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Cupapé (*Cordia dodecandra* DC., *Boraginaceae*) a fruit tree in the process of domestication in Mexico

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Abstract

The fruit tree, *Cordia dodecandra* DC., which is partly domesticated in the region of Tuxtla Gutierrez, Chiapas (Mexico) is described from the horticultural and biological point of view. The fruit is up to 5 cm in diameter and its flesh contains 14-25% of total lipids, 6-14% of total protein and 5-15% of total sugars in dry mass. The fresh fruit does not have a very good flavor but cooked with sugar is very tasty. The plant shows marked variability which can be taken into consideration in the selection of better forms for vegetative propagation and breeding.

Key words: etnobotanica, bromatological analysis, sympodial growth

Resumen

El árbol frutal *Cordia dodecandra* DC., parcialmente domesticado en la región de Tuxtla Gutierrez, Chiapas (México), se describe desde el punto de vista horticola y biológico. El fruto alcanza hasta 5 cm de diámetro, su pulpa contiene 14-25% de lipidos totales, 6-14% de la proteina total y 5-15% de los azucares totales en la masa seca. El fruto resco no es de muy buen sabor pero cocido con azucar dá un producto agradable. La planta muestra una marcada variabilidad, la cual puede aprovecharse en la selección de mejores formas para propagarlas vegetativamente o para aprovecharlas en su mejoramiento desde el punto de vista genético.

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INTRODUCTION

Due to thousand-year-old traditions of collecting and cultivating plants from the nativ flora, Mexico today is still an important source of species which can enrich the world list of horticultural plants. In Mexico, many species in the process of domestication are being collected from the wild plant communities, some are introduced into gardens and cultivated for family use or even for commercial production on a small scale.

Cupapé (*Cordia dodecandra* DC., *Boraginaceae*) is such plant. It has several other common names, such as Sirocote, Cópite, Trompillo, Chacopté, K'an-k' opté, Kopté (Pennington and Sarukhan 1968, Martinez 1979). It is a plant of warm regions found in the states of Chiapas, Veracruz and in the Yucatan Peninsula. It is also known in Guatemala. It grows in evergreen or semievergreen forests, usually up to 500 m above sea level (Standley 1920-26, Miranda 1952, Aguilar 1966, Pennington and Sarukhan 1968, Rzedowski 1978). The fruits of this species are not usually eaten fresh but are candized or processed in other ways with sugar for family consumption or for selling on the local market.

The most complete, recent botanical description of this species is given by Pennington and Sarukhan (1968) and we will refer frequently to it.

MATERIAL AND METHODS

The investigation was mainly focused on the trees which were semidomesticated in the suburbs of Tuxtla Gutierrez, Chiapas, where they were growing in family gardens, quickset hedges, or on abandoned territories. A detailed description of 8 trees growing in 5 different places was made paying attention to the characteristics of vegetative growth and fructification.

The climatic conditions of Tuxtla Gutierrez (536 m. above sea level) are presented in Fig. 1. The climate of this region is of type Aw" o (w) (i')g (see García 1981). The graph (Fig. 1) was made according to the rules used by UNESCO and FAO (1963) for ombrothermic diagrams (ombros = rain), (compare "Klimadiagrams" of Walter and Lieth 1960). In these diagrams, the scale for temperature is double in relation to the precipitation scale (10°C corresponds to 20 mm of precipitation). With such scale relations, the diagram regions in which the precipitation curve falls below the temperature curve is considered to represent drought and is darkened (in Tuxtla Gutierrez this takes place from November to April).

The trees were growing on a clay soil with 22-40% of sand in the superficial layer (0-30 cm). The organic matter content was medium (1.93-2.68%), and the percent of saturation with water was 75-82%. The soil was slightly alkaline (pH 7.6-7.8) and contained relatively high levels of carbonates.

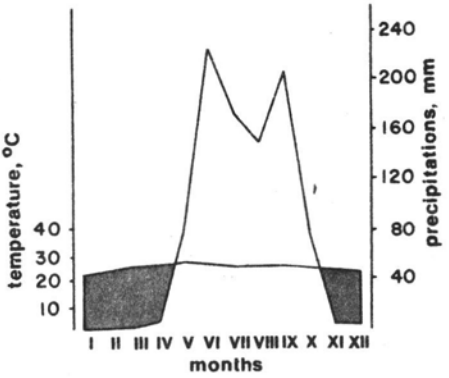

Fig. 1. An ombrothermic diagram of Tuxtla Gutierrez according to the dates of García (1981). The darkened region indicates the drought period

Electric conductivity was 0.50-1.65 mhos·cm^{-1} indicating that this soil does not show problems of salinity. Total nitrogen content was low, 0.158-0.184% in the 0-30 cm layer and 0.161-0.188% in the 30-60 cm layer; that of available phosphorus was below the sensitivity of the applied method (Olsen et al. 1954).

For chemical analyses, fully grown mature fruits were picked from trees listed in Table 1. The fruits were weighed, separating the pulp and the seeds. The pulp was lyophilized and the dry weight determined. Lyophilized composite samples were used for the following determinations:

a. Ash content. Samples were weighed in porcelain crucibles and calcinated in a Blue M muffle furnace at 550°C for three hours.
b. Crude fat. Lyophilized samples were weighed and extracted in a Soxhlet apparatus for 5 hours using petroleum ether as the solvent (Meloan and Pomeranz 1980).
c. Reducing and total sugars were determined in samples extracted in 80% ethanol. Reducing sugars were determined colorimetrically using the anthrone method (Nelson 1944).
d. Total protein. Nitrogen determinations were made by the Kjeldahl procedure. Values of protein were obtained multiplying the nitrogen content by 6.25 (Meloan and Pomeranz 1980).

RESULTS AND DISCUSSION

GROWTH OF THE WHOLE TRESS

Cupapé is a tree which does not grow very fast, attaining a height of 9 m and a crown diameter of 8 m after 15-20 years of growth. Some very old trees are found in the suburbs of Tuxtla Gutierrez. They

attain a crown height of about 20 m and trunk diameter about 40 cm. According to data from literature, it can attain a height of 20-30 m and a trunk diameter of 70 cm (Standely 1920-26, Miranda 1952, Pennington and Sarukhan 1968).

The shape of the crown depends on the conditions of growth and on the age of the tree. The crown, especially of young trees, is very dense so that only a small amount of light can pass through the superficial layer of foliage. We have found, however, trees about 15 years old whose crown was rather loose (Fig. 2). Sometimes a very strong shoot appears in the crown, especially below wounds on the large branches but also near the terminal parts of the main branch. Such a shoot shows strong

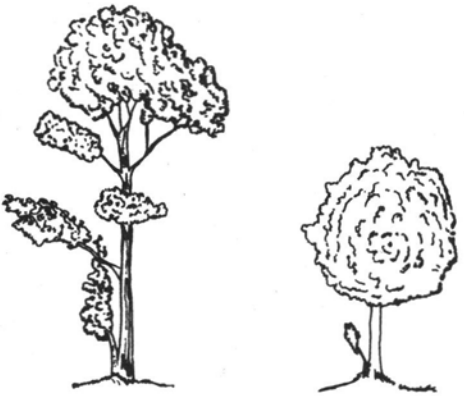

Fig. 2. Types of the crown in cupapé

vertical growth and can promptly extend the crown into regions with much light. It can also, as is expected, penetrate above the layer of lianas which frequently almost completly cover the top of the tree.

THE VEGETATIVE GROWTH

The strongest shoots grow monopodially during several cycles of growth, forming, each time when the cycle terminates, a vegetative dormant bud (Fig. 3), (see Romberger 1963). We have not investigated how long dormancy lasts. The boundary between the stem parts formed during two subsequent cycles of growth can be detected in such shoots due to the differences in surface color of the two subsequent stem parts, the younger being green, the older, brownish green. Also, the first leaves of the new cycle are usually smaller than the other ones, sometimes, a small, non-developed leaf remains at this boundary (Fig. 4). The laterals tend to appear near the termination of each growth cycle. After several cycles of such monopodial growth, the shoot finally forms a flower bud at its end (Fig. 5). The

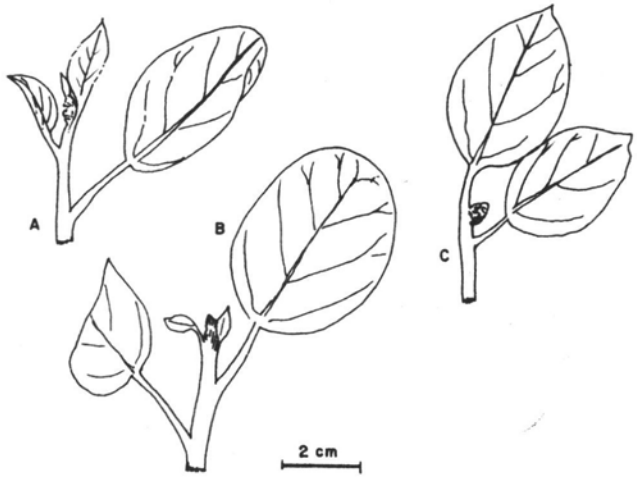

Fig. 3. A — The apical part of an actively growing shoot. B — The dormant vegetative bud with two small leaves which normally will not develop. C — The bud of an older branch, presumably reproductive

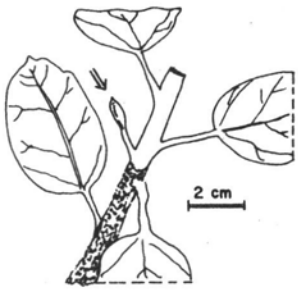

Fig. 4. Small, non-developed leaf (arrow) remains sometimes at the boundary between the parts formed during two subsequent cycles of growth. The part formed during the previous cycle shows a darker suface (as indicated)

shoots of older trees, e.g. 15-year-old, grow slowly. It was observed in the lateral plagiotropic branches of such trees that one cycle of monopodial growth, which terminates with the formation of vegetative dormant bud, is followed by the sympodial cycle during which the terminal reproductive bud is formed. Below it, a group of 2-3 laterals usually appears. Each one of these laterals subsequently passes through the same two cycles of growth. Sometimes, however, the branches pass through more than one monopodial cycle before the sympodial cycle, or pass two sympodial cycles not separated by the monopodial one.

According to literature, the leaves of Cupapé are oblong to oval or eliptic (Figs. 3, 4, 5, and 6C) with the apex abtuse or truncated, and

Fig. 5. The terminal inflorescence with buds of different size. Two branches (× and ×′) grow below it

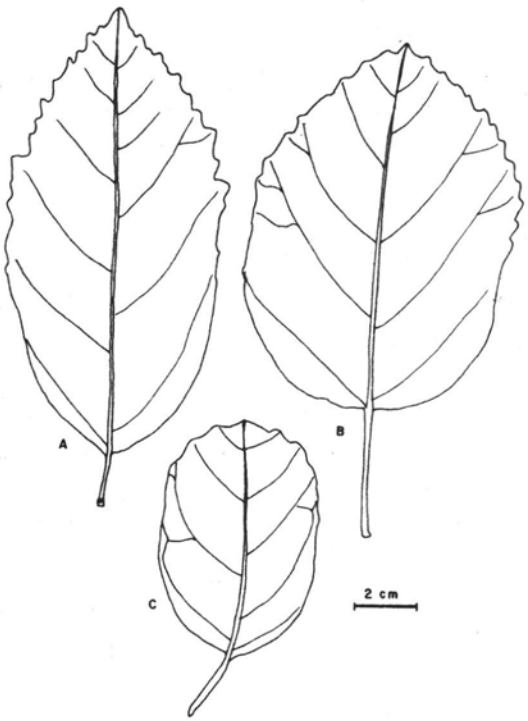

Fig. 6. Types of Cupapé leaves frequently occuring in Tuxtla Gutierrez region. A — The leaf of a young seedling (juvenile). B, C — Leaves of adult tree

repanded margin (Standley 1920-26, Miranda 1952, Pennigton and Sarukhan 1968, Martinez 1979). The forms which we have found in Tuxtla Gutierrez were of this type but very often had the apex acuminate (Figs. 6B and 8). The leaves of young seedlings (Fig. 6A) — "the juvenile leaves", were more oblong than those of the adult forms with an acute apex and showed obtuse denotations in the distal half. The adaxial part of the leaves has very hard trichomes. Due to this property, they are often used for cleaning dishes, etc. (see also Standley 1920-26).

The root system of Cupapé trees does not seem to form suckers.

FORMATION OF INFLORESCENCE AND VEGETATIVE GROWTH

When the inflorescence develops normally, producing flowers and fruits, the lateral shoots situated immediately below it usually grow weakly, especially when the cluster is large, containing 10-15 fruits (Fig. 7). This suggests that strong competition exists between the growth of vegetative and reproductive parts located on the same branch. This also suggests that the assimilates necessary for fruit development are transported to them principally from other branches having much foliage.

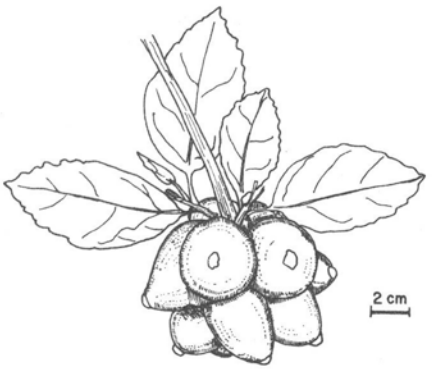

Fig. 7. A cluster of fruits. Note poor development of accompanying lateral branches

Often the inflorescence does not develop, remaining permanently in the form of a small bud (Fig. 8). In such cases, the lateral shoots developing below it grow strongly, probably because they do not suffer competition from reproductive parts. Such laterals often form narrow angles with their mother axis (10-30°). We suppose that undeveloped inflorescences can, on rare occasions, resume their growth after a longer period of inactivity because in two cases, it was observed that the fruits on the older parts showed an earlier stage of development than those on the younger part.

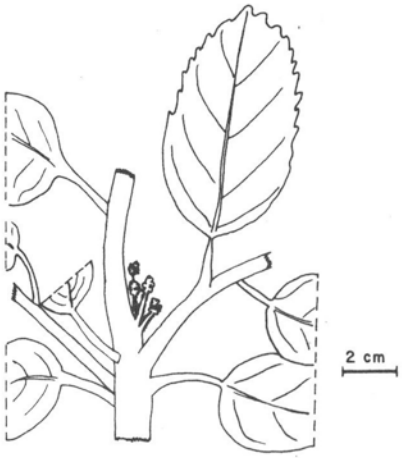

Fig. 8. An inflorescence which remains non-developed for a long time or permanently

The inflorescence is of the closed panicle type (Fig. 9). It usually contains multiple flower buds (in Tuxtla Gutierrez up to 30) which flower gradually, ones after the other, during a period of some weeks. Nevertheless, we have observed rather uniform maturation of the fruits in each cluster and only small differences, in this respect, between the clusters on the same tree.

FLOWERS AND FRUITS

The flowers (Fig. 9) show radial symmetry and are bisexual. They have a green-yellow tubular calyx, 1-2 cm long with slightly undulated margins. The corolla is 4-6 cm long, reddish-orange, tubular in its lower part, extending gradually in its upper part and terminates with 12-16 acuminate lobules. There are 11-13 stamens. The ovary is of the "semiinferior" type since in its lower part it is coalescent with the calyx base and receptacle. It terminates with a single pistil which is as long as the stamens, that enlarge gradually near the stigma. The ovary has 4 locules (cavities) with a single ovule in each (Fig. 9D). This description of the flower generally agrees with that of Pennington and Sarukhan (1968). The only difference is that Pennington and Sarukhan consider the ovary to be "inferior". The fruit is a drupe. The soft, edible parts of it originate from the swollen calyx and from the external part of the ovary wall (Fig. 10). These 2 parts of the fruit retain their epidermis up to maturity and due to this can be easily separated up to the point where they are coalescent with each other (Fig. 10B). These two parts have pulp of different character. The outer part which originates from the calyx has pulp similar

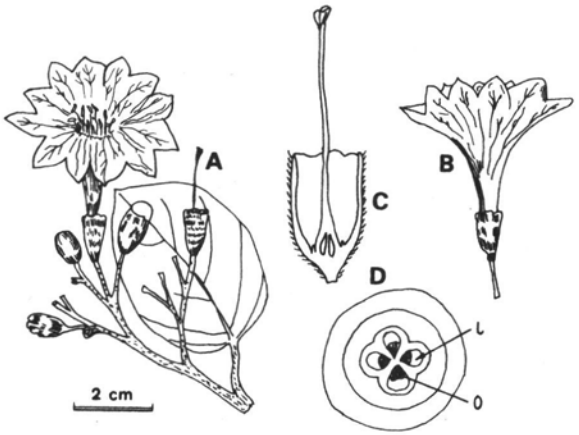

Fig. 9. An inflorescence (A), a flower (B), longitudinal (C) and cross (D) sections of a flower; l — locule (carpel cavity), O — ovule. (C and D magnified 2.0 and 4 times, respectively)

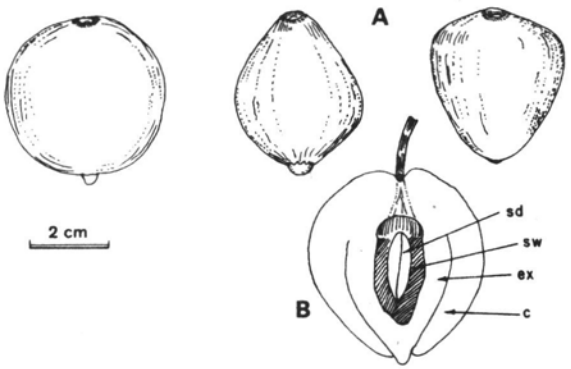

Fig. 10. The shapes of the fruits from different trees (A), and the longitudinal section of the fruit (B), sd — the seed, sw — the stone wall (endocarp), ex — mesocarp and exocarp, c — the part of the fruit which originates from the calyx

to that of an apple, whereas the inner one which originates from the ovary and surrounds the stone (exocarp and mesocarp), is very soft and semi-liquid and contains many fibers, similar to mango flesh near the stone.

The shape of the fruit is round or round to double conical, or round with a tendency to be conical in the upper or lower part (Fig. 10A). The shape partially depends on the position of the fruit in the cluster; the neighbouring fruits press on each other causing the tendency to conical shape from one or more sides in the lower part of the fruit. At the distal end of the fruit there is an opening in the parts originating from

the calyx through which the part originating from the ovary protrudes (Fig. 10A, B). The cavity is shallow and narrow. The dimensions of the fruit probably depend on the clone. The fruits collected from the trees growing in Tuxtla Gutierrez were generally small (Table 1) but the fruits from one tree, (Table 1, No. 7), outgrew the others, being more than 5 cm long and wide and having more than 50 g of fresh wight. Pennigton and Sarukhan (1968) say that fruits are 3-4 cm long and Standley (1920-26), Moranda (1952) and Martinez (1979) mention that they are 5 cm long. The mature fruits are greenish yellow up to orange-yellow. The taste of a raw fruit is tart and not very pleasant but, cooked with sugar, are very tasty and the product is highly appreciated in the region of Tuxtla Gutierrez. The fresh fruit cannot be preserved for more than one week at room temperature due to rotting.

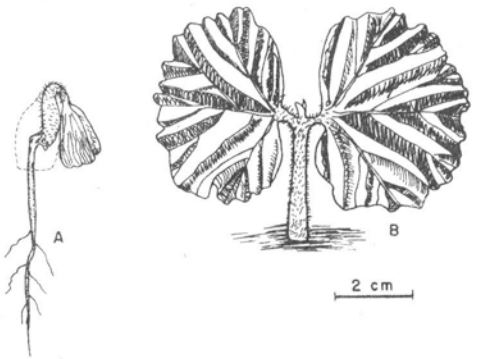

Fig. 11. A — Germination of cupapé seeds is epigeic. The stone is marked with a dotted line. B — Young seedling with developed cotyledonary leaves

The stone (Fig. 10B), is rather small (Table 1). Its wall is hard and can be crushed only with a nutcracker. Inside the stone there is an edible seed which is tasty, although small. Its flavor is similar to that of an almond, but is never bitter.

The fruits are grouped in clusters of 2-15. The number of fruits in a cluster probably depends on the clone: the mentioned specimen with large fruits (No. 7) had concomitantly very few fruits in the cluster, sometimes only singular fruit in the inflorescence. We have found the crop from 5-8 year old trees to be of about 10-15 kg. Some proprietors have mentioned that some trees give very different crops in consecutive years, which depends on unknown factors.

The content of some chemical constituents in the fruit is shown in Table 2. Cupapé fruits show a relatively high lipid, low sugar and medium protein content. Their pH is slightly acid. There is some variation

Table 1

Weight and dimensions of fruit and the stone of cupapé (*Cordia dodencandra* DC.). Average of 7-12 fruits

No. of tree	Fruit		Fresh weight of the fruit, g	Fresh weight of the strone, g	Weight of the stone after 2 months of dry storage		Average number of seeds per stone
	length, mm	width, mm			total	the seeds	
1	40.0	37.6	26.6	3.27	2.69	0.33	2.0
2	38.7	40.5	40.0	3.12	2.83	0.39	1.5
3	45.9	37.5	34.1	3.53	2.59	0.34	1.0
6	37.9	41.8	37.5	3.12	2.69	0.42	1.0
7	53.2	50.2	53.0	5.72	4.22	0.54	2.0

Table 2

Chemical characteristics of cupapé fruits. Average data, including the maximum and minimum values obtained. Determinations were made in 5 fruits of each of 5 clones investigated using two or three repetitions per analysis

Parameter	Average	Maximum	Minimum
Moisture, %	41.0	53.8	29.3
Ashes [1]	4.5	6.9	3.1
Total lipids [1]	19.2	25.0	14.0
Total protein [1]	8.5	13.9	6.2
Reducing sugars [1]	4.4	6.8	1.7
Total sugars [1]	9.4	15.3	4.8
pH	4.8	4.7	4.9
Brix	3.5	5.0	2.5

[1] Data expressed as percent dry weight of the flesh.

in the values obtained for each parameter for different trees. This variation can be due to genetic aspects or to the stage of maturity at harvest. There are no studies about maturity indexes in realtion to harvest for this species. Data on moisture showed wide variation because fruits were harvested in Chiapas and taken to Chapingo in a cold box, however, about 2 days elapsed between harvesting and processing.

GERMINATION OF SEEDS AND GROWTH OF SEEDLINGS

We have only a small amount of information concerning this problem. We have seen many plants beneath the trees which have grown from the

seeds. The proprietors of the gardens say that they sow the whole fruits on the surface of the ground. The fruits rot and the seeds germinate. In our experiment the seeds removed from the rotten fruits (1 month after collecting from the tree), were sown in a moist soil-compost mixture. They germinated in low %, 1-1.5 month after having been sown. Germination is epigeic (Fig. 11A). The cotyledonary leaves are reniforme with undulated margins and fanshaped wrinkles on the surface (Fig. 11B). The seedling has a strong tap root. As far as we know, grafting of the seedlings is not done, therefore each plant that we have described has been a separate clone.

FENOLOGY IN THE REGION OF TUXTLA GUTIERREZ

The trees flower abundantly when the rain period starts i.e. in May (see Fig. 1). In addition to this, singular flowering inflorescences sporadically appear in other times of the year. Pennington and Sarukhan (1968) say that Cupapé flowers the year round, but this is rather not true for the Tuxtla Gutierrez region where the flowering is concentrated in May.

Intensive growth of the shoots occurs in May-June i.e. during the first part of the rain season. The fruits attain maturity in the second part of July. In mid July the trees usually had dormant buds and very few branches showed active growth. According to Pennington and Sarukhan (1968) the trees shed leaves between December and April and this also occurs in Tuxtla Gutierrez, where drought occurs during this period (see Fig. 1). The shedding of leaves is not complete.

HEALTH OF THE TREES IN TUXTLA GUTIERREZ

The trees and young seedlings which were inspected were generally sound. They did not show symptoms of any disease on the vegetative parts. They showed, however, some young leaves eaten by insects, probably caterpillars of butterflies. The fruits of some trees showed cicatrized punctures and lineal scars and also scab-like lesions of unknown origin. Rotten fruits were very rarely found on the tress. The stone sometimes contained the larva of an insect. Nevertheless, some trees had very sound fruits, almost without any lesions.

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Kupapé (Cordia dodecandra DC.) — drzewo owocowe udomawiane w Meksyku

Streszczenie

Opisano, z biologicznego i ogrodniczego punktu widzenia, drzewo owocowe z rodziny *Boraginaceae* — *Cordia dodecandra* DC., które zostało częściowo udomowione w rejonie Tuxtla Gutierrez w stanie Cziapas w Meksyku. Kupapé jest drzewem średniej wielkości, którego pędy mają przeważnie na przemian monopodialny i sympodialny cykl wzrostu. Owoc powstaje ze zgrubiałych ścian kielicha i z owocni zrośniętych u dołu, z tym, że w górnej części oba te elementy zachowują niezależność aż do dojrzenia i różnią się teksturą. Świeży owoc nie jest zbyt smaczny, natomiast bardzo smaczne są zrobione z niego konfitury, które są sprzedawane na lokalnym rynku. Owoce zawierają stosunkowo mało cukrów, ale dużo tłuszczów.