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Comparison Of Patchouli Oil (*Pogostemon Heyneanus Benth.*) Yields From Samal City, San Isidro, and Mati, Davao Oriental

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Abstract

Patchouli oil was extracted from the air-dried leaves of *Pogostemon heyneanus* Benth. obtained from Brgy. Guilon, Samal City; Manikling, San Isidro, Davao Oriental and Mati, Davao Oriental by steam distillation. This study was conducted to determine a) the percentage yields of the oil, b) its physico chemical properties, and c) whether the gathered data were within the range of international standards. Soil analyses of the sites were likewise performed to determine the amount of available nutrients in the soil and to correlate these factors with the quality of the extracted oil. The percentage yields of the oil were 0.205%, 0.197%, and 0.198% for Samal City, Sah Isidro and Mati, Davao Oriental, respectively. Except for the acid value results of the physicochemical analyses of the properties of the oil were found to be lower than the minimum requirements set by the different international standards. Results of the soil analyses revealed that patchouli plant could adapt to different soil nutrient levels and appear to have an effect on the quality of the oil.

Keywords: Pogostemon heyneanus, Indian patchouli, oil yield, steam distillation, Clavenger tube, Davao Oriental, Samal City

Introduction

The Philippines has rich sources of plants and other materials from which essential oils, also called volatile oils or ethereal oils, could be distilled and extracted. A wide variety of Philippine plant species is known to have high essential oil contents, some of which are feasible for commercial production because they mature fast and require little or no maintenance at all, for some are found to grow wild in almost all parts of the archipelago. It has the potential to cultivate a wide variety of crops because of its favorable climate.

Researches on essential oils are very much needed in the country because millions of pesos are spent annually to pay for the importation of this product (Anzaldo and Brandares, 1988; Brandares, 1988). The Philippines is not exempted from this situation even if it is one of the tropical countries abundant in oil-yielding plant species.

In the Philippines, there are not very many published researches on the patchouli plant despite its pharmaceutical and commercial importance. Past studies on essential oils are concentrated on other indigenous oil-yielding plants such as ginger, lemongrass, papua, pine and guava, among others. Patchouli oil, which is a popular essential oil of commerce, is becoming in demand in the world market because of its expanding consumption, although at a slower rate because of the existence of synthetic substitutes.

This study dealt with the extraction and characterization of the essential oil from patchouli plant collected from three different localities, namely, Manikling, San Isidro, Davao Oriental; Brgy. Guilon, Pefiaplata, Samal City; and Upper Bliss, Mati, Davao Oriental. Physical and chemical examinations were conducted to determine the properties of the oil. Soil analysis was likewise done to determine the amount of available nutrients on the soils grown to patchouli plant.

Objectives of the Study

1. The specific aims of this study included the following:
2. To determine the percentage yields of the essential oil obtained by steam distillation of the young dried leaves of patchouli collected from the different sampling areas;
3. To determine the specific gravity, optical rotation, refractive index, ester value, saponification value, acid value, solubility in alcohol, boiling point, total aldehyde and percent alcohol of the patchouli oil;
4. To compare the quality of the extracted patchouli oil collected from the three different sampling areas;
5. To determine if the gathered data from the physical and chemical analysis of patchouli oil are within the range of the standards set by EOA No. 23, BS 2999/10:1965, and ISO 3757:1978, and
6. To determine the soil class, pH, organic matter and NPK contents of the soil of the three sampling sites.

Review of Literature

Essential Oils

Essential oils Constitute the savory and odorous principles of the plants. They are found in special cells, glands, ducts, sacs and veins that are located sometimes in different parts of a plant such as leaves (patchouli), flowers (ilangilang), fruits (guava), roots (vetiver), rhizomes (ginger), barks (cinnamon), woods (camphor), and rinds (lemon). These oil droplets are the “essence” of that particular plant, which give it its distinct flavor and signature scent. They are highly concentrated and they easily evaporate, hence, are called volatile oils. Completely insoluble in water, they are highly soluble in alcohol, ether, fatty oils and mineral oils. As a rule, they are not oily to the touch and leave no permanent grease spots when placed on a cloth or paper.

They disappear immediately after a few minutes leaving no trace or stains.

Most of the essential oils such as patchouli oil are lighter than water and are not water-soluble. Instead, they are "liposolvent," meaning they dissolve in fats. This property allows the essential oil to penetrate easily through the skin, nasal passages, bronchioles, lungs and gastro-intestinal tract (www.healingoil.111.com).

Many essential oils are colorless when pure and fresh. On exposure to the air they acquire various colors, becoming green, as in oil of wormwood; yellow, as in oil of peppermint; and brown, as in oil of cinnamon. Essential oils have extremely variable odor and taste making these as their characteristic features. The odor of an essential oil is sensibly modified by exposure to the air. Their tastes are almost as variable as their odors. Some. are sweet, others have mild, pungent, hot; acrid. earthy, caustic, or burning taste.

Botanical Description of Patchouli

There are 35 varieties of patchouli grown in tropical Asia, seven of which can be found in the Philippines (Coronel et al., 1984; Mimosa,1987). Pogostemon cablin (Blanco) Benth. is the most common and is cultivated in some parts of the country while Pogostemon heyneanus Benth. grows wild over wide and scattered areas.

The patchouli, also known as Indian patchouli, that grows abundantly in Samal City; San Isidro and Mati in Davao Oriental is the *P. heyneanus Benth*. It is commonly known as *kadlum or kugong-kogong and bahu-baho*. It belongs to the family Labiatae or Lamiaceae. It grows as tall as 30 to 60 centimeters in height. It is an erect or ascending branched, hairy herb. The leaves are very aromatic like those of the *P. cablin*, somewhat smooth, ovate, 5 to 11 centimeters long, 4.5 to 7.0 centimeters wide, pointed at both ends, and broadly toothed in the margins. The flowers are white in color, small, and borne in whorls on terminal and axillary spikes. The bracts are ovate or lanceolate, and equal to the calyx or a little shorter (Quisumbing, 1978).

Importance and Uses of Patchouli

Several medicinal uses of patchouli have been reported. The decoction of its roots is administered to patients having abnormal amount of fluid in the body. The roots are also processed as lotion for the treatment of rheumatism. The boiled leaves are administered for relief of coughs and asthma. This part of the plapt is madeinto poultices for boils, headaches, jaundice, and bilious fevers, and is also used as sternutatory (Quisumbing, 1978; Banzon, 1988).

In aromatherapy, the warmth and depth of patchouli aroma makes it comforting and relaxing. Its relaxing attributes, coupled with its rich and exotic nature, have led to, its inclusion in sensual and amorous blends, particularly appropriate for products like massage oil. The oil combines well with ilangilang, jasmine, sandalwood, vetiver and rose (Aqua-oleum, 1993 or www.aquaoleum.co.uk).

Patchouli oil is used externally to tighten and tone oily, chafed, and cracked skin and as shampoo mixed with crushed "gogo" to control dandruff, scalp complaints, and seborrhea (Quisumbing,1978). Finally, it is used as a base in a wide range of perfumery and cosmetics products because of its fixative property (i.e., it keeps to prevent excessively rapid evaporation of a perfume compound and thereby promotes tenacity) (Robbins, 1982).

Chemical Composition of Patchouli Oil

A recent study on the principal constituents and the percentage composition of each component recorded the following: beta-elemenes 5.8%; alpha-copaene, 1.9%; beta-caryophyllene, 1.8%; beta-patchoulene, 2.1%; alpha patchoulene, 15.7%; patchouli alcohol, 36.1%; and. alphaLbulnesene, 8.3% (Aquaoleum, 1993 or wuw. aqua-oleum.co.uk). The alcohol components are the main contributors to the oil's special character (Robbins, 1982).

Patchouli oil, like fine wine, continues to improve with storage, and is renowned for getting better, finer and fuller with age (Aqua-oleum, 1993 or www. aqua-oleoum.co.uk; Robbins, 1982). Because of the high value of the oil, adulteration is quite common at source, usually with Gurjon Balsam or caryophyllene.

Factors Affecting Quality of Patchouli Oil

The quality of the leaf material, method of distillation and ageing of the oil are some factors affecting the quality of the patchouli oil (Guenther, 1956). The soil rich in nutrients gives the best leaf material. This is indicated by having few stalks and more leaves. Good material yields about 3.5% of oil. Very immature plants give low quality oil. Age of the leaves seems to have a marked influence upon the quality of the oil. The first two cuttings on newly planted patchouli give better leaf material and better-quality oil; the quality declines with subsequent cuttings. Proper drying and storage of leaf materials affect quality of the oil. Origin of the plant materials also influences oil quality.

The steam pressure during distillation must be properly controlled and regulated. Prolonged distillation usually gives a higher yield and better quality of oil, provided that the oil is not "burned."

The longer the oil is stored, the better is its quality.

Patchouli Oil Yield

Patchouli oil yield ranges from as low as 1% and as high as 6% (Guenther, 1956). Yields up to 10% have been reported depending on the quality of the leaves (Quisumbing, 1978). Patchouli reaches maturity in four to six months. A characteristic of this plant is that it exhausts the soil rapidly and therefore crop rotation is essential (Guenther, 1956).

Soil, Climate and Shade Treatment

Patchouli is said to adapt to a wide variety of soil type and climatic conditions as some are found to grow anywhere with different types of soil and nutrient content. Patchouli is well known as a major contributor to soil nutrient depletion (Guenther, 1956; www.benzalco.com). It appears to be a part of a shifting agricultural system, being grown on a site for two to three years, until plant vigor and leaf yield fall into decline due to senility, soil-borne disease or nematode Infestation and soil exhaustion. It thrives best in damp and warm climate with evenly distributed rainfalls. High, undulating land is most suitable, but the plant flourishes also in low altitudes and slightly moist soil, provided it is properly drained (Guenther, 1956).

Extraction of the Essential Oil of Patchouli

Patchouli leaves air-dried for three days are preferably carried out through steam distillation. The stems are manually stripped from the leaves before they are subjected to distillation. LOW steam pressure does not easily yield the oil; hence, prolonged distillation will be necessary. On the other hand, high steam pressure alone does not necessary result in a better yield, although it may shorten the period of distillation. The oils obtained by different pressures give a somewhat different quality from each other (Guenther, 1956).

Materials and Methods

Plant Sample Preparation

About fifteen kilograms each of air-dried leaves of patchouli plant (Plates 1 to 3) were collected from Manikling, San Isidro, Davao Oriental; Brgy. Guilon, Pefiaplata, Samal City; and Upper Bliss, Mati, Davao Oriental. Plant samples were submitted for authentication to the National Museum in Manila.

All healthy leaves collected from the different sites were separately cleaned from soil, dirt, dust and pests, washed with water, and air-dried for three days. The dried leaves were then comminuted, ready for volatile oil extraction.

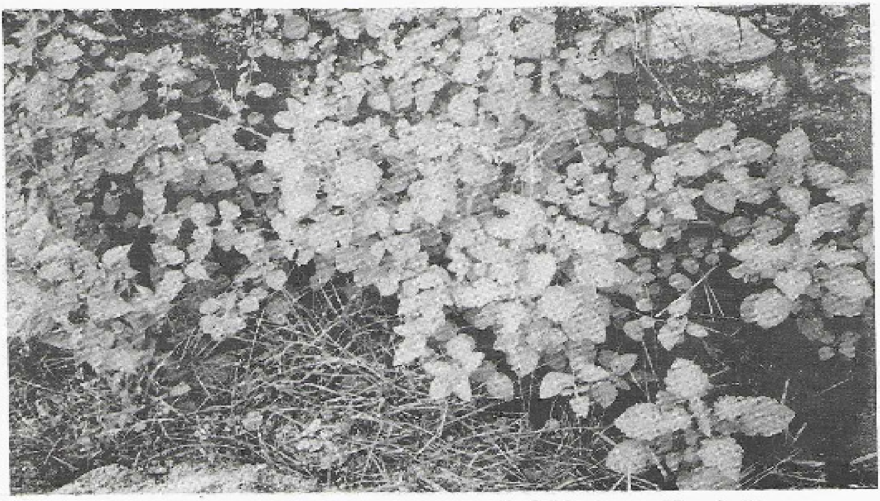

Plate 1. A cluster of patchouli plants some of which are starting to flower

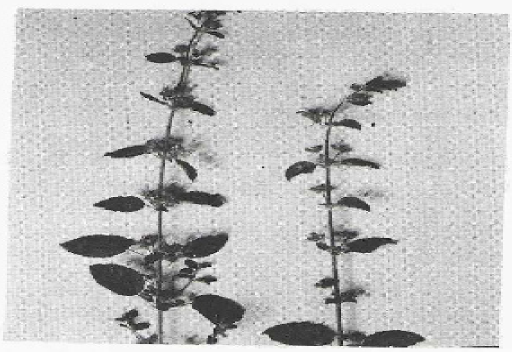

Plate 2. The shoot of the patchouli plant

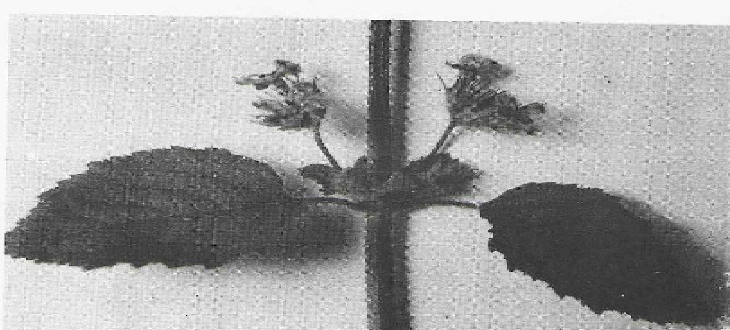

Plate 3. The leaves and inflorescence of the patchouli plant

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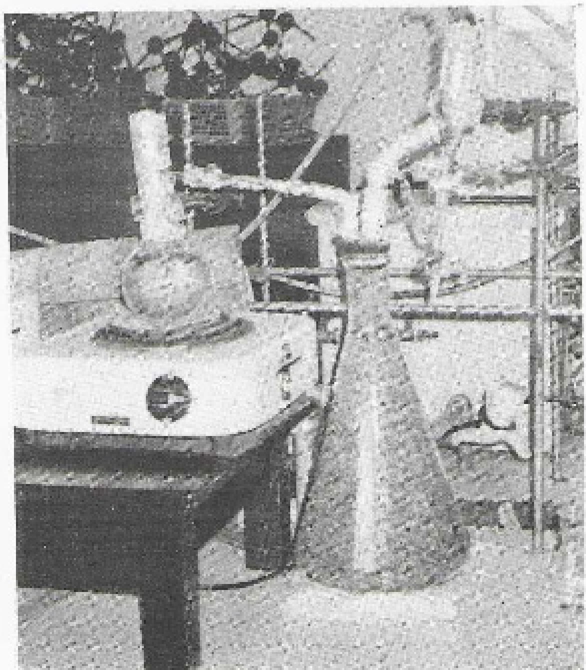

Plate 4. Steam distillation set-up

The percentage yield of the extracted oil was computed in terms of volume-weight percent by use of the formula:

$$\% \text{ Patchouli oil} = \frac{\text{volume of the oil (ml)}}{\text{weight of plant material (g)}} \times 100$$

Extraction of Essential Oil

The dried leaves were weighed and loaded in a laboratory steam distillation set-up provided with a Clevenger tube receiver attached to a condenser (Plate 4). The distillation was carried out for at least four hours, or until no more oil was distilled. The volume of the oil was measured on a wet basis and separated from the aqueous distillate. Then it was dried with anhydrous sodium sulfate until no more clumping of the salt was observed. The clear and moisture-free oil was stored in an amber-colored bottle and kept in the refrigerator.

Several batches of the plant material were distilled to obtain sufficient volume of the oil for the characterization of the physical and chemical properties.

Physical and Chemical Analysis of the Oil

Titration method was used to determine saponification and acid values (Guenther, 1956); total aldehyde and % alcohol (AOAC, 1997). Solubility in 90% ethanol, optical rotation (using a polarimeter), and refractive index (using an Abbe refractometer) were measured following the procedures of Guenther (1956). The boiling point was determined using a thermometer (Most, 1988) while the specific gravity was measured using a pyconometer (Snell and Biffen, 1944)

Soil Analysis

Soil analyses were carried out at the Chemistry Research Laboratory of the Ateneo de Davao University. Particle size (using a hydrometer), pH (using a pH meter), phosphorous (modified method using a spectrophotometer), available phosphorous (using an atomic absorption spectrophotometer). total nitrogen (Kjeldahl distillation) and soil organic matter (Walkley-Black method) were measured.

Results and Discussion

Percentage Yield of Patchouli Oil

Steam distillation of the air-dried leaves of P. heyneanus Benth. collected from Brgy. Guilon, Pefiaplata, Samal City; Manikling, San Isidro, Davao Oriental; and Upper Bliss, Mati, Davao Oriental gave average yields of 0.205%, 0.197% and 0.198%, respectively, as shown in Table 1.

Table 1. Yield of leaf essential oil from *P. heyneanus* Benth. growing wild in selected localities of Davao Province

Origin of sample	Month of harvesting	Oil content (% v/w)
Samal City	October to December 1999	0.205
San Isidro, Davao Oriental	December 2000	0.197
Mati, Davao Oriental	January 2000	0.198

Physico-Chemical Properties of the Oil

The extracted oil was clear and was lemon-like yellow in color. Other properties analyzed are summarized in Table 2.

Property	Source of oil sample		
	Samal	*San Isidro*	*Mati*
Specific gravity 25°/25°C	0.89634 (±0.00001)[a]	0.90109 (±0.00001)[b]	0.89722 (±0.00001)[a]
Optical rotation (20°C)	+72.1 - +101.9	+72.0 - +101.5	+72.4 - +101.6
Refractive index (20°C)	1.4878[a]	1.4934[b]	1.4868[c]
Solubility in 90% alcohol (20°C)	3.55 in 10 volumes[a]	3.59 in 10 volumes[a]	3.67 in 10 volumes[a]
Acid value	0.65 (±0:04)[a]	0.86 (±0.04)[b]	0.81 (±0.04)[a]
Ester value	17.2 (±0.8)[a]	19.4 (±0.7)[b]	18.5 (±0.7)[c]
Saponification value	20.9 (±0.4)[a]	21.4 (±0.4)[a]	21.1 (±0.4)[a]
Total aldehyde	4.7 (±0.2)[a]	5.9 (±0.2)[b]	5.1 (±0.2)[a]
% Alcohol	36.7 (±0.3)[a]	36.4 (±0.3)[b]	37.4 (±0.3)[a]
Boiling point (°C)	180.3 - 181.9	180.2 - 181.8	180.2 - 182.1

Similar superscripts within rows indicate that sample means are not different using DMRT

e water. The oils that are lighter than water is usually rich in hydrocarbons, alcohol, esters, and ketones (Jenkins et al., 1957).

The optical rotation of the oil gave a clockwise direction, meaning the oil is dextrorotatory, which is in contrast to the reference standard which is levorotatory.

The refractive indices of the extracted oils ranged from 1.4868 to 1.4934. Generally, organic materials have refractive indices that fall within the range of 1.3 to 1.6 (Dupont and Gokel, 1980).

The oils had a high saponification value, which may indicate that there are more esters contained per one gram of the oil. Theoretically, the difference between the saponification value and the acid value represents the ester value (APA, 1975). However, based on the results, the ester value is smaller than the difference of-the two values for the three oils. This may probably be due to the incomplete saponification of the esters in the sample during refluxing.

The extracted oils were completely insoluble in water but were soluble in 90% ethanol. The solubility of the oil in ethanol may be attributed to the presence of oxygenated substances which are also the principal odor carriers and with the exception of some aldehydes contribute to greater stability of the oil against oxidizing and resinifying influences (Brandares et al., 1987).

The collected oils were found to have a high boiling point ranging from 180.2 - 182.1 for the three oils, indicating that the oil was nonvolatile. This high boiling point may also indicate that the oil contains components with high molecular weights and high polarity of the functional groups. Based on the literature, the oil contains components which have high boiling points such as patchouli alcohol and a sesquiterpene alcohol having boiling points of 140^0C and 130^0C- 131^oC, respectively (Guenther, 1956). Alcohols increase boiling points as they have the ability to form hydrogen bonds. The ketone that is also present in the oil may also contribute to this high boiling point as it is able to pair its dipoles, and this is another force which needs to be overcome to achieve boiling.

The oils obtained from the three areas contained alcohol which ranged from 36.4% to 37.4%. This-conforms to the findings that the alcohol in patchouli oil may account for between 23% and 55%, or an average of about 33%, of its volume (ITCU/ GATT, 1986). For the three oils, percent alcohol was found to be higher than its aldehyde content. It is possible that through time, aldehyde content will increase as well as its acid content through the oxidation of alcohol, if not properly stored.

Comparison of the Properties of Oils from Three Sites

Results of the analysis of variance on the properties of the oils as affected by sampling sites showed a significant difference in the specific gravity, refractive index, ester value, acid value, total aldehyde, and % alcohol. Solubility of the oil in 90% alcohol and saponification value did not show statistical difference. As Brandares et al., (1987) and Guenther (1956) claimed, the site of collection and climatic conditions affect the quantity and possibly the quality of the oil.

The boiling points and optical rotation values of the three collected oils were not detennined if they differ significantly from each other since the values were given in ranges.

Physico-Chemical Properties of Extracted Oils as Compared to International Standards

The results of the physico-chemical. properties of the patchouli essential oil were compared with the standard specifications set by the Essential Oils Association of the USA (EOA No.23), the British Standards Institution (BS 2999/10: 1965) and the International Organization for Standardization (ISO:3757:1978) (Table 3). None of the oils from the three sampling sites gave yields that would qualify to the said international standards except for the acid value. The properties found to be below the minimum requirements were the specific gravity, - optical rotation and refractive index while those above the minimum requirements were the ester value, saponification value and the solubility of the oil in 90% alcohol. However, values may improve with aging since patchouli oil is known to get better, finer and fuller with age. Most probably, after some time, ester value may decrease. In effect, acid value may increase until such time values may be acceptable.

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Table 3. Standard specifications for patchouli oil (Robbins, 1982)

	EOA No. 23	ISO 3757:1978	BS 2999/10:1965
Specific gravity at 25/25°C	0.950 to 0.975	-	-
Optical rotation at 20°C	-48° to -65°	-40° to -66°	
East Indies	-	-	-47° to -66°
Africa	-	-	-40° to -68°
Seychelles	-	-	-40° to -68
Unspecified Origin	-	-	-40° to -68°
Refractive index at 20°C	1.5070 to 1.5150	1.5050 to 1.5120	1.505 to 1.512
Saponification value	Not more than 20	-	-
Ester value	-	10, maximum	10, maximum
Acid value	Not more than 5	4, maximum	4, maximum
Solubility in 90% ethanol at 20°C	1 in 10 volumes	1 in 10 volumes	1 in 10 volumes

S

The soil reaction and nutrient contents of the three sampling sites were analyzed following the procedures employed by the Chemistry Research Laboratory at the Ateneo de Davao University. The soil profiles of the three experimental areas are presented in Table 4.

Table 4. Chemical analysis of the soil in which the sample patchouli plants were obtained

Soil characteristic	*Samal*	*San Isidro*	*Mati*
Soil type	Sandy clay loam	Sandy clay loam	Sandy clay loam
pH	6.55	7.06	7.27
Nitrogen, %	0.119 (±0.02)[a]	0.069 (±0.098)[a]	0.031 (±0.10)[a]
Phosphorus, ppm	20.2[a]	26.3[a]	22.6[a]
Potassium, ppm	3.09 (±0.51)[a]	38.3 (±1.9)[a]	6.24 (±0.09)[a]
Organic matter, %	3.16 (±0.20)[a]	4.55 (±0.13)[a]	4.46 (±0.07)[a]

Similar superscripts indicate that sample means within rows are not different using DMRT

The soil type of the three areas was found to be sandy clay loam. The Samal site was composed of 30.2% clay, 16.7% silt and 53.1% sand. The San Isidro site was made up of 31.3% clay, 13.4% silt and 55.4% sand while the Mati area consisted of 22.9% clay, 21.4% silt and 55.7% sand.

The most common soil pH is between 4 and 8. Generally, a pH of 5.5 is suitable for grasses but 6.5 would be better (Donahue and Shikluno, 1971). The Samal site was very slightly acidic while the two other sites had neutral or very slightly alkaline pH.

Nitrogen in the soil is present m different forms and in very small quantities. The amount of nitrogen in the soil may vary from 0.01% to 0.30% (PCARRD, 1980). Samal area was found to have the highest nitrogen content of 0.119% followed by the San Isidro and Mati areas with 0.069% and 0.031%, respectively. Based on the availability index of phosphorus, all three sites contained adequate amounts (Appendix 1). In the case of potassium, a strikingly high potassium content was observed in San Isidro as compared to the other two, which inferred that Samal and Mati had very deficient potassium contents. San Isidro was rated with a possibly deficient potassium content (Appendix 1).

The organic matter content of the soil is small - only 0.40 to 5.00% by weight in case of a representative mineral soil (Buckham and Brady, ‘1967).

San Isidro and Mati were found to have adequate organic matter contents which were 4.55% and 4.46%, respectively. Samal City had a medium amount of organic matter at 3.16% (Appendix 2).

Results of the analysis of variance on the NPK and organic matter contents of the soil in the three areas showed that they are significantly different from each other. From the results, nutrient levels in the soil, thus, seem to have an effect on the oil quality as indicated by the significant difference on the properties of the oil.

Summary

Patchouli oil was isolated from the air-dried leaves of P. heyneanus Benth. obtained from Samal, San Isidro and Mati. The oils gave yields of 0.205%, 0.197% and 0.198%, respectively.

The oils obtained from the three sampling sites differed significantly in specific gravity, refractive index, ester value, acid value, total aldehyde and % alcohol. Data on the solubility of the oil in 90% alcohol and saponification value showed no significant difference. Boiling points and optical rotation were not analyzed statistically for difference because these were given in ranges.

Of the six physico-chemical properties that were compared with the reference standards, only the acid value fell within the minimum requirements. All the other properties were found to be below the minimum requirements set by the different •international standards. However, with proper aging, values may improve in time and may fall within the standard set.

The soil type of the three areas was found to be sandy clay loam, Soil pH

ranged from 6.55 to 7.27. Phosphorous was adequate while potassium was deficient in all the sites except for San Isidro which had a potassium content that is possibly deficient. Organic matter was least in Samal City and adequate in the two other sites.

Conclusions

Due to very low yield of oil production, there is little possibility of using P. heyneanus Benth. as a source of perfume base. The physico-chemical properties of P. heyneanus Benth. do not fall within the specifications set by the different international standards and that none of the three sampling areas yielded a good quality oil. The different -characteristics of the soil where patchouli plant grew indicate that theplant can adapt to a wide range of nutrient levels. These soil nutrients appear to have an effect on the quality of the oil as indicated by the significant difference on the physico-chemical properties of the oil.

Recommendations

In view of the results obtained and in consideration of the limitations of the study, the use of large extractors is highly recommended so as to shorten the time of extraction. In so doing, analysis of the oil will be done right away before any reaction in the oil can take place. The identification of the components of this volatile oil is likewise recommended for further study for its other possible and commercial uses. A further examination of the physico-chemical properties of the oil shall be conducted to monitor if values change with time.

Bibliography

APA. 1975. National Formulary XIV. 14th ed. American Pharmaceutical Association. Washington, D.C., U.S.A. pp 895-896.

Aqua-Oleum. 1993. The Essential Oil Catalogue. Glos. p.4. (www.aquaoleum.co.uk)
Anzaldo, F. E. and M.F.T. Brandares. Processing and Utilization of Essential Oils. In: Proceedings of the Seminar on the Status and Prospects of Essences of the Philippines. Bureau of Plant Industry, Manila. pp 4245.

AOAC. 1997. Official Methods of Analysis. 16th ed. Assoc. of Officiai Analytical Chemists. Vol. 2.32.3.25.

Banzon, S.A. 1988. The Nature of Essences. In: Proceedings of the Seminar on the Status and Prospects of Essences of the Philippines. Bureau of Plant Industry. Manila. p 21,
Brandares, M. F. T., A.M. Vuelban, B.B. Dar Juan, M.R. Ricalde end F.E.

Anzaldo. 1987. Stability Studies of Essential Oils from SomePhilippine Plants Il. Cymbopogon Citratus (DC) Stapf. The Philippine Journal of Science. 116 391-402.

Buckham. H. O. and NL C. Brady. 1967. The Nature and Property of Soils. The McMillan co., New York.

Coronel, V.Q., F. E. Anzaldo and M. P. Recana. 1984. Effect of Moisture Content on the Essential Oil Yield of Lemongrass and Citronella. NSTA Technology Joumal. pp 26-28.

Donahue, R.L. and J. C. Shikluno. 1971. An Introduction to Soils and Plant Growth. ed. Prentice Hall Inc., New JerSey.

Dupont, D. H. and G. W. Gokel. 1980. Experimental Orgamc Chemistry. McGraw-Hill Inc., U.S.A.

ITCU/GATT. 1986. Essential Oils and Oleoresins, A Study of Selected Procedures and Major Markets. International Trade Centre Unctad/GATT. Geneva

Guenther, E. 1956. The Essential Oils. De von Nostrand Co. Inc., New York. 3: 236-265, 552-575.

Jenkins, G.L., J.E. Christian and G.P. HayeS. 1957. Quantitative Pharmaceutical Chemistry. McGraw-Hill Book Co. Inc.- New York. pp 254-264.

Mimosa, J. C. 1987. Essence Sabila and Kabling. Plant Industry Production Guide. Department of Agriculture and Food. Manila. pp 4-6.

Most, Clark, F. Jr. 1988. Experimental Organic Chemistry. John Wiley and sons, U.S.A.

PCARR. 1980. Standard Methods of Analysis for Soil, Plant Tissue, Water and Fertilizer. Phil. Council of Agric. Resources and Research. Laguna.

Quisumbing, E. 1978. Medicinal Plants of the Philippines. Katha Publishing, Quezon City. pp 830-832.

Robbins, S.R.J. 1982. Selected Markets for the Essential Oils of Patchouli and Vetiver. Tropical Products Institute. TPI 56/62. pp 7-8, 49.

Snell, F.D. and F.M. Biffen. 1994. Commercial Methods of Analysis. McGrawHill Book co. Inc., U.S.A. pp. 42.

www.benzalco.com www.healingoils.lll.com/immunity.html

Appendix 1. Soil test data interpretation (Manual on Chemical Soil Testing for Laboratory Technicians)

1. Organic Matter (Walkley-Black Method)
   a. For upland crops in general
      (1) Low ------------------- less than 2.0
      (2) Medium ------------------- less than 2.0 - 3.5
      (3) Adequate ------------------ more than 4.5

   b. For lowland and irrigated rice, more than 3% organic matter is generally considered adequate.

pH Glass Electrode
   a. Intensely acidic: pH 4.0
   b. Moderately acidic: pH 5.0
   c. Slightly acidic: pH 6.0
   d. Neutral: pH 7.0
   e. Slightly alkaline: pH 8.0

3. Availability index of phosphorus (Modified Olsen method) and potassium

Degree	Phosphorus, ppm	Potassium, ppm
Very Deficient	Less than 3	Less than 16
Deficient.	3 - 6	16 - 30
Possibly Deficient	7 - 10	31 -50
Adequate	More than 10	More than 50