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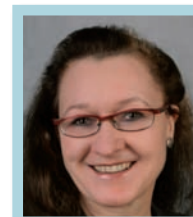
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Quillaja saponaria wood extract

Refined processing and forestry management guarantee sustainability and ecological benefits

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ABSTRACT: Used for washing since ancient times the extract of the saponin rich bark of the Chilean Soapbark tree *Quillaja saponaria* was exported since 1880 to fulfil the fast growing demand for Quillaja as a foaming agent, emulsifier, and detergent for a multitude of industrial purposes. Traditionally only the bark was extracted and the wood of the felled tree, equalling 95 percent of the biomass, was left to rot. To stop the wastage and the damage to environment, Natural Response, the Catholic University of Chile and Desert King International developed a new process strategy for saponin extraction of the entire wood. New sustainable harvesting regimes, the increasing plantations and reforestation policies guarantee future bioavailability and benefit the environment and the peasant population as well.

until mid 1990s, *Quillaja* saponin extraction took place exclusively outside of Chile and was based solely on bark processing. Chilean scientists and economists looked for answers to counter the on-going depletion of the *Quillaja* tree population and to guarantee long-term supply of the *Quillaja* extract. This case study wants to present how the *Quillaja* Extract manufacture of Natural Response complies with all facets of sustainable management: Ecology and economy accompany each other and include environmental and social benefits as well.

EXTRACTION METHODS

Saponins are common in a high number of plants of different origin, where they were found to be concentrated in specific parts of the plants. The content may be influenced by several environmental factors (4). Saponins can be extracted either by solvent or by water based processes. To enhance the rate of yield, the common methods just use those plant parts for extraction which are most rich in saponins. In *Quillaja* the saponin content of the bark (5 percent) is more than double

the content of the wood (2 percent) (5). *Quillaja* trees were traditionally debarked with knives (Picture 1) to obtain the inner bark, and for easier access most of the trees were felled. As the bark totals just 5 percent of the tree weight, the remaining wood (95 percent equivalent of total biomass) due to its minor saponin content was left to rot in the field. To fulfil the worldwide demands of bark, reaching 800-1000 tons/year, more than 60,000 large trees were felled annually, leading to scarcity of older trees (3).

The destruction of the *Quillaja* population decreased instantly when the Catholic University of Chile (PUC) developed a new process in 1996 that enabled the saponin extraction from the entire *Quillaja* wood. Instead of debarking, this process utilises corticious shoots and branches which for the first time allowed harvesting in sustainable pruning and thinning operations in degraded *Quillaja* forests and scrublands as well.

In a joint venture of PUC with Desert King International, Natural Response S.A. was

INTRODUCTION

The soapbark tree *Quillaja saponaria* Molina is a key species of the sclerophyllous Matorral forest, and endemic but once abundant in Central and Southern Chile, where the trees grow up to 15m in height (1). From ancient times, indigenous people, Mapuches, knew about the bark's natural, bioactive potential and named the tree "quillay", the native word for washing. The Mapuche used the water extract normally for the washing of hair, body and clothes, but also as an expectorant or for curing dysentery. The high concentration of more than 60 different triterpen saponins (2) in the *Quillaja* bark, their multifunctional capabilities and mainly its approval for human consumption enhanced export ever since 1880. Especially industries in the US, Germany and Japan were interested in the *Quillaja* bark extract as a foaming, emulsifying or dispersing agent, in food and beverages as well. In the last decades more and more applications like mining, livestock nutrition, odour and pest control, waste treatment and the development of vaccine adjuvant increased the industrial demand of *Quillaja* extract significantly (3). From 1880



Picture 1. Partly debarked *Quillaja saponaria* tree.

founded in Chile, where the new extraction method was scaled up and further adapted to meet special demands, like those of the cosmetics or the pharmaceutical industry. In contrast to processes used for bark extraction the new wood extraction method is based exclusively on physical processes like milling of the wood, water extraction, filtration through diatomaceous earth, removal of impurities by membrane technology (ultrafiltration and diafiltration), and concentration, either by nanofiltration or evaporation (Table 1). Further refinement depends on ultrafiltration membranes (10-39 KDa), which allow higher enrichment of saponins suitable for special applications (6). In terms of energy recycling the depleted wood chips (3.5 T/batch) are the sole source of energy in the extraction process. The water removed from extracts at evaporation stage is recycled. Thus an amount of heat also returns into the process.

FORESTRY MANAGEMENT AND REFORESTATION

The significant improvement in the saponin yield by the novel techniques has been additionally accompanied by the development of forestry-management strategies at Natural Response. These strategies meet concern to guarantee both the proper supply of raw materials required and the future sustainability of *Quillaja saponaria* woods. So this effort addresses both the traditional harvesting in natural forests, as well as the development of new extensive Quillaja plantations. Harvest policies in existing natural Quillaja forests are based mainly on pruning. Only unhealthy or damaged trees were reasonably cut and the ground cleared to promote forest regeneration. Some of those Quillaja trees, which had been felled, have regenerated by stem-born shoots: These shoots were thinned, leaving the most healthy and vigorous stems (Picture 2).

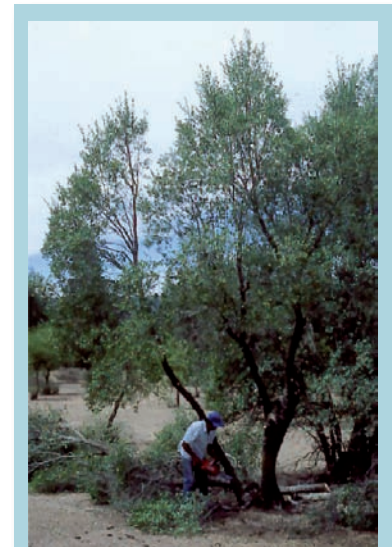
Accompanying measures demonstrate the thinning process to lead to disproportionately high biomass increase of the remaining stems (9).

	Traditional	Japanese Companies	New Process Natural Response
Source	Inner Bark (5% saponin)	Inner Bark (5% saponin)	Entire Wood (>2% saponin)
Solvent	Water or Water/Ethanol	Organic	Water
Extractives	18%	N.R.	8%
Saponin Binding	none	Resin Adsorption	none
Filter	Diatomaceous Earth	Activated Charcoal	Diatomaceous Earth
Concentration	Evaporation	N.R.	Evaporation → Membrane filtration
Solids	42%	25%	42% 20%
PH Adjustment	Phosphoric acid	N.R.	< 0.72% Citric Acid ¹⁾
Preservatives / Additives	0.1 % Sodium Benzoate	Ethanol + Maltitol	0.1 % Sodium Benzoate ²⁾

Compilation following (6) ¹⁾ in Organic extract only, ²⁾ none in Organic extract

Table 1. Methods for Saponin Extraction in Soapbark Tree *Quillaja saponaria*.

The wood extract of Natural Response yields the same percentage of solids as the traditional bark extract. For use in cosmetics this extract needs to be purified (20 percent solids) according to lighter colour, less polyphenolics and higher stability. All steps of the manufacturing process are controlled, and the quality of each batch is routinely assessed and certified. The composition of each extract as to identity and the percentage of the compounds is additionally examined by reverse phase HPLC, which had turned out to be a reliable method to guarantee continuous extract quality (7). This is especially important as natural variations in the wood saponin content may occur due to differing environmental conditions (8). After controlled evaporation the bark extract and the crude wood extract show similar concentration of solids in spite of the differing saponin content of the source bark and wood. By bark extraction the saponin yield of a standardised tree adds up to 0.6 kg/per tree compared to 5.1 kg per tree for extraction of the whole wood following the new extraction method. By the method of wood extraction just about 7000 t of wood are needed to fulfil the needs of the saponin market. This corresponds to less than 12,000 trees per year in contrast to the former 60,000 for the debarking process (7). Above all: The wood can be obtained by a sustainable forest management, which furthermore improves the health of the forest. Recent data already shows that the new wood extraction method has lead to a significant decrease of debarking of Quillaja trees (Figure 1).



Picture 2. Thinning of Quillaja shoots.

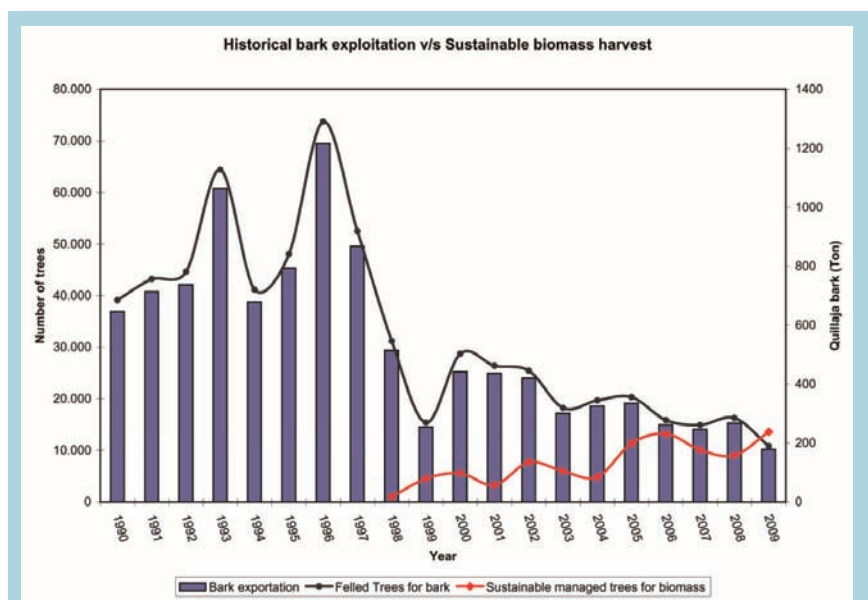


Figure 1. The development of Quillaja bark export from Chile is inversely proportional to the increase of sustainable biomass harvest and processing under Natural Response management.

Thus after some controlled harvesting periods-conducted in a sustainable rotation system the plants are reshaped to trees and twigs can be clipped.

PLANTATIONS

The major goals of the forestry program are to switch, progressively, and fully from natural forest harvesting to plantation methods, and simultaneously increase the population of Quillaja trees.

Thus Natural Response and Desert King International (DKI) have their own forestry departments, which in coordination with CONAF (National Forest Corporation) (5) develop harvesting plans and elaborate optimal growth conditions for maximal yield of saponin content. Based on the results of various forestry and agricultural studies (10) the selection processes concern all stages of development and different types of plantations. In 2010 the total area of plantations covered 270 ha. The plantations increase yearly about 250 ha/year. For their sustainable forest management DKI was positively certified by the Forest Stewardship Council (FSC).

The selected seeds (e.g. genetic renewal) germinate and grow up in a nursery, from where the most vigorous and fastest growing seedlings were selected for transplantation. There are two main modes of plantation: In the high density hedgerow plantations the shoots can be pruned after 3 or 4 years. In contrast to this, in plantations of solitary trees in a density about 1600 trees/ha (Pictures 4 and 5) branches will be cut first, depending on the quality of the site, in no less than 12 years. In a sustainable management the single planted trees shall also lead to reforestation of former degraded or even deserted sites. A detailed study on a seven-year-old Quillaja solitary tree plantation estimated a total biomass of 6.15 t/ha and an accumulation of carbon of 2.98 t/ha on a former deserted ground (11). But biomass does not strictly correlate with saponin content. Although Quillaja has shown a certain tolerance to draught, it grows better in more fertile soil (12). On the other hand Quillaja plants growing on poor soil are proven to have higher saponin contents (8). Thus to plant Quillaja could be especially interesting for land owners with poor soil, where demanding crops could not be easily grown. High saponin content is also found principally in the twigs of plants independent of their growing sites (8). This may on the other hand favour high density plantations. Overall further studies have to be done to identify the influence of intrinsic and environmental factors as well, until certain ideal plantation management for maximum biomass increase and saponin yield can be implemented.

PERSPECTIVE

The effort of Natural Response and Desert King International for the reforestation of the degraded Matorral forest and for a sustainable supply of Quillaja extracts in a growing market has been supported



Picture 3. Two year old reforestation with rabbit protection in natural Quillaja distribution area.



Picture 4. Six year old plantation.

by Government policies: In 1998, the Chilean Government launched a US\$ 2 million fund to stimulate plantations, as well as novel uses of Quillaja extracts. Thus in addition to own plantations intense forestation programs in collaboration with land owners were established. At present for cosmetic use just 7 percent of wild Quillaja plants are sustainably harvested. The plantations will replace them soon. The extension of energy recycling in the extraction process and the continual increase of plantations will result in a neutral to truly negative carbon footprint. A further benefit of the Quillaja plantations, their potential for honey production, is intensely promoted, the first harvest is intended in 2011. The typical honey bee flowers of Quillaja are favoured by wild bees and honey bees as well. It is estimated that nectar secretion of an adult tree leads to 4.2 kg honey. In plantations honey bees could easily harvest 40 kg per beehive (13). The apiculture could generate an income for the

peasant people especially in rural areas.

Quillaja extract in farming and livestock breeding adds globally to the ecological benefits of Quillaja (14).

For all these facets of sustainable management Natural Response received the Avonni award in 2009 for innovative projects of economic and national interest.

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