CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

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TRADE SURVEY STUDY ON SUCCULENT *EUPHORBIA* SPECIES PROTECTED BY CITES AND USED AS COSMETIC, FOOD AND MEDICINE, WITH SPECIAL FOCUS ON CANDELILLA WAX

The attached document has been submitted by the Scientific Authority of Germany[*].

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Trade survey study on succulent *Euphorbia* species protected by CITES and used as cosmetic, food and medicine, with special focus on Candelilla wax

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Content

SUMMARY

The focus of this market survey review is on the use and trade amounts of Candelilla wax, obtained from the succulent *Euphorbia antisyphilitica* from Mexico. Other *Euphorbia* species involved in trade as raw materials for medicinal, aromatic, cosmetic or other more technical uses are discussed.

Finished products containing Candelilla wax from *Euphorbia antisyphilitica,* a CITES Appendix II species, require CITES permits. Since 2008, an increasing number of undocumented shipments were confiscated. Consignments of products containing Candelilla are shipped by the sounds, each of them requirung re-export-certificates or import permits. This is burdensome for industry and authorities. This review investigates whether the monitoring of finished products containing Candelilla wax has conservation benefits.

Euphorbia antisyphilitica is a shrubby spurge with its natural range extending from southwest USA (New Mexico and Texas) to Mexico, having densely clustered stems that yield the multi-purpose Candelilla wax. Its distinctive properties make it an essential raw material in a wide array of products, especially for cosmetics. In order to produce Candelilla wax the plant is collected from the wild. The wax is produced by boiling the pulled-up entire stalks of the plant.

For Candelilla production only the cuticula wax of *Euphorbia antisyphilitica* is used and not the white latex with toxic properties. The demand during the 1940s was about 10-fold that of today. Certainly the natural resource was under stress by that harvesting intensity. At that time also other species of the *Euphorbiaceae* family like *Pedilanthus* were used to produce Candelilla wax. Today this is obsolete because of quality reasons. Until the end of World War II also in southern States of the USA, Texas and New Mexico, the Candelilla plant was harvested. Today the main habitats in USA are protected by National Park.

Today the demand of raw material on the international market is stable. The USA market is constant since 1980 and EU imports are slightly decreasing since 2000, paralleled by a concurrent increase in the Japanese market. Data for export from Mexico are in good correlation with import data of the main importing countries.

Within the EU and the USA the wax is processed widely into many different kinds of consumer products. Main user is cosmetic industry because of unique properties of the wax for lipsticks, mascara and eye liners. For other purposes Candelilla wax is too expensive and suitable chemical materials are available to substitute the vegetable wax.

Many cosmetic consumer product manufacturers are fearful of being criticised because of their involvement with an endangered plant product and tend to substitute Candelilla for new product developments. The mid and long term end result of these restrictions will be the decline of Candelilla Wax activity in an area of Mexico where the socio-economic conditions are already difficult.

Harvest in Mexico is limited by a permit system of the Mexican authorities and sustainability will be enhanced by reforestation programs. It is unlikely that the present level of harvest will be a threat to *Euphorbia antisyphilitica* at the species level. Cultivation of the plant is possible but until now only wild collected plant material is used.

Other *Euphorbia* species are used as medicinal plants. Due to the toxic properties of the latex of Euphorbia species, only small quantities are used traditionally in origin countries and in homoeopathy in the European market.

The technical use of succulent *Euphorbia* species for production of rubber and gasoline is more of historical interest and did not exceed the experimental stage because until now the production remained uneconomic.

For Candelilla wax extracted from *Euphorbia antisyphilitica* and exported from Mexico as raw material also in future the CITES Appendix II listing should remain in place to enable Mexican authorities to control harvest and trade and to enable conservation efforts. After the Candelilla wax has been legally exported and the raw commodity processed into finished products it seems to be without any conservation effect when re-export-certificates and import permits would be necessary for consumer products.

According to currently available data the exemption of finished products in the generic listing of succulent Euphorbia species on CITES Appendix II will not be harmful and therefore could be supported. In order to resolve the increasing enforcement problems associated with the international trade in consumer products containing Candelilla wax as an ingredient it is suggested that the international community agrees on the facilitation of trade in finished products made of Euphorbia antisyphilitica.

OBJECTIVE

The focus of this review will be the use and trade amounts of Candelilla wax, obtained from the succulent *Euphorbia antisyphilitica* from Mexico. Other *Euphorbia* species involved in trade as raw materials for medicinal, aromatic, cosmetic or other more technical uses will be discussed.

Finished products containing Candelilla wax from *Euphorbia antisyphilitica,* a CITES Appendix II species, require CITES permits. Since 2008, an increasing number of undocumented shipments were confiscated. Consignments of products containing Candelilla are shipped by the sounds, each of them requirung re-export-certificates or import permits. This is burdensome for industry and authorities. This review investigates whether the monitoring of finished products containing Candelilla wax has conservation benefits.

In a proposal to the 14th meeting of the Conference of the Parties to CITES in 2007[1] it was proposed that finished products that are packaged and ready for retail trade (excluding whole or grafted specimens, seeds, bulbs and other propagules) of *Euphorbia spp*. should be exempted from CITES controls. This issue will be discussed at the forthcoming 18th meeting of the Plants Committee (Buenos Aires, March 2009)

The current review investigates whether an exemption of finished products for the species in the generic Euphorbia listing on Appendix II would be harmful or could be supported. To this end the following questions will be answered and discussed:

- Is Candelilla wax only sourced from *E. antisyphilitica* or also from other species?
- Is Candelilla wax exported from Mexico only as raw material or also as finished products?
- Are existing *E. antisyphilitica* populations in USA (Texas, New Mexico) not exploited, if so for export reasons?
- Outline structure of Candelilla trade (countries of export, countries of import, commodities traded, typical size of consigments, frequency of trade transactions)
- Which other *Euphorbia* species involved in an hitherto unknown/unidentified trade as raw materials for medicinal, aromatic, cosmetic or other more technical uses? What is their use, trade volume, countries of origin and import?
- For all species identified, assess the amount that comes from wild collection and artificial propagation respectively.

[1] *http://www.cites.org/eng/cop/14/prop/E14-P26.pdf; see chapter 2.1 "Background" and 2.2 "Rationale"*

CANDELILLA WAX, ITS USE AND THE PLANT SOURCE

Candelilla wax

Candelilla wax consists, like other plant cuticula waxes, primarily of odd-numbered n-alkanes (C_{29} to C_{33}), together with esters of acids and alcohols with even-numbered carbon chains (C_{28} to C_{34}). Free acids, free alcohols, sterols, neutral resins, and mineral matter are also present.

	% weight
Hydrocarbon	**50-57**
Nonacosane	2.5
Hentriacontane	46-46.5
Tritriacontane	2.5
Esters	**28-29**
Simple Esters and Lactones	20-21
Hydroxil Esters	6-8%
Alcohol, Steroles and Resins	**12-14**
Miricyclic alcohol	ND
Sitosterol and other Sterols	7-8
Beta-Amirina Acetate	5-6
Free Acids	**7-9**
Linear Chain	6-7
Cyclic	ND
Humidity	**0.5-1**
Inorganic Residues	**0.7**

Chemical Composition of Refined Candelilla Wax
Source: http://www.Candelilla.org/propiedades.htm

More details on the composition of Candelilla wax and appropriate analytical procedures are available in Illmann (1979), Brossard (1994), and Regert (2005).

Candelilla wax can potentially be used in a wide range of products because of its unique properties. It can harden other waxes without significantly increasing the melting point of the mixture (Candelilla Institute). Dispersions of Candelilla wax in fatty oil (e.g.safflower oil) results in formation of an organogel with textures of potential use by the food industry (Toro-Vazquez 2007).

Current use

Currently used in more than 20 different industries worldwide, its distinctive properties make it an essential raw material for the manufacturing of cosmetics, gum base, inks, dyes, adhesives, coatings, emulsions, polishes and pharmaceutical products. Main use today is in cosmetics, less amounts as ingredients in food, pharmaceutical products and wood finish.

Cosmetics

Candelilla is listed in INCI, the International Nomenclature of Cosmetic Ingredients of the European Commission, as cosmetic ingredient and therefore is to be named as CANDELILLA CERA in the labelled declaration of constituents.

Candelilla wax is used in cosmetics as emollient and film forming agent (Löhnert 1997). In general the market is driven by consumer preference for 'natural' cosmetics, increasing the demand for natural waxes. Most important cosmetic products containing Candelilla are Mascara, one of the most used cosmetic products, followed by lipstick and cosmetic pencil. Mascara is used to darken, lighten or colour lashes, also it can be used to thicken, lenghthen and define eyelashes. Usual composition is of soft surfactants, vegetal based waxes (Carnauba wax, Candelilla wax), pigments and thickening polymers.

Lipsticks produced with Candelilla show lower tendency to sweating, a phenomen of oil excretion on the surface of the lipstick after temperature fluctuation that is regarded as unattractive by consumer (Seo 1999). So Candelilla is enhancing temperature stability and will prolong shelf life of the product without any change.

Cosmetic pencils are used as lip-liners to make a contour and as eye liners and shadows. The lead base in cosmetic pencil is a mixture of selected ingredients like oils and waxes. High-level products demand natural ingredients as Candelilla wax. They use especially Candelilla wax as raw material in the lead to strengthen thermo- stability of the pencils and provide long lasting contour lines (Mazgareanu 2004). For this special purpose Candelilla may not be substituted by other chemical substances or vegetable waxes because of its special and unique properties. Candelilla is forming a special, partly crystalline structure to enclose other waxes, oils and pigments and to enhance stability and strength of the cosmetic pencil. This may be demonstrated by 16 patents for cosmetic products with the ingredient Candelilla for one single company (Schwan-Stabilo, Germany, DEPATIS 2009).

Use in food

As food ingredient the wax should be listed on the product label as Candelilla wax (902), Candelillawachs or E 902.

The Codex Alimentarius published by FAO is listing the possible uses:

Functional Classes
- Anticaking agent (release agent)
- Bulking agent
- Emulsifier (clouding agent)
- Glazing agent
- Carrier solvent

Provisions for Food Category
- Chewing gum
- Cocoa and chocolate products
- Coffee, coffee substitutes, tea, herbal infusions, and other hot cereal and grain beverages, excluding cocoa
- Confectionery including hard and soft candy, nougats,
- Decorations (e.g., for fine bakery wares), toppings (non-fruit) and sweet sauces
- Fine bakery wares (sweet, salty, savoury)
- Food supplements
- Imitation chocolate, chocolate substitute products
- Ready-to-eat savouries
- Surface-treated fresh fruit GMP
- Surface-treated fresh vegetables (including mushrooms and fungi, roots and tubers, pulses and legumes, and aloe vera), seaweeds, and nuts and seeds
- Water-based flavoured drinks, including "sport," "energy," or "electrolyte" drinks

In the USA the FDA published a GRAS ("generally recognized as safe") status for Candelilla as a direct human food ingredient (21 CFR Ch. I § 184.1976), establishing that the ingredient is used in food with no limitation. Based on current Good Manufacturing Practice conditions Candelilla may be used as a lubricant, surface-finishing agent, in chewing gum and in hard candy.

In fruit coating Candelilla seems not to be the best agent for apple coating compared to Carnauba and shellac (Bai 2003). On the other hand in orange coating, a mixture of Candelilla and polyethylene had advantages over shellac-wood resin coatings (Hagenmaier 2000). Today, applications in fruit coatings have mostly been replaced by petroleum derived waxes, particularly paraffin and microcrystalline waxes, which can also be food grade.

Candelilla also seems not to be the optimum wax component in chewing-gum as already stated in the 1950s (Hodge 1956). As the historical chart below demonstrates, chewing-gum is no longer the main use of Candelilla in the USA like in the 1960s.

Other sources list the use of Candelilla as food glazing agent, texturizer for chewing gum base, surface-finishing agent for fruits, vegetables and bakery toppings, carrier for food additives (including flavours and colours), clouding agent, or lubricant.

Use in pharmacy

In pharmacy the wax is mostly used as lubricant in tablet manufacturing. In the German market only one company (Pfizer) is using Candelilla as excipient in coated tablets (Rote Liste online).

Technical use

Candelilla is used as wood finish for e.g. doors, artworks like violins, parquet floors, and for car polish.

History of Candelilla use

USES FOR CANDELILLA WAX

Traditional uses:
candlemaking
waterproofing leather
housing:
-thatching
-wall filler
mattress stuffing
folk remedies:
-for kidney ailments
-for venereal disease
-for wart removal
hardener in figurines and amulets
dance floor wax
fuel

1910 to 1940:
sealing wax
phonograph records
waterproofing World War I munitions
insulation compositions for electrical applications
agent in manufacturing celluloid
soaps
ointments
lubricants (in plastics, as plasticizer, filler or base)
auto, floor, furniture, leather polishes
dental molding compounds, anatomical models
paint remover thickener
coating to strengthen & waterproof stitching thread
tanning leather
solvent to treat leather shoe soles to prevent squeaking
lacquers for metals
acid-proofing agent for metal etching
plastics as plasticizer, filler or base
rubber softener & preservative
varnishes
printing, stamping, writing, and lithographic ink
crayons, lead pencils
candies
carbon paper, stencil & tracing papers
parchment, paper sizing
adhesives, cements

1941 to 1960:
waterproofing munitions
waterproofing & insect-proofing:
-K-ration packaging
-tents, tarps, ducking
linen powder bags for Army/Navy long-range guns
agent to reduce friction and deterioration:
-plane wings & fuselages
-shuttles in weaving mills
castings for precision instruments
electroplating
toughener in linoleum

1961 to present:
1960s - chewing gum companies are primary consumers

Today -
U. S. -cosmetics, breath mints
-hardener for softer waxes
-replacement or extender for carnauba wax & beeswax
-fruit coating to prevent weight loss & preserve flavor

Mexico -folk remedies of curanderos (healers)
-chewing gum
-matches
-candy

Overview on historical use of Candelilla wax
Source: http://www.texasbeyondhistory.net/waxcamps/index.html

Recent trends in use of Candelilla wax are:

- Over 90% is used in cosmetics
- For other application Candelilla is too expensive
- Candelilla is added to products like polish and varnish in very small amounts to label the natural origin of the consumer product
- Replacement for other waxes is not profitable because of comparable price level
- Other waxes like Carnauba are more available on the international market

(according to personal communication with traders).

Quality monographs

Quality monographs for Candelilla wax are published for pharmaceutical use in the USP (United States Pharmacopoeia) and for food use in FCC (US Food Chemical Codex), FAO Additive-100 (Food & Agriculture Organization), Japans Food Monographs and Korea Food Additives Code. Comparison of the specification shows the narrow margins of quality parameters allowing only high grade Candelilla to be used for food and pharmaceutical purposes.

Monograph	Melting range	Solubility	Acid Value	Saponi-fication Value	Ester value	Infrared absorption	Heavy metals	Specific gravity	Impurities	Color
USP 32/NF 27	68.5 – 72.5°C		12-22	43 - 65		According reference	0,002% total, lead 3ppm			
FCC 5th ed	68.5 – 72.5°C		12-22	43 - 65		According reference	lead 3ppm	0.983		Yello-brown
FAO Additive-100	68.5 - 72.5°C	Insoluble in water; soluble in toluene	12-22	43 - 65		According reference standard	lead 2ppm			Yellowish-brown
Korea Food Additives Code	68 - 73°C		12.0 - 24.0	43 -65		According reference	40ppm, arsenic 4ppm		Residue after ignition 0.3%.	pale yellow, yellowish brown
Japan's Spe-cifications and Standards for Food Additives 2000	68-73°C		12-22	43-63	31-43	According reference standard	40ppm total, lead 10ppm, arsenic 4ppm		Residue after ignition 0.3%.	light yellow to brown

Therefore, Candelilla will not be easily substituted by other less expensive raw materials for manufacturing a certain high quality final product. Traditionally, the price of Candelilla wax had been 70 to 75 percent of Carnauba type (de Guzman 2002) but in 2008 price for Candelilla was quite similar to usual qualities of beeswax and Carnauba wax (personal communication with German trader).

Comparing quality parameters of the wax of Slipper Plant (*Pedilanthus pavonis*), also used as Candelilla wax in the past, demonstrates that this source may not really be used for high quality Candelilla wax.

Species	Melting range	Acid Value	Saponi-fication Value	Specific gravity
Pedilanthus pavonis	64-68°C	8-21	46-67	0,941-1,002

Candelilla wax from this plant source was found to be more resinous and with a lower melting range (Warth 1956).

Definition of the plant source

Shoot and flower of *Euphorbia antisyphilitica*
Source: Frank Vincentz, www.euphorbia.de

In 1832, the botanist J. G. Zuccarini described the Candelilla plant for the first time with the scientific name *Euphorbia antisyphilitica (this is the original spelling for the plant name)*, recognizing the medicinal properties of the plant juices as a remedy used by the natives of the region for treating veneric diseases.

A new classification of the Candelilla was presented in 1911 by G. Alcocer, who named it *Euphorbia cerifera*, highlighting the properties of the plant for making wax, which serves as a protective seal for the plant in retaining moisture.

***Euphorbia antisyphilitica* Zuccarini 1832** ("1829/30"), Abh. math.-phys. Cl. König. Bayer. Akad. Wiss. 10: 292 ("*Euphorbia antisyphilitica*")

= *Euphorbia cerifera* Alcocer 1911, Anales Inst. Méd.-Nac. México 11: 155.

≡ *Trichosterigma antisyphiliticum* (Zuccarini) Small, s. a.

≡ *Tirucallia antisyphilitica* (Zuccarini) P. V. Heath, 1996

This taxonomy follows Carter & Eggli (2003), the official CITES reference for succulent Euphorbia taxa. It also uses information from R. Govaerts, World Checklist of Selected Plant Families (http://www.kew.org/wcsp/), GRIN, the National Plant Germplasm System (http://www.ars-grin.gov/), and Mansfeld´s World Database of Agricultural and Horticultural Crops (http://mansfeld.ipk-gatersleben.de/).

Additional names of uncertain status:

? *Euphorbia rossiana* Pax 1910, Rep. spec. nov. VIII 10/16, p. 161-162

See http://bibdigital.rjb.csic.es/Imagenes/P0027_116/P0027_116_667.pdf

? *Euphorbia antisyphilitica* J. Meyrán 2000, Cact. Suc. Mex. 45(3): 68-70 (fig 1, tab. 1).

According to IPNI, the International Plant Names Index (http://www.ipni.org/), this species was described from the region of Tepatepec in the state of Hidalgo.

Other species with potential use as Candelilla

In the past several other plant species from the genus *Pedilanthus* were cited as source plants for Candelilla wax.

Actually, Candelilla wax is not commercially obtained from these species, but primarily from *Euphorbia antisyphilitica*, which has higher quality wax than *Pedilanthus* species. *Pedilanthus* plants offer lower wax yields, as well as lower melting points and a lower saponification value, compared to the wax produced from the plants of the Euphorbia species.

Because of quality reason (see specification of food grade Candelilla wax) it is unlikely that these species currently will be used for Candelilla wax production. Only during the World War II when the demand was increasing also *Pedilanthus* species were used for Candelilla wax production (Warth 1956)

Pedilanthus aphyllus Boiss. ex Klotzsch & Garcke

Syn: Tithymaloides aphyllum (Boiss.) Kuntze

Only one single record published. Steep hill slopes with much caliche outcrop, very alkaline, arid scrub, with giant barrel cacti and Euphorbs of multiple genera. 2.2 mile NE of San Antonio Texcala on Hwy 125.

No image available.

Pedilanthus pavonis (Klotzsch & Garcke) Boiss.

Syn: *Diadenaria pavonis* Klotzsch & Garcke

Pedilanthus bracteatus

Euphorbia bracteata

Life form and flower of *Pedilanthus pavonis*
Source: *http://www.smgrowers.com/products/plants/plantdisplay.asp?plant_id=3272*

Distribution: Native to dry deciduous woodlands in Mexico from Sonora to Guerrero and Colima.

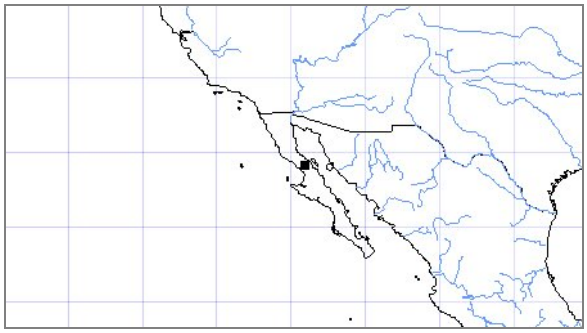
Pedilanthus macrocarpus Benth.

Syn: *Tithymalus macrocarpus* (Benth.) Croizat

Euphorbia lomelii V.W. Steinm.

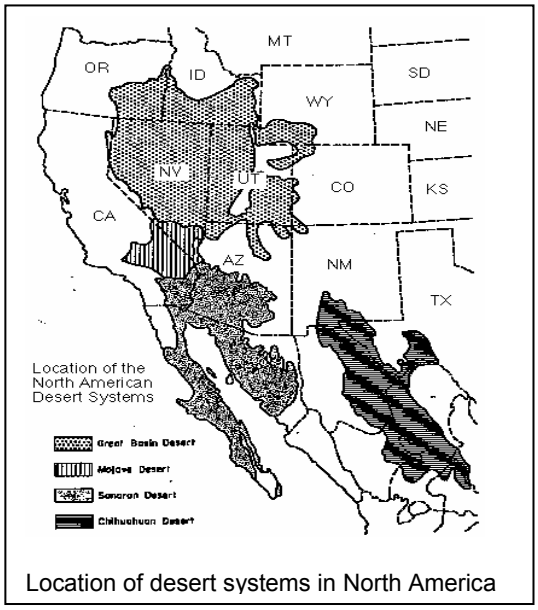
Life form and flower of *Pedilanthus macrocarpus*
Source: http://fireflyforest.net/firefly/2007/03/16/slipper-plant-or-Candelilla/, www.delange.org/SlipperPlant/SlipperPlant.htm

Distribution: Native to the Sonoran Desert of Baja California and Sonora, Mexico. Habitat is the Sonoran desert with dry and open bushland in the Central Gulf Coast section and Vizcaíno section of the vegetation map. It is a common ornamental plant in desert and xeriscape gardens in southern Arizona.

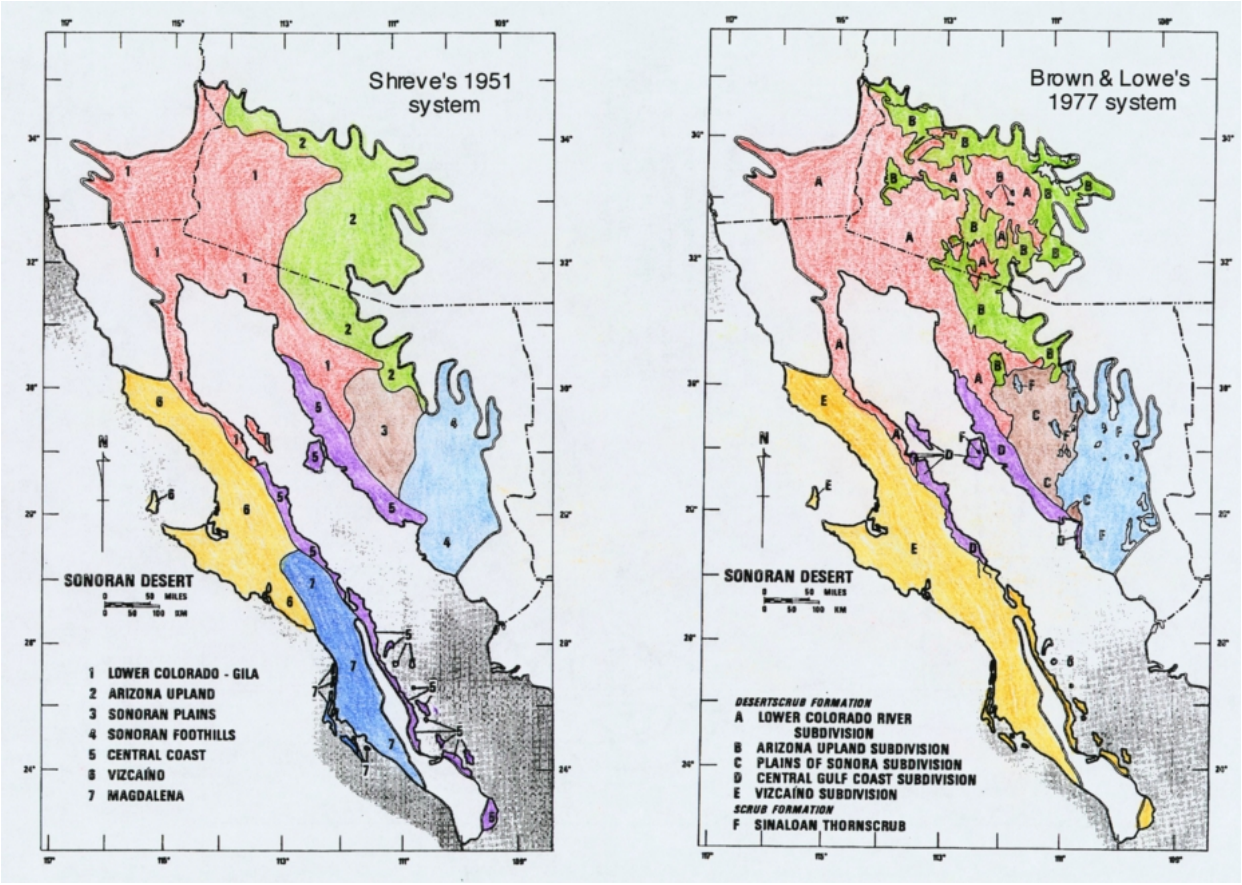


Map of distribution of *Pedilanthus macrocarpus* Benth.

Source: http://www.tropicos.org



Location of desert systems in North America



Types of desert formation in the Sonoran area, the habitat of *Pedilanthus macrocarpus*.
Source: http://instruct.uwo.ca/biology/320y/namdes.html

CANDELILLA – ORIGIN, DISTRIBUTION, PRODUCTION, AND SUSTAINABILITY

Candelilla wax is obtained from *Euphorbia antisyphilitica,* a wild plant that grows in zones of semi-arid climate and presents a succulent aspect, producing a milky latex typical for the Euphorbiaceas.

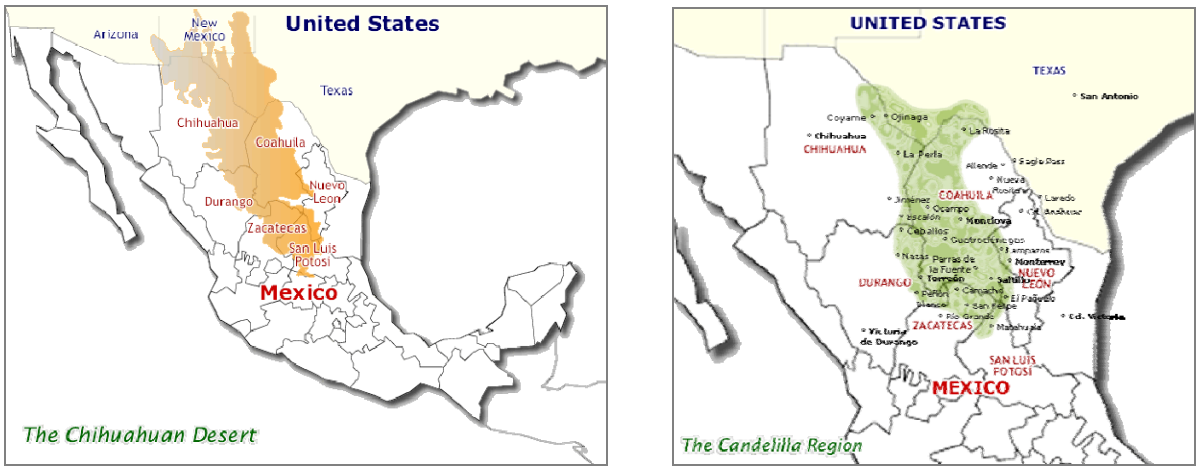
Plants grow in a narrow niche, limited to certain elevation levels and full exposure to sun. Occurrence is limited to the “Chihuahuan Desert” in northern Mexico and in USA in the southern states of New Mexico and Texas.

Typical habitat of *Euphorbia antisyphilitica* and life form of a flowering plant

Source: http://www.texasbeyondhistory.net and Wickipedia

Natural distribution area

The Candelilla plant grows almost exclusively in a semi-arid region of North America, known as "The Chihuahuan Desert". The major extension of this desert is located in Mexican territory and comprises regions of the Coahuila, Zacatecas, San Luis Potosi, Durango and Chihuahua states, extending its borders to the limits of Texas, New Mexico and Arizona in the United States.



Map of the Chihuahuan Desert and corresponding distribution map of Candelilla plants

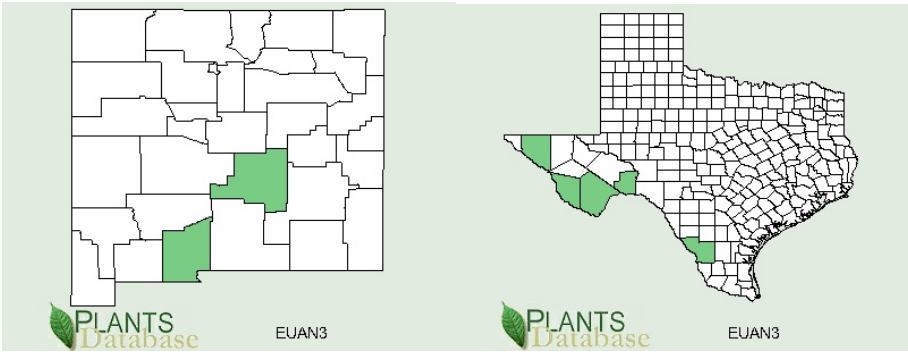
(Source: Candelilla Institute)

It is remarkable that the distribution area of the plant is not completely congruent with the area of the desert type, especially in its northern part.

The resource plant flourishes most abundantly in “Candelilla formations” at elevations between 400 and 1000 m on well-drained, south-facing limestone slopes.

In the USA *Euphorbia antisyphilitica* grows in areas of Trans-Pecos Texas such as Big Bend National Park, where hard frosts are rare (Bacon 2009). Probably in the USA there is the northern rim of distribution caused by

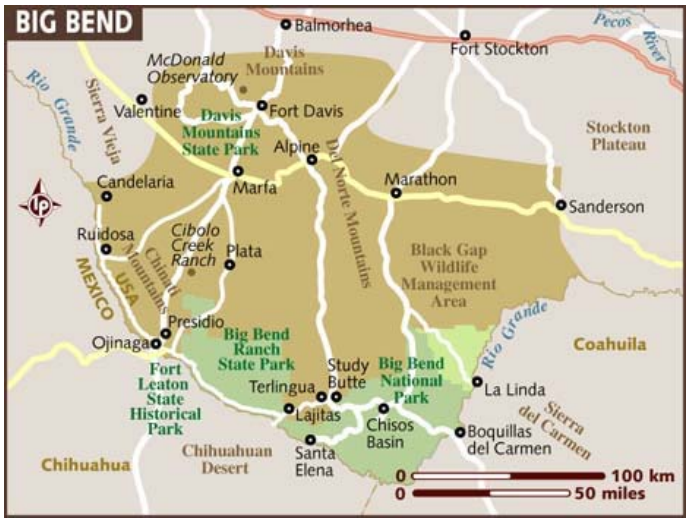
ecological factors, e.g. severe frost. Proof for this hypothesis is the disconnected occurrence in the states Texas and New Mexico. In New Mexico the species is regarded as endangered, a situation usually indicating such a borderline situation.



Detailed maps of distribution in the states of New Mexico (Dona Ana & Lincoln Counties) and Texas

(Source: USDA Plants Database)

Big Bend National Park, Texas, USA



Map of the Big Bend area in Texas and location of the Big Bend National Park

Source: US-NPS

Five ecological zones exist in Big Bend National Park: 1) River Flood Plains (550-1200 m), contains mostly broadleaf trees and shrubs. 2) Shrub Desert Formation (550-1050 m), mostly widely spaced succulents and semi-succulents and low growing shrubs. 3) Sotol Grassland Formation (1000-1600 m), characterized by many grasses and little open ground; most plants are low growing, but taller shrubs are more numerous here than in the shrub desert. 4) Woodland Formation (1100-2400 m), broadleaf and coniferous trees dominate this area. 5) Moist Chisos Woodland Formation (1500-2200 m), occurs at a few places in the higher elevation of Chisos canyons; contains “forest edge” (University of Texas at Dallas 2000).

The Candelilla plant is growing in lowland eroded plains of the Shrub Desert Formation in an elevation between 250–1400 m. Immediately beyond the trees lining the Rio Grande is an extremely arid zone where many unusual plants like Candelilla grow on the shallow soils of a limestone pavement (Deacon 2009).

It commonly grows in the lowlands on gravel slopes in limestone ledge areas like the Sierra del Carmen and Mesa de Anguila (see Big Bend National Park map).

Harvesting area

In Mexico, the location with the most important harvest are: Chihuahua, Coahuila, Durango, Zacatecas, Nuevo León, San Luis Potosí, Tamaulipas (Tecnologico de Monterrey 2004).

Production of Candelilla in the USA

In the past Candelilla wax plant was probably the most widely used species of the vegetation in the Big Bend. After establishment of the National Park in 1944, wax production was an important business in the early days of the park (University of Texas at Dallas 2000).

Already in 1914, C. D. Wood and Mr. W. K. Ellis built a factory near Glenn Spring to produce Candelilla wax. In the night of May 5, 1916, Mexican bandits attacked Glenn Spring, the major buildings partially burned and much of the wax factory was destroyed (http://www.nps.gov/bibe/historyculture/glsp.htm). A small Candelilla wax-rendering operation at Glenn Springs survived until the 1940s. The remains of old Candelilla wax-rendering operations are seen throughout the Big Bend. Several of these are still present in the Big Bend National Park but are not now in operation (Texas Bureau of Economic 1968).

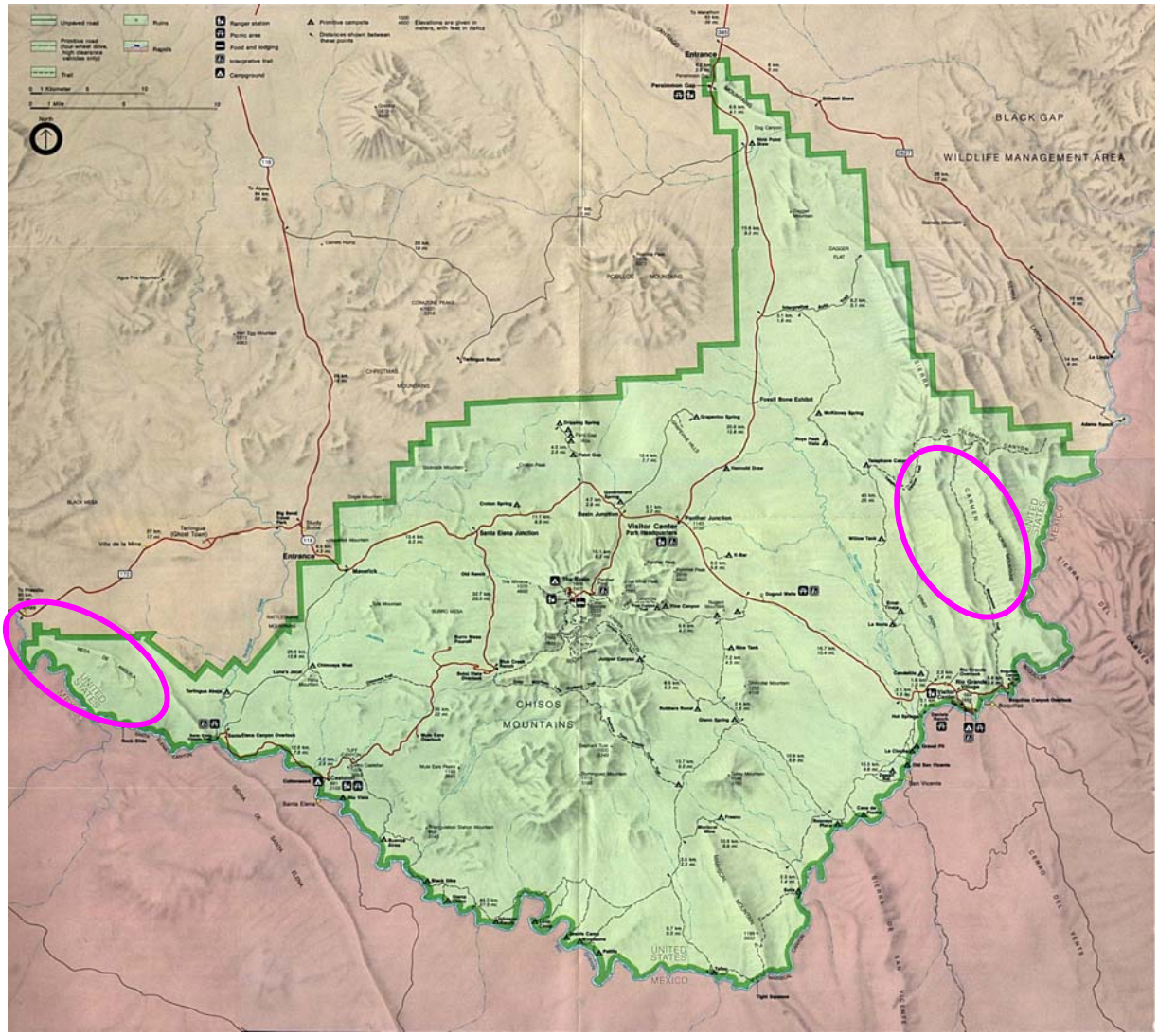
Because the price of Candelilla wax was low, the harvesting and processing activities have been greatly curtailed in Texas in 1967 (Texas Bureau of Economic 1968). In addition, production in Texas is limited to the fact that most Candelilla plants in the State grow within the boundaries of the Big Bend National Park and so are not available to the wax producers (Hodge 1956).

Smuggling

As result of the decree of Mexican authorities from 1947 prohibiting production of Candelilla wax in Mexico the wax has been smuggled from Mexico into USA. There has been an increased collection of the plant on Mexican territory adjacent to the frontier and even in the Big Bend area. The subsequent processing took place in extraction camps located just over the border in Texas (Hodge 1956).

“In April of 1966 First Lady Mrs. Johnson visited Big Bend National Park. Four Mexican nationals standing in the shade of riverbank trees shouted greetings to the First Lady passing by boat. Unknown to Mrs. Johnson, the foursome concealed a stack of Candelilla bundles to smuggle across the river” (National Park Service).

In these days, the gatherers commonly forded the river and gathered weed indiscriminately in Texas and Mexico, taking no particular note of ranch or park boundaries unless forced to do so. The National Park Service increased efforts to control illegal harvesting of Candelilla in Big Bend National Park (University of Texas at Austin 2004).



Detailed map of the Big Bend National Park and the Candelilla areas

in the Sierra del Carmen and Mesa de Anguila marked

Source: http://www.nps.gov

Harvesting technique

Well trained collectors usually pull up Candelilla plants by hand thus avoiding contact with the toxic and caustic latex of the plant. Contact with the milky latex only will be possible if the plant is cut off. So collectors harvest intact entire aboveground parts of the plants with small roots as can be seen in the picture of Candelilla plant bundles. The bundles are transported to processing sites on the back of “burros” (mule). Collecting sites are located in distances of up to 35 km away from the collectors’ villages (Barsch 2004). For this reason and due to the necessity of rivers or sufficient water supply for processing only limited portion of the total resource are that fulfil these conditions can be used. Approximately 3/4 of the available area especially in remote areas will remain untouched.

Bundles of harvested Candelilla plants ready for transport to processing.

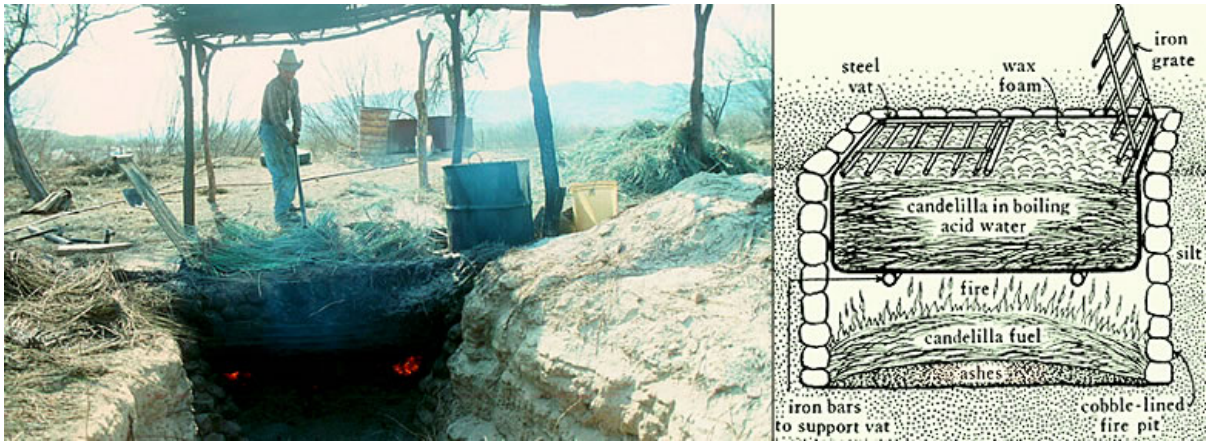
Attend to the remaining root at the entire plant.

Source: University of Texas at Austin 2004

Processing of Candelilla wax

"During the past 100 years two factors have remained virtually unchanged: The production process for making Candelilla wax and the conditions of extreme poverty of the inhabitants of the Candelilla Region" (cited after http://www.Candelilla.org/d-tecnologico.htm).

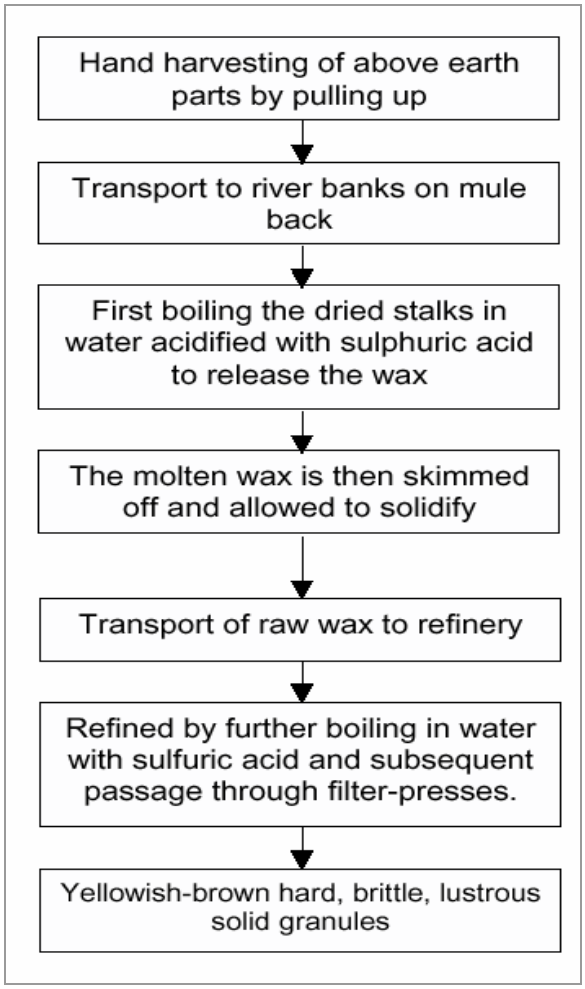
After harvesting the starting point of processing is the first boiling of Candelilla plants.



Aspect of the processing vat for first boiling and schematic diagram

Source: University of Texas at Austin 2004

The following chart shows a schematic summary of the production process as drafted by the author from different information sources.



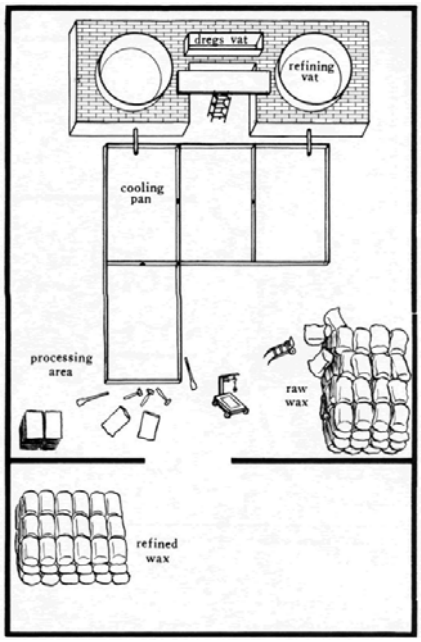
Flow chart of the processing of Candelilla wax

The vat is charged with as much as 500 pounds (= 226 kg) of weed to get twelve pounds (= 5,5 kg) of wax from each vatload of weed. Since 30 minutes are spent on each vat load, 240 pounds (= 108 kg) of wax may be produced in a ten-hour shift. The raw wax yield is about 1.5 to 2.5 percent of plant weight. Raw wax skimmed off the vat has about 10 percent dirt and water mixed up.

Refining process

In special refining factories the raw wax will be cleaned and further processed. About 2500 kg of “cerote” (name for Candelilla wax by local Mexican people) is placed in each refining vat with about 3 m of water in the bottom (University of Texas at Austin 2004). Today also filter devices are used to refine the melted wax before pouring it in the cooling pan.

Recent efforts to enhance the yield of wax obtained from the same quantity of plant material by using advanced solvent extraction methods resulted in twice as much wax compared to the actual boiling process (Campos-Lopez 1980). Also physical appearance of the product improves noticeable. So technological process development is also one of the aims of the Candelilla Institute to enhance wax yield.



Casner wax-refining plant in Alpine, as it appeared in 1976. Source:

Usually a refined wax is traded for use in consumer products. It is just nearly pure wax. For details refer to chapter “trade figures”.

Different forms of traded refined Candelilla wax

Source: Candelilla Institute

Sustainability

Situation in Mexico – the source area

Available plant material

In Mexico wild collection of Candelilla takes place in the States of Durango, Zacatecas, Chihuahua, Nuevo León, San Luis Potosí, Tamaulipas, and Coahuila. The latter State is the most important concerning area and production. 80% of Candelilla produced in Mexico is harvested in Coahuila. The total area covered with Euphorbia antisyphilitica in Mexico is about 630 500 ha with a potential annual yield of wax of 15 000 tons (= 24 kg wax per ha). But only 152 520 ha, corresponding to 25%, actually are harvested. About 16 000 families in the collecting areas benefit from harvesting wax. (Proyecto CONAFOR 2005).

Estimates provided by University of Texas at Austin (2004) present other figures: About 4 tons of the plant can be harvested per hectare (= 80 kg wax per ha) where it grows abundantly, far less in most harvest areas. Since primitive wax-extraction methods produce a yield of only about 2 percent of plant weight, the refiner who marketed approx. 450 to 500 tons of wax in a good year was representing exploitation of about 25 000 tons of wild plants from about 6 000 ha of desert. Twice that quantity of wax may be exported annually from Mexico to the USA, representing an area of as much as 12 000 ha of desert with Candelilla populations. Can any desert species survive this magnitude of exploitation? Apparently Candelilla has done fairly well, because wax production continues after more than seventy years.

Public efforts

Already at the beginning of the 1990s the Mexican government tried to establish a certain form of replanting of Candelilla plants in the range area and to evaluate the success of these measures (Tovar Villa 1992, De la Garca de la Peña 1993).

Mexico's Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias (INIFAP) conducted *in-situ* regeneration experiments. The recolonisation of harvested areas through seed dispersal yielded 28 kg of wax per hectare. Comparative studies showed that the yield can be increased up to 252 kg per hectare by vegetative propagation through cuttings. The findings of these studies resulted in the development of management rules to ensure the conservation of the populations (ZAMORA & TORRES 2001).

CONAFOR, the Comisión Nacional Forestal of Mexico has installed a system of plantations of non timber forest products also including Candelilla (CONAFOR 2007) and transplanted a greater amount (some ten million) of vegetative propagated material especially to the dry areas (CONAFOR 2008). This information of Mexican authorities on the management of the resource Candelilla plants demonstrate an example for efforts of sustainable use in semi-wild populations (Schneider 1997).

Private initiative

In Mexico an organisation called "Candelilla Institute" is working toward sustainability of Candelilla production, supported by its technological associates and government agencies which are committed to the economic and social development of the Candelilla region. The following projects for sustainable development have been defined as an essential part of the integral program being carried out by the Candelilla Institute:

- Analysis of the Candelilla plant inventory, cultivation programs and efficient exploitation techniques, with an aim to guarantee the survival and conservation of the Candelilla plant.
- Implementation of economic and social programs which will permit an improved livelihood of the inhabitants of the Candelilla region.

Regeneration of the resource and ecological data

An important ecological adaptation of succulents in arid regions is their ability of vegetative propagation. Fragments of the stems will root and establish new plants. Some plants even can disperse by means of this clonal fragmentation.

With *Euphorbia antisyphilitica* the main root of the mother usually will not be destroyed if divided or if the above ground plant is damaged or removed during harvesting. Some authors assume that the root caudex is produced in seedlings only, not in cuttings (Vincentz 2006).

When harvested, the plant is pulled out (plant, roots, rock, and all), but normally there are enough roots left in the ground for regrowth.

Plants can be dug up and kept for long periods of time, and, even after the stems have become longitudinally wrinkled, the plant will recover when replanted in the soil. When cut or broken, the stems "bleed" a white, milky substance, and, if the plants are harvested by cutting, the root systems will die (University of Texas at Austin 2004).

Underground caudex of *Euphorbia antisyphilitica*

Candelilla plants reproduce vegetatively from their roots, giving them an important advantage after harvest activities, they regenerate within a few years (Bacon 2009). The plants need two to five years of growth before they produce significant amounts of wax. The estimates how long it takes for Candelilla to regrow in an area that has been intensively harvested, range from five years to fifty years. It is said that after a first harvesting the Candelilla will return in some abundance in two years; after a second harvesting it takes about five years for Candelilla to come back; and after a third harvesting it might take ten years for there to be enough plants for economical harvesting. Some publication even estimated that a third harvest is possible not until in about 20 years (Texas Bureau of Economic Geology 1968).

In some areas of northern Mexico Candelilla populations have been depleted through overexploitation (University of Texas at Austin 2004). This occurred especially in some of the communal areas, called "Ejidos", where the resource was over-harvested and the production subsequently reduced (personal communication with Mexican producer).

The summer of 1980 was unusually hot and dry and many desert plant species such as *Agave lechuguilla* (Lechuguilla) and *Yucca gloriosa* (Spanish dagger) suffered from desiccation, while Candelilla seemed to suffer very little damage (University of Texas at Austin 2004).

A month of heavy rains that afflicted the normally arid areas of northern Mexico in 1998 was followed by a supply shortage. Although the rains have enhanced plant growth, crop harvesting and wax collection have been hampered. When fields are flooded, it is obviously difficult for farmers to get to the crop and also preparing the wax near the flooded river plains will be difficult (Papanikolaw 1998).

Cultivation

No official data are available on the volumes of existing cultivation of *Euphorbia antisyphilitica* in Mexico for production of Candelilla wax.

However, *Euphorbia antisyphilitica* can easily be cultivated as known from cultivation of ornamentals. In the dry areas of the USA the plant is used as an ornamental in xeriscapes for garden use. One may propagate the plant by seed or cuttings taken any time during the growing season. Although plants require little maintenance once established, they do require water during the growing season, late summer and early fall like in the Chihuahuan Desert (Bacon 2009).

Also *in vitro* micropropagation of *Euphorbia antisyphilitica* from shoot explants was induced and fully rooted plants were transferred to potting soil and established under greenhouse conditions (Jakobek 1986).

In India scientific research was done to introduce the plant for fuel production and to establish methods for cultivation (Mehrotra 1992), but no further data are available on the success of these trials.

An obstacle for economic cultivation outside arid areas may be the lack of wax production. A common belief is that more wax forms during droughts than in wet years. This may be true, for it has been observed that in the Austin area of Central Texas, where the normal rainfall is about three times as great as that of West Texas, the plant grows but produces very little wax (Texas Bureau of Economic Geology 1968).

Since the beginning of the 1990s there were efforts of the Mexican government to establish a certain form of re-planting of Candelilla plants in the arid range area. Elaborated handbooks explaining Candelilla plant propagation, proper transplanting of the cuttings and how to evaluate the success of this measures are available (Tovar Villa 1992, De la Garca de la Peña 1993)

The Mexican forest authority is still today trying to propagate Candelilla in their reforestation program and in 2008 already some ten millions of vegetatively propagated *Euphorbia antisyphilitica* plants were transplanted to suitable areas (CONAFOR 2008). Some of the harvesting plots in the production areas more look like defined plantations than wild collecting areas (personal communication of a German importer).

This type of management of the resource Candelilla plants demonstrate another example for efforts of sustainable use in semi-wild populations (Schneider 1997).

Recently there is a trend for organically grown plant material also in the cosmetic business. To follow the trend there are some efforts made in Mexico to establish organic plantations or organic wild collection of *Euphorbia antisyphilitica* (personal communication with traders).

TRADE FIGURES FOR CANDELILLA WAX

History of Trade

First record of commercialization of this natural resource was as early as 1909 (Tropenpflanzer 1909,1911). Already at this time the quality of the wax was tested (Hare 1910). The plant source was defined as *Euphorbia antisyphilitica* and the quality parameters were quite similar to those in modern monographs.

Due to the promotional efforts of a Mexican producers' organization and the increased demand for waxes brought on by World War II the destructive exploitation of Candelilla plants has threatened the species. As a result Mexican authorities prohibited the production of Canelilla wax between 1947 and 1954 (Hodge 1956).

Production and export from Mexico to the USA (Hodge 1956):

Year	Quantity (metric tons, MT)
1936	818
1946	4935
1955	3629

Main use in the USA in 1955 was for manufacturing of coating and polish (2269 tons/year) and for chewing-gum (1360 tons/year; Hodge 1956).

In 1974 the harvest of Candelilla wax in Mexico with 3000 tons exceeded the sales on the international market. USA at that time imported 1200 tons and all other countries 600 tons. The local market for Candelilla in Mexico had a volume of 600 tons and was used for chewing-gum and the production of carbon paper. In 1977 production was reduced to 1500 tons and demand outbalanced the bid (Illmann 1979). This information is of importance because the author was affiliated with Hoechst AG and the company applied for a Mexican patent in 1975 to improve the extraction procedure for Candelilla wax (Brotz 1975). But the efforts seem to have terminated shortly after because in 1979 Canelilla wax, although of unique properties, was seen as too expensive for a broader use and therefore considered of limited use in niche markets (Illmann 1979).

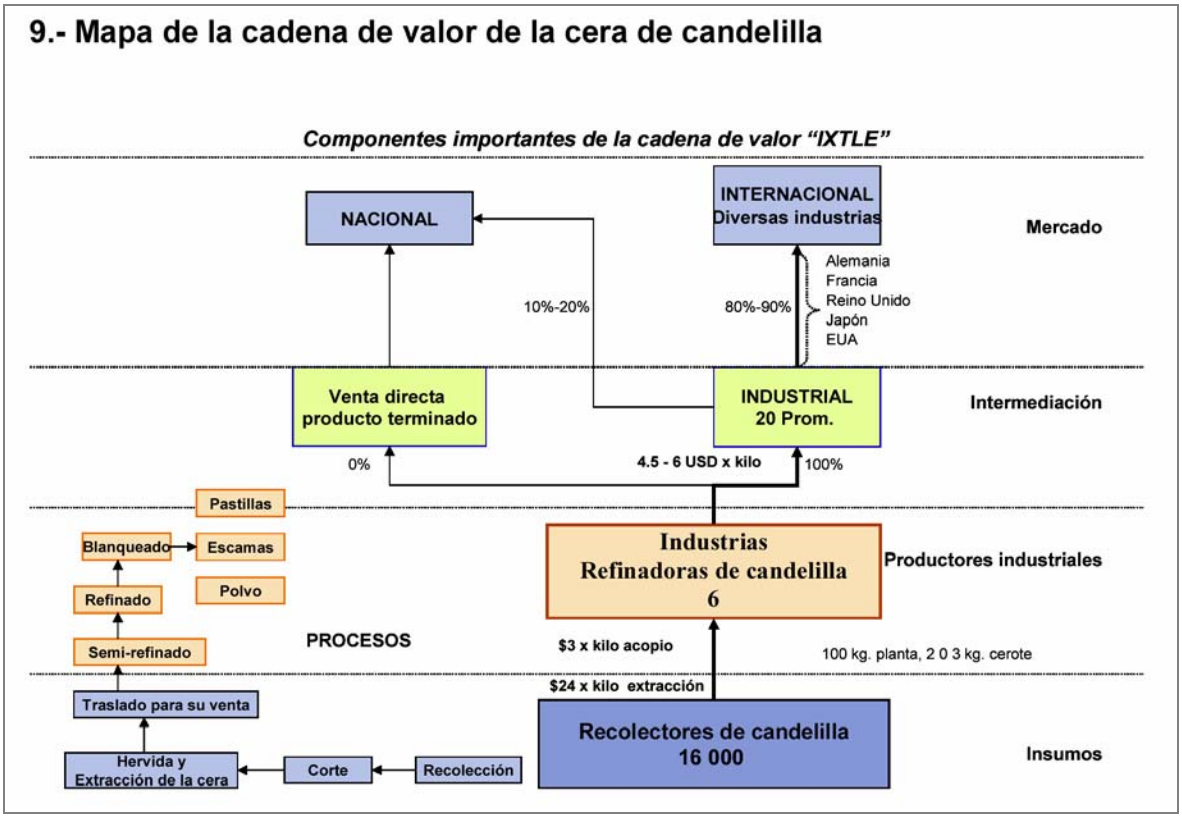
Current trade figures

In this chapter the structure of current Candelilla trade is outlined. Mexico was identified as the only country of export for raw material. Main countries of import, commodities traded and the magnitude of imports for these countries are presented. Data on typical size of consignments and the frequency of trade transactions were investigated through interviews with traders.

Situation in Mexico

Regarding the question whether Candelilla wax is exported from Mexico only as raw material or also as finished products, we can state that no official information is available that final products containing Candelilla wax like lipsticks are presently exported from Mexico. At the moment only raw material seems to be exported from Mexico.

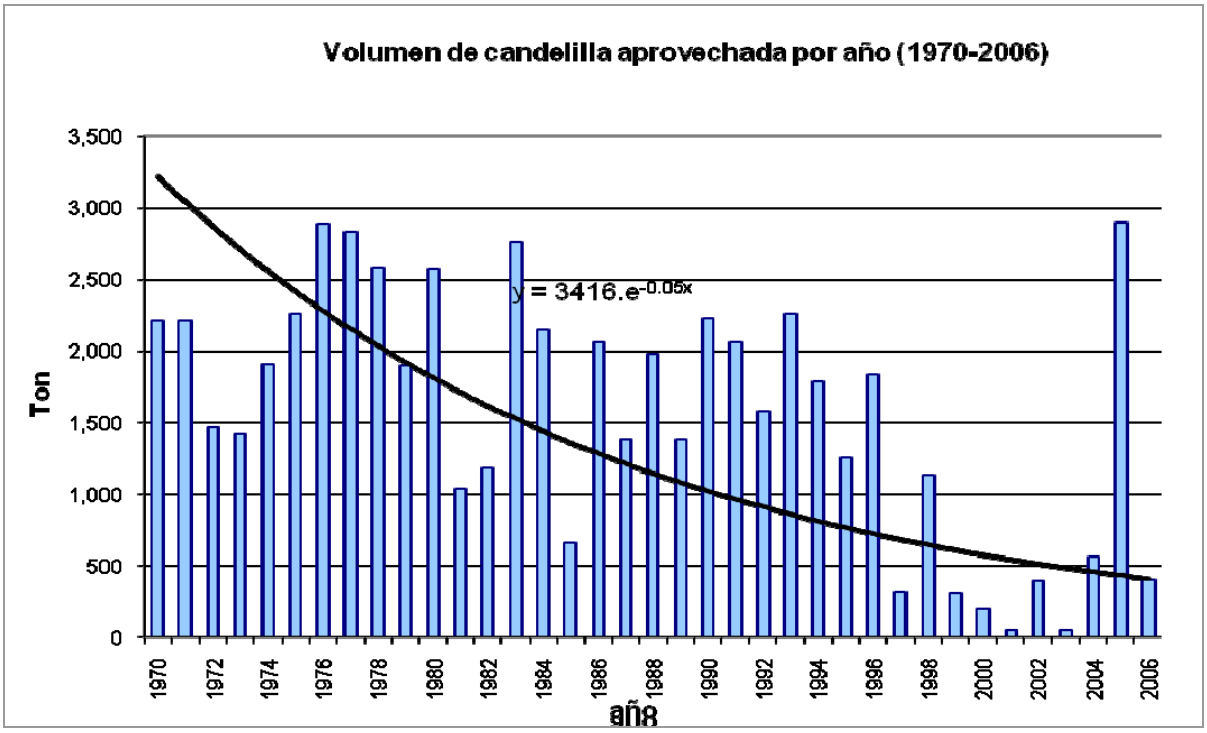
The following diagram shows the flow of Candelilla wax in Mexico and for export as it is seen by the Mexican stakeholders.



Flow chart of Candelilla wax market inside Mexico from the collectors at the bottom up to exporters

(Proyecto CONAFOR 2005)

Also data are available from Mexican authorities on the quantity of Candelilla wax harvested annually (1970-2006).



Volume of Candelilla wax annually produced in Mexico between 1976 and 2006

Source: Anuarios de la Producción Forestal. SARH, SEMARNAP, SEMARNAT

(Martin Vargas Prieto, Director-General of Wildlife, Letter to the European Commission 2008)

Data in this chart for the 2000s seem inconsistent compared to export data and production rates published by other sources. The export volume in the last years was app. 1000 tons per year. The decrease in production from the beginning of 2000 onward remains to be explaioned. Low yield only may be explained for 1998/1999 due to bad weather conditions (see chapter “Response to ecological conditions”).

Collectors

The estimated number of collectors range between 8 500 and 16 000. They are selling to about 260 small scale traders in the collecting areas. People in the States of Durango, Zacatecas, Chihuahua, Nuevo León, San Luis Potosí, Tamaulipas and especially in Coahuila benefit from harvesting wax. (Proyecto CONAFOR 2005, Barsch 2004).

Availability of labor needed for the harvesting of the wax continues to dwindle. With increasing industrial development and urbanization near the Candelilla production region the industry must struggle to hire a rural work force for collecting the wax. The labor situation has pressured Candelilla wax prices to slightly increase in the past few years (de Guzman 2002).

Refiners and Traders

Beside some others, there are 3 main stakeholders in the Mexican market:

- Ceras Naturales Mexicanas, S.A. de C.V. (Cenamex) is the best known and important harvesting and exploiting company in Mexico.
- Pronamex (Producción Natural Mexicana S.A de C.V) is the most important Mexican production and export company (Tecnologico de Monterrey 2004)
- Multiceras SA also is an important company in the business. It is developing new special qualities of Candelilla for certain applications and is doing research for customers to develop new products. The company is not strictly limited to Candelilla, but also trades with other waxes and chemicals. In 1998 the company conducted a study to assess the resources of Candelilla to make decisions for the future of this business part (Papanikolaw 1998).

In the national market of Mexico about 10% of the Candelilla wax harvested is mainly used for manufacturing floor waxes, mixed with paraffin and stearin for producing candles and matches, and mixed with rubber and gutta-percha for covering electrical wires (personal communication with Alejandra García-Naranjo, CONABIO, Mexico).

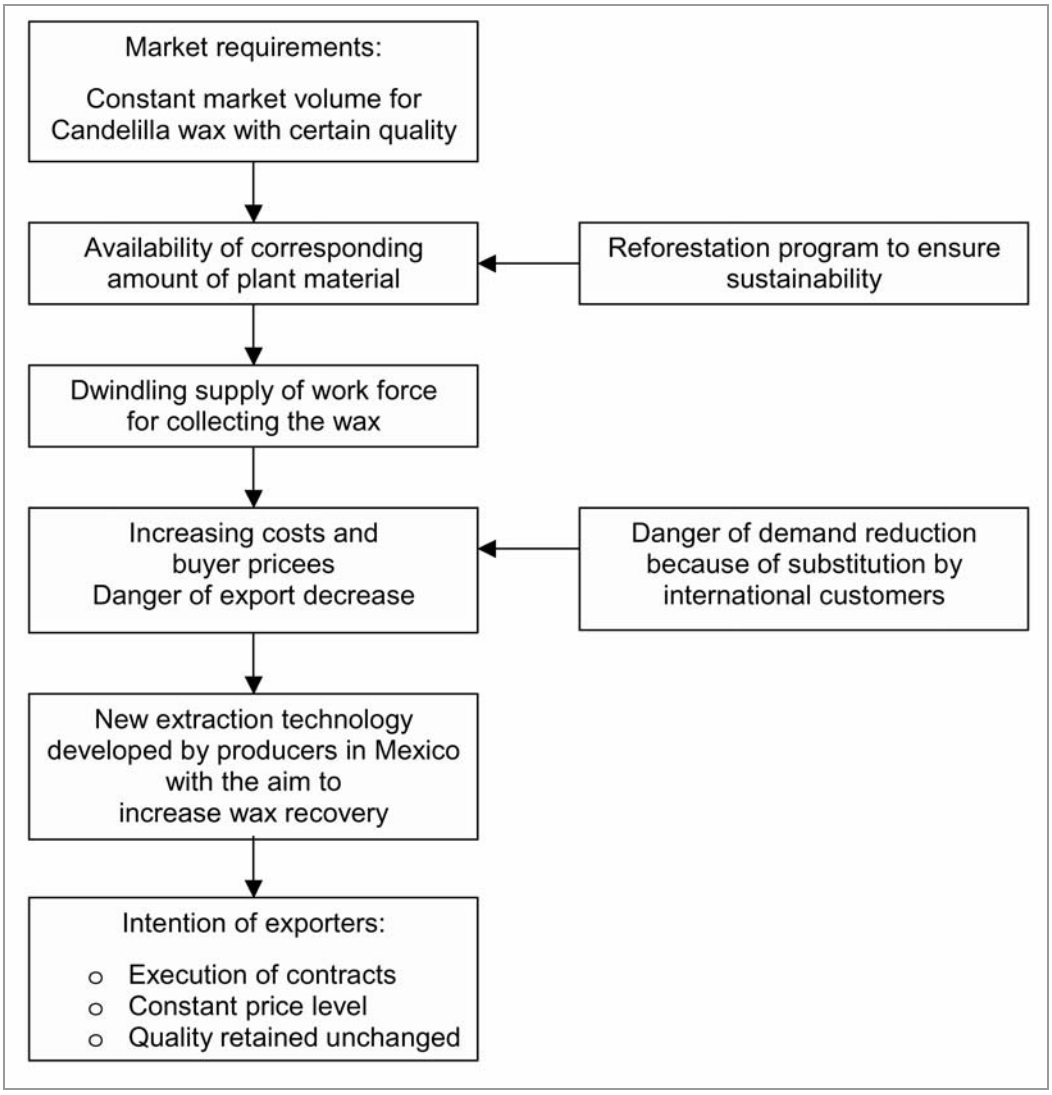
Only one intermediate product developed and manufactured in Mexico could be identified. A special formulation named Candeuba®, developed by the Mexican company Multiceras, is constituted mainly by Candelilla wax and synthetic esters of vegetable origin, which are supplemented by homopolymers of intermediate molecular weight. Candeuba® presents a chemical composition ranging between Candelilla wax and Carnauba wax, holding equilibrium between the natural hydrocarbon fraction of Candelilla wax and the esters content characteristic of Carnauba wax as demonstrated by the data in the following table (Multiceras 2009).

Candelilla		Candeuba®	Carnauba	
Component	% Weight	% Weight	% Weight	Component
Hydrocarbon	50-57	30-34	1.5-3.0	Hydrocarbon
Esters	28-29	61-62	84-85	Esters
Alcohols, sterols and resins	12-14	7.2-8.4	6-9	Alcohols and resins
Free acids	7-9	4.2-5.4	3.3-5.0	Free acids
Humidity	0.5-1.0	0-0.2	0.5-1.5	Humidity
Inorganic residues	0.7	0.42	1.0	Inorganic residues

Chemical Composition of the brand intermediate product Candeuba®
Source: http://www.multiceras.com/acweb/index.php?aid=28

Market action in Mexico – obstacles and approaches

As a summary from different information sources the market situation in Mexico is outlined in the following flow chart drafted by the author.



Flow chart of obstacles and approaches of the market action in Mexico

Export volume from Mexico

During 2003, Mexico exported 2.5 million pounds (= 1132 tons) of Candelilla wax to different countries worldwide, showing an increase of 30% compared to exports of this product in 2002 (= 878 tons).

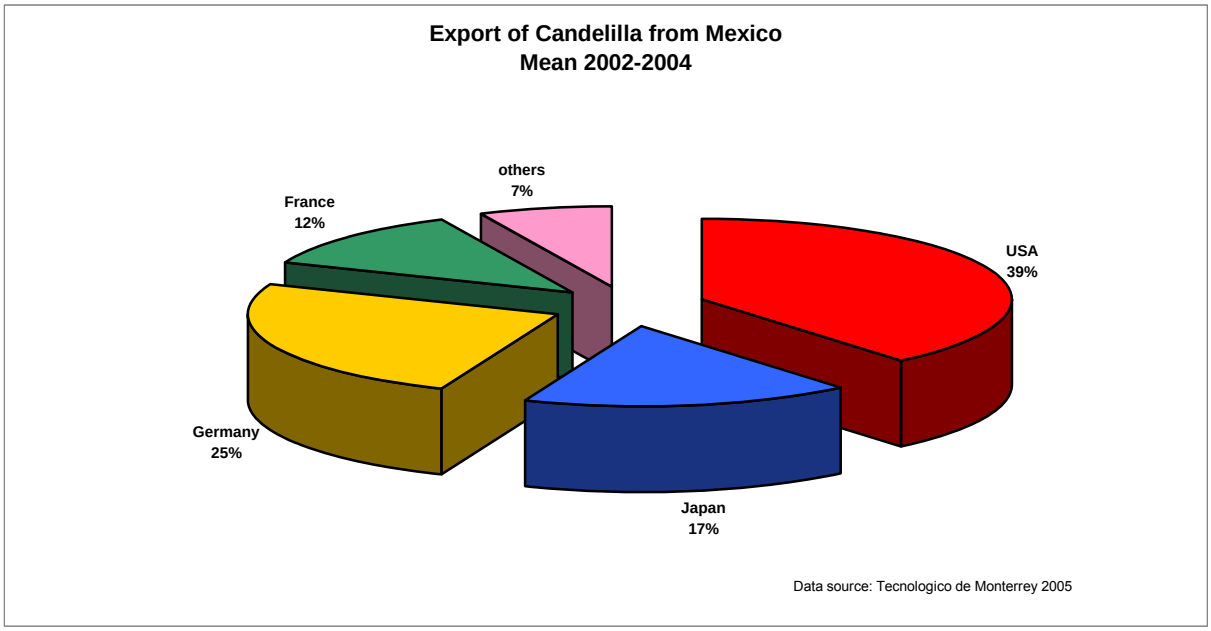
Year	Quantity (metric tons)
1999	309
2002	878
2003	1,132

(Tecnologico de Monterrey 2004)

Cross-check with the import data below shows that these figures from Mexico are plausible.

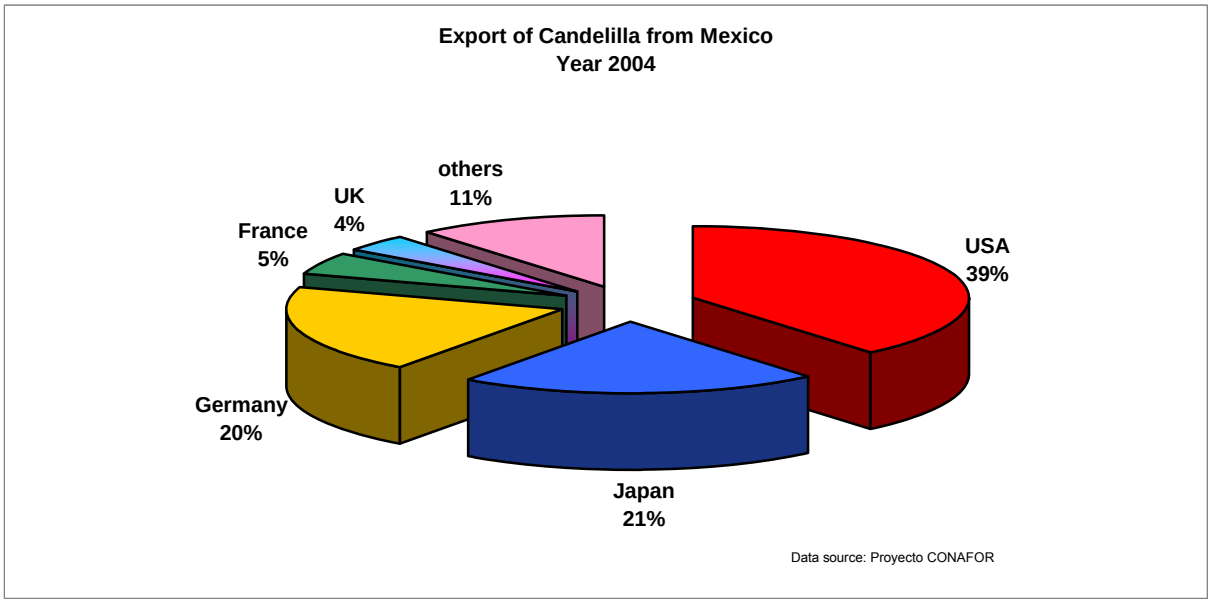
According to data from 2004, about 60-80 % (according to current estimates even 90%) of the Mexican production (in total up to 3,000 tons/year) are exported. Import in the USA are estimated with 1,000 tons/year and the European Union with ca. 350 tons/year. Total import volume to Germany in 2002 is approx. 200 tons/year (Barsch 2004).

Breakdown of export data from Mexico to other countries are available for the period 2002-2004.



Percentage of distribution of Candelilla exports from Mexico (mean 2002-2004)
(Tecnologico de Monterrey 2005)

These average data may be compared to the single year data for 2004, demonstrating the fluctuation between average value and a single year (Proyecto CONAFOR 2005).

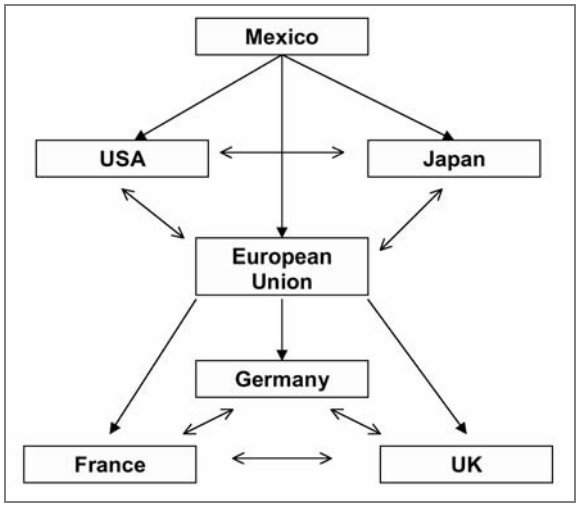


Percentage of distribution of Candelilla exports from Mexico in 2004
(Proyecto CONAFOR 2005)

International trade figures

Main consumers of Candelilla wax are the USA, Japan, Germany, France and the United Kingdom. These five countries demanded over 96% of the total Candelilla wax exports from Mexico (data for 2003, Candelilla Institute).

The international market for Candelilla currently is mainly inside and between the European Union, USA and Japan. Refined wax and final products are traded from there to other countries all over the world.



Flow chart of the international market for Candelilla wax as reasoned by the author

Usual commodities exported from Mexico are the refined wax but also crude wax to be refined for special purposes in the importing country. Typical size of consignments is the container with 18 tons. Frequency of trade transactions is depending on respective offers by Mexican producers and price situation (personal communication with traders).

It is a well known problem that official data of export and import statistics often are inconsistent and some times even contradictory because of incomplete availability of data and irreproducible data preparation (personal communication with traders). For this reason the import and export data in this survey demonstrate some discrepancy and only overall plausibility can be estimated.

Gross export trade of *Euphorbia antisyphilitica*

Taxon	Term	Unit	Country	2000	2001	2002	2003	2004	2005	2006	2007
Euphorbia resinifera	derivatives	g	DE	0	0	0	0	0	0	0	0
Euphorbia resinifera	extract	g	DE	0	0	0	0	0	0	0	0
Euphorbia resinifera	extract	kg	DE	0	0	0	10	2	0	0	0
Euphorbia resinifera	extract	kg	MA	0	0	50	50	12	0	25	0
Euphorbia resinifera	extract	l	MA	0	0	0	50	0	0	0	0
Euphorbia resinifera	live		AT	0	84	59	0	0	0	0	0
Euphorbia resinifera	live		BE	0	0	0	12	0	0	0	0
Euphorbia resinifera	live		CN	0	0	0	0	960	0	0	0
Euphorbia resinifera	live		DE	0	0	0	10	10	0	0	0
Euphorbia resinifera	live		ES	347	2995	0	0	0	0	0	0
Euphorbia resinifera	live		FR	0	0	0	0	0	92	0	0
Euphorbia resinifera	live		IT	0	10	0	10	0	20	0	0
Euphorbia resinifera	live		MA	0	0	0	0	4	0	0	0
Euphorbia resinifera	live		MC	0	0	0	0	1	0	0	0
Euphorbia resinifera	live		MX	0	0	0	0	0	1	0	0
Euphorbia resinifera	live		NL	0	0	3614	0	0	1197	0	0
Euphorbia resinifera	live		TH	0	0	0	0	5	0	0	0
Euphorbia resinifera	live		ZA	0	0	0	0	0	0	0	38
Euphorbia resinifera	stems		ZA	0	0	0	0	1	0	0	0

Source UNEP-WCMC CITES Trade Database

Gross import trade of *Euphorbia antisyphilitica*

Taxon	Term	Unit	Country	2000	2001	2002	2003	2004	2005	2006	2007
Euphorbia resinifera	derivatives	g	AU	0	0	0	0	0	0	0	0
Euphorbia resinifera	extract	g	AU	0	0	0	0	0	0	0	0
Euphorbia resinifera	extract	kg	CH	0	0	0	10	0	0	0	0
Euphorbia resinifera	extract	kg	DE	0	0	50	50	0	0	25	0
Euphorbia resinifera	extract	kg	US	0	0	0	0	12	0	0	0
Euphorbia resinifera	extract	kg	ZA	0	0	0	0	2	0	0	0
Euphorbia resinifera	extract	l	IT	0	0	0	50	0	0	0	0
Euphorbia resinifera	live		CH	320	3079	59	10	10	1309	0	0
Euphorbia resinifera	live		CZ	27	0	0	0	0	0	0	0
Euphorbia resinifera	live		DE	0	0	0	0	0	0	0	38
Euphorbia resinifera	live		FR	0	0	0	0	1	0	0	0
Euphorbia resinifera	live		IS	0	0	0	4	0	0	0	0
Euphorbia resinifera	live		JP	0	0	0	0	965	0	0	0
Euphorbia resinifera	live		MT	0	10	0	10	0	0	0	0
Euphorbia resinifera	live		NO	0	0	0	8	0	0	0	0
Euphorbia resinifera	live		SI	0	0	3614	0	0	0	0	0
Euphorbia resinifera	live		US	0	0	0	0	4	1	0	0
Euphorbia resinifera	stems		NA	0	0	0	0	1	0	0	0

Source UNEP-WCMC CITES Trade Database

The UNEP-WCMC CITES Trade Database is mostly listing living plants of *Euphorbia antisyphilitica* and only a small amount of extracts and wax imports and exports are covered compared to the data in foreign trade figures presented in this study. Living plants usually are traded for plant lovers and gardeners and will not be used for Candelilla wax production.

Import into the European Union

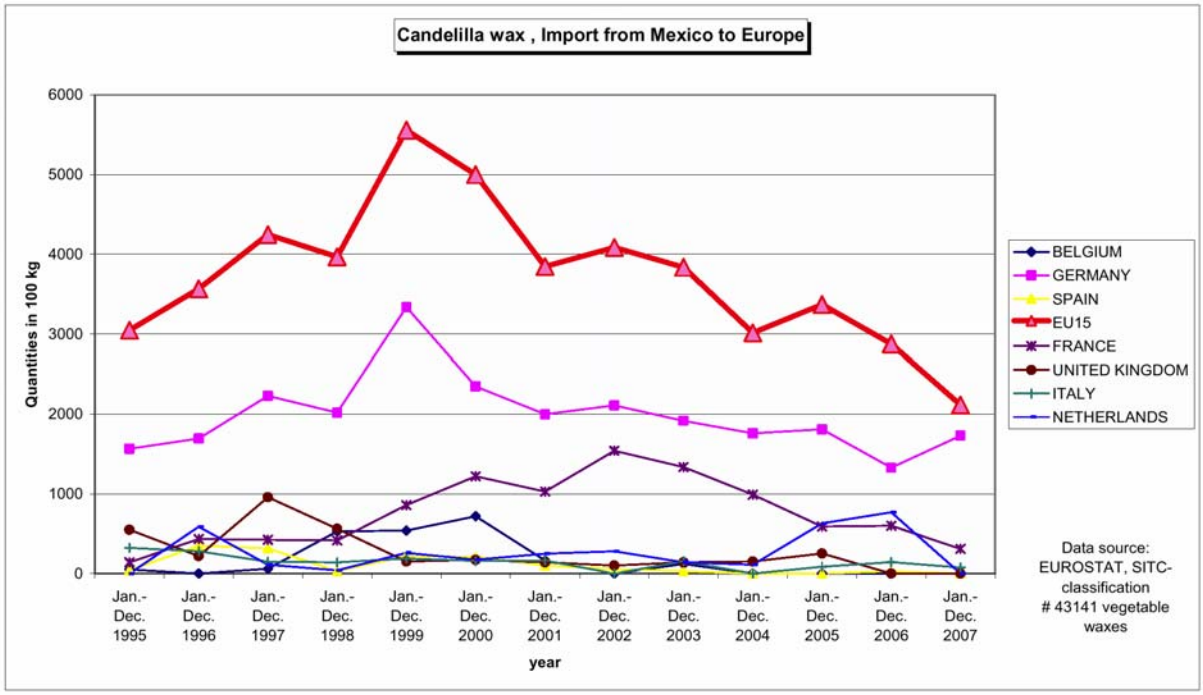
Main trade in Candelilla wax inside the EU takes place between Germany, France, the BeNeLux countries and UK. Data for import to the European Community are available at EUROSTAT for the last decade.

To generate trade data for Candelilla wax it is important to be aware that Foreign Trade Statistics use different digit systems for vegetable waxes.

HS Number	HS Description	SITC3	SIC
1521100000	Vegetable waxes (other than triglycerides)	SITC-43141	SIC-2899

Digit systems of Foreign Trade Statistics

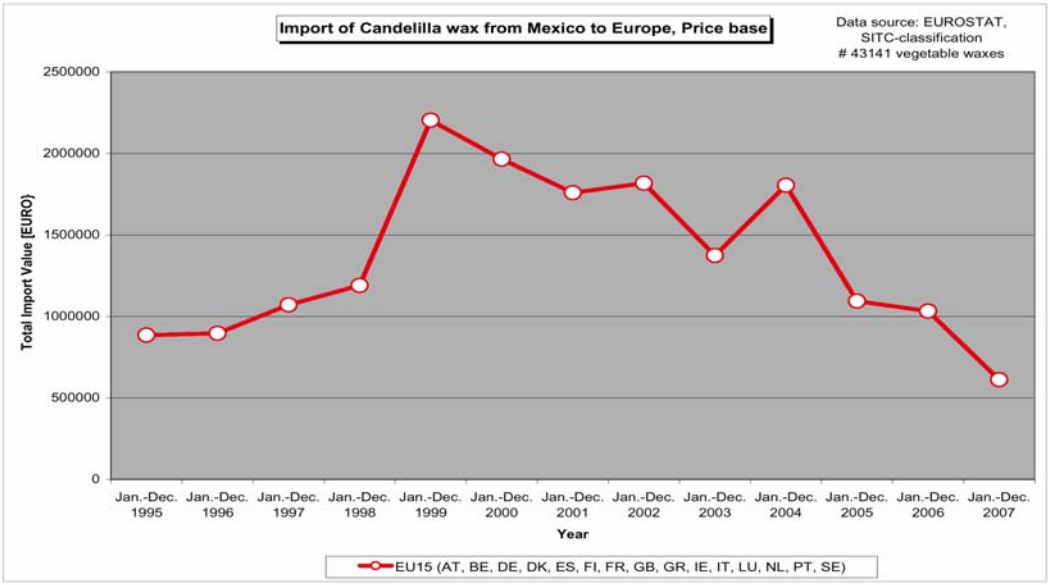
In the import statistics of the European Community vegetable waxes are not further differentiated. Although Candelilla wax is not separated in the European statistics but included in SITC- classification 43141 for “vegetable waxes” it is nevertheless possible to identify data on the Candelilla wax trade volumes by adjusting the database query to SITC-43141 and import from Mexico to European countries. Doing this the import of Candelilla wax can be estimated:



Quantities of Candelilla wax imported from Mexico to the European Community and single member states according to EUROSTAT data.

The graph is indicating a steady decrease of demand since 2000, after an increase in the 1990s. Germany is the most important market for Candelilla in the EU, followed by France.

The import on weight base is paralleled by the import value on EURO base.



Import value on EURO base of Candelilla wax imported from Mexico to the European Community according to EUROSTAT data.

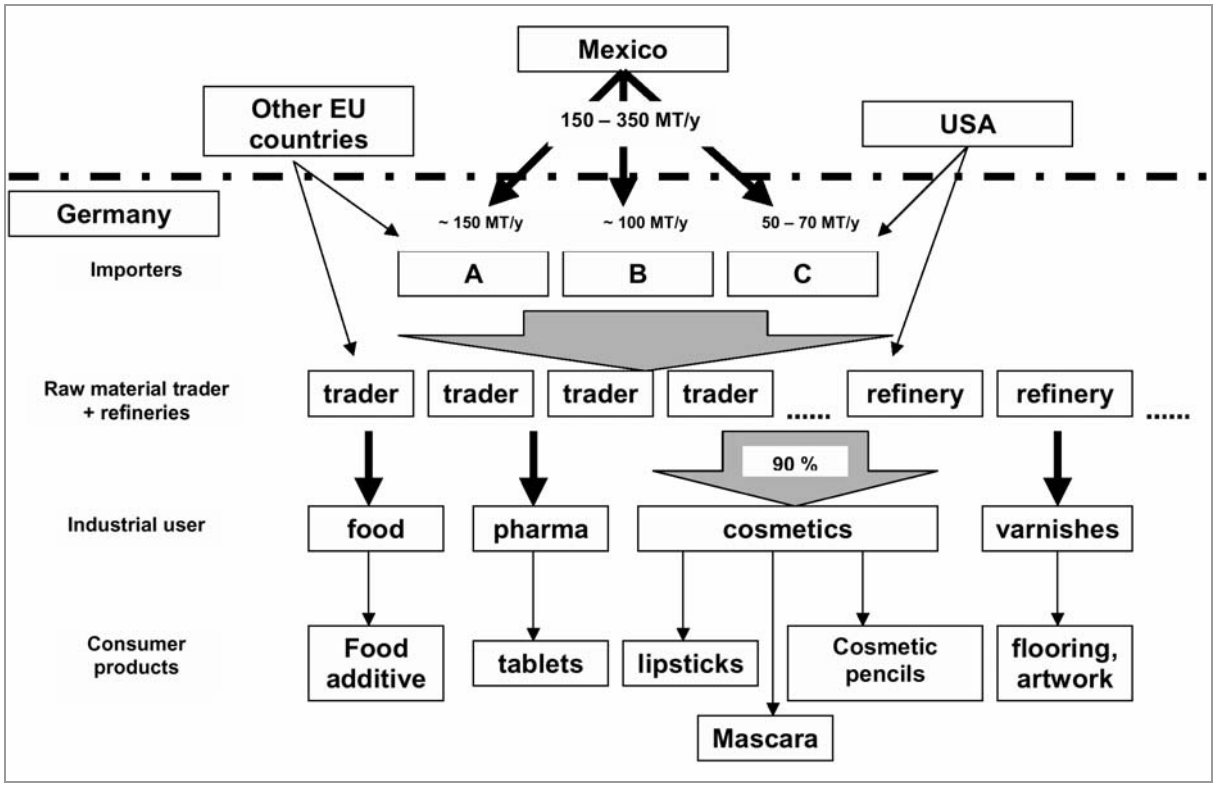
Market in Germany

Like in other countries of the European Community, in the import statistics of Germany vegetable waxes are not further differentiated. However, data for imports into Germany can be separated by the same procedure as for EU and are available for 2007 as 184 tons from Mexico (Statistisches Bundesamt 2008).

Material imported comprise mainly refined flakes and granulate but also raw lumps of Candelilla wax. The raw lumps are than further refined in Germany to pure cosmetic grade quality according to special customer specification.

Direct import from Mexico to Germany is conducted only by a few importing companies. These importers trade the product both to specialised merchants for raw material for the cosmetic and food industry in the form of refined wax and as raw lumps to refiners for further processing.

The author drafted the following scheme from different information obtained by personal communication with German stakeholders. Imports from other EU countries and the USA are not traceable from customs statistics because Candelilla is not distinguished from other vegetable waxes.



Flowchart of the Candelilla wax trade and use in Germany
drafted by the author from information obtained from stakeholders.

Imports into the USA

Through the US Census Bureau, trade statistics for Candelilla and other waxes are available. Candelilla wax is listed in Chapter 15 of the Harmonized Tariff Schedule of the United States - under 1521.10.00 Vegetable waxes and specifically for Candelilla wax at 10 digit level code as 1521.10.00.20. Customs tracks only imports.

AREA/COUNTRIES OF ORIGIN AND COMMODITIES IMPORTED CONSUMPTION IMPORTS			JANUARY - DECEMBER QUANTITIES					JANUARY - NOVEMBER COMPARISONS		
			2003	2004	2005	2006	2007	2007	2008	%CHNG
ARGENTINA	CANDELILLA WAX 1521100020	MT	3.5	0.0	0.0	0.0	0.0	0.0	0.0	–
BELGIUM-LUXEMBOURG(*)	CANDELILLA WAX 1521100020	MT	0.0	0.0	0.0	0.0	0.0	0.0	0.8	–
GERMANY(*)	CANDELILLA WAX 1521100020	MT	3.8	1.0	0.0	0.9	5.0	5.0	1.5	-70.00
ITALY(*)	CANDELILLA WAX 1521100020	MT	0.0	0.4	0.0	0.0	0.0	0.0	0.0	–
JAPAN	CANDELILLA WAX 1521100020	MT	63.1	13.6	26.8	33.8	132.1	132.1	155.3	17.56
MEXICO	CANDELILLA WAX 1521100020	MT	491.7	508.7	643.9	507.7	448.1	430.3	461.6	7.27
TOTAL		MT	562.1	523.7	670.7	542.4	585.2	567.3	619.2	9.15

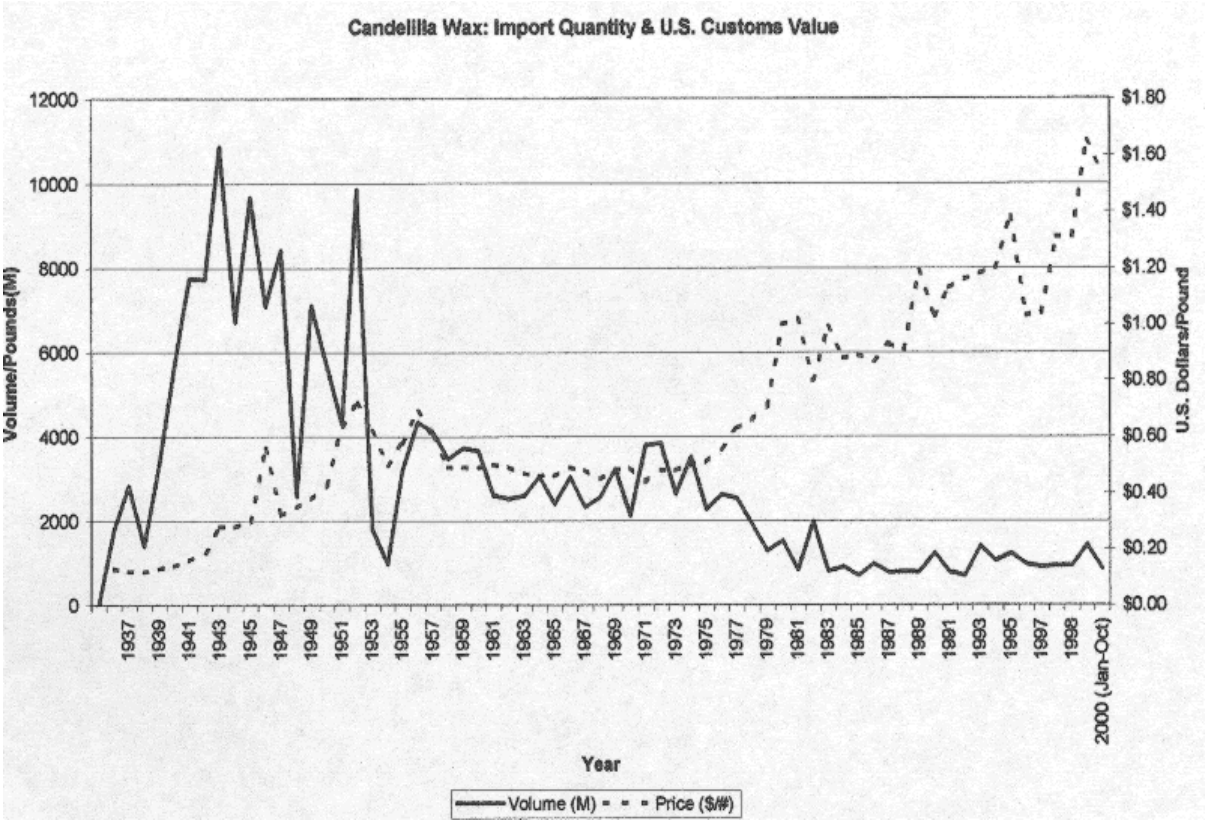
Data Source: Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics

Import quantities of the USA for Candelilla wax

AREA/COUNTRIES OF ORIGIN AND COMMODITIES IMPORTED CONSUMPTION IMPORTS		JANUARY - DECEMBER VALUES IN 1000 DOLLARS 2003	2004	2005	2006	2007	JANUARY - NOVEMBER COMPARISONS 2007	2008	%CHNG
ARGENTINA	CANDELILLA WAX 1521100020	9	0	0	0	0	0	0	–
BELGIUM -LUXEMBOURG(*)	CANDELILLA WAX 1521100020	0	0	0	0	0	0	6	–
GERMANY(*)	CANDELILLA WAX 1521100020	12	7	0	6	34	34	15	-55.88
ITALY(*)	CANDELILLA WAX 1521100020	0	3	0	0	0	0	0	–
JAPAN	CANDELILLA WAX 1521100020	93	33	43	65	204	204	188	-7.84
MEXICO	CANDELILLA WAX 1521100020	1,717	1,702	2,243	1,797	1,618	1,559	1,846	18.41
TOTAL		1,832	1,745	2,287	1,867	1,856	1,797	2,055	14.36

Data Source: Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics

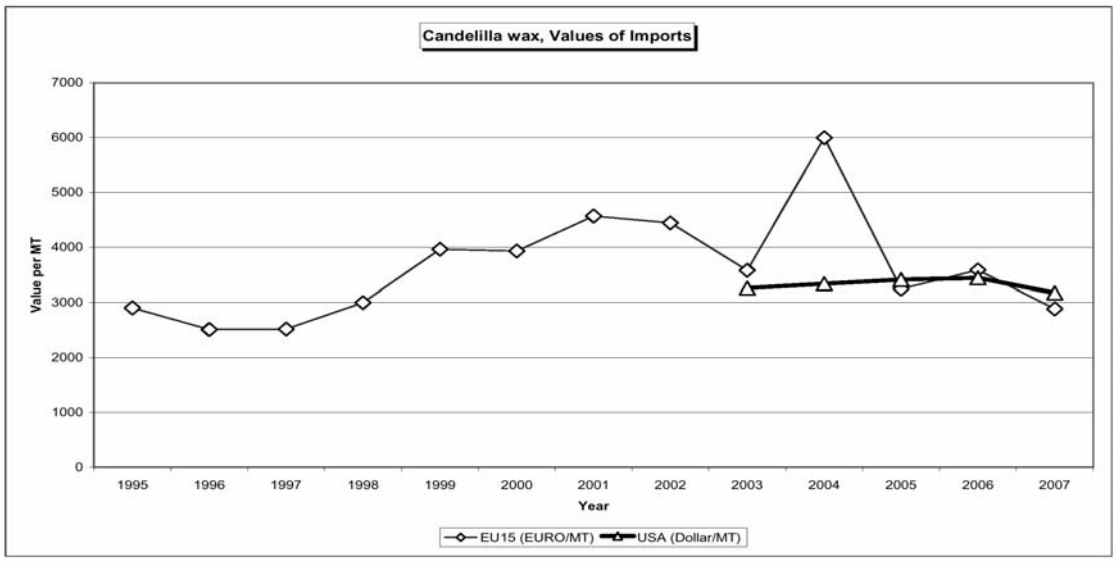
US Import value for Candelilla wax



Candelilla volume and price graph.
(Source- U.S. Dept. of Commerce: Imports of Merchandise for Consumption and General Imports of Merchandise, 2000.)
(wax is weighed in pounds; 1 lb. equals .4536 kg)

During World War II the demand increased because of military use. Meanwhile Candelilla wax is substituted by other chemical substances by most of the former users. The graphic display of US data shows a rather constant demand on the market since the beginning of the 1980s. This is indicating a stable demand of a certain range of market partners.

Comparison of import values of the European Union (as Euro per metric ton) with the USA (as US-dollar per metric ton):

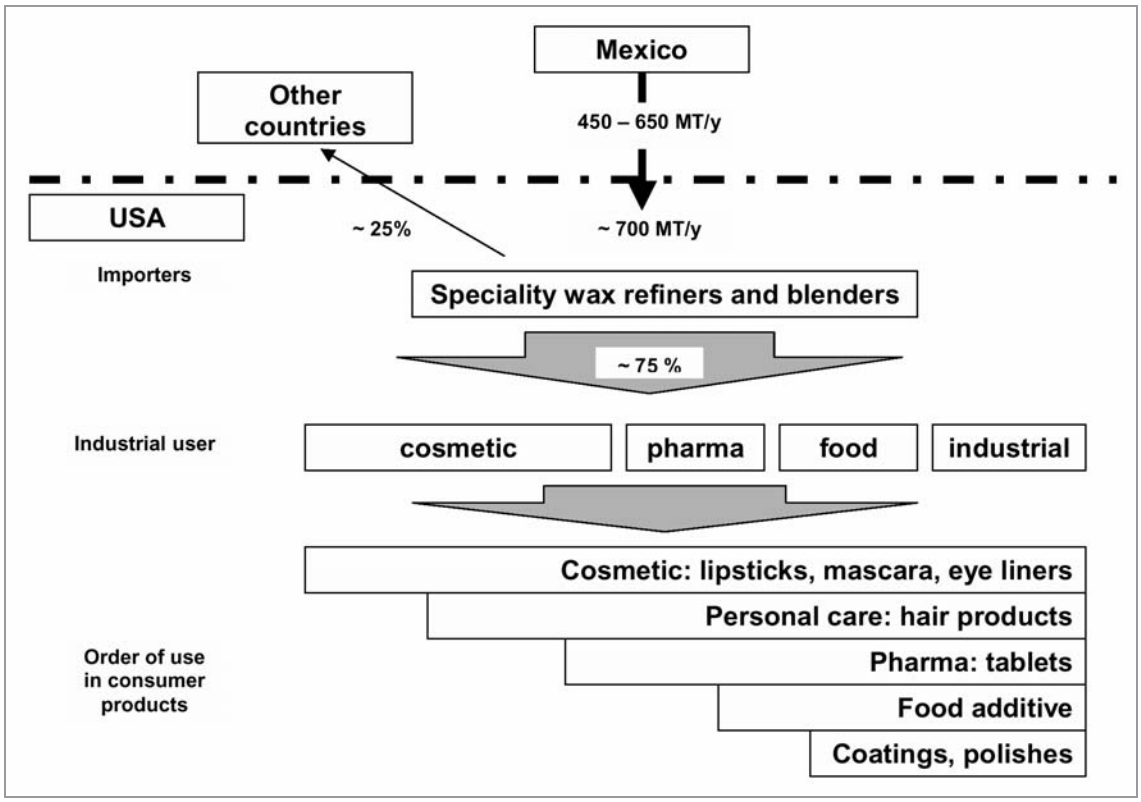


Import values of the USA compared to data from the European Union

The situation of rather constant prices for Candelilla with a constant or even decreasing demand can be observed over the last decade. Therefore, replacement of other waxes by Candelilla will not be profitable and is not obvious.

Market in the USA

The author drafted the following scheme from different information obtained by personal communication with US stakeholders:



Flowchart of the Candelilla wax trade and use in the USA
drafted by the author from information obtained from stakeholders.

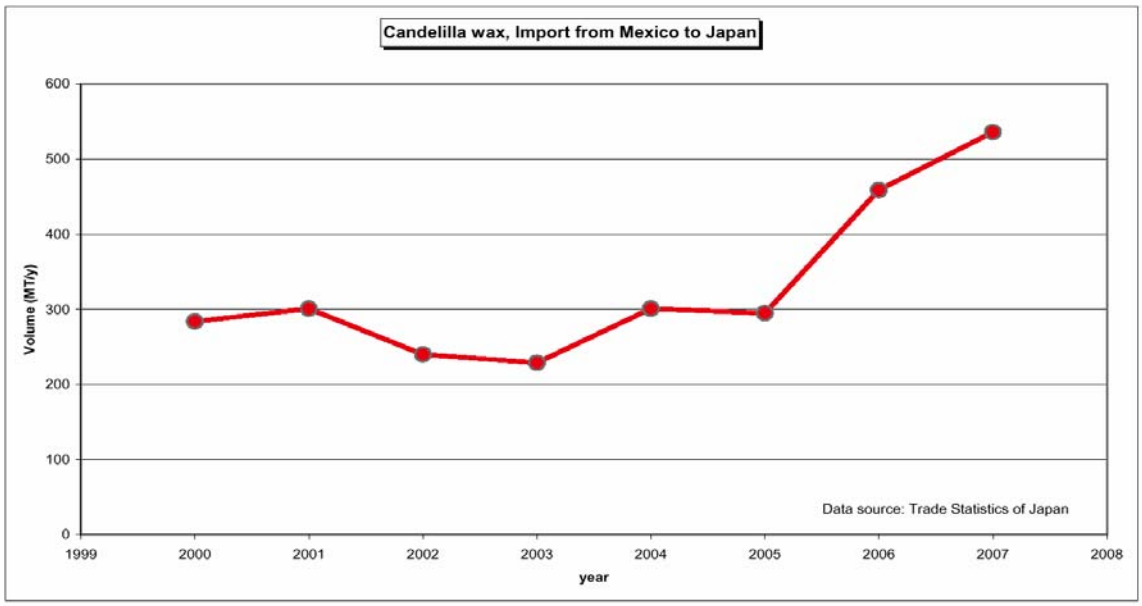
Main importers into the USA are specialty wax refiners and blenders who only use crude wax to process it into a form which ensures a finished quality preferred by industrial customer. The bulk of the consumption is in the cosmetic, personal care, pharmaceutical and food industries. Cosmetic (lipstick, mascara, eye products) and personal care (mostly hair products) are the two leading applications and especially lipstick is one of the chief

end-uses for refined Candelilla Wax. Traditional industrial uses also include coatings and polishes. Applications in chewing gum and fruit coatings have mostly been replaced with petroleum derived waxes, particularly paraffin and microcrystalline waxes, which can also be food grade (personal communication with importers).

The US based company Strahl & Pitsch is the world greatest refining company for Candelilla Cruda wax (Tecnologico de Monterrey 2004).

Import to Japan

Similar to EU the data for Japan had to be extracted from the database according to the following estimation: Country by Commodity, Country code Mexico 205. Commodity Code 15.21 vegetable waxes, 1521.10.090 vegetable waxes other than Carnauba wax.



(Trade Statistics of Japan. Ministry of Finance Japan)

The increase of imports to Japan in the last few years seems to compensate the decrease in EU import statistics. Possibly this may reflect a shift in the production of certain cosmetic products containing Candelilla from European to Japanese manufacturers.

OTHER SPECIES OF THE GENUS EUPHORBIA WITH COMMERCIAL USE

Use as medicinal plants

The following table presents an overview of *Euphorbiaceae* species used as medicinal plants in traditional medicine and in cosmetics.

Table: *Euphorbiaceae* used as medicinal plants and in cosmetics

Botanical name	Pharma-ceutical name	Plat part used	Mode and indications of use	Origin/ distribution	Succu-lent
Succulent species					
Euphorbia antisyphilitica *Euphorbia cerifera* *Pedilanthus macrocarpus*	Candelilla wax	Cuticula wax	Cosmetics: Emollient/film forming for Lipsticks and eye liners Food ingredient (E 902): as anticaking agent, glazing, binder in chewing gum; Wax coating for fruit; Technical use: varnish for doors and violins; Pharma: excipients for tablets	Mexico Texax, New Mexico, USA	+
Euphorbia resinifera	Euphorbium DAB6,HAB34	Dried sap, chyle	Skin irritating plasters Homöopathy (D3 und D4 in skin irritations, diarrhoea and common cold, in former times also against scurf and warts Drastic purgative and cathartic, toxic properties known already to authors of 16th century herbals: „hitzig und trocken im vierten Gard“	Latex obtained from Marocco, slopes of Atlas mountain Endemic species	+
Euphorbia antiquorum L.	TCM: huo yang le	Latex, trunk slices, root bark	Traditional Chinese Medicine TCM: external for warts and burns, internal: cathartic and diuretic SE-Asia: latex to relieve earache Ayurveda: purgative, gout, rheumatism, tooth-ache, warts	India, China, SE-Asia, N-Africa	+
Euphorbia trigona Haw. *(E.cattimandoo, E. hermentiana)*		Latex, chyle	In India against rheumathism Africa: purgative, hunting poison	East-India, Africa	+
Euphorbia tirucalli	Euphorbia heterodoxa HOM	HOM: latex	SE-Asia poultice applied to broken bones Africa: constipation, stomach problems, oitis, hunting poison	Tropical Africa, naturalized throughout the tropics	+
Euphorbia neriifolia L.			SE-Asia: Drastic purgative Ayurveda:earache, purgative, asthma,diuretic, warts, rheumatism	Origin south Asia from India to Malay Archipelago	+
Euphorbia candelabrum		Latex , root	East-Africa: coughs, tuberculosis, emetic, warts, tried to treat HIV infection	Ethiopia, Somalia, Zimbabwe, Sudan,	+
Euphorbia cooperi		latex	Southern Africa: dried latex for wounds, fish poison	Tansania southward to SA	+
Euphorbia unispina		Ash, leaf, twigs	Benin: asthma, constipation, dermatoses, hunting poison	Guinea, Mali, Sudan	+

Euphorbia lathyris *(E. spongiosa)*		Seeds, latex	Homoeopathy: Rheumathism TCM seed diuretic, cathartic	Marocco, Mediterranean, Asia, S-America	(+) to -
Non-succulent herbs, shrubs and trees					
Euphorbia peplus L. *(E. hyrcana, Tithymalus peplis* Gaert.)	Herba Esulae, Herba Euphorbiae pepli	Dried plant	Homoeopathy: skin irritations asthma, catarrh, insomnia in former times also against scurf and warts, as drastic purgative and cathartic, toxic properties known already to authors of 16th century herbals: „Teufelsmilch" recent increase of research to use the diterpenes against cancer (www.newcrops.uq.edu.au)	Europe, Mediterranea, Middle East, N-Asia, America	-
Euphorbia pekinensis	TCM: Jingdaji	roots	TCM: nephritic oedema, ascites from cirrhosis and external with boils	China, Japan, Korea	-
Ricinus communis	Ricinus oil, Rizinusöl Pharm Eur	Oil of the seed	Purgative and cathartic, Vehicle for drugs and cosmetics	Origin: S-Asia, today worldwide	-
Hevea brasiliensis	Kautschuk DAB6	Latex	Adhesive material for plaster	Trop. America	-
Croton tiglium	Crotonöl DAB6 Croton Tiglium HAB34	Oil of the seed Mature seed	Warts, drastic purgative Homoeopathy	W-Africa, Mauritius, worldwide tropics	-
Mallotus philippinensis	Kamala DAB6, HAB34	Peltate hairs of the fruit	Against tapeworm	Tropics. Asia from India to Australia	-
Croton eluteria	Kaskarille, Cortex Cascarilla EB6, HAB34	Stem bark	Spicy-bitter ingredient in liquors	Carribean	-
Sources: Berger 1967, Duke 1985, Hoppe 1975, Jayaweera 1980, Neuwinger 1999, PROSEA 2003, PROTA 2008, Schneider 1979, WHO 1997, Boulos 1983					

Important medicine systems accommodating populous areas like Traditional Chinese Medicine (TCM) and Ayurveda use single Euphorbia species. According to the opinion of an European specialist in TCM, however, this use is very limited due to the toxic properties of *Euphorbia* species and their drastic properties in use. In Europe, TCM only use small amounts of Euphorbia crude material and the importers did not observe considerable delivery in the last few years. Only seeds of *Euphorbia lathyris* are traded in amounts of 2 kg/year as a diuretic but TCM knows a number of better and less dangerous diuretic herbs.

In the WHO monograph of important Chinese medicinal plants the species *Euphorbia pekinesis* is listed (WHO 1997). The perennial herb grows in China, Japan, Korea and is used in nephritic oedema, ascites from cirrhosis and external with boils.

Euphorbiaceae species with more importance in European market are those used in homoeopathy, e.g. Euphorbium and Kamala, as well as the herbs from some other species growing under European conditions.

The only succulent species used for this purpose is *Euphorbia resinifera,* source plant for Euphorbium, a resin produced in the Atlas mountains of Marocco, where the plant is endemic. Market volume for Euphorbium is very limited and the plant is growing fairly well in calcareous rocks in the Atlas and Anti-Atlas mountains. Also cultivation of the plant is easily possible, it is used as an ornamental plant in all warm regions of the world.

Current trade volume for Euphorbium resin for production of homoeopathic mother tincture is approx. 1 kg/year. At the moment sourcing in Marocco is not possible due to lack of official export permits (personal communication with DHU, Germany). Also France homoeopathic producers have difficulties to purchase Euphorbium resin. For this reason they terminated selling of mother tincture and only produce dilutions to

prolong the stocks. In addition, in France Euphorbium is only rarely used in homoeopathy (personal communication with Boiron, Fance).

Technical use of Euphorbia species

Of more historical interest is the technical use of *Euphorbia* species.

Table: Euphorbiaceae species of current and historical technical use

Botanical nomenclature	**Plant part used**	**Technical application**	**Origin**	**Succu-lent**
Euphorbia tirucalli (Euphorbia rhipsaloides)	Latex	Tests to produce gasoline (1976, Melvin Calvin, USA, 1980ies Pertrobras, Brazil)	Eastern and Southern Africa (all tropical areas)	+
Euphorbia lathyris	Latex	In former times for rubber production: Almeidina-Kautschuk 1941, French scientists tested to produce gasoline	Marocco	-
Jatropha curcas	Seed oil	Test to produce gasoline Soap, candles, molluscicide	Origin unknown, widely cultivated in the tropics	-
Euphorbia intisy	Latex	Kautschuk, rubber Charles Fletcher Swingle, Bureau of Plant Industry, U.S.D.A. in 1928 explored Madagascar for *Euphorbia intisy*, previously believed extinct, to subsequent propagate the plant in USA for rubber production.	Madagascar threatened by habitat loss (2006 IUCN Red List)	+
Euphorbia lagascae	Seed oil	Oil with technical application (USDA projects 1950-2009): seed oil contain high levels of vernolic (12,13 epoxy-cis-9-octadecenoic) acid (in seed 45%-50% oil, of which 60%-65% is vernolic acid), used as a drying solvent in alkyd resin paints, a plasticizer or additive in polyvinyl chloride (PVC) resins	Southern Spain, Sardinia	-
Euphorbia fulva (Euphorbia tanquahuete)	Latex	The amount of rubber collected has been so small that it has not entered into commerce to any appreciable extent.	Mexico (States of Michoacan, Guanajuato, and Jalisco)	-
Sources: Duke 1983, Berger 1967, Hall 1921, Heller 1996, Roseberg 1996, Terry 2009				

Because of their milky latex some succulent species were used in tests to produce rubber and more recently to produce gasoline. There are historical records of commercialization of rubber products derived from *Euphorbia intisy*, *E. rhipsaloides*, *E. fulva* (= *E. tanquahuete*), and *E. tirucalli*. But all these intentions failed because of low yield. Only the annual herb species *E. lagascae* was of interest for at least 40 years in the potential development of the seed oil containing a special fatty acid with technical applications in oleochemistry. An extension procedure is currently evaluated by USDA to introduce it as a crop to arid areas in the USA (Terry 2009).

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