

Kavalactone content and chemotype of kava beverages prepared from roots and rhizomes of *Isa* and *Mahakea* varieties and extraction efficiency of kavalactones using different solvents

Jun Wang · Weiyue Qu · Harry C. Bittenbender · Qing X. Li

Revised: 1 May 2013 / Accepted: 4 June 2013 / Published online: 25 June 2013
© Association of Food Scientists & Technologists (India) 2013

Abstract The South Pacific islanders have consumed kava beverage for thousands of years. The quality of kava and kava beverage is evaluated through determination of the content of six major kavalactones including methysticin, dihydromethysticin, kavain, dihydrokavain, yangonin and desmethoxyyangonin. In this study, we determined contents of kavalactones in and chemotype of kava beverages prepared from roots and rhizomes of *Isa* and *Mahakea* varieties and extraction efficiency of five different solvents including hexane, acetone, methanol, ethanol and ethyl acetate. The six major kavalactones were detected in all kava beverages with

these five solvents. Different solvents had different extraction efficiencies for kavalactones from the lyophilized kava preparations. The contents of kavalactones in the extracts with acetone, ethanol, and methanol did not differ significantly. Ethanol had the highest extraction efficiency for the six major kavalactones whereas hexane gave the lowest extraction efficiency.

Keywords *Piper methysticum* · Kava · Kavalactone · Chemotype · Extraction efficiency

Jun Wang and Weiyue Qu contributed equally to this work.

J. Wang
Key Laboratory of Aquatic Botany and Watershed Ecology, Wuhan Botanical Garden, Chinese Academy of Sciences, Wuhan 430074, China

J. Wang · W. Qu · Q. X. Li
Department of Molecular Biosciences and Bioengineering, University of Hawaii at Manoa, Honolulu, HI 96822, USA

H. C. Bittenbender
Department of Tropical Plant and Soil Sciences, University of Hawaii at Manoa, Honolulu, HI 96822, USA

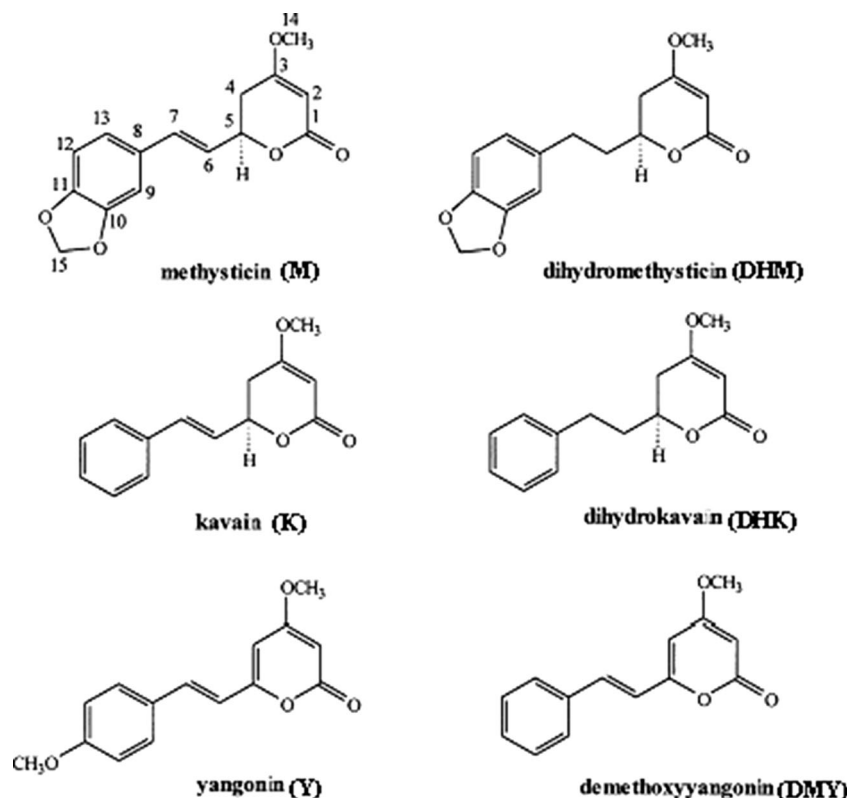
H. C. Bittenbender (✉)
Department of Tropical Plant and Soil Sciences, University of Hawaii, 3190 Maile Way, St. John 102, Honolulu, HI 96822, USA
e-mail: hcbitt@hawaii.edu

Q. X. Li (✉)
Department of Molecular Biosciences and Bioengineering, University of Hawaii, 1955 East-west Road, Honolulu, HI 96822, USA
e-mail: qingl@hawaii.edu

Introduction

Kava is known as the common name of both a shrub plant, *Piper methysticum* and the beverage prepared from the plant materials (BHMA 1996). The South Pacific islanders have consumed kava beverages for thousands of years (Singh 1992). The kava beverage is traditionally prepared from macerated roots and/or stump with water or coconut water (BHMA 1996; Kilham 1996). It is reported that beneficial effects of the kava beverage include relaxation, euphoria, anti-convulsion, neuroprotection, analgesia and attenuation of menopausal symptoms (Lebot et al. 1992; Bilia et al. 2002; Lebot and Lévesque 1989; Baum et al. 1998; Whitton et al. 2003; Schulz et al. 2001). The safety of kava consumption has been a topic of debate in recent years (Anke and Ramzan 2004; Russmann et al. 2001; Anon 2001; Campo et al. 2002; Gow et al. 2003; Brauer et al. 2003). In general, the kava beverage and products made from rhizomes and roots have been considered being safe (Teschke and Lebot 2011).

Six major kavalactones are considered to be the main psychoactive components of kava. Some reports suggested

Fig. 1 Molecular structures of the six major kavalactones

that these kavalactones exert advantageous physiological functions on humans such as diuretic, soporific, antiepileptic, spasmolytic, analgesic, local anaesthetic, bacteriocidal and antimycotic functions (Whitton et al. 2003; Lebot and Lévesque 1996a). Lebot and Lévesque divided the active ingredients of kava into two main groups — major kavalactones and minor kavalactones, and numbered and used only the six major kavalactones (1 = desmethoxyyangonin, DMY; 2 = dihydrokavaia, DHK; 3 = yangonin, Y; 4 = kavain, K; 5 = dihydromethysticin, DHM; and 6 = methysticin, M (Fig. 1) (Lebot and Lévesque 1989; Wang et al. 2010)). It was reported that no liver enzymes were elevated in rats with a daily dose of 200 or 500 mg kavalactones/kg for 2 weeks (Singh and Devkota 2003). Dragull et al. (2003) suggested that an alkaloid, pipermethystine, in kava may be toxic to liver cells.

It was reported that contents and chemotypes of kavalactones vary among parts, kava varieties and plant ages (Siméoni and Lebot 2002). The contents and chemotypes of kavalactones are the main criteria of kava beverage quality. The traditional method for preparing kava beverage made the content of kavalactones decline in the kava beverage. However, no studies were reported about extraction efficiency of different solvents for kavalactones in kava material and kava beverage. In this study, the aim was to study chemotypes and contents of kavalactones from rhizomes and roots of two kava varieties in five different solvents and extraction efficiency of different solvents for kavalactones from kava materials.

Materials and methods

Raw materials

All solvents were of high-performance liquid chromatography (HPLC) grade from Fisher Scientific (Fairlawn,

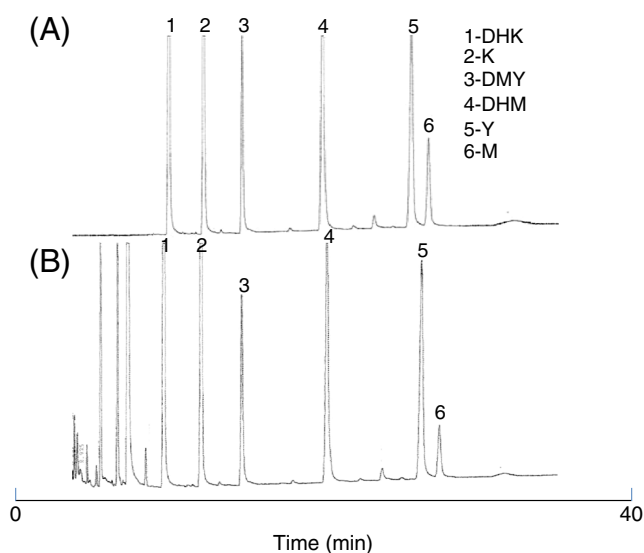
**Fig. 2** GC chromatograms of six kavalactone standards (A) and a typical kava extract (B)

Table 1 Comparison of solvent extraction efficiencies for kavalactones and the total content and chemotype of kavalactones extracted from kava beverages that were prepared from roots and rhizomes of Isa and Mahakea varieties (g/g in lyophilized beverage materials)

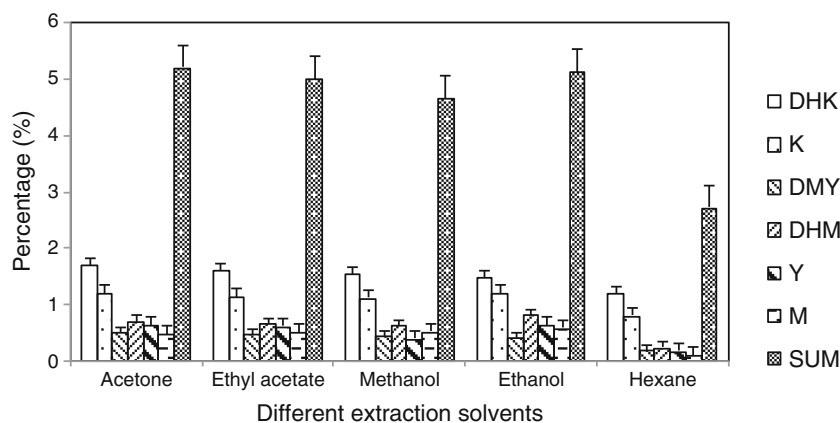
Solvents	Mahakea variety		Isa variety	
	Total kavalactone content		Total kavalactone content	
	Root	Rhizome	Root	Rhizome
Acetone	0.0819±0.0005	0.0513±0.0002	0.1764±0.0018	0.0870±0.0002
Ethanol	0.0948±0.0003	0.0569±0.0002	0.1782±0.0023	0.0590±0.0001
Ethyl acetate	0.0754±0.0002	0.0513±0.0003	0.1442±0.0020	0.0416±0.0003
Methanol	0.0797±0.0003	0.0482±0.0001	0.1763±0.0015	0.0514±0.0002
Hexane	0.0338±0.0004	0.0286±0.0002	0.0737±0.0004	0.0442±0.0003

NJ). Kavalactone standards including methysticin (M), dihydromethysticin (DHM), kavain (K), dihydrokavain (DHK), yangonin (Y) and desmethoxyyangonin (DMY) (Fig. 1) were purchased from Sigma-Aldrich Corp. (St. Louis, MO, USA). Other reagents were purchased from Sigma (St. Louis, MO) too otherwise stated. Kava materials were Kava roots and rhizomes of Isa variety and Mahakea variety at 3.4 years of age grown in the Waimanalo Research Farm on Oahu, University of Hawaii.

Preparation of kava materials and beverages

The fresh kava root or rhizome materials mixed with warm water (45 °C) at a ratio of was 1:3 (W/V) in blender, shredded (0.1–3 mm diameter) for 1 min and agitated, and then filtered and squeezed manually. The extractions were repeated three times and the water extracts (beverage) were combined. An aliquot (40 mL) of the beverage was frozen dried. The dried kava powders were extracted with 10 mL of ethyl acetate, methanol, ethanol, acetone or hexane under sonication for 10 min. After a brief centrifugation at a low speed (2,000 rpm), the supernatant (solvent layer) was decanted into a test tube. This extraction process was repeated three more times. The extracts were combined followed by evaporation of the solvent under a gentle stream of nitrogen gas to an appropriate volume (1 mL).

Fig. 3 Percentages of six major kavalactones and their total content in the beverages prepared from Mahakea rhizome and extracted with different solvents (% in lyophilized beverage powder). *DHK* dihydrokavain; *DHM* dihydromethysticin; *DMY* desmethoxyyangonin; *K* kavain; *M* methysticin; *Y* yangonin



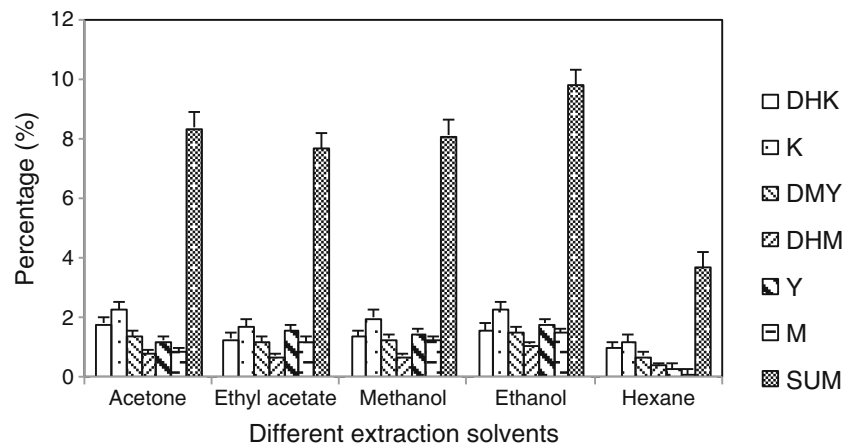
Analysis of kavalactones with gas chromatography-flame ionization detector (GC-FID)

The six major kavalactones were analyzed on a Hewlett Packard model 5890 series II gas chromatograph equipped with an FID, an autosampler, and a DB-5 capillary column (30 m×0.25 mm, 0.25 μm; J&W Scientific, Rancho Cordova, CA). The carrier gas was set at a flow rate of 1 mL/min of helium. The injector and detector temperatures were 250 and 300 °C, respectively. The oven temperature started at 120 °C for 1 min, increased to 300 °C at a rate of 10 °C/min and then held at 300 °C for 5 min. The injection was at splitless mode and the injection volume was 2 μL. Octadecane was used as an internal standard to calculate the concentrations of the six major kavalactones. Figure 2 shows GC chromatograms of six kavalactone standards and a typical kava extract.

Quality control and quality assurance (QA/QC)

Sample preparations and analytical procedures were performed according to quality assurance and quality control measures. Work standard solutions of kavalactones were run at the beginning of sample analysis to evaluate peak resolution and possible contamination. The limits of detection (LOD) were determined as signals three times of the background signals. Peaks that were smaller than three times of

Fig. 4 Percentages of six major kavalactones and their total content in the beverages prepared from Mahakea root and extracted with different solvents (% in lyophilized beverage powder). *DHK* dihydrokavain; *DHM* dihydromethysticin; *DMY* desmethoxyyangonin; *K* kavain; *M* methysticin; *Y* yangonin



the signal-to-noise ratio were considered undetected. Each sample was analyzed in triplicate otherwise stated. The LOD for six kavalactones ranged from 0.5 ppm to 1 ppm.

Results and discussion

Comparison of extraction efficiency of different solvents for kavalactones

Extraction efficiency of kavalactones from kava beverages varied with extracting solvents (Table 1). Among all solvents tested, ethanol yielded the highest total content of kavalactones from Mahakea and Isa root beverages and Mahakea rhizome beverages. The total kavalactone content of acetone extract of Isa rhizome beverages was higher than that of ethanol. Ethanol had the strongest extraction efficiency, whereas hexane had the lowest extraction efficiency among the five solvents. Solvent polarity is apparently important for good extraction efficiencies for kavalactones as kavalactones have moderate polarity.

Comparison of kavalactone content in kava beverages prepared from root and rhizomes of Isa and Mahakea varieties as extracted with different solvents

The total kavalactone content in roots was higher than that in rhizome of the same kava variety, as reported by others (Siméoni and Lebot 2002). The total kavalactone content in Isa root beverages was approximately twice as much as in Mahakea root beverages, which the kava plants were grown in the same field and harvested at the same age (Table 1). The total kavalactone content in Isa and Mahakea rhizome beverages was approximately equal (Table 1). The results suggest that kavalactone content depends up on kava varieties and plant part.

Figure 3 shows the profiles of six major kavalactones and their total content in the beverages prepared from Mahakea rhizome and extracted with different solvents. In general, the concentrations of dihydrokavain (DHK) and kavain (K) were higher than the other four kavalactones. Figure 4 shows percentages of six major kavalactones and their total content in the beverages prepared from Mahakea root and extracted with different solvents. Except hexane

Fig. 5 Percentages of six major kavalactones and their total content in the beverages prepared from Isa rhizome and extracted with different solvents (% in lyophilized beverage powder). *DHK* dihydrokavain; *DHM* dihydromethysticin; *DMY* desmethoxyyangonin; *K* kavain; *M* methysticin; *Y* yangonin

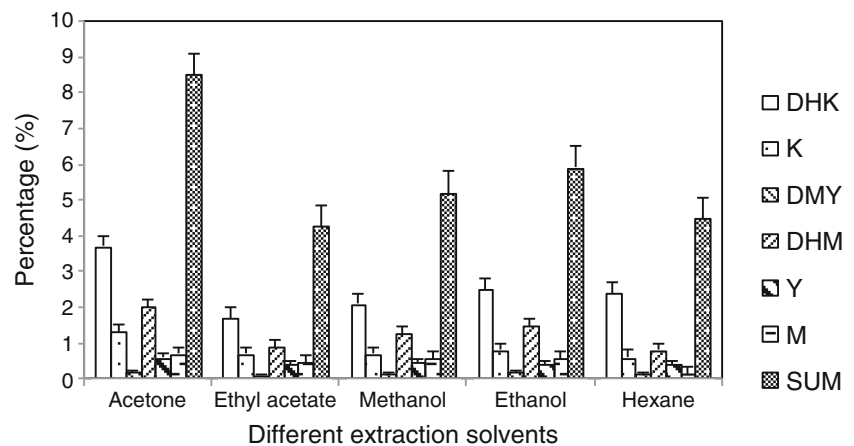
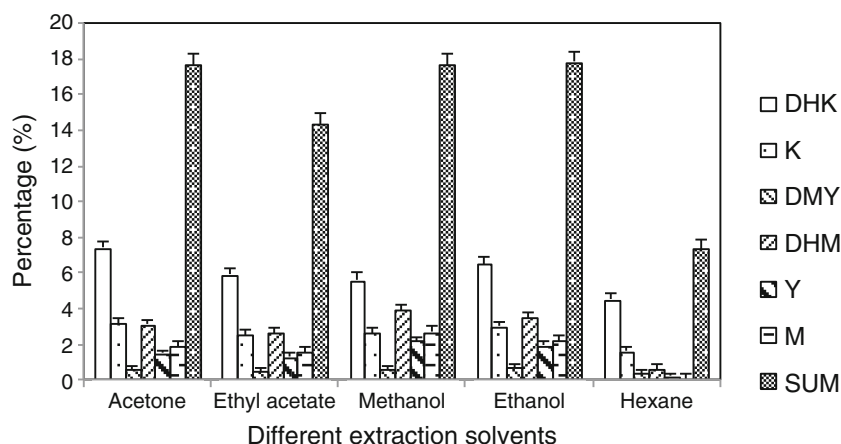


Fig. 6 Percentages of six major kavalactones and their total content in the beverages prepared from Isa roots and extracted with different solvents (% in lyophilized beverage powder). *DHK* dihydrokavain; *DHM* dihydromethysticin; *K* kavain; *M* methysticin; *Y* yangonin



extracts, the concentrations of the six major kavalactones were approximately similar. Figure 5 shows patterns of six major kavalactones and their total content in the beverages prepared from Isa rhizome and extracted with different solvents. DHK had the highest concentrations in the beverages followed by dihydromethysticin (DHM) and then K. Figure 6 shows the profiles of six major kavalactones and their total content in the beverages prepared from Isa rhizome and extracted with different solvents, which the profiles are similar to those of Isa rhizome beverages.

It is well documented that the content of kavalactones in kava plant or kava beverage depend on kava plant varieties, part and age and geographic locations of the plants, and even orientation of kava plant and time of harvest (Siméoni and Lebot 2002; Lebot and Lévesque 1989; Lebot et al. 1999). Smith (1983) and Smith et al. (1984) found that the content of the kavain, demethoxyyangonin and yangonin were higher in the roots than in the stems and leaves, whereas dihydrokavain, methysticin, and dihydromethysticin were higher in the roots than in the stems and the leaves. Content of kavalactone in kava beverages also depend on temperature of water, ratio of water and kava material, and size of kava material and times of extraction.

Chemotype in kava beverages prepared from roots and rhizomes of Isa and Mahakea varieties as extracted with different solvents

The results of the present study indicate that there are some variations in chemotype in kava beverages prepared from Mahakea roots and rhizomes, as extracted with different solvents, whereas the chemotypes of kava beverages prepared from Isa roots and rhizomes appear to be stable (Table 1). The chemotypes of kava beverages prepared from Isa roots and rhizomes as extracted with the five solvents were the same (chemotype, 254631) with an exception of acetone extracts of Isa roots (chemotype, 245631). In the beverages prepared

from Mahakea rhizomes, the chemotypes of the first three kavalactones as extracted with five different solvents were 245 (DHK:K:DHM). In the beverages prepared from Mahakea roots, the chemotypes as extracted with ethanol, ethyl acetate and methanol were the same 432615 (K:Y:DHK:M:DMY:DHM). The most varying kavalactones are DMY (1) and Y (3) for Mahakea kava beverages.

Chemotypes varied among kava cultivars (Lebot and Lévesque 1996a) and different parts (roots, stumps and stems) (Siméoni and Lebot 2002). Lebot and Singh had reported high levels of dihydrokavain (DHK) and kavain (K) in root samples of kava from Vanuatu, whereas methysticin (M) is majority in samples from Fiji (Lebot and Lévesque 1989, 1996b; Singh 1999).

Conclusion

This work reports the content and chemotype of kavalactones in kava beverages prepared from Mahakea and Isa roots and rhizomes as extracted with different solvents. Ethanol had the highest extraction efficiency of kavalactones from kava beverages lyophilized materials. The total kavalactone content in Isa root beverages was approximately two-fold of that in Mahakea root beverages. The total kavalactone content in Isa and Mahakea rhizome beverages was approximately equal. The chemotypes of Isa root and rhizome beverages were the same (chemotype, 254631). The chemotypes of the first three kavalactones in the Mahakea rhizomes beverages were 245. The dominant kavalactone in Mahakea root beverages was kavain (4).

Acknowledgments This work was supported in part by grants from the State of Hawaii Department of Agriculture and Department of Health, USDA TSTAR (2005-34135-15989) and the Open Funding Project of the Key Laboratory of Aquatic Botany and Watershed Ecology, Chinese Academy of Sciences (JW).

References

- Anke J, Ramzan I (2004) Kava hepatotoxicity: are we any closer to the truth? *Planta Med* 70:193–196
- Anon (2001) Medicines Control Agency Meeting, London UK, December 2001
- Baum SS, Hill R, Rommelspacher H (1998) Effect of kava extract and individual kavapyrones on neurotransmitter levels in the nucleus accumbens of rats. *Prog Neuropsychopharmacol Biol Psychiatry* 22:1105–1120
- British Herbal Medicine Association's Scientific Committee (1996) British herbal pharmacopoeia, 4th edn. BHMA, Bournemouth, pp 28–29
- Bilia AR, Gallori S, Vincieri FF (2002) Kava–kava and anxiety: growing knowledge about the efficacy and safety. *Life Science* 70:2581–2597
- Brauer RB, Stangl M, Stewart JR, Pfab R, Becker K (2003) Acute liver failure after administration of the herbal tranquilliser kava-kava. *J Clin Psychiatry* 64:216–218
- Campo JV, McNabb J, Perel JM, Mazariegos GV, Hasegawa SL, Reyes J (2002) Kava-induced fulminant hepatic failure. *J Am Acad Child Adolesc Psychiatry* 41:631–632
- Dragull K, Yoshida WY, Tang CS (2003) Piperidine alkaloids from *Piper methysticum*. *Phytochem* 63:193–198
- Gow PJ, Connelly NJ, Hill RL, Crowley P, Angus PW (2003) Fatal fulminant hepatic failure induced by a natural therapy containing kava. *Med J Australia* 178:442–443
- Kilham C (1996) Kava: medicine hunting in paradise. Park Street Press Publisher, Rochester, p 166
- Lebot V, Lévesque J (1989) The origin and distribution of Kava (*Piper methysticum* Forst. f., Piperaceae): a phytochemical approach. *National Tropical Botanical Garden, Hawaii Allertonia* 5:223–380
- Lebot V, Merlin M, Lindstrom L (1992) Kava: the pacific drug. Psychoactive plants of the world series. Yale University Press, New Haven, p 260
- Lebot V, Lévesque J (1996a) Genetic control of kavalactone chemotypes in *Piper methysticum* cultivars. *Phytochem* 43:397–403
- Lebot V, Lévesque J (1996b) Evidence for cospecificity of *Piper methysticum* Forst. f. and *Piper wichmannii* C. DC. *Biochem Sys Ecol* 24(7/8):775–782
- Lebot V, Johnston E, Zheng QY, McKern D, McKenna DJ (1999) Morphological, phytochemical, and genetic variation in Hawaiian cultivars of 'awa (kava, *Piper methysticum*, Piperaceae). *Eco Botany* 53:407–418
- Russmann S, Lauterburg BH, Helbling A (2001) Kava hepatotoxicity. *Ann Intern Med* 135:68–69
- Schulz V, Hansel R, Tyler V (2001) Rational phytotherapy, a physician's guide to herbal medicine, 4th edn. Springer, Germany, pp 172–173
- Singh S (1999) Variability of kavalactone content of yaqona samples in Fiji. M.Sc. Dissertation thesis, School of Pure and Applied Sciences, University of the South Pacific, Suva, Fiji
- Singh YN (1992) Kava: an overview. *J Ethnopharmacol* 37:13–45
- Singh YN, Devkota AK (2003) Aqueous kava extracts do not affect liver function tests in rats. *Planta Med* 69:496–499
- Siméoni P, Lebot V (2002) Identification of factors determining kavalactone content and chemotype in Kava (*Piper methysticum* Forst. f.). *Biochem Sys and Ecol* 30:413–424
- Smith RM, Thakrar H, Arowolo TA, Safi AA (1984) High performance liquid chromatography of kava lactones from *Piper methysticum*. *J Chromatogr* 283:303–308
- Smith RM (1983) Kava lactones in *Piper methysticum* from Fiji. *Phytochem* 22:1055–1056
- Teschke R, Lebot V (2011) Proposal for a kava quality standardization code. *Food Chem Toxicol* 49:2503–2516
- Wang J, Jun S, Bittenbender HC, Li QX (2010) Rapid determination of six kavalactones in kava root and rhizome samples using Fourier Transform infrared spectroscopy and multivariate analysis in comparison with gas chromatography. *Anal Methods* 2:492–498
- Whitton PA, Laua A, Salisbury A, Whitehouse J, Evans CS (2003) Kava lactones and the kava-kava controversy. *Phytochem* 64:673–679