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The horticultural potential of jiotilla (*Escontria chiotilla* [weber] rose) from the Mixteca region of Mexico

Abstract

Jiotilla is a small, round, purple fruit that has a pineapple like appearance. It is produced by a columnar cactus tree (*Escontria chiotilla* [Weber] Rose) that grows in semiarid regions of Central Mexico, particularly in the states of Oaxaca and Puebla. Although jiotilla has long been known for its palatability by the locals it is only now emerging globally as a new horticultural resource. On this paper we present some features of this fruit, from the general description to nutritional values of the fruit to let it be widely known. Jiotilla fruit is produced in a tree-like cactus about 4-6 m high, as today fruit is basically harvested from wild populations and has been considered "in the process of domestication". Fruit is a small 3-5 cms in diameter, 20-25 gr, and looks like a small, purple pineapple, with paper-like scales. Production is asynchronous with two peak of fruit production one in May-June and a second one in August- September. Natural populations can reach over 100 plants /ha.

Keywords: jiotilla, quiotilla, alternative resources, semiarid lands, columnar cacti, sustainable agriculture.

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Introduction

Jiotilla is a small, purple fruit that grows in the semiarid regions in south east of Mexico. Locals have been eating this fruit for generations and it now has a formal classification and is part of the local economy.[1,2] However, jiotilla remains largely unknown outside of its natural habitat. Most people are more familiar with a relative of jiotilla, the prickly pear, which has received substantially more international attention. The purpose of this article is to educate the international horticultural community of the many attributes of this fruit for commercial exploitation to bring the attention to this plant. Although jiotilla is in the early stages of cultivation.[3–7] most local farmers continue to allow livestock to graze within the fields.[8] Same authors reach the conclusion that this plant has been "domesticated" because slight differences in DNA composition could be detected between wild populations located at long distance of human settlements and populations close to them. Casas et al.[4] suggest that larger and fleshier fruits from wild populations are taken more frequently by the people, they eat the fruit and spit seeds close to towns, which over generations made populations show genetic and physical differences.

Plant description

Jiotilla is the only species that belongs to the genus *Escontria* within the subtribe *Stenocereae*.[9] This plant lives as endemic species, in the xerophytic scrubs and shrublands of arid zones of Puebla, Oaxaca, Guerrero and Michoacán, Mexico.[10]

Jiotilla-plant grows from a three to four-meter high (3.08±0.1031 n=54)[1] columnar cactus (Figure 1a) with a short, wide trunk (about 40 cm diameter), many dark green, 20 cm diameter, divided, rigid branches and seven to eight prominent ribs. Fruits are produced in the terminal branches; these are the last and younger branches (number of final branches 41.12 ± 4.6) final branches per tree. Coverture varies according with branch number but for full growth plant can be important (6.03±0.928 m^2 per tree).

The areoles are 1 cm in length, located close together and where they join, form an elliptical shape with the presence of gray wool. Dark gray spines with darker tips[10] are 1 cm long, straight and extend laterally and radially, sometimes orienting downwards. There are three to five central clusters of spines, one of which is a much larger spine (7 cm long) than the others. Spines are straight, and slightly plain, and dark gray, with a darker tip.[10]

Our own data indicate that the probability that the developing areole will become a bud is 28% and from bud to flower is only 0.54%. Flowers that develop at the tip of the branch are infundibuliform, 3 cm long, including the ovary (Figure 2). The inner perianth segments are yellow and acuminate. The pericarpal and the tube have big, yellow-bright- paper-like (Figure 3), translucent, pungent, acuminate scales; armpits lack wool; stamens are yellow; the stigma has 8 to 10 lobes. There is a 15% probability that the flower will produce fruits.

Plant growth

The seed germination percentage is high, up to 90%, before three months from sown[11] in the lab whereas in the field seeds did not germinate during 21 days from sown.[12] These opposite results suggest that some type of induced dormancy could be part of the natural development of the plant.

To date minimal data are available on the development of this cactus as a seedling, although jiotilla trees are common in semiarid regions of Oaxaca it is difficult to find seedlings and small plants. Loza-Cornejo and Terrazas[13] found a delay in stem and root development occurs in jiotilla and this is similar condition to *Myrtillocactus geometrizans*, another cactus tree with a similar growth pattern, both species have the smallest seeds among several studied cacti.

[1]All presented data are in m and in meters plus minus standard error, n is the number of plants sampled.

Figure 1 A) Mature plant of Jiotilla, B) early stages of flower development.

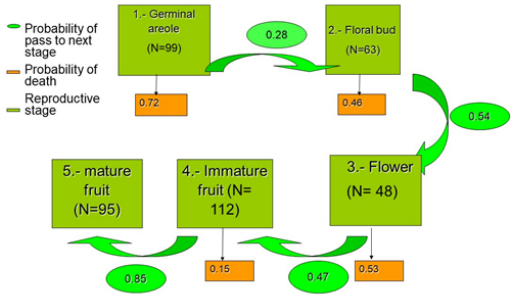

Figure 2 Schematic probability to success of different stages of Jiotilla development stages (N is number structures marked for each category.

Figure 3 open Jiotilla flower.

No agricultural data are reported for the sown or reproduction of *Escontria* because the plant is very abundant in nature. Most of the traditional exploitation is by collection of ripe fruits by peasants.

Fruit features

Fruit description

Jiotilla looks like a small (3 to 5 cm diameter, 20-25 g) red-purple pineapple, with yellow, paper-like (Figure 4), scales and spines at the base. The pulp is purple and edible with a sweet and sour flavor that sometimes has an aftertaste like a tomato. Jiotilla seeds (15 mm long) are black with a wide basal hilum and a rough seed coat.

Jiotilla fruit has an 85% probability of reaching its ripe stage from fertilization throughout its production season that begins at the end of May and lasts through August due to the asynchronous development of the fruit.

Jiotilla has long been sold in local markets[1,10,14] with no relevant changes in many years. Fruits are offered in baskets by women outside the traditional markets of middle side cities not far from the production area.

Production of jiotilla is asynchronous, starting in April and running until the end of August or even early September. Within this period two production peaks can be detected: the first in May-June and the second in August with a noticeable reduction in fruit production in between, however bud, flowers and immature fruits can be seen during this period (Figure 4).

Figure 4 Jiotilla fruit.

Pigments

One of the most important features of jiotilla fruit are the deep red (purple) pigments. Dominant pigments are betaxantines (yellow pigments), although the most visible color in the fruit is red purple, suggesting that hypothetically betanine is the predominant one Figure 5.

Figure 5 Development of color in Jiotilla fruit.

Results from thin layer chromatography showed that the yellow fraction of jiotilla is composed of vulgaxantine I, vulgaxantine II, and indicaxantine (together occurring in 1196 mg/kg of fruit). Its red purple fraction is made of betanine (89 mg in raw extract). The high percentage of mucilage and high viscosity of the juice made it difficult to extract its pigments. They are not stable at oxygen, light, metals, acidity, etc.[14,15] On the other hand, Jiotilla has a high content of biologically active pigment, i.e., betaxanthins (4.17 ± 0.35 mg/g dry sample). (4.17 ± 0.35 mg/g dry sample).[16]

This attractive purple color has been used to dye fabrics since pre-Hispanic times and food.

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Flavor and aroma

Using CE-CG we found a variety of volatile compounds in jiotilla such as: methanol, acetone, acetaldehyde, ethanol, metile butyrate, and butyle acetate. These compounds were present at 420-450/L, whereby esters represented only a small proportion. Esters have been known to confer intense fruity notes, as determined by trained panelists.[14,17] MFS and Mass-GC provided the identification of ethyl butyrate ester, pentanal, hexanal, and trans-hexanal as aldehydes and pentanol.

Nutritional contents

As many other cacti family fruits, jiotilla is juicy and fibrous, with many, tiny seeds. Proximal analysis on Tables 1 & Table 2 show that jiotilla fruit is a good source of fiber. However, the small size of fruit makes the need to eat several of them to gain good nutritional food.

Table 1 Nutritional values of different parts of the Jiotilla fruit[2]

	Part of the Fruit		
Nutritional element	**Peel**	**Pulp**	**Whole Fruit**
%Crude protein	7.08	10.12	9.08
%Crude fiber	23.1	9.77	19.04
%Crude fat	49	2.25	1.96
Ashes	7.55	4.38	5.81
Nitrogen	60.8	73.48	64.11
Free extract			

Table 2 Nutritional features of jiotilla according to the AOAC standards

Fiber component	Part of the Fruit		
	Peel	**Pulp**	**Whole Fruit**
%DNF	69.49	48.07	43.62
%DAF	56.2	29.06	38.65
% Cellulose	24.27	21.74	22.43
%Hemicellulose	19	4.97	13.28

DNF, detergent neutral fiber

DAF, detergent acid fiber

Dietary fiber composition (Table 2)

Horticultural process

Although there are no actual jiotilla orchards, natural densities in Oaxaca could be from 10 to more than 100 plants/ha. Since there are no real culture practices plants from different sizes may be found growing together,

Basically, this is a process of gathering- most of the people combines the recollection of fruit with goat shepherd after the flowering stage-, primordial fruits develop in a fruit (Figure 1b) at the tip of the branch, which normally coincides with the tissue added during the previous year. Fruits have asynchronous development (figure 5) and they can be found in different stages of development in the same branch.

During development process fruits increase in diameter and turn purple (although peel´s color might not change from green if the exposure to sunlight is not enough, or by contrast situation, a fruit with sun exposure might turn purple before reaching ripeness. Therefore, Color cannot be used as a harvest index.

Harvest

As mentioned before, Jiotilla plants are not really cultivated, people collect "mature" fruits using a hook attached to the tip of a long stick, they pull the fruit when (they consider) it is ripe, if ripe fruit separates easily from the plant the junction of the fruit and the areole, however the lack of a good maturity and harvest index makes not uncommon that the spines surrounding the fertile areole are collected along with the fruit. Since one of the main economic systems in this region is associated to goat cattle production Jiotilla-fruit collection is performed during goat grazing. Fruits are collected in buckets.

No harvest index is used to differentiate between ripe and unripe fruits.

Since jiotillas are non-climacteric fruits[18] they should be harvested at optimum ripeness. Fernández-López et al.[19] found that color can be a misleading indicator of ripeness because the peel and pulp of jiotilla contain betalains and betaxantins, pigments in which synthesis is stimulated by exposure to light.[20] For this reason, color development depends on position of the fruit on the plant rather than its maturity stage. Sensory evaluation confirmed a disparity between color and palatability since panelists detected unpleasant flavors in some purple fruits (called "frutos llegados" by local people) while they said some green fruits provided pleasant flavors (called "camahuas" by local people).[17] Chemical parameters similarly indicated disparity between color and maturity stages as measured by sugar/acidity balance.

Microscopy studies reveal changes in fruit anatomy in developing fruits, providing one of the most reliable techniques for obtaining a precise harvest index. However, they are no practical measurement instruments in the field and, therefore, they need to be correlated with other more readily observed parameters. The most practical and objective harvest index correlated with microscopy studies is fruit size (fullness) since soluble solids (i.e. simple sugars, organic acids and minerals) increase fruit density as evidenced in a water test in which ripe fruits sank while unripe fruits floated.

Harvest

Jiotilla is collected by means of a long reed stick with a basket at the top, called "chicolo". This instrument provides a cushion to protect fruits against bruises since they are generally picked from a high position on the tree. Fruits are then put on a basket under the shade.

Suggested postharvest handling

The highly perishable nature of jiotilla makes it difficult to be commercialized non-locally. To date there is no official postharvest handling guide for jiotilla. Here we make a few suggestions with regards to protecting and storing the fruit to extend its shelf life as follows:

It is best to use a dry technique to clean the fruit (i.e. with soft, horse tail brushes) since the paper-like scales on the fruit that likely protect them from impurities maintain humidity following wet cleaning techniques, creating an ideal environment for fungi (i.e. *Pennicillium spp*) to germinate and develop; forced-air-cooling is suitable to decrease pulp temperature; pre-packing the fruit in perforated plastic containers and storing at 10±1°C preserved fruits for 12 days as compared to the control (stored at ambient temperature) where fruits only lasted 5 days.[21]

[2]Data shown are based on at least 40 fruits on the consumption stage using basic Kjeldahl method).

Conclusion

Jiotilla has the potential, with proper handling and storage techniques, to be a substantial horticultural resource within its distribution range as well as outside of the classical borders. Jiotilla has many favorable qualities including its juicy nature, unique flavor, health benefits due to its antioxidant pigments, fiber, and relatively simple growth requirements. However, the small size and seasonality of jiotilla will likely require that it be grown in association with another product. Although there is a high potential for its inclusion in both minimally processed and processed products, the small amount of edible material per fruit generates large losses in fruit mass and price.[22]

Despite the relative abundance of jiotilla in some regions of Mexico it is not possible to sustain an economy based on it alone. Instead jiotilla needs to be accompanied by other commercial plants to compensate farmers during the off-season.[22,23]

More research into the selection of better producing trees and more flavored fruit will be helpful.

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Conflicts of interest

The authors have no conflict of interest for this research.

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