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KAVALYTICS™

Instant lab quality results at the push of a button

KAVALYTICS™

Fast • Affordable
Accurate • Validated

The new standard in Kava quality testing and traceability

KavaLytics™ provides clients with a fast, affordable, accurate and validated quality assessment method for Kava using a state of the art handheld Near Infrared spectrometer, paired with a powerful, cloud-based artificial intelligence machine-learning platform that is intended to implement quality controls and traceability throughout the Kava value chain. Simply point the scanner at a bag of Kava powder and get instant lab quality results on any blue tooth enabled IOS device. Print, save, or email the analysis results on the spot, or create a label to apply to the product, complete with a QR code for quality control, traceability compliance and added value at each step of the value chain.

The new standard in kava quality testing and traceability

KavaLytics™ is the result of listening to the quality control and traceability needs of kava industry stake-holders at all levels of the value chain in 7 kava producing regions. Based upon industry feedback, KavaLytics™ proudly partnered with the data science experts at Sagitto in Hamilton New Zealand, to build a machine-learning platform that was trained on over 500 analyses of kava performed by a highly credentialed ISO17025 analytical lab with vast experience in kava analysis. The result is the most technologically advanced, comprehensive and robust kava analysis system ever built. Thanks to machine learning, the method continues to learn from each new kava sample it is given and will always be at the forefront of fast, affordable, and accurate kava analysis. As you read this paper, the KavaLytics™ method has already learned from new data acquired by a user scan.

Value Added Through Quality Control and Traceability

> "ON AVERAGE, BUYERS ARE WILLING TO PAY A 20% PREMIUM FOR KAVA THAT HAS BOTH A CERTIFICATE OF ANALYSIS AND TRACEABILITY FROM THE PRODUCING REGION"

Quality control and traceability are two of the most important factors of value chain management. Enormous efforts have been made in recent years by South Pacific governments, researchers, and organizations such as PHAMA, to protect the reputation of kava to ensure its long-term economic success. Kava laws[1] and codexes[2] have been developed and kava quality export manuals [3,4,5] have been distributed to farmers, buyer agents, processors, exporters, regulators and bio-security departments to educate members at all levels of the kava value chain in quality standards from planting materials all the way to finished products and enforcement. As a result of these efforts, Kava has become a standardized commodity, which has led to an increase in consumer confidence and demand as well as the international acceptance of kava as a traditional beverage. This sharp increase in the demand for kava, has skyrocketed the market price to an all time high and all members of the kava value chain have benefited. It is therefore the responsibility of all members of the kava value chain to uphold the safe reputation and value of kava through the uniform implementation of standardized quality controls and traceability. This "chain of custody" concept is essential for reducing the risk of adulteration,

misidentification, and the distribution of poor quality materials and ensuring compliance with all national and international standards.

The vast majority of value chain members consulted have expressed a strong willingness to implement quality control and traceability systems to add value and safety to their products, if presented with an affordable option that does not impede the flow of goods through their operation or otherwise obligate them to unrealistic financial burden.[6] On average, buyers are willing to pay a 20% premium for kava that has both a certificate of analysis and traceability from the producing region.[7]

KAVA BY THE NUMBERS

VANUATU

POPULATION
292,860 (2019)[8]

PRODUCTION
6,000 Metric tons of dry weight kava[9]

EXPORTS
1,500 Metric tons[10]

MARKET VALUED AT
450-480 million USD[11]

KAVA FARMERS
18,000[12]

FIJI

POPULATION
883,483 (2018)[13]

PRODUCTION
4,500 Metric tons of dry weight kava[14]

EXPORTS
250 Metric tons[15]

MARKET VALUED AT
150 million USD[16]

KAVA FARMERS
10,400[17]

The kava value chain is similar in all kava-producing regions in that there are three major market segments by which a farmer's kava reaches the consumer: The immediate local segment, the urban market segment, and the export segment. The export segment accounts for approximately 30% of the total crop grown in Vanuatu and 5% in Fiji, as most of the kava is consumed locally, sold in markets or drank in kava bars called "nakamals", in urban areas.[18]

Organoleptic-Based Quality Controls in The Agricultural Value Chain of Kava

Since the majority of Kava produced is consumed locally or relatively locally in urban areas, quality control mechanisms are implemented in the form of organoleptic analysis and immediate consumer feedback about the product. The immediacy of feedback from locals and urban marketers allows farmers the opportunity to quickly remedy any quality issues or risk their sole source of income. Quality control issues leading up to the kava export market however, still plague farmers, buyer agents, processors and exporters alike due to the lack of access to practical analytical methods and the lack of timely feedback inherent in kava's long agricultural value chain.

The average South Pacific kava farmer generally lacks the access to resources such as proper FDA registered facilities, drying and milling equipment, and analytical tools necessary to implement quality controls post-harvest and therefore generally lack direct access to the export market. As such, farmers must sell to middle-men and processors, who combine lots from different farmers and cooperatives to produce a buyers order. One lot of kava roots headed for the export market can contain several different varieties, plant parts, and quality grades of kava. Farmers, buyer agents, processors and exporters find it difficult to spot-check every root from every lot that they purchase and lack access to analytical methods to implement standardized quality controls. Thus, organoleptic quality control methods are used to determine whether or not the kava moves to the next link in the value chain.

Organoleptic quality control methods rely primarily upon visual inspection, characteristic smell, and often times taste. Kava is visually inspected for mold, defects, dirt, insect damage, unacceptable plant parts and particularly yellow or fibrous material that is recognized as being unacceptable based upon a value chain member's personal experience and industry knowledge. Members of the kava value chain currently have no practical options to formally analyze the quality of the kava they are buying and selling as the price for HPLC analyses in the South Pacific as of June 2019 is approximately $250 USD per sample.[19] They therefore rely upon organoleptic and feedback-based methods for quality controls.

Feedback-Based Quality Controls in The Agricultural Value Chain of Kava

Aside from organoleptic methods, members in the kava agricultural value chain rely upon feedback from other members who are either up or down the value chain from them. For farmers selling to their local village, feedback is often immediate. However, the further the material moves up the value chain, the less feedback the farmer is able to receive about the quality and value of his or her crop. Likewise, a buyer agent who purchases kava from a farmer or a village cooperative will hear immediate feedback as to the quality of the kava that he or she sold from the local kava bar or market. However, the buyer agent is less likely to receive feedback once the kava is sold to a processor where it is combined with other buyer agents' lots and forwarded to an exporter. Without access to analytical quality control methods, feedback from an individual one step up in the value chain is essentially the sole indicator of the quality of the kava that was sold.

For the export market, it is often not until kava makes its way to bio-security before a standardized quality control method is used to formally determine the quality of the kava. At present, the colorimetric quality control method is being almost exclusively enforced upon exporters, while farmers, agents, processors and nakamals, are not routinely monitored. Thus, the only feedback mechanism in place is when an exporter discovers a problem with their kava because its not being allowed for export. At this point in the value chain, there is limited traceability and accountability for the poor quality material and the opportunity to correct the quality control issue is lost. Lastly, the feedback that an exporter has to offer down the value chain is simply that it was of poor quality and couldn't be exported.

The Shortcomings of Wet Chemistry Based Quality Control Methods

Wet chemistry refers to classical analytical methods such as HPLC, HPTLC, GC/MS or other methods that utilize solvents to extract samples into a liquid phase for analysis. The colorimetric quality assessment method that is used for regulatory enforcement in Vanuatu and Fiji is considered a wet chemistry method because it involves the sonication of the kava sample in acetone before centrifuging and presenting the sample to a UV/VIS spectrometer to obtain an absorbance reading. This method allows for a good degree of discrimination between genetic classes of kava cultivars and as an initial quality assessment method, it is cost effective, relatively rapid and easily deployable in a properly outfitted laboratory.[20] However, sample preparation steps such as oven drying, sonication in volatile solvents, and centrifuging, render it impractical as a field-deployable or process analytical method. Furthermore, this method only allows for a qualitative deter-

mination of a sample rather than quantitative, meaning that it does not provide the information on the quantities of Kavalactones, moisture content, or other valuable metrics in the determination of the quality of a sample.

There are also sampling difficulties in properly implementing wet chemistry based quality control methods on large batches of heterogeneous products like kava. For example, it is practically impossible for anyone from a buyer agent to an exporter to a biosecurity agent, to spot check a few roots out of every bag of kava using a costly, time consuming and destructive method of analysis involving wet chemistry and lengthy sample preparation procedures. Rather, a small sample of roots is taken from the batch and analyzed as a representation of the batch as a whole. It is often difficult to obtain a representative sample of a 500kg shipment based upon a single analysis of a few grams from a few roots in the batch. Therefore, the results are only relevant to one root, or one group of roots tested that no longer exist in the shipment since they were destroyed during the analysis. Since kava is a heterogeneous product having remarkable variability in chemical composition throughout its plant parts, and shipments of kava contain a mix cultivars, it is likely that the roots that are gathered for analysis are very different from the roots next to them, even if they were from the same harvest or the same cultivar or even the same plant. Destructively testing multiple samples from a batch to obtain more accurate and representative results is time intensive and cost prohibitive for all parties involved and is therefore not feasible.

Despite the tremendous steps taken by the kava industry to implement quality controls, wet-chemistry based methods will prove to become ever more costly and time consuming to implement, operate and maintain as the kava market continues to experience explosive growth. As it stands, importers still struggle with receiving poor quality raw materials that are inconsistent with the "pass" results obtained by the current quality control method. There is a serious and immediate need for a validated, fast, affordable, accurate, and rapidly deployable quality control method that can be used in the field to analyze kava as it moves throughout the value chain improving quality, traceability, accountability, and adding value at each step.

The Advantage of NIRS

Near Infrared Spectrometry, or NIRS, is a popular non-destructive analytical method that measures the absorbance of near infrared light at different wavelengths as it passes through a sample. From these absorbance measurements, attributes about a sample can be inferred. Near Infrared Spectrometry is referred to as a "process" analytical method because it is implemented in-line throughout the manufacturing process or value chain to monitor quality attributes without impeding the process itself. The aim of process analytical meth-

ods is to examine the extent to which each step in a manufacturing process or value chain, affects the quality of the end product and to prioritize the factors that have the largest impact on quality in order to enhance consistency and minimize defects.

Process methods have become preferred by many industries to implement quality controls for heterogeneous products that require multiple samples for accurate batch testing or in instances where rapid results are required for products to continue to move through the manufacturing process or value chain. The most notable advantages to using NIRS is that it is fast, accurate, non-destructive, solvent-less, involves low upfront and operational costs and little formal training is required to accurately use the equipment. Calibration sets are transferable between units allowing for rapid deployment of new units that produce consistent analyses. Furthermore, whereas wet chemistry is practical for single samples of homogenous materials, NIRS is far more economical and accurate for analyzing batches of heterogeneous materials that require multiple measurements to get an accurate representation of a batch. NIRS does this without the use of highly flammable, environmentally toxic solvents that require a fully equipped laboratory, trained technicians and proper safety equipment to handle. Lastly, NIRS analysis takes less than 2 minutes per sample making its throughput many times faster than even the fastest wet chemistry reference methods.

The KavaLytics™ Solution

The focus of the KavaLytics™ strategy is to weave the issues of quality into every link of the value chain and to make the implementation of fast, affordable and accurate standardized quality controls and traceability, a reality for the kava market. KavaLytics™ believes that an affordable and accurate NIRS-based process analytical method is the answer. To accomplish this goal KavaLytics™ spoke to various stakeholders in the kava industry involved in various levels of the value chain from 7 kava producing regions. After receiving industry stakeholder input, it was determined that the following criteria had to be met:

FAST

AFFORDABLE

ACCURATE

SCIENTIFICALLY VALIDATED

EASY TO DEPLOY AND SCALE

REQUIRE LITTLE FORMAL TRAINING

SIMPLE SAMPLE PREPARATION

NON-DESTRUCTIVE

NO VOLATILE SOLVENTS

DETAILED RESULTS – NOT SIMPLY PASS OR FAIL

INTEGRATED TRACEABILITY FOR ACCOUNTABILITY

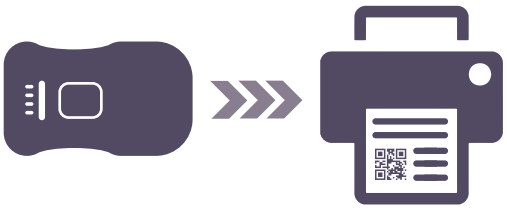
Based upon the above criteria, KavaLytics™ has developed a fast, affordable, accurate and scientifically validated quality assessment method for kava root samples. The KavaLytics™ method uses a state of the art handheld Near Infrared spectrometer, paired with a powerful, cloud-based artificial intelligence platform to implement quality controls and traceability throughout the Kava value chain. It's a non-destructive, point and shoot method that requires little formal training and minimal sample preparation. Simply powder the kava sample and scan the bag for instant lab quality results on any Bluetooth enabled IOS device. QR codes on the analysis label allow for tractability from the farm all the way to the importer adding value and regulatory compliance to the product.

The KavaLytics™ system is priced such that anyone from medium sized kava farmers and buying agents, to processors, exporters, importers and governments, can afford to implement this system into their process. Below are some of the different applications of the different applications of the KavaLytics™ quality control system as it is implemented by various members of kava's agricultural value chain.

Medium Size Kava Farmers and Cooperatives

Kava growers and cooperatives utilize the KavaLytics™ system to distinguish the high quality cultivars from the low quality cultivars growing in their region. Farmers also use the system as a process analysis method to determine the potency and maturity of their crop and to identify any growing conditions, environmental factors and post harvest techniques that lead to higher quality kava. Villages and cooperatives utilize the system to protect their reputation as high quality kava producing regions and can hold farmers who contribute unacceptable quality kava to the cooperative accountable.

A sample of several dried roots from several bags are powdered and scanned, and within minutes, an analysis is generated and an electronic record of traceability is created. A weatherproof sticker is printed directly from the IOS device to a wireless label printer and it is attached to the bag. The sticker contains information such as the sample name, its potency, chemotype, noble or non-noble status, and moisture content, and a QR code which can be scanned by the next link in the value chain. Certifying the quality of the kava adds value to the product- Premium quality demands a premium price.



KAVA BUYING AGENTS

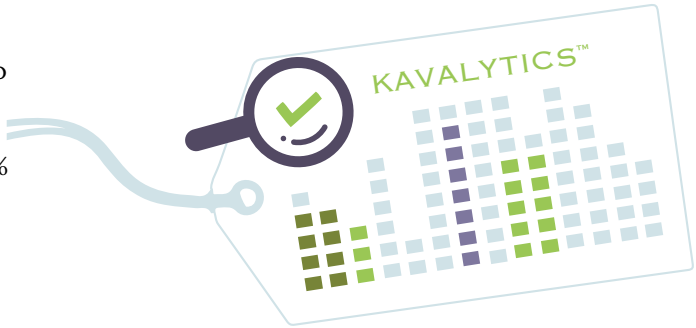
Kava buying agents who purchase kava from the local villages and cooperatives utilize KavaLytics™ to obtain valuable information about the quality of the kava that they purchase from different farmers and villages. This allows the agent to provide meaningful feedback to the farmers on the potency and chemotype of their harvests if they do not have a KavaLytics™ unit. The buyer agent then selects the highest quality kava to purchase and identifies the farmers and cooperatives that produce it. Likewise, the agent can immediately inform villages of quality control issues with their kava and encourage accountability should inferior material be discovered. Now that the kava buying agent has selected the best kava and has an analysis of the material, value has yet again been added to the product and a premium price can be demanded when it is sold to the next step of the value chain. Furthermore, if both the farmer or cooperative and the buying agent are utilizing the KavaLytics™ system, the buyer agent can simply scan the QR code on the bag and scan the sample with the unit to verify that it is the same material. This adds another line to the traceability section of the certificate of analysis and adds accountability throughout the value chain.

PROCESSORS

A buyer agent generally sells his kava to either a processor or a local market or a nakamal who also benefits from implementing the KavaLytics™ quality control system. Processors obtain kava from many buyer agents who have obtained kava from many individual kava farmers. Processors implement quality controls at the time of purchase by spot-checking several roots from each bag of kava in order to make a determination of the kava is of acceptable or unacceptable quality. If the analysis of the kava is of lower than average potency or high moisture content, the processor can either reject the material or present a lower buying offer. Likewise, if the kava tests favorably or the buying agent is also utilizing the KavaLytics™ system, he or she may consider buying much more of this agent's kava, which in turn benefits everyone down the chain. Lastly, if a processor shows that his or her material is of excellent quality and has traceability back to the farm, it adds value to the product when it goes for sale to a Nakamal, or local market, or exporter who can then advertise the analytics and traceability of their kava and fetch a premium price.

Exporters

Exporters benefit substantially from implementing the KavaLytics™ system. By spot checking the kava that they purchase from processors and buyer agents or scanning in QR codes from KavaLytics™ members down the value chain, they not only ensure that their kava will pass bio-security on both sides, but also have built-in regulatory compliance in terms of electronic record keeping and traceability. Exporters also track the quality of the kava that is incoming to them over time and select processors and buyer agents who consistently provide them with high quality materials. Lastly, importers overseas are willing to pay more for kava with a certificate of analysis that shows valuable information such as chemotype, nobility, potency, moisture content and traceability. This leads to fewer misunderstandings and trade disputes between exporters and importers as to the quality of the material that is being exported to them. The KavaLytics™ quality control has often paid for itself in a single shipment due to the premium that overseas importers are willing to pay for quality analytics and traceability from the source. On average, buyers are willing to pay a 20% premium for kava that has both a certificate of analysis and traceability from the farmed region.



KavaLytics™ 3.5.0 Model Features

POSITIVELY IDENTIFY KAVA

PROVIDE TOTAL KAVALACTONE CONTENT

DETECT COMMON ADULTERANTS OF KAVA INCLUDING:

- Excessive Peeled stems or *"White Kasa"* Content
- Unpeeled stems or stem peelings or *"Black Kasa"*
- Aerial stalks, vstems, and leaves
- Spent kava or *"Makas"*

DETERMINE IF KAVA IS NOBLE OR NON-NOBLE

PROVIDE THE FIRST THREE NUMBERS OF THE CHEMOTYPE I.E. "4-2-3" (BETA)

How accurate Is KavaLytics™?

KavaLytics™ has achieved remarkable accuracy and continues to improve every month as new samples are added to it. As a validated quality assessment method, it is currently able to correctly classify kava as "Noble" and "Non-Noble" in 95%+ of samples and is also able to the total Kavalactone content of kava powders typically between 4% to 15% by weight with an average error of 0.7% of a properly calibrated HPLC at an ISO 17025 credentialed laboratory using the official USP Kava method. It can also determine moisture content within 0.2%. The method meets the standard method performance requirements (SMPRs) issued by the AOAC for the determination of Kavalactones in terms of repeatability and reproducibility.[21]

Continuous Improvements Through Machine Learning

The machine-learning algorithms that convert NIR spectra into analytical results are continuously updated such that users always have the most up to date version of the model with the current feature set. Samples used to update the model are prioritized to achieve the greatest level of improvement. For example, if the model is detecting anomalies in the data coming from samples scanned from a specific farm or region, then these samples are acquired and the model is trained to more accurately predict these samples and ones like them. KavaLytics™ strives to bring anomalous samples to a level of accuracy equal to or beyond the average accura-cy of the current model. The updated version of the model is automatically utilized by the device, requiring no action on the users part.

Future Features implementation

Thanks to powerful machine learning technology, patterns continuously emerge from the analysis of new samples being scanned daily. With these new patterns, emerge new capabilities that lead to new features being integrated into the model. When a pattern is identified and it can achieve 60% predictive accuracy, it becomes available as a "Beta feature" for our customers to explore. Once the feature becomes validated at the 90% accuracy level, it is released as a standard part of the model. Future features include "heavy filth" detection and a mold pass or fail model.

Advantages over traditional HPLC and "Other" quality assessment methods

There are several advantages to implementing KavaLytics™ as an initial quality assessment model as opposed to HPLC, TLC, and UV/Acetone methods.

1. No wet chemistry involved! Say goodbye to harsh chemicals like acetone, diethyl ether, methanol, and acetyl nitrile.
2. No complicated sample preparation- Simply point and shoot at a bag of powder.
3. Instantaneous results – No more waiting weeks for HPLCs to come back.
4. Receive the Certificate of Analysis on your phone, saved in the cloud, and/or printed via a Bluetooth sticker printer with QR code for verification of results and traceability through the supply chain.
5. Low initial cost compared to HPLC, GC/MS, and other methods.
6. Very low staff training costs – Simpler than the Acetone method.
7. Low ongoing testing cost per sample compared to paying lab tech hours to operate sophisticated equipment.
8. High degree of accuracy and reproducibility of results.
9. Rapid deployment – Units work out of the box.
10. Units automatically utilize the latest version of the model as revisions are made

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KavaLytics.com

References

1 Republic of Vanuatu. Kava Act No. 2 of 2002; Government of the Republic of Vanuatu: Port-Vila, Vanuatu, 2002. Available online: http://www.paclii.org/vu/legis/num_act/toc-K.html (accessed on 19 June 2019).

2 PROPOSED DRAFT REGIONAL STANDARD FOR KAVA PRODUCT THAT CAN BE USED AS A BEVERAGE WHEN MIXED WITH WATER. Joint FAO/WHO Codex Alimentarius Commission. FAO/WHO COORDINATING COMMITTEE FOR NORTH AMERICA AND THE SOUTH WEST PACIFIC. Agenda Item 10. Rome, Italy (July 2019). Accessed on June 19, 2019 (Online). Available: http://www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FMeetings%252FCX-732-15%252FWorking%2Bdocuments%252Fna15_13e.pdf

3 Samoa Ava Regulations Manual. Pacific Horticultural and Agricultural Market Access (PHAMA) program. Suva, Fiji. (2018). Accessed on June 19, 2019 (Online). Available: http://phama.com.au/wp-content/uploads/2018/06/Samoa_Ava_Regulations-Final_ecopy.pdf

4 Fiji Kava Standard. Pacific Horticultural and Agricultural Market Access (PHAMA) program. Suva, Fiji. (2018). Accessed on June 19, 2019 (Online). Available: http://phama.com.au/wp-content/uploads/2017/03/Fiji_Kava_Standard_ecopy.pdf

5 Vanuatu Kava Quality Standard. Pacific Horticultural and Agricultural Market Access (PHAMA) program. Suva, Fiji. (2018). Accessed on June 19, 2019 (Online). Available: http://phama.com.au/wp-content/uploads/2017/07/Vanuatu_Quality_Standard_ecopy.pdf

6 Personal communications from generational kava farmers, middlemen, processors, exporters, and government officials in Fiji, Vanuatu, Papua New Guinea, Samoa, Micronesia and Tonga from July 2018-June 2019.

7 Personal communications with kava importers, distributors, Kava Bars, and retail customers in the United States from July 2018-June 2019

8 World Bank Population Statistics. The World Bank Group. NW Washington DC, United States of America. (2019) Accessed on June 08, 2019 (Online). Available: https://data.worldbank.org/indicator/sp.pop.totl

9 Buveurs de Kava. Siméoni P., Lebot V.. 2014. Port-Vila, Vanuatu : Ed. Géo-consulte, ISBN 978-2-9533362-3-8

10 - 13 Ibid

14 Fiji Kava Value Chain Analysis Report. Pacific Horticultural and Agricultural Market Access (PHAMA) program. Suva, Fiji. (2018). Accessed on June 10, 2019 (Online). Available: http://phama.com.au/wp-content/uploads/2018/06/Fiji-Kava-Value-Chain-Analysis-Report-FINAL.pdf

15 - 18 Ibid

19 Telephone call to University of Fiji Suva, Institute of Applied Science June 15 2019.

20 Lebot, V., & Legendre, L. (2016). Comparison of kava (Piper methysticum Forst.) varieties by UV absorbance of acetonic extracts and high-performance thin-layer chromatography. Journal Of Food Composition And Analysis, 48, 25-33. doi: 10.1016/j.jfca.2016.01.009

21 AOAC SMPR 2018.005. Standard Method Performance Requirements (SMPRs®) for Determination of Kavalactones and/or Flavokavains from Kava (Piper methysticum) AOAC Inernational. Rockville, MD 20850-3250 USA (2018)