Influence of Oil Extraction Process on Chemical Composition and Yield of Essential Oil from Vetiver (Khus)

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Article History: Received:12/05/23 Revised:29/05/23 Accepted: 15/06/23

ABSTRACT

The vetiver root (Vetiveria zizanioides) has been used to extract essential oil using two different techniques: hydrodistillation and steam distillation. Due to its quicker extraction times, simplicity of use, and capacity to produce greater yields of 0.83% and 0.79%, respectively, this study proved that the hydrodistillation technology is preferable than steam distillation. Though the relative concentration of the major constituents was similar by both methods, the absolute amounts were higher with steam distillation. The vetiver oil was extracted by hydrodistillation, and more components can be observed in the oil after analysis with GC-MS (gas chromatography mass spectrometry) and GLC (gas liquid chromatography). Additionally, GC-MS research showed that only steam distillation could remove 63 of the total major and minor components from vetiver oil, whereas hydrodistillation could extract 74 of them.

Keywords: Vetiver, Distillation, Yield, Chemical Composition

Doi: 10.31838/ecb/2023.12.Si6.741

1. Introduction

Vetiver, a native of India is known for its perfumery and medicinal value since ancient Times. The annual world trade in vetiver oil is estimated to be around 250 tons, with Haiti, Indonesia (Java), China, India, Brazil, Japan being the main producers, and USA, Europe, India, and Japan being the main consumers. It is a gift of India to modern world, and finds its greatest use in modern perfume creations. It is widely grown in south India and also cultivated in most Indian states. It is naturally grown in most regions of Rajasthan, Andhra Pradesh, Maharashtra, Uttar Pradesh and Madhya Pradesh. Vetiver oil is obtained from root extraction by several distillation methods, one of which is water and steam distillation [1]. India exports most of it's Vetiver oil to United States, United Kingdom and Taiwan and is the largest exporter of Vetiver oil in the World. One of the most economical ways to overcome these problems and can be done by small-medium industries.

The characteristics of a good vetiver oil have a brownish yellow colour, slightly thick, and has a sweet, earthy, and woody aroma [2]. Vetiver oil is one of the main ingredients used in the cosmetic, perfumery, pharmaceutical, flavour, and fragrance industries which causes the demand in the global market to be high. Its many forms include oils, gels, lotions, soaps, shampoos, sprays, perfumes, and candles. Used in aromatherapy applications, the scent of Vetiver functions as a natural aphrodisiac, stimulating sensual desire. To ease a stressed mind, which is known to consequently relax the body and thereby boost libido, simply dilute and diffuse this oil.

Hydrodistillation is the most extensively used conventional process for isolating volatile chemicals from plant materials [3]. In general, traditional vetiver oil extraction via hydrodistillation typically lasts more than 10 hours [4,5] at quite high temperatures (steam or boiling water) [6], resulting in the breakdown of several oxidizable and thermo labile components as well as a significant decrease in oil yield [7]. Vetiver oil is commonly used as a major fragrance contributor in the fragrance and aromatherapy industry [8]. In the vetiver plant, which contains much oil is the root part, the oil is taken by distillation, while other parts such as leaves and stems do not contain oil [9]. The root of vetiver has many benefits in traditional medicine, commonly used to treat fever, anemia, hemoptysis, phthisis, edema, skin diseases, urinary disorders, jaundice, and flatulence [10]. In nutraceuticals applications, extracts or waste from vetiver are used as antioxidants for protection against oxidative stress. In commercial applications, the root of vetiver is used in agriculture, handicrafts, refrigeration, construction, and textiles, while its vetiver oil for fragrances and aromatherapy [11]. The economic value of the vetiver plant lies in its roots which can be distilled to produce oil containing sesquiterpenoid compounds, such as α-vetivone, β-vetivone, khusimone, isovalencenol, vetiselinenol [12]; khusinol [13]; khusimol, (+) - zizaene (syn. khusimene) [14]; δ-selinene, and β-vetivenene, valerenol, valerenal, β-cadinene [8]; nootaktone, nootkatol, bicyclo-vetivenol, epi-α-cadinol, and khusinol acetate . The primary odor contributors from vetiver root are -vetivon, -vetivon, and khusimol, where -vetivone, -vetivone, and khusimol are in the fingerprint area [11]. Antimycobacterial [15], antimicrobial [8], antioxidant [16, 17], anti-inflammatory [18], repellent [19], and antifungal [20] activity were found in vetiver oil.

The current study will compare the chemical composition of vetiver oil obtained using the novel methods such as hydrodistillation (HD) and steam distillation. The current study is to determine whether the use of a green method can improve the quality or quantity of vetiver oil.

2. Extraction and Yield of Essential Oils

2.1 Hydrodistillation method

Vetiver essential oil was extracted by hydrodistillation - Clevenger distillation method (fig 1(a). The basic hydrodistillation process is conducted on 3000 mL of water was added to 300 g of vetiver root. The mixture then was put into a Clevenger distillation flask (5000 ml.). The volume of essential oil (mL) was collected after 8 hrs distillation continuously. Finally, the essential oil was dehydrated (de-moisture) by sodium sulphate. The distillation yield of the obtained essential oil was calculated using following equation: (1);

$$\text{Yield\% of Essential oil} = \frac{\text{Weight of Oil}}{\text{Weight of material}} \times 100 \qquad (1)$$

2.2 Steam Distillation

Steam distillation process establish as water is boiled to create steam, which then travels through a bunch of herbs (fig 1 (b). The steam breaks the structure of herbs, extracts oil, and then flows into the condenser. There, it becomes a liquid solution of water and oil and goes into a separator. The oil being lighter than water is physically separated and the water is discarded. The oils are clear.

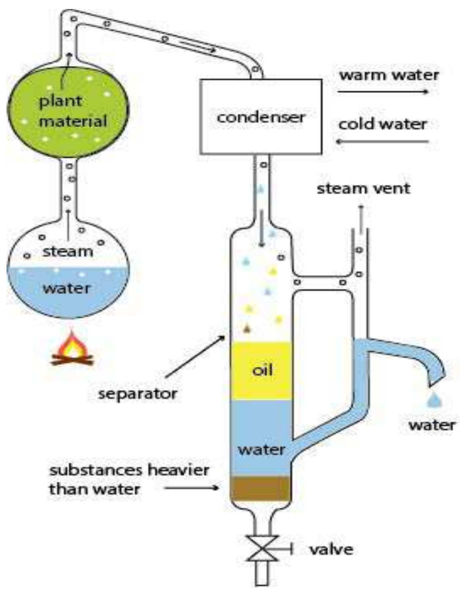

Figure-1. (a) Hydrodistillation-Clevenger method (b) Steam distillation method

2.3 Yield of Essential Oil

The yield percentage was calculated as a volume of essential oil per 100 g of Vetiver roots weight. Essential oils acquired from Vetiver roots by Hydrodistillation and Steam distillation methods produced a oil with colour golden-brown to amber-brown to olive. It exudes a strong aroma that smells earthy, woody, and rich. liquid with strong scent. The yield in both used distillation methods is different as shown in table 1. It indicates that the amount of essential oil yield is influenced by used distillation method.

Table 1. Effect on of Yield of Essential Oil by different distillation methods

S. No.	Distillation method	Oil yield (% v/w)
1.	Hydrodistillation-Clevenger	0.83
2.	Steam Distillation	0.79

3. Result and Discussion

3.1 Physio-chemical properties

It has been observed that physical and chemical values are almost similar. The noticeable value is relative density of vetiver oil is more of hydrodistilled than steam distillation. It is due to more numbers of molecules are present in hydrodistilled vetiver oil. Gas Chromatogram-Mass Spectrosmetry (GC-MS) analysis supported by showing 74 molecues in vetiver oil of hydodistillation method and 63 molecules in steam distillation.

Table 2. Physicochemical properties of Vetiver oils extracted by different hydrodistillation & steam distillation methods.

S.N.	Physicochemical properties	Distillation Methods	
		Hydro-Distillation	Steam Distillation
1.	Relative density (at 27 °C	1.0020	0.9975
2.	Optical rotation	+40.00°	+31.20°
3.	Refractive index(at 27 °C	1.5171	1.5151
4.	Solubility in 80% alcohol (at 27 °C	2 vol. Soluble	2 vol. Soluble

5.	Acid value	15.51	12.18
6.	Ester value	13.98	13.11
7.	Ester number after acetylation	164.28	153.23

3.2 Chemical Composition of Essential Oil

The qualitative and semi-quantitative composition of the essential oils is reported in Table 3, where the components are listed according to the class of compounds. Content (expressed as %) was calculated as ratio of peak area of individual compound and total peaks area in GC-MS chromatograms. The composition of Essential Oils obtained by both distillation techniques is different in the presence of compounds and also in their relative percent content. Gas Chromatogram-Mass Spectrosmetry (GC-MS) analysis revealed that 63 of the total major and minor components in vetiver oil were only removed using steam distillation, whereas 74 components were found as using the hydodistillation method.

There were observed differences when compared the percentage content of individual compounds. The biggest difference was observed in the case of eucalyptol, when essential oil isolated by HD contained higher amount of eucalyptol than SD oil, difference was 10.3%. Another apparent difference in content was at α-pinene (2%), sabinene (3.31%) and α-terpinyl acetate (2.13%), where on the contrary in SD oil there was a higher relative percentage content than in HD oil.

Table 3. Effect of different extraction methods on chemical compositions of essential oils from Vetiver roots.

Extracted by Hydro-distillation-Clevenger

Name Of Chemical Compound	% Of The Compound
1. Ylangene-Alpha	0.14%
2. Acoradiene-Beta	0.11%
3. Terpinolene	0.10%
4. Cedrene-Beta	0.11%
5. Amorphene-Gamma	0.13%
6. Murrola-4(14),5-Diene-Cis	0.11%
7. Himachalene-Gamma	0.36%
8. Bergamotene-Alpha-Cis	0.62%
9. Italicene-Iso	0.18%

Extracted by Steam-distillation method

Name of chemical Compound	% of the compound
1. Ylangene-Alpha	0.35%
2. Acoradiene-Alpha	0.25%
3. Chamigrene-Alpha	0.25%
4. Cedrene-Beta	0.31%
5. Cadinene-Gamma	0.32%
6. Murrola-4(14),5-Diene-Cis	0.26%
7. Sativene	0.82%
8. Bergamotene-Alpha-Cis	1.51%
9. Duprezianene-Alpha	0.37%

10. Calamenene-Cis	0.09%
11. Amorphene-Alpha	1.61%
12. Eudesma-6,11-Diene-Cis	0.49%
13. Cycloisolongifolene-Didehydro	0.77%
14. Amorphene-Gamma	0.51%
15. Cadina-1(6),4-Diene-Trans	0.13%
16. Amorphene-Delta	0.31%
17. Copaene-Alpha	0.09%
18. Bicyclogermacrene	0.14%
19. Calamenene-Trans	0.68%
20. Zonarene	0.20%
21. Calacorene-Alpha	0.50%
22. Elemole Acetate	0.50%
23. Cycloisolongifolene-Didehydro	0.26%
24. Eudesma-6,11-Diene-Cis	2.19%
25. Piperitenone	0.12%
26. Guaiene-Trans-Beta	0.44%
27. Amorphene-Delta	0.20%
28. Occidentalol	0.51%
29. Vetivenene-Beta	0.26%
30. Copaene-Alpha	0.68%
31. Presilphiperfol-7-Ene	0.29%
32. Funebrene-Alpha	1.41%
33. Zonarene	5.42%
34. Guaiene-Cis-Beta	0.88%
35. Isoledene	0.87%
36. Cadina-1(6),4-Diene-Trans	0.57%
37. Guaiene-Trans-Beta	0.70%
38. Gurjunene-Gamma	1.15%
39. Cadina-1(6),4-Diene-Trans	5.55%
40. Muurolene-Gamma	1.56%
41. Drima-7,9(11)-Diene	2.04%
42. Farnesene-(Z)-Beta	1.15%
43. Caryophyllene (Z)	1.66%
44. Alloaromadendrene-Epoxy Allo	2.23%
45. Farnesene-(Z)-Beta	0.58%

10. Amorphene-Alpha	3.39%
11. Eudesma-6,11-Diene-Cis	0.97%
12. Cycloisolongifolene-Didehydro	2.36%
13. Amorphene-Gamma	0.92%
14. Amorphene-Delta	0.81%
15. Amorphene-Delta	0.32%
16. Muurolene-Alpha	0.26%
17. Zonarene	1.47%
18. Zonarene	0.38%
19. Calacorene-Alpha	0.91%
20. Elemole Acetate	0.59%
21. Cycloisolongifolene-Didehydro	1.26%
22. Eudesma-6,11-Diene-Cis	2.58%
23. Guaiene-Trans-Beta	0.32%
24. Occidentalol	0.66%
25. Vetivenene-Beta	0.51%
26. Muurolene-Gamma	0.95%
27. Khusimone	1.56%
28. Linalool-Dehydro	0.69%
29. Zonarene	5.47%
30. Guaiene-Cis-Beta	0.99%
31. Cadina-1(6),4-Diene-Trans	1.38%
32. Muurolene-Gamma	0.64%
33. Longipinene-Beta	0.96%
34. Selinene-Delta	1.50%
35. Cadina-1(6),4-Diene-Trans	6.41%
36. Germacrene D	1.94%
37. Muurolene-14-Oxy-Alpha	3.73%
38. Aromadendrane-Dehydro	2.24%
39. Cedranol-5-Neo	1.82%
40. Maaliene-Beta	0.46%
41. Eudesm-7(11)-En-4-Ol-Juniper Camphor	2.33%
42. Gurjunene-Gamma	1.30%
43. Khusimol	3.47%
44. Atlantol-Beta	1.19%
45. Khusimol	9.79%

46. Khusimol	0.48%
47. Aromadendrene	2.16%
48. Alloaromadendrene-Epoxy Allo	0.56%
49. Guaiene-Cis-Beta	1.43%
50. Spathulenol	4.18%
51. Cadinene-Gamma	0.27%
52. Khusimol	14.51%
53. Caryophyllene-E	0.72%
54. Silphiperfol-4,7(14)-Diene	1.03%
55. Vetivenol-Bicyclo	0.57%
56. Gurjunene-Beta	1.01%
57. Cadina-1(6),4-Diene-Trans	0.61%
58. Vetivenene-Beta	9.16%
59. Atlantol-Beta	2.16%
60. Vetivenene-Beta	0.70%
61. Germacrene D	0.54%
62. Vetivenol-Bicyclo	0.68%
63. Vetivone-Beta	4.73%
64. Helifolen-12-Al B	2.45%
65. Vetivenene-Beta	0.33%
66. Vetivone-Alpha	5.39%
67. Cedren-13-Ol-8	0.23%
68. Vetivenene-Beta	3.39%
69. Apritone-E	0.22%
70. Cyclocolorenone	0.24%
71. Vetivenene-Beta	3.14%
72. Vetivenene-Beta	0.26%
73. Artemisia Triene	0.13%
74. Eupatoriochromene	0.11%

46. Cadinene-14-Hydroxy-Delta	0.41%
47. Caryophyllene-E	0.67%
48. Cedren-13-Ol-Acetate-8	1.00%
49. Valencene	0.51%
50. Muurolene-Gamma	1.21%
51. Zonarene	0.69%
52. Vetivenene-Beta	6.84%
53. Cuparene	1.46%
54. Vetivenene-Beta	0.47%
55. Nootkatone	0.42%
56. Vetivenol-Bicyclo	1.19%
57. Vetivone-Beta	3.17%
58. Arisolone	1.23%
59. Vetivenene-Beta	0.50%
60. Vetivenene-Beta	1.09%
61. Vetivone-Alpha	2.99%
62. Cycloisolongifolene-Didehydro	2.74%
63. Vetivenene-Beta	2.48%

Conclusion

This study demonstrated that the hydrodistillation technique is superior to steam distillation due to its quicker extraction times, ease of use, and ability to provide higher yields of 0.83% and 0.79%, respectively. GC-MS analysis revealed that 63 of the total major and minor components in vetiver oil were only removed using steam distillation, whereas 74 were extracted using the hydodistillation method. In conclusion, it is not possible to say with certainty whether hydrodistillation or steam distillation is better because each of them has different results in yield and chemical composition of essential oils as different crops or materials. When selecting the distillation method, it is necessary to consider the purpose of Vetiver roots distilling, whether we prefer higher yield and higher content of some of the compounds.

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