Phenology, Postharvest Physiology and Marketing of Pitaya (*Stenocereus griseus*, L.) as a Sustainable Resource

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Keywords: Mexico, alternative resource, cactaceae products, integrate system

Abstract

To understand properly the production process and characteristics that allow a plant to be sustainably exploited it is necessary to obtain information derived from several disciplines A long-term project on *Stenocereus griseus,* a cactus species traditionally used and commercialized in SW Mexico, has been initiated, using a multidisciplinary approach, following the product from the mother plant to commercialization in order to assess true sustainability in the exploitation of this resource. Individual plants were identified and labeled, to track their development through time and correlate annual production with environmental factors. Fruit development has been studied to establish a harvest index. Studies on firmness, respiration, physiological weight loss, extractable juice, °Brix, pH, titratable acidity and vitamin C, as well as reducing sugars and a proximal analysis were made to determine quality, postharvest handling and refrigerated storage potential. A commercial evaluation was also made to predict the economic value of this potential crop. Results indicated that the more young branches the plant has the more fruits it could produce. It is suggested that experiments in pruning should be undertaken as a next phase. Characterization of fruits was made to select the best varieties for establishment. °Brix showed to be the best parameter to determine time of harvest. The fruit loses its spines 24 hours after harvest. Vitamin C decreases from 14.5 mg to 2.5 mg during the storage period. Results of proximal analysis are shown for the three most common types of fruits found in the Region of La Mixteca, Oaxaca. Commercial analysis shows that fresh fruits are suitable for exploitation.

INTRODUCTION

Pitaya the fruit of *Stenocereus* spp. has been proposed as a new crop (Mizrahi, 1977) with potential to become a truly sustainable product. Being a fruit of a cactus naturally has many advantages for being considered a good candidate for sustainable exploitation. In this paper we will use as reference the so called “Pitaya de Mayo”, fruit of *Stenocereus griseus*, produced in the southern Mexican state of Oaxaca. Here an organized group of peasants have cultivated this fruit from more than a century. However there is no clear idea as to the ecology, postharvest handling and marketing of this product.

“Pitaya de Mayo” (*Stenocereus griseus*) has many advantages for becoming a truly sustainable resource. As a native plant it is adapted to the uncertain weather, typical of the Mexican southern hills. Long-standing cultivation (in human terms) has provided farmers with an intuitive knowledge of proper cultural practices. The juicy fruit has been used as a water and carbohydrate source, and is traditionally consumed as a fresh seasonal dessert. Several elements of pitaya have not been explored as complementary resources such as fresh or processed products like jelly, jams etc.

In 1999 we initiated a program to turn the Pitaya into a completely usable produce within an integrated system. However, to become a good sustainable resource, a product has to generate optimum profits so as to reduce the need to convert more forest lands into crop fields. To achieve this, a detailed analysis of the entire process is required. It must cover a series of aspects, ranging from the knowledge of plant's ecology and its

Proc. IS on Sust. Use Of Plant Biodiv.
Eds. E. Düzyaman &Y.Tüzel
Acta Hort. 598, ISHS 2003

implications on increase in productivity, throughout the analysis of postharvest life to increased shelf life and commercial value, as well as the study of possible marketing channels, among other factors, to improve the profit/cost relationship. Only with this whole understanding of the process it is possible to provide producers with a sustainable resource.

METHODS

All plants and fruits studied came from La Mixteca Region, provided by "Unión de Ejidos y Comunidades DICHI-CUAHA" at the southern State of Oaxaca, Mexico. For phenological and ecological studies we selected several "Pitaya de Mayo" populations from the eight different communities of the Union, making a weekly record of the number of flowers and fruits and number of fruits per branch. With this information we assessed production rates and relationships with plant structure.

Postharvest studies of fruits were made at the Postharvest Physiology of Fruits and Vegetables laboratory where homogeneous-sized fruits with or without spines were randomly chosen to be stored under ambient or refrigerated (7±1°C) temperatures and 85-90% R.H. Parameters such as physical: size, weight, color, extractable juice volume; physiological: respiration (by gas chromatography, according to Yáñez, 1995), physiological weight loss; chemical: °Brix, pH, titratable acidity (up to an 8.25 pH), vitamin C, were evaluated during their storage period as well as reducing sugars. All of them made in fruit pulp (except for the epidermis' color and spines evaluation).

Marketing studies and acceptance tests were made at three levels: local including small towns < 3,000 people within 40 km from production zone, medium-sized cities (3,000< >100,000) within 100 km of the production site, and big cities (>100,000) far away from production zones. Cost-benefit evaluation was made for raw and added value products and a marketing model was suggested for Pitaya's commercialization.

RESULTS

Phenology and Ecology

Two harvesting seasons were studied, from June 1999 throughout May 2001. We determined that Pitaya de Mayo's anthesis is in early March, once temperature reaches 17°C. Flowering lasts until early April. First fruits appear in late April, but these are normally small and farmers face big competition with birds. In May production has a normal shape curve reaching the peak around the second week when it produces between 1 and 20 fruits per branch.

Productivity is related to the age of the branch: young branches produce around 20 % more fruits than old ones. Well-managed farms include old branch pruning. So far, variation in handling and genetic variability overshadows the effect of the ecological environment.

Farmers believe they can recognize several "varieties" mostly due to the community of origin, however, open pollination produces a wide range of almost all the morphological features, such as plant size, plant branching pattern and, of course in fruit characteristics (see below). From the nine communities of the union we recorded 17 different types (according to producers). We selected 5 well-defined fruits from three of them and made a proximal analysis (Table 1). No significant difference was found between them, indicating that nutritional value does not differ one from another.

Postharvest Physiology of Fruits

The fruit is round or oval shaped, its epidermis is red or changes from bright green to a yellowish green as it ripens, according to the type of fruit. It has many areoles or groups of spines, which are inconvenient to consumers. However the spines fall off after the first 24 hours in suitable cold storage. Areoles have a velvet-like base on which spines are inserted (Pimienta-Barrios & Nóbel, 1994).

The harvest season is restricted to May and it is made by hand, by means of a

large stick with a basket like structure at the top called “chicolo”. Up to now the only harvest indexes are color of epidermis, and hardness of spines’, which are difficult to determine due to their subjectivity and the particular harvester’s opinion or, sometimes, the necessity to fulfill the buyer’s requirements. The pulp varies in colour: red or orange are the most common, with purple and white also reported. The flavour is sweet, juicy, and the texture soft, fibrous and grainy due to the abundant black, soft seeds of 1mm diameter (Arnaud, et al., 1997). The aroma is slight and characteristic. Thus, it is necessary to make postharvest physiology studies of this species to determine a suitable harvest index. Postharvest handling and its refrigerated storage potential also need to be assessed in order to introduce Pitaya de Mayo not only throughout Mexico but to make it eligible for its global marketing (Armella & Yánez, 1997).

As it was mentioned before, Pitaya de Mayo is a plant in the process of domestication. Varieties have yet not been established, so a great variability was found in obtained data. Generally speaking, pitaya fruit size averages 8.04 ± 0.23 cm length and 6.21 ± 0.11 cm equatorial diameter. Refrigerated fruits with spines had a 20 days storage period while fruits stored at room temperature lasted only 5 days. The weight averages 150 up to 250 grams. Physiological weight loss was studied in fruits with or without spines stored under both ambient and refrigerated temperatures. A marked physiological weight loss was found in those Pitayas stored without spines at room temperature (18 %) as compared to those stored with spines at the same temperature (14 %) or under refrigeration (8 % without spines and 4 % with spines). Extractable juice volume decreased with time (105 ml up to 0.5 ml at the end of the storage period) mainly in those fruits stored without spines at room temperature, due to spines removal and to the drastic physiological weight loss as well as to cell walls degradation as fruits reached senescence. Fruits stored under refrigeration showed less decrease in this parameter, which remained almost constant and without significant changes ($p < 0.05$). Equatorial firmness apparently increased markedly during the storage period in fruits with spines stored at room temperature as compared to the refrigerated ones, due to their elasticity provided by their flaccidity as a result of water loss (Kays, 1991). Also differences in spines removal were found: fruits stored with spines at room temperature became flaccid and toughness hard to remove, due to water loss, while refrigerated fruits’ spines fell off by themselves approximately 24 hours after their storage period. At the end of storage all of them had already thrown their spines away.

Respiration pattern in all studied fruits is characteristic of non-climacteric fruits (10mg CO_2/Kg/hr up to 4 mg CO_2/Kg/hr in average), always changing asymptotically toward a decrease through the storage period. Fruits stored at room temperature had a more intense respiration activity than the ones with spines stored under refrigeration due to its lowered metabolism.

Quality parameters’ studies were made from the fruit set stage up to its harvest, which showed that the only parameter that had significant changes was total soluble solids. Thus, at 13°Brix the fruit is suitable for harvest. Its apparent increase in °Brix, 11.5 up to 13, during storage was due to its water loss, so sugars concentrated. Reducing sugars were, on average, 9.4 %. Other quality parameters like pH, 4-5 in average, and titratable acidity 0.07meq/ 100gr of fresh weight, remained practically constant through all the storage period, which is characteristic of non-climacteric fruits, hence, it is very important to have greater precision in determining the harvest index. Vitamin C decreased during the storage period from 14.5 mg to 2.5 mg. Fruit types recommended for new varieties establishment are: the ones with red pulp known as “Olla” or “Sandía” (according to the people of the zones under study), the ones with the orange pulp with yellowish green epidermis “Jarra”, or the ones with orange pulp and yellowish green epidermis covered with a whitish dust, called “Ceniza” for fresh consumption. Other pitayas are smaller in size, not as beautiful in appearance but palatable. After a 20 day storage period refrigerated fruits do not have an attractive appearance but still have a good taste, sweet pulp, therefore it is suggested to process them and the smaller, less attractive ones for marmalade, jams, juices, nectars, dehydrated pulp, frozen pulp, etc.

processing (Arnaud et al., 1997).

Marketing

According to the studies, even when it is possible to extend the shelf life of this fruit poor knowledge of this commodity in larger markets makes it difficult to obtain higher prices at the cities, while limited budgets in small towns reduces their cost-effectiveness. Therefore added value products must be considered as an important option to access these markets. However, fresh fruit market must be the leader in letting people know about the properties of this commodity. Also, added value products will help regulate Pitaya's market prices.

DISCUSSION

Stenocereus griseus is a plant in under domestication in southern Mexico (as are close relatives in other regions) but genetic variability does not yet allow distinct varieties to become established. As a consequence, better technological management becomes a challenge. Manual and low technological handling improves the possibility to develop a fully sustainable crop from this new commodity. However, understanding of the whole production chain will help increase profits for producers thus reducing the need for expensive and non-sustainable technology and or destruction of more wild land for traditional crops.

Ecological and postharvest characteristics show this commodity's great potential, but long lasting added value products must be produced to enhance the markets and extend the short sale season of fresh "Pitaya de Mayo".

ACKNOWLEDGEMENTS

The authors are grateful to the undergraduate students who contributed with the lab-work through social service: García R.L., Quintanar, M.C., Juárez M.A., Moreyra G.M.

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Tables

Table 1. Proximal Analysis of Three Pitaya Types from San Juan Joluxtla (Municipality of Chazumba), Oax.(g/100 g).

Type	Jarra	Ceniza	Olla
Proteins	1.64 ± 0.04	1.72 ± 0.03	1.55 ± 0.03
Carbohydrates	6.66 ± 0.10	4.57 ± 0.09	5.04 ± 0.12
Lipids	0.11 ± 0.05	0.19 ± 0.06	0.18 ± 0.04
Fibre	4.37 ± 0.15	6.10 ± 0.18	5.64 ± 0.16
Humidity	86.48 ± 0.10	85.76 ± 0.20	86.51 ± 0.30