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Contributions to the quality control of two crops of economic importance : hops and yerba mate

Wilson, E.G.

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Author: Wilson, Erica Georgina

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chapter 6

Yerba Mate: Past, Present and Future of The Most Popular Herbal Tea of S. America

Erica G. Wilson and Robert Verpoorte

Introduction

Yerba mate or mate is the roasted and dried leaf of *Ilex paraguariensis* A. St-Hil. var. *paraguariensis* (Aquifoliaceae), one of the 400 or more species of the *Ilex* genus.



Fig. 6-1 Leaf of Ilex paraguariensis (Aquifoliaceae)

This species is autochthonous to the southern region of S. America having a very limited distribution outside this area (Giberti, 1994). In Argentina, Uruguay, Paraguay and south of Brazil it is, at present, the most popular non-alcoholic beverage and has a growing culturally symbolic meaning. It is known as yerba mate or mate in Argentina and Uruguay, erva mate or cimarrao in Brazil and tereré in Paraguay or in general when prepared with cold water.

What makes *I. paraguariensis* (var. *paraguariensis* and var. *vestita*) unique among other plants used as herbal teas – excluding black and green tea and coffee – is its relatively high xanthine content, especially caffeine, which has only been detected in one other species of the genus (*I. vomitoria*) that is autochthonous to N. America.

Another species, *Ilex guayusa*, autochthonous to Perú and Ecuador reportedly also has some methylxanthines, albeit in low concentrations.

Its consumption as a decoction, but more popularly as a sort of *in-situ* lixiviate has been documented right back to the very first occupation of S. American territories by Spanish colonizers and Jesuits in the northeastern zone of what is now Argentina, Paraguay and south of Brazil and even if its use by Guaraníes was banned at times due to its stimulant properties, its consumption steadily grew, spreading to all the south of S. America with the exception of Chile.



Fig. 6-2 Occurrence area of *I. paraguariensis* in S. America

Yerba mate has thus become one of the most important commercial crops with a great socio-economical regional importance in the provinces in which it is grown and is

considered to be strategically relevant in terms of the jobs created by its production and commercialization.

Its agroecological requirements restrict its cultivation to a zone that includes the northeastern provinces of Argentina, known as the Mesopotamia, and a small zone comprising S. Brazil, E. Paraguay and N. Uruguay, as can be observed in Figure 6-2.

Important world players in the beverage market such as Coca Cola have perceived the importance of yerba mate and launched a bottled drink in 2003 based on a mate extract, which was later discontinued due to a lack of commercial success. However, they are back again and have recently launched their own brand of yerba mate in Uruguay and in Argentina, with a production plant in Misiones, Argentina.



Fig. 6-3 Typical mate gourd and "bombilla" and commercial yerba mate.

The term "mate" in Spanish or "cuia" in Portuguese, derives from the Guaraní term "mati" for the gourd made from the dry and hollowed fruit of *Lagenaria vulgaris* Ser. (*Cucurbitaceae*) in which the beverage is prepared (Villanueva, 1995). These gourds vary in size throughout the region ranging from 7 to 12 cm in diameter and have an approximate volume of 50-100 ml. The hole at the top allows the "mate" to be filled with the dry roasted leaves (Fig. 6-3). Once this is done, water that is heated to approximately 90°C is added to the gourd and a straw like metal tube is inserted into the "tea". This tube or "bombilla" has a flattened open end that serves as a mouthpiece and finishes in a closed perforated bulb-like filter that is inserted into the mate. This bulb is approximately the size of a teaspoon and the perforations, which are the size of a pinhole, act as a filter avoiding the aspiration of solids – the mate leaves – when the infusion is sucked up through it (Bracesco *et al.*, 2011). Once this "extract" is drunk, hot

water is poured into the gourd again and the process is repeated till the yerba is "washed out", approximately after 10 rounds. This particular way of drinking allows the mate to be drunk while one is going around doing things, so that it is quite usual to drink at least 0.5 litres per hour or more. Several people often share one same mate, a habit that is frequent in S. America but has not been adopted in other parts of the world (in Syria for example each person has their own "mate").

It can also be drunk as a decoction that is known as called "mate cocido", that is prepared by adding yerba mate to boiling water which is kept boiling for 5 minutes after which it is strained and drunk as tea. Nowadays, this has been replaced by tea-bags, so that it is drunk as an infusion.

Drinking mate from the gourd, a person will ingest a total of 120 mg of caffeine in the first 8 rounds, spread over a volume of about 0.5 litres and drunk in approximately 30 minutes. Successive rounds naturally yield a decreasing amount of caffeine, but up to 196 mg could be ingested in a total of 20 "rounds". This quantity greatly exceeds the caffeine ingested when drinking a small cup of regular coffee - an espresso (33 mg/30ml), a cup of tea (55 mg/200 ml) or a mate decoction (30 mg/200ml)(Wilson *et al.*, 1981).

Popular uses of mate

The traditional use of the infusion of leaves and small stems ("palos") of mate is as a stimulant and diuretic. It stimulates mental and physical activity, contributing to eliminate the feeling of tiredness or fatigue (González Torres, 1992). Yerba mate is sometimes mixed with other aromatic or medicinal plants, acting thus as a vehicle for their administration. In fact, in Uruguay, these "mixtures" now have a 50% share of the yerba mate market. In Paraguay it is used for weight loss (Gupta, 1995; González Torres, 1992), probably due its diuretic and laxative effects, although as will be described later, there is evidence of other mechanisms associated to this effect.

In Uruguay, Paraguay and S. Brazil, large amounts of caffeine in the population's diet are provided by the consumption of mate. Sometimes sugar is added to it and/or other parts of plants, such as mint, cedrón (*Aloysia triphylla*) or bitter orange peels for flavouring. Water is often replaced by milk when administered to children.

In NE. Argentina, Paraguay and S. Brazil, ice-cold water or artificial powdered juices are used instead of hot water. This is usually known as "mate tereré" and is extremely popular especially in the hot summer months.

Medicinal uses of yerba mate

Yerba mate is not only used as a herbal tea and thus codified as a foodstuff but is also included in the main S. American Pharmacopoeias, including the Argentine and Brazilian national Pharmacopoeias. The German Commission E has also included a monograph on Mate in which it is indicated for mental and physical fatigue. The following activities are described for Mate: analeptic, diuretic, positively inotropic, positively chronotropic, glycogenolytic, lipolytic (Commission E, 1988). The Committee of Herbal Medicinal Products (HMPC) of the EMA (European Medicines Agency) has approved a Community Monograph in 2010 under the name of *Ilex paraguariensis folium*, in which it lists the use of the comminuted herb as a herbal tea for two therapeutical indications: Traditional herbal medicinal product for 1) symptoms of fatigue and sensation of weakness and 2) to increase the amount of urine to achieve flushing of the urinary tract as an adjuvant in minor urinary complaints (EMA, 2010). There is no monograph for roasted Mate leaves in this case.

The "Deutscher Arzneimittel Codex 2010" (DAC) includes a monograph on "Roasted Maté Leaves" (DAC-065) and "Green Maté Leaves" (DAC-066) and also the Pharmacopée Française 10.ed includes "Maté".

The *Ayurvedic Pharmacopoeia* lists "Maté" for psychogenic headache, fatigue, nervous depression, and rheumatic pains (Karnick, 1994). In Germany, Mate leaf is used as a monopreparation in an aqueous infusion dosage form and also as a component of prepared bladder and kidney teas, headache teas, and laxative teas. A Mate dry extract is found as a component of instant teas and its alcoholic tincture is used in compound fluid preparations. In the United States, Mate is used in monopreparations and as a component of central nervous system stimulant dietary supplements for mental and physical fatigue, aqueous infusion, alcoholic tincture, and aqueous dry extract (Blumenthal *et al.*, 2000).

The British Herbal Pharmacopoeia (1988, 1996) also has a monograph on Mate with similar indications to the Commission E. In these cases, the caffeine content is defined and the uses are mainly attributed to this alkaloid. Actually, as will be described further on, the saponin and polyphenolic content seems to be more related to the medicinal properties of Yerba mate than caffeine *per se*.

6.2 Botanical description



Fig. 6-5. *Ilex paraguariensis* var. *paraguariensis*- leaves, fruit and flowers (Missouri Botanical Garden)

Ilex paraguariensis A. St-Hil. var. *paraguariensis* is a dioecious evergreen tree that grows to a height of up to 18 m (Fig. 6-5). Its leaves are alternate, coriaceous and obovate with a serrate margin and obtuse apex. The inflorescences are in corymboid fascicles, the male ones in a dichasium with three to 11 flowers, the female ones with one or three flowers. The flowers are small, and simple, number four or five and have a whitish corolla. The fruit is in a nucule; there are four or five single seed pyrenes (propagules) (Giberti, 1994).

There are a number of cogeneric wild *Ilex* species that are autochthonous to the zone and that are used as adulterants of Yerba mate. Among them, the most common are *Ilex dumosa* Reisseck var. *guaranina* Loes. (*yerba señorita*, *aperea ka'a*, *cauna*, *caá chirí*),

native to Paraguay, Argentina and Brazil, the producer of a bitter-tasting maté and supposedly cultivated in Misiones by the Jesuits to produce their famous "caá mini" maté; *I. dumosa* var.*dumosa* is also used. *Ilex theezans* C. Martius ex Reisseck (cauna de folhas largas, ca'a na, congonha), is a good substitute for *I. paraguariensis*, found in Paraguay, Argentina and Brazil. *Ilex brevicuspis* Reisseck, known as cauna or voadeira, produces low quality mate.



Fig 6.6 *Ilex paraguariensis* tree plantation (INYM- Argentina)

6.3 History

A brief review of the history of yerba mate helps to understand the multiple problems faced by the industry nowadays and the difficulties involved in an adequate control of its quality.

According to the testimony of the first Spanish colonizers, the indigenous population of this region, mainly Guarani Indians, chewed yerba leaves apparently due to their nutritional and medicinal properties. There are also records of the aspiration of powdered leaves by witch doctors as part of religious rites. In the XVIth century, one of the first successful Spanish expeditioners to arrive in this part of S. America, Juan Diaz de Solis reported that..... "The Guarani Indians drunk a preparation of certain leaves that produced excitement and freedom from fatigue...."

Other accounts of the use of yerba mate by native populations and its effects can be found in the writings of Father Ruiz de Montoya, a very famous Jesuit, author of a great amount of literature on the Jesuit missions in the NE of Argentina, "*the consumption of mate is a habit that "stimulates work" and "awakens the senses"*". He also described the extremely hard life of the Indians that were made to work practically as slaves on the collection and processing of yerba mate (Montoya, 1639). At the beginning of the XVIIth Century, the recently arrived Jesuits had banned the use of mate, considering it a diabolic vice that caused severe disturbances of behaviour. However, many years later, this ban was lifted since the indigenous population, deprived of mate, turned to the consumption of an alcoholic beverage "chichi"- made from fermented fruit, corn and honey – and drunkenness became rampant. The consumption of mate was therefore considered to be, comparatively, a minor vice (Barchuk, 1998).

There are also records of the "medicinal" qualities which were observed by other Jesuit missionaries such as Father Antonio Sepp (Sepp, 1974) who referring to mate, wrote "...this herb is very healthy and has various beneficial effects: it refreshes the lungs and the boiling liver, avoids the formation of kidney or gall-bladder stones. It quenches the thirst, stops the hunger and calms the stomach, is a bit bitter and templates the soul. These are the reasons for which it is highly appreciated by the Indians and consumed daily. And women consume yerba just as much as men."

Yerba mate eventually became popular among Spanish colonizers who tried it and finding it agreeable, demanded that the Jesuits, who were working among the Indians, develop plantations from the wild species growing in Paraguay. This turned out to be very difficult. Yerba mate grew wildly in certain regions of what is today Paraguay and the colonizers forced Guarani Indians to undertake long and dangerous expeditions to the "yerbales" approximately 660 km south of Asunción, the capital of Paraguay, to a location known as Mbaracayú, to collect and process the leaves *in situ*.

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The trade of yerba mate therefore became one of the main incomes for the missions and towns of this region and a means of paying the heavy tributes demanded by the Spanish crown. It was to take the Jesuits practically one whole century, however, to be able to domesticate and produce *I. paraguariensis* crops. Father Cardiel, a Jesuit, explained how this was finally achieved "... the seed is the size of a grain of pepper, with some small particles covered in gum. Finally, after many trials, it was found that if the gum was removed from the particles, the seed were born (germinated); if these tender plants were transferred from the fertilized (with manure) nursery to another place, they could become stronger and could eventually be transplanted in the yerbal, and after watering them for two or three years, could grow well" (Furlong, 1978). From this moment, yerba mate became even more, one of the most important goods to be grown and sold by the Jesuits. The product, which was even shipped to Europe, was known as "Jesuit's tea", "Paraguayan tea" or "maté tea."

By the beginning of the 18th. century, all missionary towns had their own plantations of *I. paraguariensis*, some of which produced high quality mate. The process by which green *I. paraguariensis* leaves were converted into yerba mate was basically the same as that used today and consisted of the following steps: after cutting the "yerba", the bunches of small branches were passed over a flame with the purpose of avoiding the fermentation of green leaves. This process is known as "sapecar". After this, these bunches of branches were tied to a wooden stick and these sticks were placed on a frame or tied together in cone-like fashion. These were placed over glowing embers for 24 hours in order to toast the leaves. After this, while still hot, these toasted branches were beat with sticks to break them into smaller pieces obtaining a product known as "yerba canchada". There were two types or qualities of maté: "yerba de palos", a product consisting of leaves and twigs and stems and caá- mini that consisted only of leaves. Yerba mate, as mentioned above, became one of the major sources of income for Jesuit missions, being sold to Buenos Aires and other parts of the Spanish colonial territories in the South of S. America, and considered a favourite beverage among missionaries, Spanish and natives. Although its whole leaves were sometimes chewed, in general it was processed to be prepared in a "mate gourd" and drunk

through a straw generally made of bamboo stalks, although it is probable that tin straws began to be used in the missions at this stage. But it was not just an agreeable beverage: it was also perceived by the conquerors and missionaries as a civilizing aid, since it replaced alcohol and its destructive effects, apart from being a genuine source of income for many small towns.

Ilex paraguariensis was produced by cultivation throughout the existence of Jesuit missions and even after their expulsion its production continued to flourish thanks to the revenues generated for the Spanish crown. It did not survive, however, the political chaos that followed the expulsion of the Spanish in 1810, and most crops and towns were burnt down and attacked by Paraguayan and Brazilian military raids in the following years. The slave-like treatment of the Indians was also condemned as inhumane by some of the military generals of the newly formed territories including General Belgrano from Buenos Aires and Artigas from what is today Uruguay. As a result, the production of yerba mate relied more on the wild growing crops and a great amount of the knowledge of crop production was lost.

Despite the political turmoil and the resulting difficulty in obtaining it, yerba mate continued to be one of interesting crops of the region and the monopolisation of zones where it grew wildly was very often behind many of the skirmishes and disruption between the "strongmen" of Paraguay and NE. Argentina. A famous French naturalist, Amadeo Bonpland, who lived in S. America most of his life, studying the autochthonous flora and aspects related to it, became intensely interested in *I. paraguariensis* when he was introduced to it in 1820, and studied its properties and botanical characteristics. He published numerous papers that constitute one of the most important bases of the botanical study of the plant and even set up a farm in which he carried out experiments on its growth and industrialisation (Bonpland, 1897). It was not, however, until 1895, that the method for domesticating yerba mate was rediscovered by in Buenos Aires by Carlos Thays, who found that soaking the seeds in warm water for a long time allowed them to germinate and thus obtain yerba mate plants. Other versions attribute the germination of yerba mate seed to Federico Neumann from the "Nueva Germania" colony in Paraguay in 1896 (Parra, 2006). From this moment and greatly thanks to the work of a large population of immigrants who were established in the provinces of Corrientes and Misiones, yerba mate became an industrial crop evolving through the first half of the XXth century into a well-established industry.

6.4 Yerba mate today

Interest in yerba mate has now increased because in the last ten years its consumption as tea has been approved in the USA and EU countries, and most big commercial herbal infusion brands include "mate" either alone or in combination with other herbs in its assortment of products. In this case, the emphasis is put on its stimulant activities and is marketed as anti-obesity also, in both cases due to its caffeine and polyphenolic content. It has also been proposed as a functional food.

Yerba mate production

Today, Argentina is the main producer of yerba mate in the world and the second consumer behind Uruguay. The annual consumption per capita of yerba mate in Argentina was 6.7 kg in 2005 while in Uruguay it was 7.8 kg in the same period (Parra, 2006). Official figures are rather inconsistent though, as can be appreciated by the information available in Food and Agriculture Organization (FAO) website, in which apparently the figure for the Brazilian production of yerba mate actually corresponds to the harvested unprocessed mate crop.

The total mate harvest in 2010 in Argentina was actually 745 thousand tonnes, resulting in the production of above 250 thousand tonnes of Yerba Mate, while the total annual crop of mate in Brazil was in the order of 470 thousand tonnes

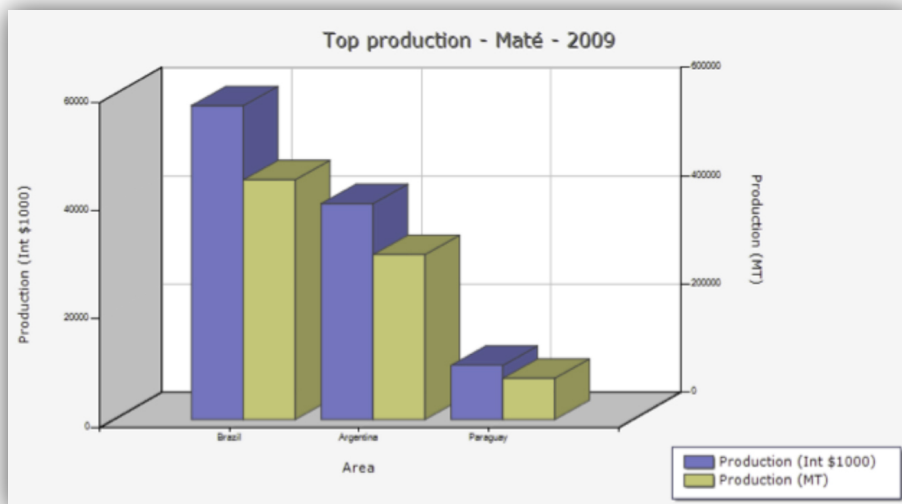


Fig. 6-7 Annual (2009) production of Yerba mate in Argentina, Brazil and Paraguay (FAOSTAT-FAO, 2011)

Argentina exports around 39 thousand tonnes of yerba mate per year, which is approximately 16% of their production, the principal buyer being Syria with a 61% share of total exports and a rapidly increasing consumption. Chile is in the second place, followed by Brazil, Spain, USA, Lebanon, Uruguay and Paraguay. In USA, increasing sales are due to the growing interest of Yerba mate as a tea marketed for its stimulant, diuretic and antiobesity properties.

Processing of Yerba mate

The process by which fresh *I. paraguariensis* leaves are transformed into the Yerba mate that is used for consumption is quite complex, consisting of several steps, all of which have a great incidence on its sensory attributes. The control of these steps is thus crucial in order to be able to offer reproducible taste and quality. Though the industrialisation process has been optimised, the basic steps are very much like those used by the Guaraní Indians centuries ago.



Yerba mate trees are cultivated and pruned in order to reach a height of 2-3 m, facilitating the collection of leaves.

Harvesting of mate leaves is done manually (mostly) during the winter months and its processing must begin no later than 24 hours after collection to avoid the initiation of fermentation processes in the leaves which lead to disagreeable taste and aroma of the final product.



The main steps involved in mate production are the following:

ROASTING (SAPECADO)	Consists in exposing the leaves to direct flames during a very brief period (20-30 seconds) in a rotary oven with temperatures of around 400-460 °C. Leaves loose around 50 to 55% of their water content. Enzymes and main leaf cellular structures are destroyed. The time, heat and size of the flames are vital variables for this process.
DRYING	The material is then dried to a water content of 5- 6%; 100 kg of leaves result in a yield of approximately 30 to 36 kg of yerba mate. This takes about 36 hours.
GRINDING (CANCHADO)	The dried material is ground coarsely and packed in loincloth sacks.
SEASONING	The yerba mate sacks are stored for periods that vary between a minimum of 9 month and up to 12 months for its aging and development of flavour. This period can be accelarated in specially designed chambers, but the resulting product has quite different organoleptic characteristics that are not always acceptable for the market.
SELECTION/PACKING	Aged yerba mate is milled and sieved and diverse categories of yerba mate are obtained according to the amount of leaf and stalks. Lower quality mate has a larger propotion of stalks.

Fig.6-8 Flow chart for the processing of I. paraguariensis leaves to yerba mate (Burtnik ,2006)

This is a very schematic description of the industrial process such as occurs in Argentina. There are variations in this process according to the company and innovations are being introduced continually to improve the final product.

- **Problems faced by the yerba mate industry**

Production of yerba mate as a foodstuff and the optimisation of its production in order to reach both sustainable and reproducible quality require a great deal of research. While coffee and tea production have a long tradition of hundreds of years, the history of industrial mate production is relatively new, considering that it was reinitiated in 1912.

Critical points in its production have still to be better understood and traditional chromatographical methods only provide a partial insight into what happens to the chemical composition of the plant material during its processing and the incidence that this can have on its sensory attributes.

Although there are several big yerba mate growers, there are a great number of small producers who sell their crops to the big yerba mate processing plants. This implies that there is a great variability in the quality of the raw material that should be detected to avoid variations in the taste and aroma of yerba mate tea.

In response to an inquiry made to big yerba mate producing companies about the real problems affecting the industrial production of yerba mate that required an analytical solution, the following issues were listed:

- Detection of adulterants in plant material that is sold to the big manufacturing companies.
- Detection of origin, season and type, mechanical or manual, of collection. Manufacturers of yerba mate must control all these factors since they lead to different tasting brews.
- Detection of the amount of "stems" –palo – contained in plant material which is bought already milled by the companies and which results in an inferior tasting brew.
- Detection of microbiological contamination (fungi) in material which might have occurred previous to its drying and is only detected once processed, causing a remarkable difference in the taste of the brew.

None of these problems has yet a satisfactory analytical solution, because no specific marker or markers that might be used to identify or quantify any of these issues has been found.

6.5 Objectives of our work

The chemical composition of yerba mate has been quite extensively studied. Its main secondary metabolites belong to three phytochemical groups: purine alkaloids, phenylpropanoids and saponins. Chromatographical analysis has proved to be useless for the detection of any of the above-mentioned problems, basically because it has been impossible to find a characteristic profile of metabolites through the analysis of individual samples.

Considering the nature of the issues, we considered that the application of a tool that allowed the acquisition of as much data as possible on both the primary and secondary metabolite content of the samples, could be the only way to characterise the acceptable raw material. This "holistic" approach can be achieved by applying methodologies such as NMR -based metabolomics, which allow the acquisition of a vast amount of information on all types of metabolites (through NMR analysis) coupled to the multivariate analysis processing of the obtained data. The identification of similar or discriminating metabolites characteristic to each situation is thus possible.

Consequently we decided to tackle one of the most complicated issues: the detection of adulterants among the *I. paraguariensis* leaves. These adulterants are usually other *Ilex* species that are also autochthonous to the region and have quite a similar chemical composition, with the exception of the caffeine content.

While working on the NMR analysis of *Ilex* samples, we detected the presence of a very active phenol, arbutin, *p*-hydroquinone glucoside, in some of the analysed species. Interestingly this compound had never been detected previously in these *Ilex* species and is not present in *I. paraguariensis*. The great quantity detected in some species (up to 10% DW) is extremely interesting. We thus quantified arbutin by NMR (results within Choi et al., 2004) and also by HPLC. The latter is described in Chapter 8 and 9.

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