Caesalpinia spinosa (tara): the sustainable source of tannins

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Abstract
The fruit of the tara tree is evaluated as a sustainable source of tannins and other by-products for the leather industry and other applications in food, pharmaceutical or cosmetics. Taxonomy and growing conditions in nature or in agroforestry farms are described, as well as industrial processes among the value chain from harvesting to international markets. Finally, commercial opportunities for economic exploitation are presented.

Background
Caesalpinia spinosa (Molina) Kuntze, commonly known as tara1, is a small leguminous tree or thorny shrub. Tara is recognized as a source of high value products from its pods and seeds as tannins based on a galloylated quinic acid structure, used in the leather industry, and gum for food industry. It is also grown as an ornamental plant because of its large colorful flowers and pods.

Having its origin in the Andean Region, pre-Incas civilizations used the fruits of the tree to produce dyes for textiles and ceramics, tannins for leather and medicines. Known, therefore, as “Incas green gold”, there is a strategic interest in Peru, Bolivia and Ecuador, supported by international organizations for cooperation, to promote productive processes under environmental sustainability criteria and social benefit.

The tara name comes from Aimara language and means flat because the shape of the pods.

Synonyms: Caesalpinia victoria (H.B.K.) Bentham ex Reiche; Poinciana spinosa Molina; Caesalpinia pectinata Cavanilles; Coulteria victoria HBK, Tara Spinosa (Molina) Britt & Rose; Caesalpinia stiulata (Sandwith) J.F.
Cesar Barriga\(^2\) resumes this specie as:

- **Plastic**: it is able to adapt to several climates and soils
- **Rustic**: it is not exigent and can grow in superficial, acid and low fertility soils
- **Multiple uses**: the fruit is profitable, fixes the nitrogen, produces pollen and nectar, and can grow in agro-forestry systems together with other crops.

Due to its wildness, there exists a variety of plants according the regions and the living conditions, thus the content of tannins can vary from 30\% to 80\%. Currently, institutions and universities carry out researches to characterize the genetic variability\(^3\).

**Distribution and habitat**

*Caesalpinia. spinosa* can be found growing throughout northern, western and southern South America, from Venezuela to Argentina, subtropical and semitropical regions between 4º to 20º South latitudes. It has been introduced in dry parts of Asia, the Middle East and Africa and has become naturalized in California.

Normally tara grows in areas with a yearly rain of 400 to 1,100 mm, and on sanded or degraded soils. It is a wild tree, normally isolated, but sometimes, can form small forests. Generally resistant to most pathogens and pests, it lives between 0 and 3,000 meters above sea level. Trees begin to produce after 4–5 years. If well irrigated, they can continue to produce for 80 years, though their highest production is between 15 and 65 years of age.

### 2.3. Botanic characteristics

<table>
<thead>
<tr>
<th>Kingdom</th>
<th>Subkingdom</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Tracheobionta</em></td>
<td>Vascular plants</td>
</tr>
<tr>
<td>Superdivision</td>
<td><em>Spermatophyta</em></td>
<td>Seed plants</td>
</tr>
<tr>
<td>Division</td>
<td><em>Magnoliophita</em></td>
<td>Flowering plants</td>
</tr>
<tr>
<td>Class</td>
<td><em>Magnoliopsida</em></td>
<td>Dicotyledons</td>
</tr>
<tr>
<td>Subclass</td>
<td><em>Rosidae</em></td>
<td></td>
</tr>
<tr>
<td>Order</td>
<td><em>Fabales</em></td>
<td></td>
</tr>
<tr>
<td>Family</td>
<td><em>Fabaceae</em></td>
<td>Pea family</td>
</tr>
<tr>
<td>Genus</td>
<td><em>Caesalpinia</em></td>
<td>Nicker</td>
</tr>
<tr>
<td>Species</td>
<td><em>Caesalpinia spinosa</em> (Molina) Kuntze</td>
<td>Spiny holdback</td>
</tr>
</tbody>
</table>

**Industrial processes**

The fruit of tara tree and its derivates have a high interest in a number of industries and, thus, a great worldwide economical potential for commerce. The properties of pods and seeds result in a sustainable and quality raw material for several applications.

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\(^2\) Cesar Barriga: PEBAVI – Peru. Personal interview in June 2010

\(^3\) RAPDs (Random Amplifies Polymorphic DNAs) molecular makers is the most common technique to characterize the genetic variability.

The fruit of tara contains 60-64% of pods, 34-38% of seeds and 2% of non-valuable residues of its weight. Figure 1 shows the industrial flow chart of by-products obtained from tara fruits.

Figure 1: Industrial flow chart of by-products obtained from tara fruit

The current source of tara is mainly natural forests from the Andean region of South America where some agro-forestry exploitations are introduced. Peru is the main area for sourcing tara fruits to obtain tannins followed by far by Bolivia, Chile, Ecuador and Columbia. The tara supply chain starts from planting the tara tree seeds in agro forestry farms or from harvesting the fruits from wild trees in natural forests. Much of the tara production consists of wild collection, thus, a major problem comes from the quality differences between collected tara and cultivated tara.

The actors of the production and supply chain are those that are involved in the trading process, from farming, harvesting, collecting, transforming and trading the product and the final users.

Currently, the major source of tara pods are wild forests and, only in certain areas, tara pods come from forestry farmers.
The pods are threshed and the seed separated. Tara powder is obtained by simply mechanically milling and sifting the gross powder. The tara powder is a fine (100 to 200 mesh) yellowish sawdust. The leather industry appreciates the tara powder as a source of vegetable tannins to obtain light colors, with good light fastness, and full and soft leather articles, with a firm and smooth grain. Tara is easily soluble in water and do not contain color substances like other vegetable tannins.

Tara powder can be used to tan all kind of hides and skins and to re-tan chrome tanned leathers to improve the grain-tightening. The main application is in the manufacture of leather for car seats. The general specifications for commercial tara powder for tanning application are:

<table>
<thead>
<tr>
<th>Specification</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tannin content</td>
<td>min. 48%</td>
</tr>
<tr>
<td>Water content</td>
<td>max. 13%</td>
</tr>
<tr>
<td>pH (at 6.9ºBé)</td>
<td>3 – 4</td>
</tr>
</tbody>
</table>

There are, however, some difficulties of the tara tannin when compared with other vegetable tannin extracts:

- High concentration of insoluble solids (tara powder contain high quantities of cellulose compounds from the tara pods if tannins are not extracted and concentrated)
- Tanning effect limits when tara tannin is the single compound for tanning. Hydrolyzing vegetable tannins cannot increase the shrinking temperature.
- Easily produces complexes with iron and other metals and form dark spots on the leather when is contaminated.

To obtain tara extract, the tara powder should be treated at 65-70°C for 30-40 minutes adding to the powder 4 to 5 parts of is weight with water and washing the liquor 5 times. Then the liquor is...
purified by decantation and filtration, and concentrated from 2-5º Bè to 11-12ºBè. The powder of tara tannin extract is obtained by atomization.

Tara extract is used to produce tannic acid, and founds valuable applications in the food and beverage industries, to clarify and give astringency to wine, tea, coffee, cacao, beer and other food.

Recent investigations demonstrate that tara tannin and its derivates have excellent properties as antioxidant agents to prevent cardiovascular diseases. Also, they have astringent properties with pharmaceutical capacity to avoid irritation and harm by reducing protein coagulation. The tannic acid is used as hemostatic to cut down hemorrhages and, mostly, for burning treatment.

The gallic acid can be obtained by hydrolysis of tannic acid with sulfuric acid. Chemical hydrolysis is, however, costly and contains impurities, but enzymes, like tannases from bacteria, can be used. It founds valuable applications in the pharmaceutical industry because has biological properties as antioxidant, biocide (virus and bacteria) and analgesic, but also, is used in other industries, e.g. to clarify vegetable fats, beer, or to obtain inks and as analytical reactive.

The tara gum is obtained by milling the endosperm from the tara seeds, after mechanical separation of the husk and the germ. The high viscosity of the tara gum is well appreciated in the food industry and it is an excellent hydrocolloid with good properties as thickener and stabilizer agent used to prepare ice creams, gelatin, powder and liquid soaps, yogurt, sauces like mustard, mayonnaise, ketchup; cream and soft cheeses, bakery, meat, among others. It is stable at pH higher than 3.5, retains water, soluble at cool temperatures, and do not modifies the savors. Further than the food industry, tara gum has also applications in the pharmaceutical industry, cosmetics, mining, paper, textile, oil, and others.

The germ of tara, obtained from the seed cotyledons, has a high content of proteins and it is sold for animal feed and, also, to the pharmaceutical and cosmetic industry as a source of proteins. The germ of tara is also rich in vegetable oils.

**Global production**

Despite tara tree is native from a wide range of countries according to the World Agroforestry Center, approximately 80% of global production takes place in Peru. Sources of tara are also

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found in Chile, Ecuador and Colombia and other countries like Bolivia, Venezuela, Cuba and cultivated in China, India, Ethiopia, Kenya and Morocco.

According to Schiaffino, production of tara in 2004 was between 115,000 and 138,000 tons of tara pods, considering that a tree of *Cesalpina spinosa* is able to produce 50-150 kg of fruit per year, and 20-40 kg. of pods.

It is calculated that 97% of the production was exported as a tara powder or tara gum, therefore, we can make some estimation based on export trade data.

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOB Value USD</td>
<td>13,959,936</td>
<td>16,705,333</td>
<td>20,956,791</td>
<td>31,756,831</td>
<td>41,326,224</td>
<td>25,317,943</td>
</tr>
<tr>
<td>Delta FOB Value</td>
<td>20%</td>
<td>25%</td>
<td>52%</td>
<td>30%</td>
<td>-39%</td>
<td></td>
</tr>
<tr>
<td>Tons</td>
<td>12,878</td>
<td>15,043</td>
<td>15,005</td>
<td>19,918</td>
<td>17,852</td>
<td>17,828</td>
</tr>
<tr>
<td>Delta volume</td>
<td>17%</td>
<td>0%</td>
<td>33%</td>
<td>-10%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>Price USD/kg</td>
<td>1.08</td>
<td>1.11</td>
<td>1.40</td>
<td>1.59</td>
<td>2.31</td>
<td>1.42</td>
</tr>
</tbody>
</table>

Table 1: Tara exports statistics. Peru.

Table 1 clearly shows how the variability of the market prices has impacted in terms of export value. Since exports in volume (demand) increased from 2004 to 2006, prices rose from an average of USD/kg 1.08 to USD/kg 1.40. During the years 2005 to 2007 the market was consolidated because the highest demand of chrome-free leather for automobile seats.

As production of tara is unable to satisfy the demand, obviously prices go up. In 2007, tara powder exports achieved the highest values, probably the full availability of production, close to 20,000 tons. Export selling prices also increased to USD/kg 2.31 exceeding expectations of demand. As a consequence, during 2008 the export value increased but volume production was stabilized to 18,000 tons.

During 2009 the automobile industry, and also the leather industry in general, suffered the international financial crises and figures were stabilized to volume production of 18,000 tons/year and average price around USD/kg 1.50.

For better understanding, Figure 6 compares the trends of the export value in Peru during the years 2004 to 2009 compared with the progress of the production volume.

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8 Schiaffino, JC. Estudio de mercado de la tara. Perú Programa Desarrollo Rural Sostenible, GTZ, Universidad del Pacífico, GOPA. 2004

9 Average price is the mix price for tara powder and tara gum.
Figure 6: Development of tara exports from Peru comparing value and volume

Figure 8 compares the yearly increase of FOB value of the export trade of tara products and the progress of volume. While the exports in 2007 increased in demand, the market reacted negatively to the price increase. Prices went down in 2009 and production was stabilized.

![Image of graphs showing Delta FOB Value and Delta Volume]

 Expectations for the tara production during the next years

Currently, administrations from the three Andean countries project new forestry developments of 4,730 ha and future production of tara powder can be estimated according to the table 2.

<table>
<thead>
<tr>
<th>Region</th>
<th>Peru</th>
<th>Ecuador</th>
<th>Bolivia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product ha</td>
<td>7,730</td>
<td>7,500</td>
<td>50</td>
</tr>
<tr>
<td>t harvested pods</td>
<td>115,950</td>
<td>112,500</td>
<td>750</td>
</tr>
<tr>
<td>t available tara powder</td>
<td>71,889</td>
<td>69,750</td>
<td>465</td>
</tr>
</tbody>
</table>

Table 2: Estimated tara production. Period 2011-2012

The goals of the development of the tara in the region for 2005 is to double this production figures and exploitation plans are going to be implemented. This is supported with the highest

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demand of tara products in the leather industry, but also for other products with high potential
demand, as the gallic acid and vegetable thickeners.

<table>
<thead>
<tr>
<th>Production ha</th>
<th>Peru</th>
<th>Ecuador</th>
<th>Bolivia</th>
</tr>
</thead>
<tbody>
<tr>
<td>harvested pods</td>
<td>14,000</td>
<td>10,000</td>
<td>2,000</td>
</tr>
<tr>
<td>t available tara powder</td>
<td>210,000</td>
<td>150,000</td>
<td>30,000</td>
</tr>
</tbody>
</table>

Table 3: Objective of tara production in 2015

From the production point of view, there is enough experience for forestry technical
assistance related to forest and forestry management, plagues control and seed selection and
reproduction.

There is a demand for Standardization of the technical quality of the products what is under
discussion with International Standardization bodies to coordinate quality requirements
according the final application.

There is no doubt that the interest and demand of tara products is growing at international
levels. However, alternative products are also available, either from other natural species or
by organic synthesis. It is important to develop technologies to improve the present offer of
tara products, by customizing or improving the quality, but at the right costs for the market.

There is an opportunity for the leather industry in order to replace chemicals and to obtain
sustainable process and articles. Tara tannins offer a wide range of advantages if quality and
prices fulfill the expectations of the market.

Analysis of tara potential for the leather industry

Table 4 summarizes market issues and tara consumption opportunities for each leather article.

<table>
<thead>
<tr>
<th>Market trend</th>
<th>Footwear</th>
<th>Furniture</th>
<th>Auto</th>
<th>Garment</th>
<th>Gloves</th>
<th>Other leather goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable growing higher than population growth rates</td>
<td>Central and North Europe, USA</td>
<td>USA, Europe</td>
<td>Europe</td>
<td>USA</td>
<td>USA, Europe, Japan</td>
<td></td>
</tr>
<tr>
<td>Stable</td>
<td>Growing</td>
<td>Variable</td>
<td>Growing for specific uses</td>
<td>Stable, growing luxury goods.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China, Italy, India, Brazil</td>
<td>Italy, China, Argentina</td>
<td>Germany, Argentina, China, Mexico, Brazil</td>
<td>Spain, China, India, Italy, Pakistan</td>
<td>South East countries, Africa</td>
<td>Spain, France, Germany</td>
<td></td>
</tr>
<tr>
<td>WorldWide</td>
<td>Central and North Europe, USA</td>
<td>USA, Europe</td>
<td>Europe</td>
<td>USA</td>
<td>USA, Europe, Japan</td>
<td></td>
</tr>
<tr>
<td>Comfort, fashion, functionalities</td>
<td>Elegancy, design</td>
<td>Elegancy, comfort</td>
<td>Fashion</td>
<td>Compliance to the end uses</td>
<td>Trademark positioning</td>
<td></td>
</tr>
<tr>
<td>Soft, waterproof, breathable</td>
<td>Surface resistances, light fastness</td>
<td>Very high technical performances</td>
<td>Soft and lightness</td>
<td>Soft and fastness.</td>
<td>High quality, elegance, natural</td>
<td></td>
</tr>
<tr>
<td>Textile and plastics</td>
<td>Textile</td>
<td>Textile</td>
<td>Textile</td>
<td>Textile</td>
<td>Plastics</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Analysis for tara potential for the leather industry
European Policy of Chemicals (REACH)

The European REACH Directive is a great opportunity for the trade of tara tannins in Europe\textsuperscript{11}. Since 2006 there is a Directive in Europe (CE 1097/2006) concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH).

To point out the most important advantage for tara products, compared with syntans and other vegetable tannins, they are exempted of such Registration as defined in Annex V, \#8: “Substances occurring in nature, if they are not chemically modified, unless they meet the criteria for classification as dangerous according to Directive 67/548/EEC”

According to Chapter 2, “Definitions and general provision”, Article 3, “Definitions”, \#39: “Substances which occur in nature: means a naturally occurring substance as such, unprocessed or processed only by manual, mechanical or gravitational means, by dissolution in water, by flotation, by extraction with water, by steam distillation or by heating solely to remove water, or which is extracted from air by any means”

Trading in Europe with tara powder or tara tannins extracted with water does not need to incurred with tremendous cost required for collecting safety data and register them in REACH.

Conclusion

The fruits of Caesalpinia spinosa (tara) are reach in high value hydrolysable tannins for the leather industry and other industrial applications as a hydrocolloid or polyphenol with nutrient properties in food, pharmaceutics or cosmetics.

It is a sustainable source of tannins for the treatment of hides and skins in the leather process. However, market opportunities depend on ensuring availability and quality consistence among competitive market prices.

Acknowledgements

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