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Constraints and Solutions for the Profit-Optimization of Passion Fruit (*Passiflora edulis*) Food Business in Colombia

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ABSTRACT

Passion fruit is grown in several countries in Latin America including Colombia. But the profit with this is very unstable and normally their production costs have not been optimized, additionally, their offer to the international market is mainly fresh product and only seven percent is processed fruit, creating economic constraints and again reducing their possibilities to profit. Development and improvement of fruit production represent an opportunity for supporting the economic growth in Colombia because of their favorable conditions regarding climate and fruit diversity. This could result in job creation and equity in the development in the different regions across the country. This review illustrates the constraints within the food business development of the Passion fruit which are discussed under the subheadings of pests and diseases, sub optimal genetical utilization of passion fruit, un-rational usage of pesticides and fertilizers, soil quality poor handling resulting in the harvest contamination of the harvest, Post-harvest disease, insufficient grading, packaging, storage and transportation and recommendations.

Kolombiya'da Çarkıfelek Meyvesi (*Passiflora edulis*) Yiyecek İşletmesinin Kâr-Optimizasyonu İçin Kısıtlamalar ve Çözümler

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ÖZET

Çarkıfelek meyvesi, Kolombiya da dahil olmak üzere Latin Amerika'da birçok ülkede yetiştirilmektedir. Ancak elde edilen kâr çok istikrarsızdır ve üretim maliyetleri optimize edilememiştir, ayrıca uluslararası pazar teklifleri esas olarak taze ürün üzerinedir ve yalnızca yüzde yedi işlenmiş meyve oranı ekonomik kısıtlamalar yaratmakta ve yine kar olasılıklarını azaltmaktadır. Meyve üretiminin geliştirilmesi ve iyileştirilmesi, iklim ve meyve çeşitliliği açısından elverişli koşullar nedeniyle Kolombiya'daki ekonomik büyümeyi desteklemek için bir fırsattır. Bu, ülke genelinde farklı bölgelerde iş kolu yaratma ve kalkınmada eşitlik ile sonuçlanabilir. Bu inceleme Çarkıfelek meyvesinin gıda sektörü içinde gelişimine engel olan hastalık ve zararlılar, ile meyvesinin yetiştiriciliğinde uygun olmayan pestisit ve gübre kullanımı, düşük toprak kalitesi ve kötü uygulama hasat sırasında meydana gelen bulaşma, hasat sonrası hastalıklar ve yetersiz sınıflandırma, paketleme, depolama ve taşıma ve öneriler alt başlıkları altında açıklanmıştır.

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1. Introduction

Passion fruit belongs to the *Passifloraceae* family and can be yellow or purple, measuring about 6 to 7 cm in diameter and 6 to 12 cm in length [1]. It is grown in several countries in Latin America including Colombia. But the profit with this is very unstable and normally their production costs have not been optimized, additionally, their offer to the international market is mainly a fresh product and only seven percent is processed fruit [2], creating economic constraints and again reducing their possibilities to profit. Development and improvement of fruit production represent an opportunity for supporting the economic growth in Colombia because of their favorable conditions regarding climate and fruit diversity. This could result in job creation and equity in the development in the different regions across the country [2]. For quite a long time, Passiflora species have been utilized for different purposes as medication, particularly as tranquilizers and anxiolytics, and in ongoing many years have been used as the food, drug, and beautifying agents' ventures. At present, the concentrated juice-making market is extending around the world. A particularly wide-scale enthusiasm organic product preparing unavoidably winds up creating immense measures of squanders (i.e., seeds, skins and bagasse). Moisture (g) and Energy (kcal) in *Passiflora edulis* is 72,93 and 97,00 respectively [3,4].

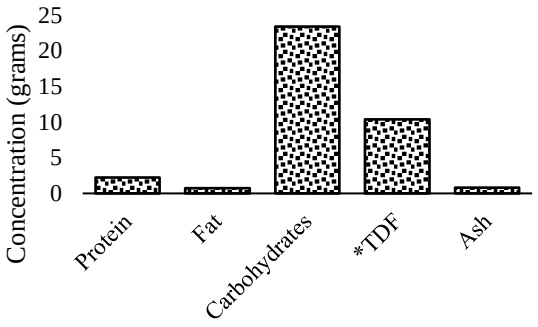

Figure 1. Nutritional content of *Passiflora edulis*

*Total Dietary Fiber

This review illustrates some of the constraints within this food business.

2. Common Pests and Diseases

Some common pests for Passion fruit are *Diabrotica Sp., Agraulis Sp., Dasiops Sp., Tetranychus Sp., Leptoglossus Sp., Anastrepha Sp*. and common diseases are *Fusarium oxys porum F. passiflorae, Alternarla passiflorae, Cladosporiun herbarum* [1].

3. Problems in the Pre-Harvest Stage

3.1. Low Usage of Seed Variety

Propagation with cutting, layering, and grafting leads to crop homogenization [3] and more susceptibility to loss by insects.

3.2. Chemical (Pesticides and Fertilizers) Residues

Farmers use chemicals that are not required by the soil, it increases the cost of production and creates an imbalance in the soil nutrient condition. Deep plowing is practiced which opens the soil for moisture conservation and maintains fertility but if it is done without beds or ridges which enhances the flooding directly in the root zone favoring the microbial growth and attack of disease [5]. Pesticides are applied based on the recommendations by the seller, which is not always valid for every field and every condition. Usually, these chemicals increase the cost of production and affect the quality and quantity of the fruit. These chemicals are also responsible for the killing of those insects, which are responsible for pollination [6].

Proper timing of the application is also an essential part of fertilizer application. As a plant that responds well to fertilizer application, formula dose and timing of application should be determined for different planting areas, based on soil analysis and the status of plant development. In general, application timings for fertilizers are at transplantation time, at beginning of flowering, and repeated after every two months. Method of application is also very important, for example, calcium, magnesium, zinc, and iron can be supplied through the leaves [7]. Normally analysis for nutrient deficiency should be done on the leaf to detect nutritional deficiencies so corrections can be made. Leaves taken for sample analysis are the fourth or fifth leaf, counted from the apex, vigorous plants taking four leaves per plant, for a total of 80-100 per hectare [3].

3.3. Low Soil Fertility

A major factor involved in soil fertility is erosion. Soil erosion is a process in which particles from the ground are separated and dragged by the wind and the water [7]. The presence of water is either a consequence of rain or floods. When terrains have been affected by erosion, they are less fertile because they have a lower content of organic matter and nutrients, which significantly changes its structure and water retention capacity [8] Even though erosion is considered a natural process, it

can be accelerated by several factors. One of these is having inadequate crop management, which, for fruits is known as "mono-cultivation" or having the same crop at the same terrain for a long period [8]. This is because the same types of crops consume nutrients and nitrogen from the ground in the same way for their growth. Another consequence of this negative practice is that it can increase plagues because they develop resistance mechanisms with time [9]. Since Passion fruit cultivation is continuously increasing due to its demand, large farms are dedicated exclusively to it, so changing crop types is practically impossible.

Besides erosion, other factors can cause low soil fertility. That is the case of contamination and salinization of the soil. In the first case, contamination is due to the accumulation of pesticides, herbicide, and fertilizer residues that are not eliminated and remain for a long time. At the same time, salinization occurs specifically because of fertilizers that give an excess of salt to the soil [9].

Once a terrain has suffered from erosion it will never be the same. This phenomenon is known as "ground degradation" and as defined by the Faculty of Agricultural Sciences of the National University of Colombia in Medellin, ground degradation is "the reduction of the ground's capacity for supporting life" due to changes at a physical, chemical, and biological level [8,9].

Depending on the intensity of inadequate practices and the terrain's original conditions (slope and soil quality), the time needed for reaching the third level could be longer or shorter [8]. Passion fruit has several nutritional requirements, which naturally are fulfilled through the roots. According to García Torres [3], author of a technical guide for Passion fruit cultivation, Passion fruit plants have continuous growth and therefore, they need a lot of nutrients. The nutrients they need are nitrogen, calcium, phosphorous, magnesium, boron, zinc, sulfur, manganese, copper, iron, and molybdenum [3]. Consequences of deficiency of nutrients of are elaborated in Table 1.

A possible alternative to deal with the challenges associated with pre-harvest conditions would be to convert the crops to organic farming that avoids the chemicals associated with agricultural production and uses alternative techniques to assure proper conditions for planting.

A problem regarding excess water is when farmers do not control high moisture concentration, increasing the susceptibility to fungal diseases and also affecting the maturation. The preventive measures that can be used are to promote good aeration and to do regular weeding, where this practice besides avoiding competition, also helps in reducing humidity accumulation [6]. It is recommended to use a proper tutoring planting system to promote good aeration, increase leaf area with solar exposition, better phytosanitary control, and in general a good crop control [5].

Table 1. Nutrients needed by Passion fruit plants vs. consequence of their deficiency

Nutrients	Consequences
Nitrogen	Smaller and weaker plants. Leaves are usually yellow due to the lack of chlorophyll.
Calcium	Damage on the leaves: chlorosis and necrosis of veins and black spots.
Phosphorous	Yellow leaves and fewer flowers are produced.
Magnesium	In the beginning, leaves look old and yellow, then they turn brown.
Boron	Smaller plants and leaves. Leaves have chlorosis and necrosis.
Zinc	Leaves with chlorosis
Sulfur	New leaves turn yellow, and the branches are weak.
Manganese	New leaves have chlorosis
Molybdenum	Old leaves suffer from chlorosis and deformations.
Copper	Old leaves have a dark color, are big and long. Within time, they develop yellow spots and deformations.
Iron	Chlorosis and necrosis of veins. If the problem persists, the leaves will turn white-yellowish, and the stem will also have chlorosis.

3.4. Poor Collection Techniques

Farmers are lacking in good practices during the manipulation, and it is common to have poor handling and absence of hygienic measures resulting in the contamination of the harvested product with dust, leaves, larvae, fungus, and germs. Furthermore, once the fruits have been detached from the plant, they lose weight rapidly representing a loss in quality. This contributes to the fact that farmers can obtain from 20 to 22 tons per ha compared to 45 up to 60 tons per ha (considering one harvest cycle) applying good farming practices [6].

As a possible solution to maintain a good quality after collecting is important to have gentle handling and not in excess as well as proper

transportation and storage conditions [20]. Also, the people doing the harvesting should not be paid based on their development; rather they should be full-time workers who have experience with the crop. Additionally, when the crop is collected rapidly to meet quotas, it causes increased lesions and fruit losses [1].

3.5. Post-harvest Sicknesses

Passion fruit is very vulnerable to fungus attack. These microorganisms can be found either at the plantation or the place where fruits are packed. The majority belong to the "*Ascomycetes*" or "*Phycomycetes*" families and the genus: *rhizopus*, *mucor,* and *phytophthora.* They infect only the fruits that have wounds or scratches [1]. According to a document written by the Post-Harvest Technology Research and Information Centre from the University of California Davis, "a proper management temperature and relative humidity during post-harvest handling" are required to prevent infections. They also mention three specific pathological disorders that are common: the "Brown Spot", the "Phytophthora Fruit Rot", and the "Septoria Spot". In the first one, a "circular, sunken, light-brown" spot appears on ripening fruits (usually during warm and humid periods) and is caused by *Alternaria passiflorae.* The second disorder is caused by *Phytophthora nicotianae* var. *parasitica* and looks like humid "dark-green patches". Finally, the Septoria Spot is caused by *Septoria passiflorae* and causes a less severe outcome: uneven ripening [10].

3.6. Insufficient Research of Post-harvest Physiology

Even though Passion fruit is one of the important crops in Colombia, there is still insufficient research on Passion fruit, especially on its post-harvest physiology [11].

3.7. Improper Grading of Fruits

As the NTC 1267 is not a guideline and not all parties follow the recommendation to classify the fruit, it may lead to a non-standardized classification of Passion fruits in the Colombian market. A possible solution is to educate farmers and wholesalers in terms of the importance of standardized classification and establish widely accepted industrial norms.

3.8. Improper Packaging Material

It is recommended to use packaging material that ensures the product´s best quality and freshness by preserving color and appearance, minimizing dehydration, weight loss, and shriveling, as well as slowing down the ripening process. This can help them to gain higher profitability due to less waste and sustained quality throughout the supply chain and market expansion enabled through prolonged storage [12].

3.9. Improper Storage Conditions

Before the fruits are transported, Passion fruits, theoretically, need to be cooled as soon as possible in forced-air cool to 10°C. They should preferably be stored at reduced temperatures but not below the recommended since they will suffer chilling injury. But, many farmers do not have the equipment and store them simply at room temperature. This condition allows the Passion fruit to continue to ripen after harvest and produce ethylene at 160 to 400 µL/kg/h at 20 °C (exposure to 100 µL/L ethylene for 24h accelerates ripening) at their climacteric peak [13].

Maintaining hygienic conditions protects them from heat and rain and should not be placed directly on the floor but on platforms or pallets to allow good ventilation and they must be separated from other products [14].

At the wholesaler's and exporter level, Modified Atmosphere (MA) can be considered. Equilibrium modified atmosphere packaging (EMAP) can also be used in the package and the shelf-life of the product will be increased [14].

3.10. Long Transportation Times

Farm vehicles for transporting farm products should not be used for transporting animal manure and pesticide [14]. It is recommended to transport using decent vehicles that protect the product from the sun, rain, and dust, but at the same time allow some ventilation [1]. Usually, when using wooden boxes, they are staked to use maximum space. Since these boxes are not uniform, and bouncing and vibration occur in transportation, movement of boxes can damage both boxes and fruit [16].

In what has to do with ground transportation, it can be said that there are several problems. First of all, certain farmers have high costs due to the region in which they work. This sometimes discourages them to expand to longer distance distribution because their return is not cost-effective. Moreover, another obstacle that they have is the poor road conditions or even their absence (in remote areas). This issue has as a consequence huge post-harvest losses and a reduction of sales [1]. Secondly, high-speed

driving could get bruises or even fall from the truck. For avoiding these outcomes, vehicles must have good air suspension and proper cushioning for shock absorption. Also, fruits have to be immobilized to prevent damage when rubbing against each other or the truck's surface. [16]. For export to overseas countries, refrigerated containers are needed. For the best results, the temperature has to be maintained as close as possible to the recommended levels, therefore Passion fruits are sent to Europe by air [17].

Fruits should be transported at night or early morning when the temperature is low because some small-scale farmers do not have temperature-controlled vehicles [1].

4. Conclusion and Recommendations

Implementing organic agricultural techniques and good agricultural practices in small to medium-sized Passion fruit farms in Colombia will improve the quality and yield of the product. Collective efforts with other businesses that are functioning as partners or clients can improve the producer's competitive position, can generate a bigger volume throughout long periods to fulfill market needs and improve profitability. If these initiatives are taken further in the supply chain, utilizing vertical integration, processing the fruit, more added value can be given to farmers. This is seen in better prices and more profit [18]. This can be done by exploiting the characteristics of the region and what it can provide to generate a product differentiation strategy different from the country of origin when is not exclusive. Alternatives include using local ingredients or adapting local culinary practices. In this market, an added value to the fresh product has a great potential to increase the profitability [2]; where the profitability depends on three factors: production costs, yield, and sale price [20]; but at the same time it would be important to reduce the transaction costs for the small producers to access the international market by providing information regarding the market opportunities, requirements and demand; also by offering direct business contact, economic support for boosting their exposure (like in international fairs) as well as providing training for agricultural good practices as well in how they can give added value to their products [2].

Farmers should have to get advice from a scientific officer after examining soil and plant conditions. Farmer and industrial workers do not have enough knowledge or common agreement on the post-harvest physiology of Passion fruits. As a result, they may face difficulties when classifying the fruits or commercialization. Suggestions can be given to the government, research institutes, or universities to point out the importance of researching Passion fruits.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

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