with China being the main producer followed by India, Thailand and Vietnam (Mitra and Phatak, 2010). In Mexico litchi production has increased in recent years, reporting an area of 3 738.19 ha planted and a total production of 18 271.88 t (SIAP, 2016). As shown in Figure 1, the state of Veracruz ranks first with 9 223.47 t of production equivalent to 50% of the national total, followed by Puebla, San Luis Potosí and Oaxaca with 3 524.25 t, 1 957.65 t and 1 983.48 t, respectively (SIAP, 2016).

Figure 1. National litchi production data in 2016 (SIAP, 2016).

In Veracruz, the municipalities with the highest production of litchi are Chicontepec (1 800 t), Papantla (1 300 t), Tihuatlan (766 70 t) and Misantla (653 20 t), which are located in the northern part of the state. Recently, production has increased in the Central zone of the state, particularly in the municipalities of Martínez de la Torre (486 98 t) and Vega de Alatorre (24 t), waiting for production to increase over time (SIAP, 2016). In the case of the state of Oaxaca, where the production of the fruit is considerable, it is centered in the municipality of Tuxtepec, in the town of San Jose Chiltepec, with 668 4 t reported in 2016 (SIAP, 2016).

The increase in litchi production stands out, especially in the Central zone of the state of Veracruz and in the region of Tuxtepec, Oaxaca; however, it is unknown what is the current situation of the crop in these places, in addition to the advantages and disadvantages that it has in these places. It is known that litchi fruit suffers from some disadvantages in post-harvest handling as its deterioration shortly after harvest, in addition to other problems such as darkening of the pericarp and the degradation of some compounds present in the fruit, reducing its value in the market (Jiang *et al*., 2003), causing qualitative and quantitative losses, decrease in fruit availability and increase in production and marketing prices (Underhill and Critchley, 1995).

Alejo-Santiago *et al*. (2015) report that there is a high international demand for litchi fruit and Mexico is a country that has adequate climatic conditions to produce and satisfy part of this demand, but there is not enough technical and scientific information regarding this crop. The objective of the work was to analyze the current status of litchi cultivation (productivity, organization, production costs, fruit utilization and commercialization) in three municipalities of Veracruz and Oaxaca and in this way contribute to the establishment of improvements in production conditions, conservation and marketing of the crop in the region.

Materials and methods

The investigation was carried out during the months of March and April of 2017 in the Central region of the state of Veracruz, in the municipalities of Martinez de la Torre and Vega de Alatorre and in the town of San Jose Chiltepec, belonging to the municipality of Tuxtepec, Oaxaca (Figure 2) where litchi production has recently increased.

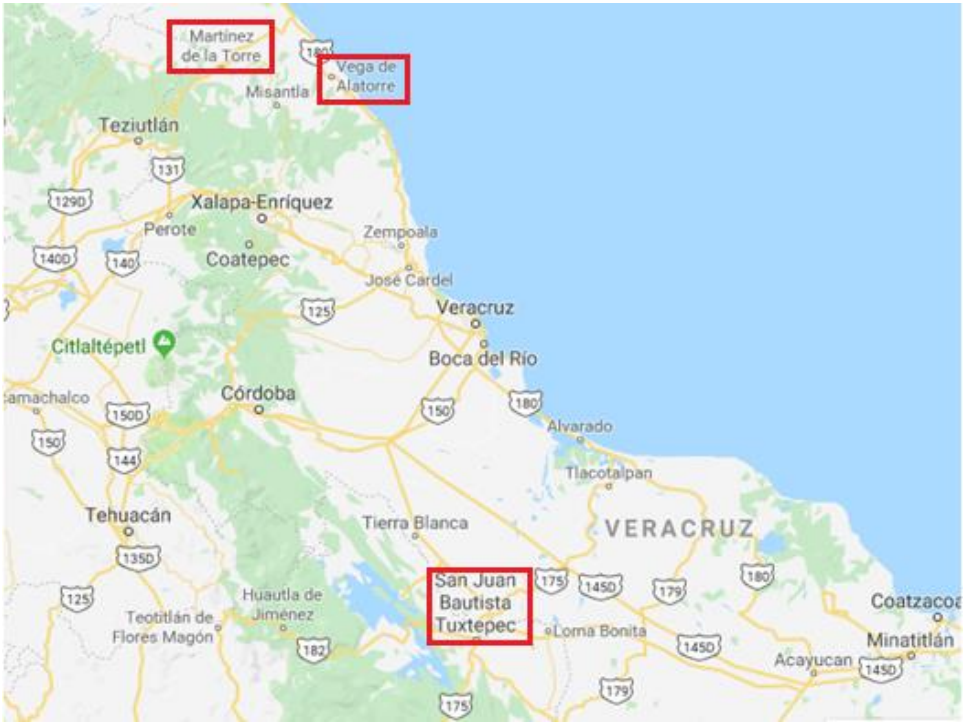

Figure 2. Map of the geographical location of the study regions (Google Maps, 2017).

In both regions, a survey was applied to 18 producers, for which a structured questionnaire with 56 items was designed, where different aspects related to litchi cultivation were considered. The method used to establish the population sample was by snowball (linear sampling), due to the fact that there is not a register of producers in the municipalities of both states and in addition the number of these is reduced, since by means of the same producers were contacted to apply the surveys (Mendieta-Izquierdo, 2015). The data obtained were analyzed in Excel through descriptive statistics. The explored categories of the investigation by means of the questionnaire were: productivity, organization of the producers, costs of production, use of the fruit and commercialization.

Results and discussion

Profile of the producer

According to the data collected in the municipalities studied in the state of Veracruz, it was found that the average age of the producers is 59 years, which is considered an advanced average age. They have a schooling of 11.6 years, which places them in the upper secondary level (preparatory), which allows them to understand processes and make decisions about crop management. 33.3% of producers are in Vega de Alatorre and the remaining (66.6%) in Martínez de la Torre, this percentage denotes an increase over previous years, since Martinez de la Torre was more dedicated to the cultivation of orange and Vega de Alatorre to the cattle ranch; it is worth mentioning that in the municipality of Vega de Alatorre litchi production began only a few years ago.

In these municipalities 100% of litchi producers mention that they exercise production as individuals and their property is private; therefore, they own the land where they farm and do not pay rent for the land and their properties have legal records, which gives them security about using it as they see fit and having greater freedom in the management of the crop. In the case of the municipality of the state of Oaxaca, it was found that the producers had an average age of 45.3 years and a schooling of 10 years, which is equivalent to a higher average education. All producers carry out the activity as individuals and their land is owned (private property).

Regarding the cultivated area of litchi, it was observed that in the state of Veracruz, the producers cultivate approximately 2.16 ha on average; that is, they are considered as small producers, since they have a land area of less than 5 ha (FAO, 2013). In this sense, although Veracruz is the state with the highest litchi production at a national level, it was found that, particularly in these municipalities, the area destined for the cultivation of the fruit is smaller than the one used for the same crop in the northern area of the state (10 ha or more, approximately). On the other hand, litchi producers surveyed in Oaxaca allocate an area of 30 ha on average and are harvested for export. Production is centered in the municipality of Tuxtepec in the town of San José Chiltepec, with 668.4 t reported in 2016 (SIAP, 2016).

Management of litchi culture

The cultivar that is sown is Mauritius, because it is the one that best adapts to the region, given the climatic conditions that are required, since the fruit is not native to Mexico, influencing the variability of cultivars. In Asian countries such as China and Thailand, other types of cultivars are

used, among which stand out: Wai Chee, Fay See Siu, Bah Lup, Lanzhu, Haak Yip, Kway May and No Mai Chee (Menzel, 2000). The average age of the plantations in the Veracruz area is approximately 13.8 years, while in Oaxaca the age of the plantations is higher (23 years on average), and in both cases the trees begin to produce fruit in a period of 3 to 4 years after planting the tree (aerial layering), so they are considered relatively young, which has been reported in other works (Nagera-Rodríguez, 2010).

As the age of the tree advances, after it starts its production, it is necessary to carry out more fertilizations in the year, in order to avoid the decrease in yield (Nagera-Rodríguez, 2010). The litchi presents some restrictive factors for its production and others of the ways to mitigate them are an adequate management and the use of techniques based on the physiological processes related to phenology, foral initiation, flowering, fruit fall and nutritional extraction of the fruit in its different stages of growth (Ying and Davenport, 2004).

Regarding the management of the crop, it was found that 83% of the production in the region of Veracruz, producers mention that it is organic (free of the use of pesticides and chemical fertilizers), since they seek certification and the rest is conventional (use of pesticides and chemical fertilizers), this means that a large part of the production is free of the use of agrochemicals (Figure 3). In Oaxaca, 100% of the production is organic, since the producers of this region is in the process of certification of the crop to increase the value of the product, open the market and have more places to export and market.

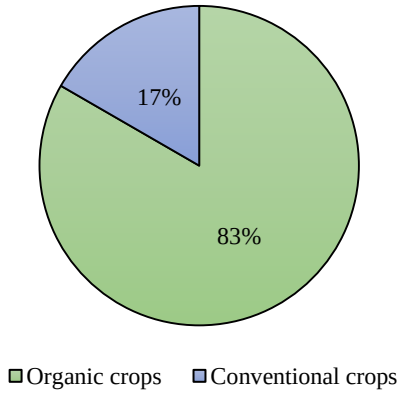

Figure 3. Management of litchi cultivation in the Veracruz region.

The method of propagation used in both regions is by grafting by aerial layering, since in this way the plant begins to produce fruits in less time (three to four years), allowing a better adaptation and reducing the probability of replanting. In Veracruz, the topological arrangement is rectangular with a distance between trees of 4 x 4 m up to 5 x 10 m (Figure 4), with a density of 200-625 trees per hectare, while in Oaxaca the arrangement is real and rectangular with distances between trees of 10 x 10 m and 6 x 7 m, while the density ranges from 100-283 trees.

Regarding planting density authors mention that the ideal arrangement is 4 x 4 m, since the growth of the tree is slow, so it is recommended to make plantations with high densities, rectangular shape and real frame (as is done in the region). of study), since in this way the space is used better and consequently there is greater fruit production (Ministry of Agriculture, Fisheries and Food, 2006).

Producers mention that all plants receive a pre-treatment through the application of fertilizer (organic or chemical depending on whether the production is organic or conventional), with the purpose of adapting the plant to the soil.

Figure 4. Topological arrangement of litchi culture in the Veracruz region.

Producers from both states mentioned that they use micro-sprinkler irrigation in the orchards, which is considered as ideal, since water consumption costs are reduced, especially in the case of Veracruz where the liquid is scarce in the drought period in Oaxaca the orchards are located on the river bank, so water does not represent a limitation. These irrigation methods are similar to those used in European and Asian countries, such as Spain and India, where it is reported that maintaining the tree with irrigation reduces the cracking of the fruit (cracking of the peel) and therefore maintains the quality of the same (Singh and Babita, 2002).

According to the literature, it has been determined that it is ideal to apply fertilization in three stages: before flowering, during flowering and during fruiting (Carvalho and Salomao, 2000; Singh and Babita, 2002). The results obtained in the present investigation indicate that 100% of the producers of both regions apply fertilizer before flowering. During flowering, 100% of producers in Oaxaca also apply fertilizer, while in Veracruz, only 33% do so, since the rest do not consider it indispensable. None of the producers of both regions applies fertilizer during fruiting, since they mention that applying it at this stage would only cause an increase in foliage but not fruit production.

In Veracruz 50% of producers use vermicompost, 33% commercial organic fertilizer and 17% chemical fertilizer; while in Oaxaca, all producers apply organic fertilizer, because before seeking certification they used Nitrofoska® S special and triple calcium phosphate, since they mentioned that these generated better results. The fertilization used in other countries is different from that practiced in the study area. For example, in China they apply conventional fertilizer (composed of N, P and K) before flowering, during flowering and in the development of the fruit, managing to produce up to 100 kg of tree^{-1}, this means that as long as there are fertilizations with greater regularity, there may be more fruit production (Menzel, 2000). In other cases, such as India, fertilizer is applied three times a year, without considering the important stages in fruit production (Singh and Babita, 2002).

Regarding the pests that attack litchi culture, similar species were reported in both regions. Among these are aphids (*Tessaratoma papillosa*), spiders (*Tetranychus urticae*), mites (*Aceria litchi*), worms (*Elasmopalpus angustellus*) and mealybug (*Planococcus citri*). In Spain, the main pests that attack this crop are thrips (*Scirtothrips* spp.), Mites (microscopic spider and red spider), fruit fly (*Anastrepha ludens*) and mealybug (*Planococcus citri*) (Tropical Fruit Department, 2011).

Only 33% of the producers interviewed in Veracruz control the pests organically (same that apply organic fertilizer), with a preparation based on extract of Nim (*Azadirachta indica*) at 2% and mineral broth, 17% perform it in a conventional manner (malathion C50 0.2%), applying in both cases 3.6 L tree^{-1}. While the remaining 50% does not apply any type of pest control, since they mention that there is no attack to the crop, or that they do not cause significant damage (Figure 5). All the producers surveyed in Oaxaca do their control in an organic way, using 2% Nim extract, applying 3.6 L tree^{-1}.

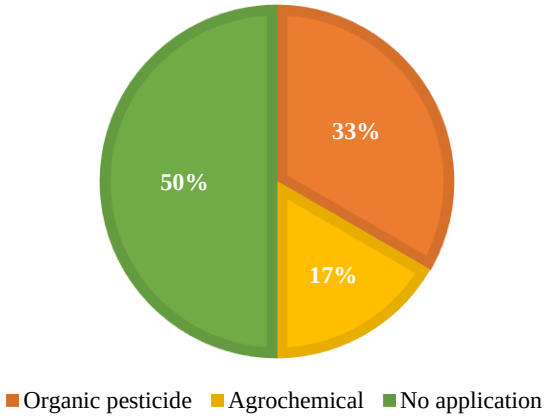

Figure 5. Litchi control methods applied in Veracruz.

With respect to whether the producers receive technical assistance for the management of the crop by a technician or specialized person, it was observed that in Veracruz, the producers do not receive technical assistance from any technician, but that 50% of them receive recommendations from Some other producer that has greater knowledge about the management. In Oaxaca, only 33.3% of the producers receive assistance of a private nature (through a specialized technician other than the producers and commercial houses of agrochemicals).

Productivity

The harvest of the fruit is done once a year (late May-early June) when the fruit has a uniform color and an appropriate weight (red and 20 g, approximately), because it is a non-climacteric fruit. The yield of Litchi in the study region in Veracruz is 5.25 t ha^{-1} on average, while in Oaxaca it is lower (4.66 t ha^{-1}). This could be due to the fact that in Oaxaca the density of trees per hectare is lower compared to that of Veracruz. In addition to the aforementioned, these variations in yield are also mainly related to the management of the crop in each zone and the geographical location (latitude and altitude).

However, both figures are below those reported in other countries, for example in Brazil the cultivar Bengal has an average yield of 11 t ha^{-1} (García-Pérez, 2006), while in China and India they report 9.4 t ha^{-1} and 7.63 t ha^{-1}, respectively (Mitra, 2002). The production of Litchi represents 74% of the income of the producers from Veracruz, while for the Oaxaca it constitutes 63%; that is, this crop is their main source of income.

Organization of producers

According to the information gathered in the questionnaires applied, it was found that 100% of Veracruz producers do not belong to an organization, contrasting with the data found in Oaxaca, where all producers belong to the organizations: 'Litchi-Rambutan Product System' and 'Production Council AC'. These organizations have mainly helped producers to improve the selling price and marketing, exporting approximately 70% of the production to Asian buyers who are in the United States of America.

In the literature there are reports of schemes of organizations of producers at international level, such is the case of China where the government supports the creation of the so-called 'dragon head companies' which are large distributors specializing in post-harvest handling, marketing and export of fruit that is bought from different producers; These companies in turn guide the producer on the management of orchards to produce high yields of quality fruits (Xuming, 2002). A similar case occurs in Australia, since in 1980 the Australian Litchi Producers Association was formed, which every four years organizes a national conference and publishes an industry newsletter every three months (Menzel, 2000).

Production costs

Production costs vary for all producers, since some produce their own inputs and others obtain them from suppliers. In the case of Veracruz, those that buy agricultural inputs acquire them with local and regional suppliers (50 and 16.7% of the producers, respectively). In the case of Oaxaca, 100% obtain their inputs from the local supplier. In both cases it is mentioned that the inputs are used to improve production yields, the quality of the fruit and in some cases by recommendation of the other producers with greater experience in the crop. Production costs range from MN $4 500.00 to MN $30 000.00 ha^{-1}, being lower in the case of organic management.

In addition to the inputs required, the payment of external labor must be considered when the harvest season arrives, since in this period each producer contracts an average of 2.33 daily wages in the case of Veracruz, while in Oaxaca the number of wages is higher, due to the fact that the producers have a greater extension of cultivation, using an average of 11.6 wages per day. In general, per day is paid $150.00 MN per day, on average, during the time of harvest (3 weeks approximately), this period is short because the litchi is a fruit that is highly perishable, which lowers the quality of the fruit.

Harvesting of the fruit and commercialization

After harvest, the fruits are periodically monitored and stored by refrigeration (4 °C) in both entities. The 33.3% of producers in Oaxaca spray a chemical agent called Bisphenol A (BPA), a plastic polymer that is used as a coating to protect the fruit; However, this polymer is harmful

to health and is said to be carcinogenic, so it would be advisable not to use it. But according to recent research, in countries of Asia and Africa the fruit can be preserved through the application of sulfur dioxide, packed using modified atmospheres (Chen *et al*., 2001), cold storage (Khan *et al*., 2012), applying ascorbic acid (Sun *et al*., 2010) and using antioxidants (Kumar *et al*., 2013). This means that the producers are outdated in terms of new technologies for fruit conservation.

The fruit can be consumed fresh or transformed into jam, wine, preserves, juice, dehydrated, etc. These value-added products are commercially non-traditional foods since they are not part of the basic basket, although they represent alternatives for the problem of the temporality of the harvest and the shelf-life that limits their commercialization (Rodríguez-Cardoso, 2000). However, only 16.7% of the producers in Veracruz produce this type of products with added value, since most market the fruit in a fresh way, as do all the producers in Oaxaca.

In litchi marketing there are different types of agents or intermediaries that sell products, among which are wholesalers, collectors and retailers (Figure 6). Wholesalers are those marketing agents that operate with large quantities (tons) of products, including a large number of agents with very varied characteristics, depending on the product and the place. There are also the collectors (secondary wholesaler), who buy the product directly from the farmers; they generally collect small volumes (10-50 kg) and transport them to the consumption or processing centers, they can work with a wholesaler or processor. Finally, there are retailers (groceries, fruit sellers, among others), who are marketing agents whose most important characteristic is selling to retail consumers, being the only intermediary (Rodríguez-Cardoso, 2000).

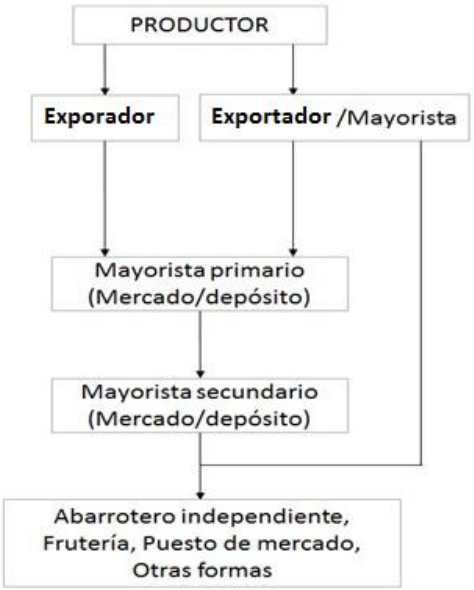

Figure 6. Diagram of litchi marketing channels in Veracruz and Oaxaca.

Most of Veracruz's production is sold in the local market of the region (65.8%), 26.67% is sold to an intermediary (stockbroker) and the remaining 7.53% is exported to countries such as France, Canada, Japan and the United States from America. For its part, the production of Oaxaca is distributed as follows: 70% of production is exported to the United States of America; it should be

noted that each year the producers negotiate the price and the buyers pay for the packaging of the product, while 30% of the production is sold in the local market, either in markets or street vendors (Rodríguez-Cardoso, 2000).

In the related literature, some marketing strategies were found in other countries to raise awareness and increase litchi consumption. One of them is implemented in Asian countries (Singapore, Hong Kong and Japan), where marketing takes place through local and urban markets. In the case of local markets, the litchi tree is spread in the home gardens of the villages in the subtropical climate zones and for this reason it is customary to consume fruit, either fresh or as an ingredient for meals. On the other hand, in urban markets consumers appreciate the fruit and are willing to pay high prices for it, since in various countries cannot meet the demand for it because the supply is insufficient or not having the right weather conditions the crop (Rodríguez-Cardoso, 2000).

In other developed countries, consumption is very widespread. What limits a greater demand is the lack of knowledge about the fruit and the consumption rooted on other agricultural products more common among consumers. Although litchi demand is growing significantly, it must be considered that it competes with other fruits to occupy a space in the national market (Rodríguez-Cardoso, 2000). The export price is higher, compared to the price in the domestic market, hovering around \$40.00 and \$35.00 MN kg^{-1} for Veracruz and Oaxaca, respectively.

It is worth mentioning that the sale price for export of the fruit from Oaxaca is lower than that of Veracruz, since the producers do not pay for the packaging that is covered by the buyers. As mentioned, the export prices are higher than the selling price to the local market or to national intermediaries, which is \$20.00 MN. However, the export value is lower than compared to what is estimated in other parts of the world, such as in Asia where the kilogram of litchi has an approximate value of \$60.00 MN kg^{-1}, especially in cultivars No Mai Chee and Kwai May where the price is still high, hovering around MN \$200.00 kg^{-1} (Menzel, 2002).

The amount of fruit to export is very low in the two regions but more markedly in Veracruz, because it is very difficult to market abroad, since the export requirements (tariff barriers) are more demanding (uniform color, weight specific and free of pesticides), in addition to which certification is needed. 78% of the producers in both regions mention that the crop is profitable and they consider that the payment they receive for the fruit is fair, which is mainly because they argue that the production costs are reduced and therefore there is more margin of profit. However, they point out that marketing prices can be improved by encouraging consumption of the fruit in the country, in addition to the need to diversify the use of litchi by adding value, increase export to different places and therefore improve its commercialization.

They also indicate that the government should help the development of the crop through supports, infrastructure (cooling chambers, transport, packing) and opening markets for marketing. Both states producing litchi present limitations in the regions studied. Among the main ones that stand out and affect the crop are: low yields of production (which is affected mainly by climatic conditions and by the management of the crop), ignorance of the producers on the crop (chemical composition, requirements of the crop, management of this one, among others) and mainly the commercialization, since due to the standards that are requested for its export is complicated.

Conclusions

The cultivation of litchi has increased its production in recent years. It does not require production expenses (profits are greater than production costs), which makes it a profitable crop, but which requires adequate care to have good yields. It was detected that an effective technology transfer process is lacking for post-harvest management of the fruit and to develop technological packages appropriate to each growing region. It is advisable to update the knowledge on the methods of conservation of the fruit of litchi or to look for new alternatives that are more effective than those used in the regions of study; likewise, it is vitally important to adapt vehicles to properly transport the fruit and also to technify the harvesting process used.

One of the main limitations in general are the unsuitable climatic conditions in some areas where it is grown, the commercialization of the fruit due to the lack of certification by the producers, the price of the fruit is lower than in other countries where it is produced and the bad use of this to diversify its use in the elaboration of products with added value.

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