

The quality of the mexican strawberry

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Abstract

Strawberry production in Mexico to be exported goes back to the fifties. Nowadays the production has expanded from two to six states in Mexico. The strawberry grown in Mexico is appreciated and valued in the international market due to quality achieved in the crop. Nevertheless, the technological lag has a significant negative impact on farming activities. Therefore, it is necessary to incorporate a technological innovation process which allows crops to be grown with efficient yields which lead to achieve competitiveness. Currently, new production processes have been undertaken, which are focused on the characteristic of the crop in order to diversify products according to the environmental conditions and the weather of each growing region. Such situation implies a positive impact on the yields obtained, the quality and the competitiveness achieved.

Strawberry production, Mexican strawberry, agricultural production, competitiveness, harmlessness.

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Introduction

Mexico has produced strawberry since the decade of the forties. From the early fifties the cultivation was extended and focused on the domestic market, however in the late fifties, commercial companies began the exportation process. Irapuato became the main strawberry producer for domestic consumption whereas Zamora became the main producer for exportation. Other communities that have started the cultivation, production and marketing of strawberries, include the states of Baja California, Baja California Sur, Guanajuato, Jalisco, Mexico, Michoacan and Morelos.

This paper shows the quality achieved by the Mexican strawberry according to significant parameters including: size, uniformity, color, texture, aroma and flavor. In addition, the paper highlights the main issues to be faced in order to maintain and to improve cultivation processes. Such issues are approached by the analysis of aspects such as: competitiveness, the physical yield per hectare, quality and safety vegetative material.

One limitation that national producers must face since the beginning of the process, is the dependency on the importation of vegetative materials, which have to be adapted to local and regional microclimates. The undeveloped status of research projects focusing of strawberry production has led to the lack of technological capabilities intended to produce own plant varieties, which negatively impacts the production costs.

The strawberry is a vegetable that is eaten as fruit due to its nature and characteristics. It is accepted worldwide and there is a high demand in developed countries. The main producers in the American Continent include: Canada, USA, Mexico, Guatemala, Costa Rica and Chile.

However, the Mexican strawberry was able to develop a competitive advantage because of its quality, which is given by the microclimates of Irapuato and Zamora; condition which enabled the particularly market positioning in the United States.

The strawberries has a set of qualities that make it appetizing due to its taste and consistency; in addition, it has a significant nutritional content, especially its vitamin and mineral content helps in the prevention of diseases such as cancer and arthritis. Its consumption is part of balanced diets of consumers in developed countries.

This paper analyzes the production of strawberries and the market conditions in an international and national context in order to determine key aspects associated with this crop. In addition, the characteristics, problems and challenges for the quality of Mexican strawberry are addressed.

The international context of strawberry

Originally, the strawberry was from Europe. Its consumption is antique specifically in the Alpine region. Nowadays, there are 30 countries, which produce strawberry; Mexico is one of the main eleven producers worldwide. The United States, Spain, South Korea, Russia, Japan, Poland, Mexico, Italy, Turkey, Morocco and Germany generate 78% of world production of strawberry.

The production and consumption of strawberries have grown given different aspects: the increase of population, social status, changing food consumption patterns towards balanced diets, preventive health care, factors; such factor have encouraged the consumption of fruit, particularly strawberry consumption.

Therefore the expansion of the demand encourages the production and the cost-benefit approach provides an attractive profitability.

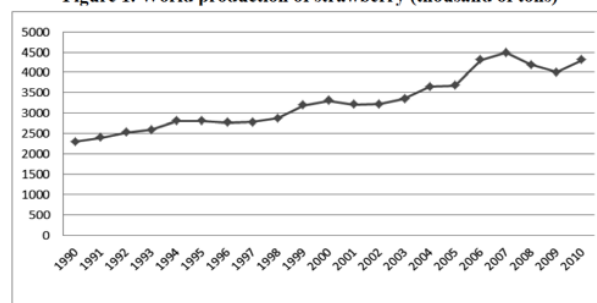
The United States has been an important actor in the world market, in production, exports and imports. Together European countries like Germany, Spain, Italy, France, Poland and

Russia overcome the United States in production. In Asia the main producers include South Korea, Japan, Turkey and China; in Africa Morocco is identified an important producer whereas in Latin America Mexico, Guatemala, Chile, Costa Rica and Argentina are major producers.

The world production raises 4.5 million tons, 20% of which is exported, 80% is for domestic consumption. This is given by the fact that the USA, Europe and Japan, which are developed economies, produce 70% of the strawberry production, from which 90% is for domestically consumed, thus the most important strawberry market is represented by the developed world. The developing countries produce strawberries for exportation and its consumption is limited within domestic markets.

World production of strawberry has been expanding from 2.3 million tons at the beginning of the nineties, to 4.5 million tons nowadays. Despite the years of decline such as 1996, 2003 and 2005 where the global economic downturn has impacted exports of strawberries, the proportion of exports has also grown from 500,000 tons to 800,000 tons (Figure 1).

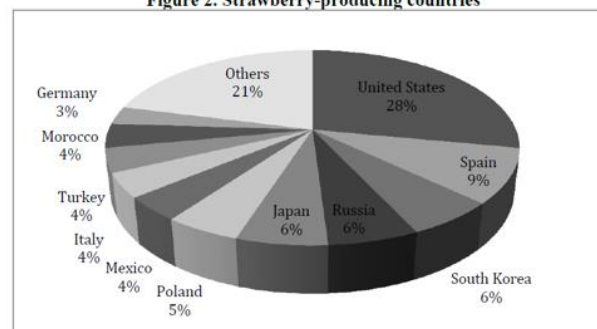
Figure 1. World production of strawberry (thousand of tons)



The demand of strawberry varies depending on the quality and the capacity of commercialization. Strawberry produced in France and Italy are highly prized in the international market, and in a smaller proportion the United States and Spain. On the other hand, among the developing countries, Morocco and Mexico are the main exporters of strawberry. In addition, the United States and Europe are the largest importers of strawberry with 75% of the world imports.

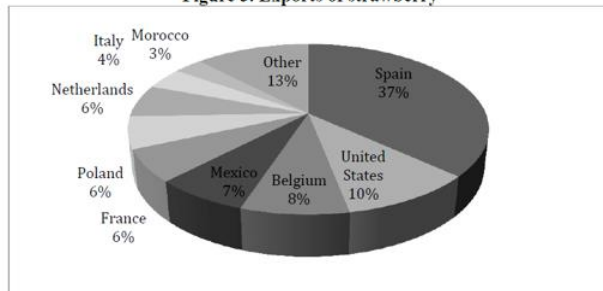
Figure 2 shows the participation of strawberry-producing countries in the world during the first decade of the XXI century; on average the USA and Europe account for 70% of the world production.

Figure 2. Strawberry-producing countries



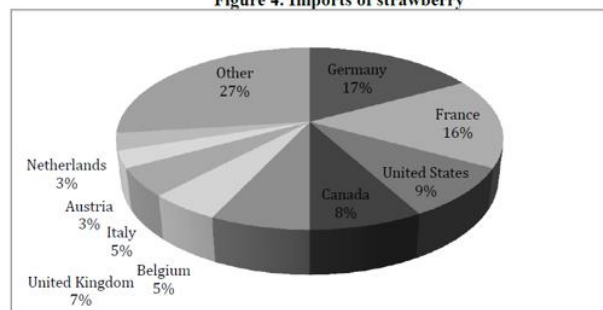
Together, the USA and Europe are identified as the main exporters; Spain is the major exporter worldwide with 37% of the total exports. Mexico is located in the sixth place with 7% of the total (Figure 3).

Figure 3. Exports of strawberry



The USA and Europe are also the main importers of strawberry and they consume mostly the majority of their domestic productions. Developing countries including Mexico, Morocco, Turkey, Chile and recently China, complement the consumption of markets in developed countries.

Figure 4. Imports of strawberry



The strawberry production in Mexico

Strawberry was introduced into Mexico during the Second World War. It was introduced into the state of Guanajuato and Michoacan. The commercialization for domestic consumption began on the fifties. It was in the late fifties when some marketing and processing transnational companies settled in the city of Zamora in the municipality of the same name in Michoacan. These companies organized the production and processing of fresh strawberry to be exported to the United States in the winter period, which is when US production declines.

Some companies also settled in the city of Guanajuato in Irapuato. Zamora has been distinguished by his production focused on exportations whereas Irapuato is identified as a producer for domestic consumption.

The original European varieties have been combined locally, which has resulted in the production of multiple varieties that have been refined in order to increase the efficiency of the plant, and to improve quality. The varieties used in Mexico have changed, an initial variety was the variety Fresno, then others were introduced including the “Pico de Pajaro” (Spanish for Bird Beak), Parker, Chandler, Douglas, “la Selva” (Spanish for the jungle), “la oso” (Spanish for Bear), the Camarosa, among others.

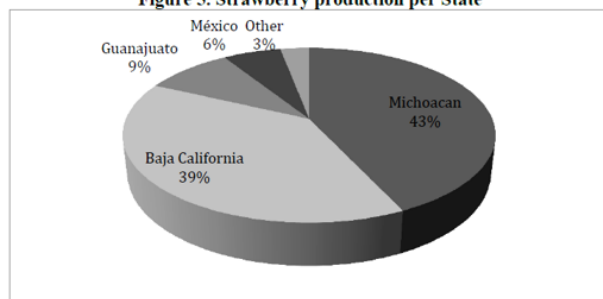
The strawberry production in Mexico has defined several cycles, the cycle of initial commercialization was in the fifties; then a boom cycle for exportation appeared during the seventies, however, such a boom cycle was characterized by the foreign investment. It was during the late seventies that the commercialization was exclusively national however, in the nineties; the production was again dominated by transnational enterprises due to the globalization context, situation that remains.

During the first export boom approximately 5000 hectares were grown in Michoacán and Guanajuato; then the production was halved until the introduction of the NAFTA, when the production raised approximately 7000 hectares. In addition, new States, including Baja California Norte, Baja California Sur, Mexico and Morelos, initiated the production of strawberry.

The Zamora Valley in the State of Michoacán remains as the leading producer and exporter of strawberries. Michoacán, with an area ranging from 2000 to 2500 hectares, produces half of the domestic production and 70% of the total exports, these levels of production are followed by Baja California Sur and Baja California Norte. The State of Mexico and Morelos have focused on production for domestic consumption.

The physical yield per hectare in other countries has increased significantly; in the last 20 years, the yield increased from 40 tons per hectare (t / ha) in California, United States up to 60 ton/ha in China (recently incorporated in strawberry production). In Mexico the average yield is 25 ton/ha, Baja California reaches yields of 45 ton/ha, Michoacán is located within the national average, even though some yields from producers in the Zamora Valley exceed 60 tons/ha.

Figure 5. Strawberry production per State

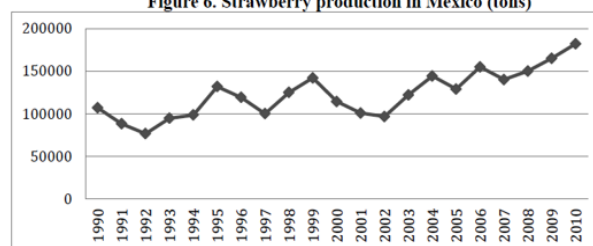


This situation led the most advantaged producers to apply technological innovations in the production process, which resulted in 1) the production of most resistant varieties with higher yields, 2) the improvement of strategies and schemes of commercialization, 3) the capture of higher investment levels, and 4) the extension of areas for cultivation in the whole country.

The strawberry production has been duplicated in the last 20 years, from 100 thousand to 200 thousand tons.

The cultivation area was almost triplicated from 2500 to 7400 hectares in its highest point, with an average area of 7000 ha during the last five years (Gonzalez, 2010). The production and exports were negatively impacted by the recession in 2008- 2009, during 2010 and 2011 there was a recovery period; however, if the negative situation appears again due to the economic recession of the United States, the exports and production would decrease again not only in Mexico but also worldwide given the uncertainty in European economies (figure 6).

Figure 6. Strawberry production in Mexico (tons)



The physical yield per hectare has increased. During the seventies, the average yield per hectare was 18 tons whereas in the eighties was 24 tons. During the nineties, the average yield was 28 tons with yields up to 40 tons per hectare. During the first decade of XXI century the average yield per hectare is 30 tons, however, certain producers reach 70 tons per hectare (González, 2010) (Medina y Aguirre, 2007). These differences are due to disadvantaged producers in terms of area, quality of vegetable materials, expenses in growing and harvesting activities; situation that impact negatively on the physical yield per hectare (Figures 7, 8 and 9).

Figure 7. Physical yield of strawberry in Mexico (ton/ha)

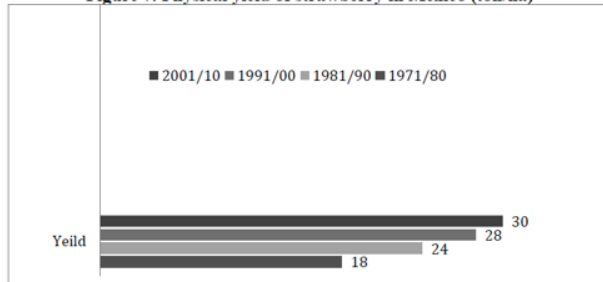


Figure 8. Physical yield per hectare per State (ton/ha)

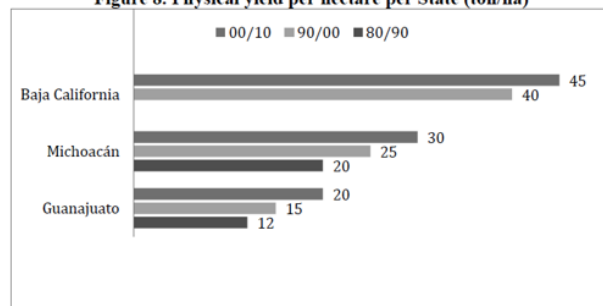
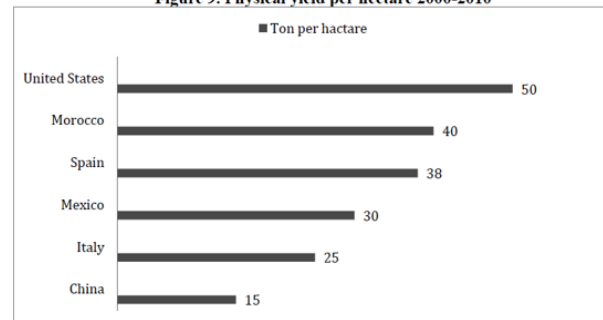
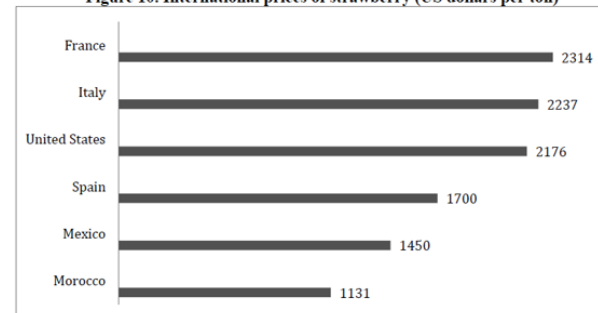


Figure 9. Physical yield per hectare 2000-2010



Regarding to the prices of the strawberry, the quality of the product defines the price levels. In this way, the valuation of the Mexican strawberry is ranked fifth worldwide. The highest valuation is located in European countries and in the United States (Figure 10).

Figure 10. International prices of strawberry (US dollars per ton)



The market of the Mexican strawberry

The United States are the main market of the Mexico strawberry. The strawberry consumption in North American, represent the 11.3% from all fruit consumption (the fourth most consumed), the North American strawberry imports represent 20% of its consumption, and the remaining is domestic production. Mexico provides the 80% of all strawberry imports in The United States. Canada imports 96% from The United States and 4% from Mexico.

Figure 11 shows the strawberry imports in the United States according to country of origin. Mainly the imports (92%) come from three Latin-American countries; Mexico, Argentina and Chile, the remaining comes from different countries from which China begins to highlight.

Figure 11. Strawberry imports in the United States

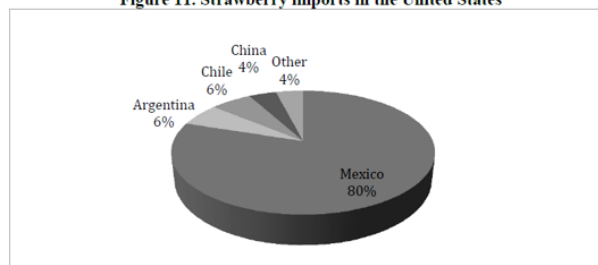


Figure 12 shows the distribution in the consumption of strawberry per region. The Northeast region (23%), the Great-Lakes region (16%) and the Southeast region (13%), together represent the 52% of the entire consumption in the United States. California, which in the main producing region, represents 11% of the national consumption only.

The Northeast region and the Great-Lakes region are the main areas and due to climatic seasons during the winter, they may be potential markets for strawberry imports (see table 1).

Figure 12. Regional consumption of strawberry in the United States

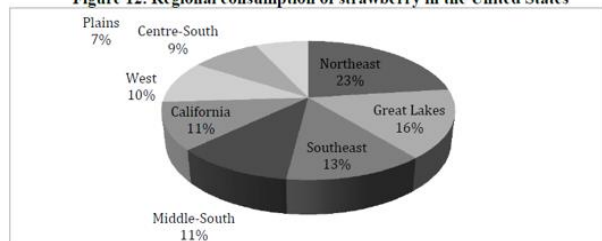
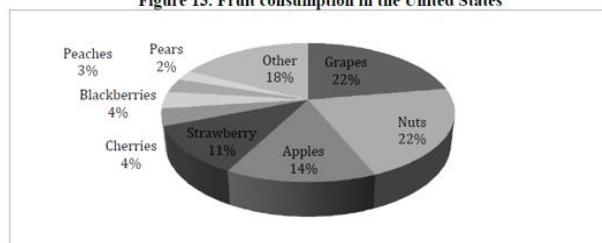


Figure 13 shows the consumption of strawberry according to type of fruit. The strawberry represents the fourth most consumed fruit after grapes, nuts and apples. The single consumption of strawberry is equivalent to the consumption of cherries, blackberries, and peaches.

Figure 13. Fruit consumption in the United States



The determining factors for the fruit demand include: demand of processed fruits, diet trends, availability of information, demographic trends, prices, exchange rates, motivations and attitudes (UARPFHVZ, 2009).

The demand of processed fruit is for the elaboration of juices, canned products, trends in diets, sweets, yogurt, soft drinks, and ice creams. There is a trend to increase the demand of strawberry due to the growing of the market. A demand expansion of 5% is expected in average in the following years. Balance diets have impacted on the fruit consumption; the per-capita consumption of fruits in the United States grew from 169 pounds in the last decade to 180 pound in the present decade, and the trends shows a continuous growing in following years (UARPFHVZ, 2009).

Consumers have increased the consumption of fresh and processed fruits due to health and diet issues, and although there is not an homogenous impacts from all kind of fruits, apples, pears and bananas have impacted significantly on consumption trends.

The demographic growth in the United States has positively impacted on the demand of fruits and nuts. Fruit has become a staple product, in any case, if the prices increase, the consumers will purchase a different variety of fruits.

The exchange rate can affect the demand. The exchange rate in the United States have favored imports due to devaluations in producing countries, its effect is adverse with respect to exports, provided that its price elasticity of demand abroad is not inelastic.

Table 1. Strawberry consuming regions

| Region | Northeast | Great Lakes | Southeast | Middle-South | California | West | Centre-South | Plains |
|--------|----------------------|-------------|----------------|--------------|------------|------------|--------------|--------------|
| State | New York | Illinois | Florida | Tennessee | California | Washington | Texas | Kansas |
| | Pennsylvania | Ohio | Georgia | Louisiana | | Arizona | Oklahoma | Nebraska |
| | New Jersey | Michigan | North Carolina | Mississippi | | Colorado | | South Dakota |
| | Massachusetts | Indiana | Virginia | Arkansas | | Utah | | North Dakota |
| | Maryland | Wisconsin | Alabama | | | Nevada | | |
| | Connecticut | Minnesota | South Carolina | | | New Mexico | | |
| | Maine | Iowa | Kentucky | | | Idaho | | |
| | New Hampshire | Missouri | | | | Montana | | |
| | Delaware | | | | | Wyoming | | |
| | Vermont | | | | | | | |
| | Rhode Island | | | | | | | |
| | West Virginia | | | | | | | |
| | District of Columbia | | | | | | | |

Fruit consumption is greater in women than in men and it must be noted that the majority of population is composed by women. The consumption also has a greater demand in children and in the elderly, by the properties and benefits, on the one hand women tend to care more about their weight than men, on the other hand, the consumption in children is represented as a very good substitute for candy and elderly consume fruit for health and taste.

The quality of the Mexican strawberry

The United States are the main export destination of Mexican strawberries, the NAFTA helped to increase the Mexican strawberry exports. The participation of such exports has turned Mexico into the main supplier of strawberries in the North American market.

The acceptance of the Mexican strawberries among a strong international competition is represented by the quality. Particularly the entry of Mexican strawberries to the US market is carried out on November and December, which is when the fruits reach their highest quality to be consumed as fresh strawberry. After that, although the quality drops, the Mexican strawberry remains competitive in the period from January to April. Strawberry quality depends on several factors, which can be integrated into three groups, one group is the quality of planting material which impacts on the growing, resistance to pests and the development of the fruit; a second group is represented by the environmental conditions that will influence the development of the plant, the temperature, the insolation, the light and the humidity; a third group is represented by the cares which should be taken in the growing and harvesting (Rodriguez, 2010).

Currently there are about 1,000 varieties of strawberry plants in the world, these varieties are developed according to weather conditions and the demands of market competitiveness. Mexico has imported vegetative material, the variety "Fresno" was predominant in the sixties and seventies, then other varieties came like the "Pico de Pajaro", "Parker", "Chandler", "Douglas", "la Selva" "la oso", nowadays varieties including the "Alvion", "Aromas", "Camino Real", "Diamond", "Camarosa" and "Festival" predominate.

The "Colegio de Postgraduados - ColPos" in the State of Mexico (Spanish for Graduate College) has initiated the development of plant materials for the cultivation of strawberries and created two varieties: the CPZamorana and the CPJacona, which have been successfully tested and have been adopted by Mexican producers.

This aspect has been one significant weakness of strawberry production in Mexico, the import of plant material adversely impact on productions costs because the excessive price of such materials, in addition the material must be constantly renovated in order to acquire more pest-resistant varieties with fastest growing as well as better performance.

In this context, the contribution of the ColPos is not only important but strategically vital to reduce costs and produce more varieties suitable to microclimatic characteristics of regions where the crop is cultivated. The plant should be rich in saccharose and urea to accumulate a good amount of starch in the fruit; winter temperatures favor its development, allowing obtaining a quality fruit since the first flowering and until subsequent blooms.

The first stage is the spread of varieties acquired in the vivarium, the quality of the plants is favorable in a high altitude vivarium, the resistance to diseases and pests and the performance and yields of the main plant, are critical factors. There are varieties that are suitable for its cultivation in summer, whereas others are development more efficiently during winter. In Mexico, for marketing reasons in the United States, the cultivation is done in autumn and winter, when demand of strawberry grows due to climatic factors, since during this period its production is limited to the State of Florida.

Strawberry can be grown in opencast, in tunnels or in greenhouses. It has been shown that yields and quality are improved in tunnels or in greenhouses against the yields and quality from opencast systems. Technological changes in strawberry production, through tunnels with irrigation system and the use of agrochemicals, have helped raise yields significantly.

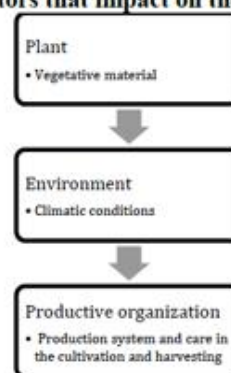
Thus, the quality of strawberry depends on multiple factors that take place in the cycle of reproduction, cultivation and harvest. On the one hand, the resistance to diseases and pests depends on the quality of the plant material; on the other hand, the season of cultivation (Winter or summer) depends on the type of variety. In addition, the yields in fruits and plants depend on genetic quality, and the density per area, the number of blooms, the size, volume and taste of the fruit, depend on the cultivation techniques. The climatic factors also impact on the yields and quality (Rodriguez, 2010) and (UARPFHVZ, 2009) (Figure 14 and 15).

The commercial importance of Strawberry has increased due to nutritional qualities and its characteristics to prevent diseases. Strawberry is rich in vitamins and minerals, and help to prevent cancer and rheumatoid arthritis. The increasing consumption of fruits in the basic diet of the population to achieve a healthy life, enables a potential increase in consumption. This is a powerful reason to encourage research focused on the plant and focused on generating varieties of competitive plants. Hence the importance of the development of research projects in Mexico focused on the creation of plant materials.

It must be noted that the increase in yields and in quality involves investments in science and technology and the rising in production costs. However.

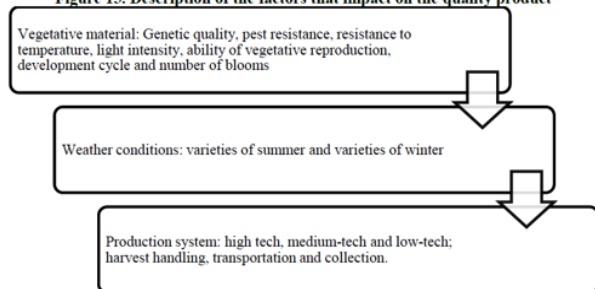
This financial increase is offset by the increase in yields, which enables the coverage of unit costs and/or the improvement of the quality of strawberries and the improvement of international prices which impact on the cost-benefit relation. The varieties used for export production in Mexico, are for growing in an autumn-winter cultivation cycle, the fruit quality is high due to weather conditions and the yield depends on the intrinsic quality of the plant material, techniques and inputs applied to the crop. Activities of cutting transport and storage of strawberries should be carried out very carefully in order to avoid damages in the fruit (Figure 14 and 15).

Figure 14. Factors that impact on the quality product



The quality of the fruit depends on the size, shape, consistency, color, maturity, brix levels, and season of harvest. The first bloom provides the highest quality and the fruit is used in confectionary, basis for yogurt and frozen strawberries. The second bloom provides fruit to supply national markets, although the quality is lower, the fruit is consumed as fresh fruit or dehydrated fruit. The third and subsequent blooms generate fruit to produce marmalades and purees (UARPFHVZ, 2009).

Figure 15. Description of the factors that impact on the quality product



The strawberry consumption criteria in confectionary are given by the shape, size, color, and consistency. Restaurants and hotels use strawberries in desserts and salads, given the size, smell, color, and consistency; whereas industries of juices, ice creams and candies, select the strawberries because of the smell, flavor, and yield.

Strawberry has different consumption forms, which include: fresh fruit, frozen fruit, semi-processed fruit, and processed fruit. The fresh fruit with the highest quality, and which is used in confectionary, should have a proper size, color, consistency and flavor.

This type of fruit is also required by restaurants and hotels to be offered as dessert or salad. The ice cream production requires strawberries with good quality in the same way that in domestic markets.

The frozen strawberry represents an advantage due to its capacity of being storage during large periods of time. The frozen strawberry guarantees a constant supply; in addition, it can be used in the production of soft drinks, juices and candies. There is a high demand of this type of strawberry to produce yogurt and flavored milk. However, the main disadvantage is given by the expenses for congelation and storage for large periods of time.

The semi-processed strawberry is used as a base for yogurts and dairy desserts; it is also used in cereals. The semi-processed strawberry is more expensive than the fresh one due to the necessity of special treatments which implies an added value.

The processed strawberry is used as dehydrated fruit to be used in candies and confectionery. This fruit is combined with chocolate, sugar, salt and chili, strawberry covered in chocolate, candied fruit and chamoy. Strawberries sold in the United States can be qualified or not qualified. Qualified strawberries have a higher price in the market; the qualified strawberries are classified into US No. 1 and US No. 2. The US No. 1 includes firm fruits with a medium degree of maturity, without mold, without damage, without damage caused by dirt, moisture, foreign matter, diseases, insects or mechanical damage. Each fruit has to have three quarters of surface pink or red (Table 2).

The US No. 2 includes strawberries which are free of decay, severe damage caused by dirt, disease, insects, mechanical or other means. Each fruit has at least half of the surface pink or red.

The combined US relates to the combination of No 1 and No 2, except for size, given that at least 80% of the fruit must meet the requirements of the US No 1.

Table 2. Strawberry quality degrees

| Degree | Size | Defects Allowance | Off-Size Allowance |
|-------------|---|---|---|
| US No. 1 | The minimum diameter of each fruit is not less than 3/4 | Up to 10% of the strawberry in each batch cannot meet the requirements.
Up to 5% of strawberry with serious defects.
Up to 2% of strawberries with deterioration. | No more than 5% in each batch can be off-size |
| US Combined | The minimum diameter of each fruit is not less than 3/4 | Up to 10% of the strawberries with severe damage in each batch.
Up to 20% of strawberry with lesser diameter in damaged strawberry
Up to 35% of strawberries U No 2 in each batch | No more than 5% in each batch can be off-size |
| US No. 2 | The minimum diameter of each fruit is not less than 5/8 | Up to 10% of the strawberry with fruit badly damaged.
Up to 30% of damaged fruit with smaller diameter.
Up to 3% of strawberries with impaired | No more than 5% in each batch can be off-size |

The harmless of the Mexican strawberry

According to the PAHO (Pan-American Health Organization), food harmfulness can be defined as the aptitude that food has to be consumed without causing any type of disease.

The lack of food harmfulness, results in significant health risks due to possible diseases generated (Rivero, 2004).

The lack of harmfulness represents severe affectations on developing economies due to, this lack involves: health risks in consumers, medical costs, loss of productivity. The lack of harmfulness also involves the possible destruction of the product in international docks which implies commercial losses and negative affectations on tourist activities (Rivero, 2004).

Food is considered to be harmless with there is not negative affectations when is consumed by human beings.

Harmlessness includes three main characteristics: 1) the food should meet standards of hygienic quality, 2) the food must be nutritive, 3) it must be sensually and culturally accepted (Télez, 2009).

Activities to ensure the food harmfulness are fundamental factor to produce quality products, nevertheless, if the product is harmful regardless the quality, it has to be withdrawn from the production and distribution system.

Consumers point out that the main threat to the food security is of microbiological nature. There have been disease epidemics caused by food in which, specifically the food has been identified as the source of the pathogen (Kader, 2002). The Mexican strawberry has achieved a significant presence in international markets due to quality and the fulfilment of requirements in harmfulness tests. When problems related to harmfulness appear in an specific region or locality, local governments control the situation by the prohibition of commercialization.

Conclusions

Strawberry production has increased worldwide, over the past 20 years has almost doubled from 2.4 million tons to almost 4.5 million tons, the physical yield per hectare also doubled from 30 ton/ha in the decade of the nineties to 60 ton/ha in the first decade of XXI century.

Strawberry production in Mexico has also increased in volume, physical yield, sown and harvested area, and strawberry producing states. In volume, the production nearly doubled from 100 000 tons per year to 180 thousand tons, yield terms.

The production increased from 20 ton/ha to 40 ton/ha on average, in area terms the production increased from 2000 hectares to 7400 hectares and from only two producing States, nowadays there six producing States.

There was a significant increase in the production indicators of Strawberry in a national and international context; such an increase was given by: the economic globalization, the NAFTA, the changes in eating habits of the population, the standards of quality and harmlessness of the product, the costs and competitive prices.

Mexican strawberry has maintained its standards of quality and safety in the international market, which is reflected in its acceptance and the increasing production, area and physical yield per hectare. Currently, a production process of vegetative varieties has started. These varieties are based on specific conditions of each producing region; in addition these varieties can favorably affect competitiveness in the global market by reducing costs, improving the yield and the quality of strawberries.

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