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Is the Quality of Kava (*Piper methysticum* Forst. f.) Responsible for Different Geographical Patterns?

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Abstract

We argue that kava (*Piper methysticum* Forst. f.) is a Pacific domesticate that originated in Melanesia. We provide botanical, chemical, genetic and cultural evidence to suggest that farmers in the northern part of Vanuatu were the first to select the species as an asexually reproduced root crop. From Vanuatu, cultivars were carried eastward into Polynesia and westward into areas of New Guinea and Micronesia. Using herbarium data, isozyme and AFLP markers, we correlate the information gained from field surveys to HPLC analyses and attempt to demonstrate that chemotypes result from a selection process that is still active. The selection of particular mutants by farmers must have been, and still is, a rational process to preserve new characters when they appeared. Growers have selected cultivars to improve the chemical composition responsible for the physiological effects. Field experiments demonstrate that the chemotype is genetically controlled although the kavalactones content is determined by both genetics and environmental factors. The control and improvement of quality is therefore a cultural approach that aims at the identification of locations suitable for the cultivation of particular kava varieties. The appreciation of quality, appears to reflect the different cultures within Melanesia and between Micronesian, Polynesian and Melanesian consumers. Different ways of benefiting from the psychoactive properties of the plant explain the use of particular chemotypes and therefore the selection operated to preserve them. Clearly, the word kava refers to different beverages that produce different physiological effects according to what consumers desire.

Introduction

Kava (*Piper methysticum* Forst. f.) is a mild narcotic, soporific, diuretic and muscular relaxant but it is neither a hallucinogen nor a stupefacient. Kava evokes an atmosphere of relaxation and easy sociability among drinkers. Today *P. methysticum* is grown widely throughout the Pacific region and is used for daily drinking in local bars or at home. It is also exported to the nutraceutical and pharmaceutical industries which are interested in the outstanding physiological properties of its active ingredients: the kavalactones. These molecules are concentrated in the underground organs of the plant and consumers ingest the psychoactive compounds by drinking cold-water infusions of chewed, ground, pounded and macerated stumps and roots.

In Vanuatu, where kava is the first source of income for farmers, there are more than six million plants in the ground, cultivated over approximately 3,000 hectares (ha) most of which is still intercropped. Fiji had a planted area of 4,800 ha in 1998, but farmers are facing difficulties with the spread of a serious viral disease called 'kava die back'. In Samoa, the total area is estimated to be over 1000 ha and growing at a rate of 20% per year. Tonga (700 ha), Pohnpei (3000 ha) and Hawaii (50 ha) are also expanding their crops. Overall, more than 12,500 ha are in production (Siméoni, 2001).

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The beverage can be prepared from fresh or dried material. Fresh kava, when prepared by mastication, pounding or grinding, yields a greenish milky solution that is considerably stronger than the greyer mixture obtained from dried roots. The main factors determining the psychoactive effect are the bioavailability of the liopphilic resinous kavalactones and the chemical composition of the suspension. In countries where kava is prepared from fresh roots, it is rarely prepared from dried roots and vice versa.

The aim of the present paper is to explain how growers have selected cultivars to improve the chemical composition responsible for the physiological effects. No other psychoactive species has been subjected to such intense selection pressure in the Pacific. The selection of particular cultivars must have been, and still is, a rational process to preserve new characters when they appeared. The control and improvement of kava quality is the reflection of a cultural approach. The appreciation of the beverage appears to reflect the different cultures within Melanesia and between Micronesian, Polynesian and Melanesian consumers. Using evidence produced by morpho-agronomic, HPLC, isozyme and AFLP studies, we attempt to demonstrate that different Pacific Islands societies are benefiting differently from the psychoactive properties of the plant. This is explained by the use of particular chemotypes and therefore the selection operated to preserve them.

Geographical Distribution of the Species

Piper methysticum is a slow growing perennial resembling other Piperaceae. It is an attractive shrub that can reach more than three meters of height. It is typically dioecious and is a decaploid (2n=10x=130 chromosomes) incapable or reproducing itself sexually. Kava is the only species of relatively major economic importance that exists in the Pacific and nowhere else (Lebot et al. 1992). None of the native species of *Piper* existing in Polynesia or Micronesia are morphologically related to *Piper methysticum*. The probability that kava was domesticated in Polynesia or Micronesia is therefore very low. Only one species is closely related to *P. methysticum* and is endemic to northern Melanesia, that is *P. wichmannii* C. DC. which is also decaploid with 130 chromosomes (Lebot et al. 1991). *Piper wichmannii* is common from sea level to 800m altitude in Papua New Guinea, the Solomons and northern Vanuatu.

An inventory of specimens of *P. methysticum* and *P. wichmannii* conducted in 1986 and 1987 in major world herbaria (Paris, Singapore, Lae, Honolulu, Kew, London, The Hague, Kuala Lumpur, Bogor, Brisbane, Sydney, Christchurch, St. Louis MI, Cambridge MA) and in smaller herbaria (located in the Solomons, Vanuatu, Fiji, New Caledonia, Tahiti and Guam) provided an accurate picture of the geographic distribution of the species. A total of 111 specimens of *P. wichmannii* are preserved and all are from Papua New Guinea, the Solomons and Vanuatu. The 284 specimens identified as *P. methysticum* were collected from Pohnpei, Kosrae, Hawaii, French Polynesia, Wallis and Futuna, the Cooks, Niue, Samoa, Tonga, Fiji, Vanuatu, Papua New Guinea and Irian Jaya. No specimens were from the Solomons or New Caledonia.

Morphological Variation

Morphologically, *P. wichmannii* and *P. methysticum* are very similar. The major morphological difference between the two taxa is the length of the inflorescence. The inflorescence of *P. wichmannii* is as long as the lamina (15-30cm), that of *P. methysticum* varies between 6 and 20 cm but is always shorter than the lamina. There are minor differences in root characteristics, the tissue of *P. wichmannii* is significantly harder. Misindentifications between the two taxa are common in herbaria and in the field.

A comprehensive survey of the genetic resources of *P. methysticum* and *P. wichmannii* has been conducted throughout the tropical Pacific region (Lebot & Lévesque 1989) and a total of 55 distinct islands were visited. Cultivars show considerable variation of habit. Some are prostrate having short internodes, and others are normal with many stems or erect with few stems and long internodes. Local cultivars have been collected, established in germplasm collections and accessions characterized with seven standardised morpho-agronomical descriptors: general appearance of the plant, stem coloring, internode configuration, leaf coloring, lamina edges, leaf pubsecence, and internode shape. The qualitative scoring of these traits produces a coded morphological description used to differentiate morphotypes.

Kava in Vanuatu is represented by 82 different morphotypes. Only 4 morphotypes exist in Papua New Guinea, 2 in Pohnpei, 12 in Fiji, 6 in Samoa, 3 in Wallis and Futuna, 7 in Tonga, 2 in Tahiti, 1 in the Marquesas and 9 in Hawaii. However, a similar work conducted ten years later in Hawai'i revealed 13 distinct morphotypes which are now preserved at Alia Point Nursery on the east coast of the Big Island (Lebot et al. 1999). This work revealed that morphological variation is greater on some islands than on others. It also suggests that some cultivars have travelled along historical exchange routes. However, some very attractive morphotypes existing in Polynesia with bright purple, short and thick internodes with rounded shape laminas do not exist in Melanesia and in Micronesia. They were probably selected locally and recently as nothing similar exists west of Fiji (Figure 1).

Isozyme Variation

Isozyme studies have been used to provide an assessment of the degree of genetic diversity within and between

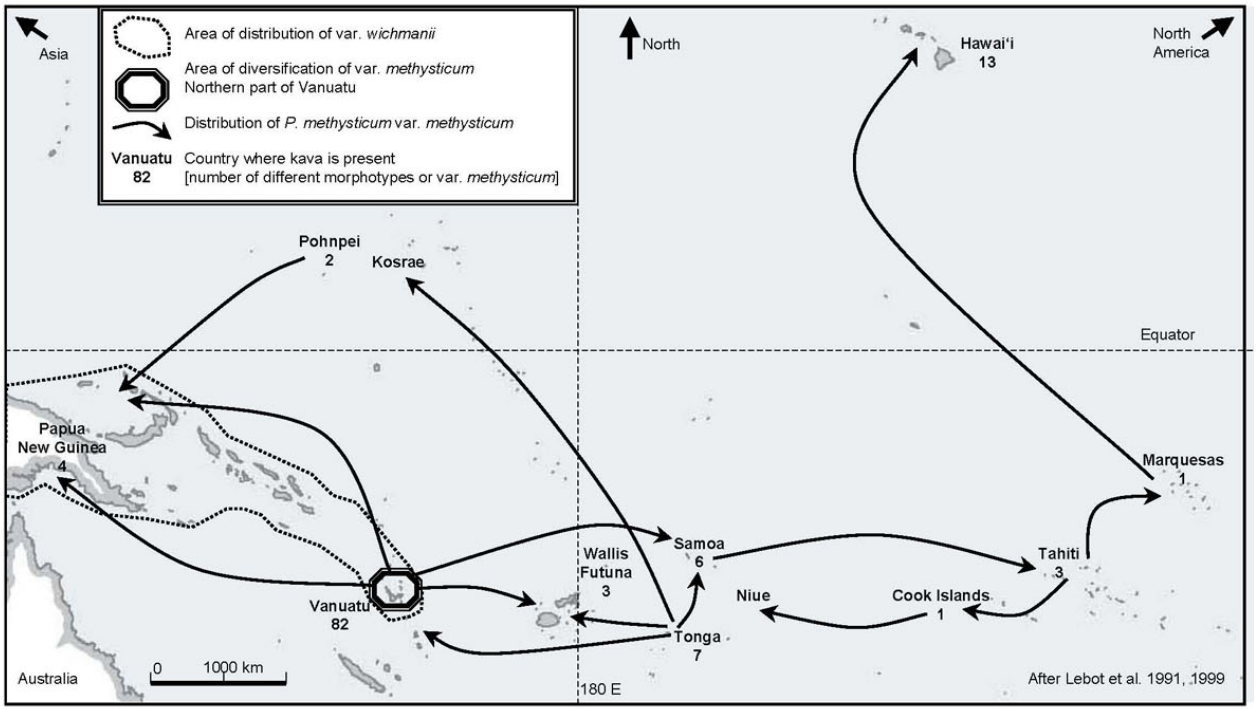


Figure 1. Geographical distribution of *Piper wichmanii* and morphological variation of *Piper methysticum*.

P. methysticum and *P. wichmannii* and to elucidate the human dispersal of cultivars (Lebot et al. 1991). More than 300 accessions, representing 43 wild forms of *P. wichmannii* and 118 cultivars of *P. methysticum*, were electrophoresed using seven enzyme systems. A total of 53 different electromorphs were identified, including 5 for aconitase, 2 for aldolase, 6 for diaphorase, 3 for isocitrate dehydrogenase, 16 for malate dehydrogenase, 5 for mallic enzyme, 5 for phosphoglucoisomerase and 11 for phosphoglucomutase. Overall, ten distinct zymotypes were identified but none of the enzyme systems could reveal a species specific band in either *P. methysticum* or *P. wichmannii*.

In *P. wichmannii* accessions, all enzyme systems were polymorphic and a total of eight distinct zymotypes were identified (no. 1 to 7 and no. 9). Among the cultivated *P. methysticum*, there was less variation of zymograms and only four of the eight enzyme systems were polymorphic. Altogether, only three distinct zymotypes were identified (no. 8, 9, 10) for *P. methysticum*: no. 8 and 9 exist in Papua New Guinea, no. 9 and 10 exist in Vanuatu and no. 10 in the rest of the Pacific. In Papua New Guinea, all cultivars collected in the south were uniformly of zymotype 9 and differed from those from the north (no. 8). However, zymotypes 8 and 9 are so similar (two missing bands at MDH and DIA) that differences could be explained as somatic mutations. In Vanuatu, one accession of *P. wichmannii* exhibited a zymotype (no. 9) identical to *P. methysticum* cultivars. Throughout Polynesia (from Samoa to Hawai'i) and Micronesia, only one zymotype was identified (no. 10) although 59 cultivars of *P. methysticum* originating from 23 islands were studied.

The taxonomic distinction between *P. wichmannii* and *P. methysticum* is not supported by isozyme data. The two taxa overlap in Vanuatu (zymotype no 9). The cultivars found in Papua New Guinea are probably very recent introductions, maybe at the beginning of the 20th century, from Vanuatu. In Polynesia, kava is probably a recent introduction also since there is no variation at the isozyme level for all cultivars electrophoresed (Figure 2).

Using field and herbarium observations and cytological and morphological comparisons as evidence, we can conclude that *P. methysticum* is not a separate species but is rather a group of sterile cultivars selected from somatic mutants that possessed desirable attributes. *Piper methysticum* should therefore be considered not a species. However, as *P. methysticum* was described first (1786) it has priority above C. De Candolle's *P. wichmannii*. Lebot and Lévesque (1996) suggested that the two should be considered as botanical varieties of the same species: *P. methysticum* var. *methysticum* and *P. methysticum* var. *wichmannii*.

AFLP Polymorphism

In order to have a better understanding of kava genetics, AFLP markers (Amplified Restriction Fragment Length Polymorphism) were used on selected accessions. A first

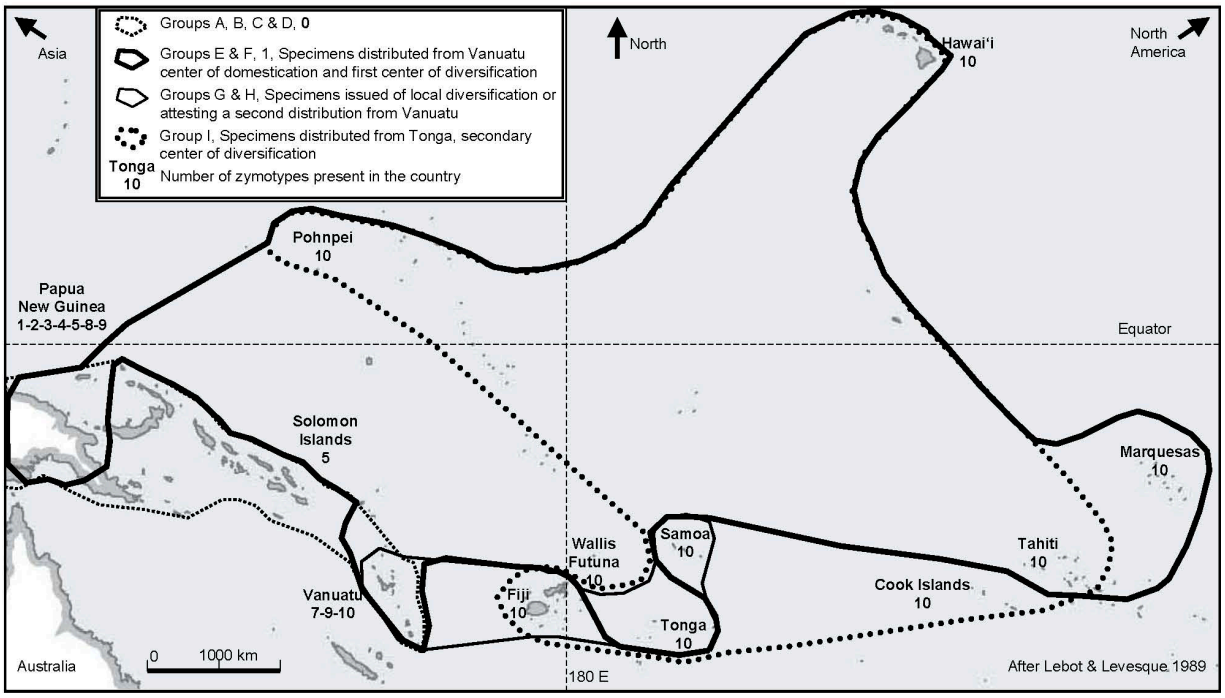


Figure 2. Distribution of *Piper methysticum* chemotypes and zymotypes.

batch of 22 accessions representing different morphotypes cultivated in a common garden (Alia Point Nursery in Hawai'i) were assessed for their genetic variation. Restriction fragments for amplifications were generated by two endonucleases: EcoR I and Mse I adaptaters to generate template DNA for amplification and 21 pairs of primers were assayed (Lebot et al., 1999). The 21 primer combinations revealed a total of 1149 distinct bands. Most accessions, representing all Hawaiian and Samoan morphotypes were monomorphs for the 21 primer combinations. Cultivars **Mahakea** and **Apu**, however, exhibited respectively 11 (0.9%) and 8 (0.7%) polymorphic bands. Cultivars **Rahmedel** and **Rahmwagner**, both originally from Pohnpei were differentiated from the Hawaiian cultivars using primers E-AGG/M-CTA. **Rahdmel** was differentiated from cultivar **Moloka'i** by four polymorphic bands. Cultivar **Isa** from Papua New Guinea, appeared to be the most genetically distant from Polynesian accessions with 117 (10.2%) polymorphic electromorphs. However, for six primer combinations this cultivar was also found to be identical to the others (Lebot et al. 1999). A second batch of only three accessions originating from Vanuatu and representing a var. *wichmannii* wild form (**Sini bo**), and two cultivars of var. *methysticum*, one considered as being primitive (**Tudei**) and another considered as being more domesticated (**Borogu**) because of relative psychoactive strength [i.e., **tudei** effects last two days.], were assayed for four primer combinations (E-AAC/M-CAT, E-ACA/M-CAA, E-AAC/M-CAA, E-ACA/M-CAT). Overall, 109 bands were revealed. The most improved cultivar was identical to the Hawaiian cultivars for these primer combinations. Variety *wichmannii* had 11 polymorphic bands and cultivar **Tudei** exhibited 3 polymorphic bands.

Polymorphisms detected in AFLP fingerprints can result from alterations in the DNA sequence including mutations, insertions, deletions, or inversions between two restriction sites. Consequently chances of detecting and revealing variation increase with the number of primer combinations tested. The fact that most cultivars exhibit identical fingerprints for numerous primer combinations demonstrates that variation within var. methysticum is controlled by very few genes. These results, obtained using modern DNA fingerprinting techniques, confirmed those obtained 10 years earlier with isozymes.

Chemical Variation

The physiological and psychological properties of kava have been demonstrated to result from the kavalactones content and the chemotype (Hänsel, 1968; Lebot and Lévesque 1989). Six major kavalactones account for approximately 96% of the lipid extract and are pharmacologically effective. They, however, differ quantitatively and qualitatively in their action. Therefore, different chemical compositions of crude kava extracts have different physiological effects on human subjects both in the laboratory and in the field (Lebot et al. 1992). The six major kavalac-

tones are used to define the chemotype (1= demethoxyyangonin, DMY; 2= dihydrokavain, DHK; 3= yangonin, Y; 4= kavain, K; 5= dihydromethysticin, DHM; and 6= methysticin, M). Chemical compositions are coded by listing in decreasing order of proportion these kavalactones in order to identify different chemotypes.

Kava in Vanuatu is represented by five main chemotypes: A, E, F, G, and H (Lebot & Lévesque 1989). A clear correlation appears between the traditional uses and the chemotype. Chemotypes 521634 and 526341 for example, represent cultivars that are rarely consumed and that belong to var. *wichmannii*. When ingested, the beverage induce an unpleasant nausea due to the very high proportions of DHM (5). The same is true for a group of cultivars of var. *methysticum* famous for their long lasting effect and called **tudei** which present chemotype 256431. Chemotype 265431 includes cultivars used in traditional medicine; chemotype 246531 are those used for daily drinking; and chemotype 426135 are those known for their rapid effect. This can be explained by the fast absorption of kavain, which causes a sudden high, compared to the much slower absorption of DHM that frequently produce nausea. When different cultivars are planted on the same day in the same plot, they produce different chemotypes inducing different physiological effects.

Chemotypes A, B, C, and D are all restricted to Melanesia and are forms of var. *wichmannii* typified by a very low kavain content. Chemotypes E, F, G, and H and I occur only in cultivars of var. *methysticum* and are found in Melanesia (Vanuatu, Fiji, New Guinea), Polynesia (Tonga, Wallis, Fatu Hiva and O'ahu), and Micronesia (Pohnpei). Chemotype F is distributed only in Papua New Guinea and Vanuatu and all *P. methysticum* cultivars in Papua New Guinea exhibit this unique chemotype. Chemotype F is rich in DHK and DHM and does not produce the most favoured psychoactive effects. Chemotypes G, H and I are well distributed throughout Vanuatu, Fiji and Polynesia and are acceptable for daily consumption depending on the way they are prepared. The chemotypic diversity of kava within Vanuatu is greater than anywhere else in the Pacific (Figure 2).

The two major determinants of kava quality are the chemotype and the kavalactone content. Vegetative propagation of kava allows the reproduction of a mother plant chemotype when its clones are planted and grown at the same location but also in different locations. The chemotype is genetically controlled. Our study (Siméoni & Lebot 2001) confirmed that there is significant cultivar variation within and between islands for kavalactone content, but that this content can also vary according to location for a given cultivar. This was revealed by comparing the performances of the plants of same cultivar (**Borogu**) having the same age but grown in different locations. The ecological (geographical) factor appears to be more important than the genetic factor in determining kavalactone content, and therefore the growing location appears to play a significant role.

Kavalactone content and chemotype also vary according to the organ of the plant, and these differences are independent of the age of the plant. The total kavalactone concentration is highest in the roots and stumps, and progressively decrease towards the aerial portions of the plant. Differences in chemotype and kavalactone content between the organs of the plant (roots, stumps, and basal stems) are maintained while the plant is aging (Siméoni & Lebot 2001). The selection of the cultivar, the specific part of the plant to be consumed, and the geographical area of its cultivation are factors contributing to quality control.

Domestication Process and Clonal Selection

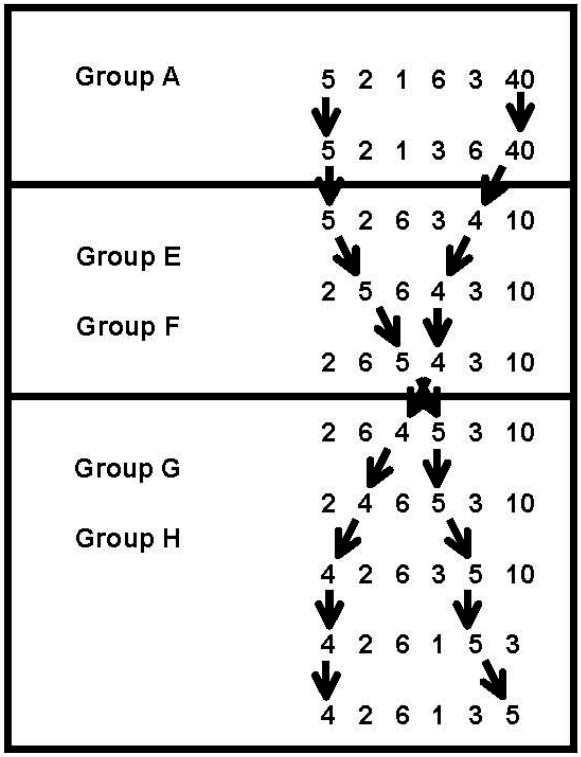
Kava was selected through vegetative propagation from a narrow genetic base in var. wichmannii as indicated by its limited isozyme and AFLP diversity. It is possible that cultivars have become sterile through the accumulation of mutations. Their morphological and chemical variability is largely the result of human selection and cloning of somatic mutations. The genealogy of kava cultivars from wild var. wichmannii to var. *methysticum* cultivars is a lineage of chemotypes (Figure 3). The evolution of these chemotypes appears to have resulted from human efforts to improve the plant's useful traits, its psychoactive characteristics. Because selection is made each time a farmer uproots an individual plant for self consumption and experiments with its physiological effect, the domestication process is in fact a progression in clonal selection. This progression is based on a "trial and error" approach that involves elimination of plants giving a poor beverage and propagation of those from elite individuals.

It is possible that all cultivars trace back to a single ancestral plant that has been developed, cloned, and dispersed throughout the Pacific. A genealogy of kava chemotypes has been suggested and supports the assertion that Vanuatu is the place of origin of var. *methysticum*. Domestication could not have occurred elsewhere, i.e. in New Guinea, because the wild forms of var. *wichmannii* found in this country have unsuitable chemotypes and the same observation is true for the Solomons. This suggests an early transmission of cultivars to a few isolated places of New Guinea with limited subsequent selection. Vanuatu being the center of origin of most cultivars, kava may be a relatively recent domesticate considering that the first settlers in the archipelago, only arrived about 3000 years ago.

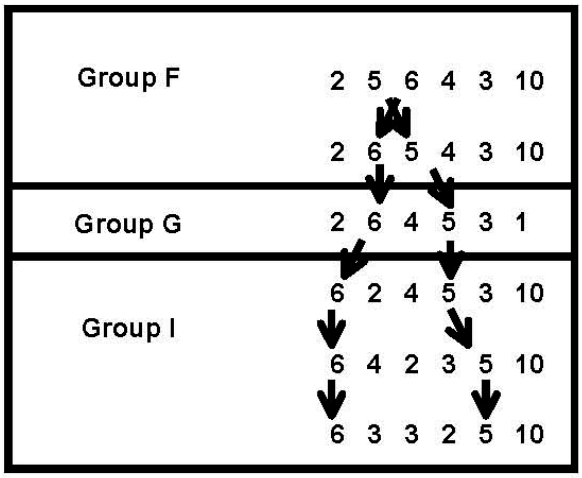
The Polynesian cultivars were probably obtained from Vanuatu more recently in the culture history of kava. The attractive morphotypes existing in Polynesia and nowhere else are a clear indication that diversification occurred in this geographical area. It is also assumed that several

Figure 3. Lineage of *Piper methysticum* chemotypes.

Lineage of chemotypes from *P. methysticum* var. *wichmanii* to var. *methysticum* resulting from domestication in Vanuatu.



Lineage of chemotypes within var. *methysticum* leading to a second diversification in Polynesia with Tonga as a probably center.



In Vanuatu, domestication resulted in decreased proportions of dihydromethysticine (5) and increased proportions of kavaine (4).
In Polynesia, diversification contributed to increasing the proportion of methysticine (6) and decreasing the proportion of dihydromethysticine (5).

chemotypes were developed locally. Chemotype I is very rich in methysticin (6) as are most cultivars from Fiji now found in central Polynesia. This was observed by Lebot and Lévesque (1989) and confirmed by Singh (1999) for the Fijian cultivars. It is also observed that in Polynesia, as in Vanuatu, selection is aimed at reducing the DHM (5) content while increasing the kavain content (4). The question as to why the Fijian cultivars produce such levels of methysticin (6) remains without a satisfactory answer; but it is probable that both the environment and some changes in the traditional uses are respinsible. According to Meyer (1967), methysticin has a very slow, but long lasting action. Hänsel (1968) considers methysticin (6), yangonin (3) and demethoxy yangonin (1) to be pharmacologically inert.

Geographical Distribution of Traditional Uses

Nowadays consumption of kava is common nearly everywhere in Vanuatu, despite the numerous and intense attempts of various Christian missions to ban it during the colonial era. In all the islands of the archipelago, kava is always consumed fresh and never from dried roots. Numerous varieties have been selected for diverse uses, and kava can be ingested for medicinal reasons, to treat particular symptoms, or for daily consumption. Some varieties are famous for the very subtle physiological effect they produce. In Fiji, kava is consumed by both of the major ethnic communities, Fijian and Indian, but always prepared from pounded dry roots (Figure 4).

Piper methysticum var. *methysticum* has a very disjunct and relatively limited distribution in Papua New Guinea and Irian Jaya. It is found only in Baluan (Manus) and Karkar islands, along the Maclay coast around Madang, and in the Fly River area around Nomad, Isago, Daru and Wando. In Irian Jaya it is found on the large Kolepom island. In all these places, kava is not drunk for daily consumption but occasionally, for funerals and mourning, and it is always prepared from fresh roots. Drinkers seek a severe and fast intoxication that can induce a rapid loss of control and a deep sleep. The chemotype and kavalactone content induce effects closer to those of a psychoactive drug and this is what drinkers are seeking. Unlike in the other drinking areas in the Pacific, the plant has low

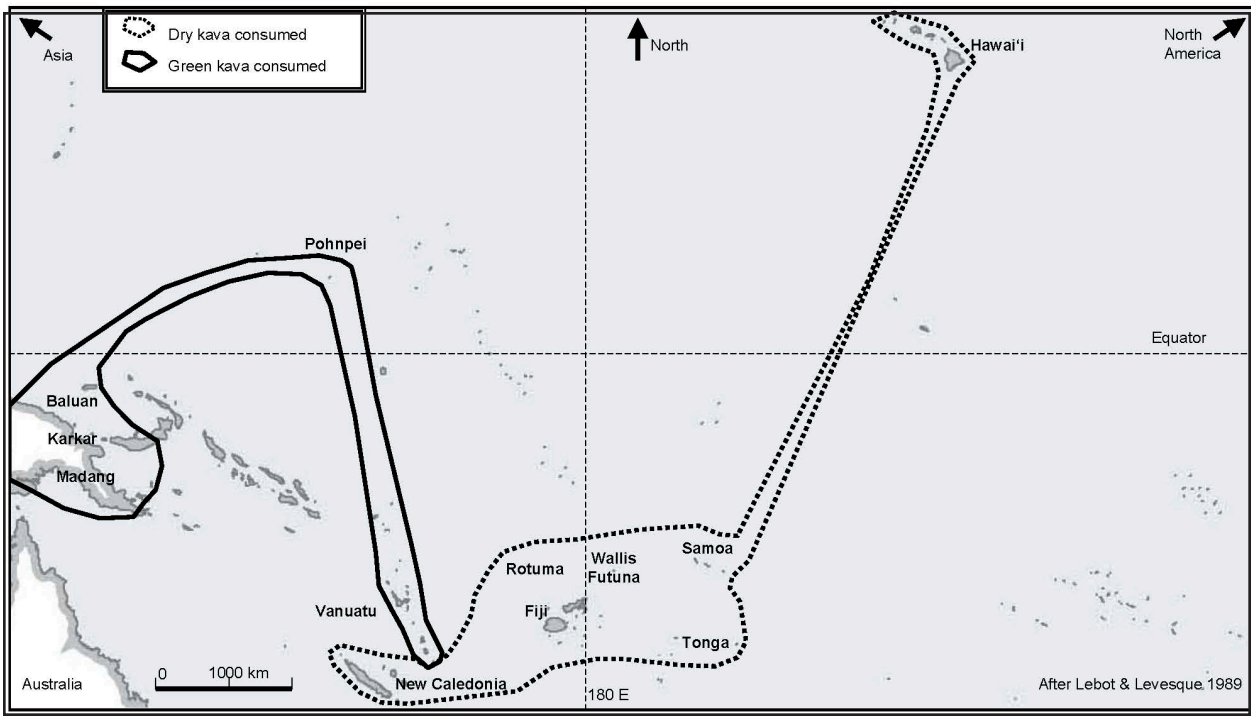


Figure 4. Contemporary consumption of kava.

cultural importance and farmers do not seem to be actively selecting from within the plants they have. All indications are that kava and its use are alien introductions to both Papua New Guinea and Irian Jaya. Cultivation is always very localised and restricted to coastal areas.

In the Solomon Islands, limited and scattered kava use has been reported on Vanikoro and Utupua and on the Polynesian outliers of Anuta and Tikopia, located in the Santo Cruz group (Rivers 1914, Firth 1970). Polynesians arriving from their homeland probably brought the plant with them to these areas in more recent times. No indications exist to confirm if it was prepared fresh or dried in these islands. When Kirch and Yen (1982) visited Tikopia in the late 1970's, kava was no longer cultivated there. Kava has been recently introduced in Malaita from cuttings collected in Vanuatu (Grahame Jackson, pers. comm., 2000).

In Polynesia, people living on all the high islands (except New Zealand, Easter Island, Rapa and the low-lying islands of Kiribati, Tuvalu, Tuamotus and Chathams) used kava at one time or another. In isolated Polynesian islands, shortages due to ecological limitations or scarcity of planting material as well as a stratified society may have induced a greater ritualisation of the consumption. Kava was prepared from fresh and dried roots. It is nowadays prepared from dry roots only in Tonga, Samoa and not consumed anymore in the rest of Polynesia. A renaissance of kava is however developing in Hawai'i. French Polynesia has shown interest in developing its commercial cultivation. In Fiji and Polynesia, consumers tend to prefer an infusion similar to tea in the sense that the effects are so mild that it can be absorbed quite early during the day and during long lasting hours.

In Micronesia, kava was consumed in only two islands ,Pohnpei and Kosrae in the Eastern Caroline Islands. Its use has been abandoned on Kosrae because of the intense missionary influence, but kava consumption is increasingly popular in Pohnpei where it is consumed daily in **Sakau** bars and always prepared from fresh roots as it was in the past. In Pohnpei, **Sakau** is always mixed with the mucilage extracted from the bark of *Hibiscus tiliaceus* in order to produce a locally favored taste.

Cultural Differences in the Appreciation of Quality

The definition of kava quality reflects distinct cultural backgrounds. It can refer to a sudden high or to a very gentle relaxing effect. The beverage can have a very bitter taste or a slightly spicy flavour. In fact, the quality of kava depends on four major conditions and on their complex combination: 1- the chemotype, 2- the total kavalactone content, 3- the preparation and dilution, and finally 4- the use of fresh or dry plant material. The chemotype is largely

dependent on the cultivar and the organ used, as we observe an increase in DHM in the upper part of the plant (basal stems and stumps versus roots). The total kavalactone content varies according to the cultivar, the age of the plant, and the environment.

Different attitudes towards drinking affect the responses to ingestion of kava. Local cultural expectations about kava intoxication as well as the specific physiological effects of a given cultivar influence a drinker's comportment while drinking and when under the influence of the beverage. The appreciation of quality differs greatly according to Pacific Island societies as different communities individuals are expecting different physiological effects. Those communities who expect an intoxicating effect are more likely to experience it. When the kava beverage is not too concentrated in kavalactones and when the chemotype is appropriate, drinkers rapidly attain a state of happy unconcern and contentment. Conversation flows gently and easily and drinkers retain control of their conscience and reason. However, if the concentration is excessive and the chemotype too rich in DHM and DHK, drinkers suffer from photophobia, diplopia and finally nausea. They feel the need to sleep, and sometimes they can be found prostrate at the place where they have drunk.

Before the arrival of the Europeans, kava was always prepared from fresh roots except maybe, when Polynesians were transporting rootstocks on their voyaging canoes for long transpacific journeys. In that case, they probably relied on dried kava. Fresh kava is never drunk very far from where the plants are grown. Everywhere where kava is drunk fresh, in Pohnpei, Papua New Guinea and Vanuatu, roots, stumps, occasionally basal stems, are mixed together when processed. Varieties, however, are always differentiated and not mixed. The stumps are occasionally pealed to remove the bark which is rich in tanins and polyphenols that are responsible for the bitter taste.

However, where kava is prepared from a dry powder, the organs of the plant: roots, stumps and/or basal stems are never mixed together. In fact, they represent different grades and are sold at different prices which reflect their total kavalactone content, roots being more expensive than pieces of stumps and basal stems. The beverage prepared using dry material is therefore a solution obtained from a specific organ. However roots of different varieties are frequently mixed together to produce '**waka**', **'lewena**' or '**kasa**' in Fiji, corresponding respectively to roots, stumps and basal stems originating from different cultivars.

From a chemical composition point of view, fresh and dry kava are also very different. The chemical composition of the fresh juice is much more complex as numerous acidic, volatile or enzymatic compounds are lost during the drying process. We recently compared two juices obtained from the same plant (variety **Borogu** from Vanuatu) processed with fresh and dry material. Chromatograms were obtained from HPLC analysis of the freeze dried extract of the fresh juice. The use of three different wave lengths reveals several peaks, significantly distinct from the six major kavalactones. These have yet to be characterized. Drinkers who ingest fresh kava juice, notice a rapid and sudden high that dry kava cannot produce. There are obviously many compounds that are interacting together to induce this subtle physiological effect. For a given cultivar, two very different brews can be prepared with dried or fresh roots of the same plant. The taste is different as is of course, the total kavalactone concentration and chemical composition.

Consequently, and based on the results obtained from field experiments (Siméoni & Lebot 2001), it can be said that in places where kava is consumed fresh, the appreciation of quality focuses on the variety and therefore on the chemotype; in places where kava is consumed dry, the appreciation of quality focuses on the organ and therefore on the total kavalactone content.

However, chemotype and total kavalactone of the raw material alone cannot guarantee the quality of the beverage, there is a craftsman's knowledge involved in the preparation. The methods of preparation aim at extracting the active ingredients from fresh or dried plant material. Processing involves chewing, grating, grinding, or pounding and then infusing the mass in cold water. This process breaks up tissues so that kavalactones, which are lipid-like compounds, are released in suspension into cold water when the processed vegetal mass is squeezed through a filter. In the case of dry kava, this is done in two steps: first the material is dried, grounded, preserved as a dry powder, and second it is infused, squeezed and filtered. Infused kava is never kept long and is always prepared for immediate consumption.

The kava juice, prepared from dry or fresh roots, has a pH around 7 just after filtration and decreases slowly to 4.5 in a few hours depending on warm temperatures which accelerate the phenomenon. Once the beverage reaches this acid pH, it is stable but never drunk. The acidification process is much faster if the beverage is prepared from the fresh root. Warm temperatures activate the bacterial degradation but there is no fermentation process.

The dilution ratio is of course of utmost importance. In Vanuatu, kava bars adopt a 1:1 mix comparable to what farmers do for their own consumption. One liter of water is mixed thoroughly with one kilogram of fresh ground roots The mixture is then pressed. The opera-

tion is conducted twice. For dry kava powder, the mix ratio depends on the organ of the plant used.

Discussion and Conclusion

In this paper we have attempted to make a number of points: 1- the genetic base of kava cultivars is extremely narrow, 2- morphotypes and chemotypes were diversified via clonal selection, 3- diversification occurred in different agro-climatic and socio-cultural environments, and 4- kava beverages are prepared in various ways and produce distinct physiological effects. The future of the plant in the Pacific, and on international markets, depends on these four points.

Isozyme and AFLP markers demonstrate that the genetic base is extremely narrow. The crop is genetically highly vulnerable, and in the absence of sexual recombinations, cultivars cannot adapt to the rapidly changing Pacific Island environments. Because kava has been domesticated through clonal selection, it is probable that its vascular systems is loaded with endophytes, bacteria and viral particles. The most serious disease, the die back, is a complex pathology where several co-factors are involved, including the CMV (Cucumber Mosaic Virus). Considering our knowledge of kava genetics, it is very unlikely that the plant can be improved using traditional plant breeding techniques. If it was possible to obtain true botanical seeds, those would not represent a practical solution for farmers as the species in diocieous and heterozygous.

Piper methysticum cultivars are the result of an old selection process that was initiated when domestication occurred in northern Vanuatu, probably starting about 3,000 years ago, considering the date of arrival of the first humans. It can be assumed that the selection approach was similar to what some farmers are still practising in various islands of Vanuatu today. The kava plant is first uprooted, the leaves are eliminated and the stems are placed in the hole left by the harvest of the stump and its root system. The beverage is usually prepared the same evening and farmers judge the physiological effect. If the effect is undesirable, they will leave the stems were they are and they will collapse. Selection is therefore operating each time an individual plant is uprooted and consumed. Kava being propagated exclusively by stem cuttings, growers must make judicious choices when selecting mother-plants. The selection of particular mutants must have been a continuous and conscious process otherwise it would be difficult to explain the numerous distinct morphotypes found today and spread way beyond their area of origin.

In Vanuatu, this process is dynamic and efficient. New cultivars are regularly found in farmer's fields and a recent census (Siméoni 2001) recorded cultivars that did not exist in 1983 (Lebot & Brunton 1985). Although a rare event, the appearance of an interesting mutation always attracts farmer's interest. Considering the high ploidy level of the species, the chances of fixing these mutations in the kava plant genome are enhanced. The useful traits of the plant, those on which selection operates in priority, are the physiological effects which are determined by the chemotype. Morphological and chemical variation are independent and the occurrence of new morphotypes is not a consequence of the chemotype selection. It however, helps farmers to distinguish their cultivars.

This process is efficient in locales where kava is still consumed daily by farmers themselves. Theoretically, the rate of apparition of somatic mutants is directly correlated with the propagation rate. Thus, with cultivation expanding throughout the Pacific, chances of selecting new morphotypes and/or chemotypes are increasing. Unfortunately, cultivation is largely done on a commercial basis and farmers do not always drink what they sell.

The selection initiated in Eastern Melanesia continued in much of Polynesia, and parts of Micronesia where it was conducted in diverse environments, and aimed at the satisfaction of different needs, from daily consumption to rituals. The selection process being conducted in distinct geographical environments by farmers from different cultures, chances of selecting clones with different characteristics are increased. The geographical diversity of the Pacific Islands has most likely contributed to the clonal diversification of the plant. Islands where kava was cultivated were more numerous in the past and it is obvious that genetic erosion has already occurred in French Polynesia, the Cooks, Niue as well as in Fiji, Kosrae, and Hawai'i. However, now that the crop is expanding again, it is possible that diversification will continue, although it is very limited genetically, as explained above.

The adoption of dry kava consumption results from the heavy pressures imposed by Christian Missionaries during the 18th and 19th centuries to ban kava. For some reasons, in Melanesia and Micronesia, the local communities succeeded in protecting their traditional uses of the plant. In Fiji, Samoa and Tonga, consumers adopted the dry powder and diluted their beverage so that it corresponds to a beverage acceptable for European standards, but is also adapted to their way of socialising. While doing so, they contributed to the erosion of their local traditional knowledge related to cultivars and to their distinct uses. In countries where kava is prepared from the dried plant material, the selection process cannot be efficient because varieties are not identified. This might explain the high levels of methysticin found nowadays in Fijian cultivars. In the future, it will be important that varieties are clearly differentiated when their distinct organs are sold on the local markets so that farmers can have a feedback they can use for selection. If not, it is likely that selection per se, will be difficult to conduct in farmers fields, at least for traits related to quality.

Beacuse diverse chemotypes are being cultivated by farmers with different cultural backgrounds, chances of producing different beverages are again increased. An Indian farmer from the Island of Taveuni (Fiji) does not look at kava as a farmer from the island of Pentecost in Vanuatu. Their vision of the crop reflects their culture and motivate the use of the product. The kava beverage is what different communities want to produce, using their knowledge of the plant species *P. methysticum*. The drink is a reflection of their various intentions to communicate with gods, treat a moral or physical pain, socialise with friends at the end of a day of work, or be under the influence of the psychoactive substance.

The parameters, factors and conditions necessary to achieve what they intend to produce are numerous and complex. It is their subtle combination that result in different local brews similar to vintages. The quality of kava could therefore be regulated by the use of geographical indicators to develop appellations of origin. This system could regulate the use of indicators relating to a specific village, island or country, when the morpho-types and/or chemotypes are closely related to a particular geographical area, such as appellations of origins for wines, for example. New products are now being developed in different countries, and it is likely that this will have an impact as well, soon or later, on how farmers select their germplasm.

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