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Comparison of Production and Physicochemical Properties of Vetiver Essential Oil Extracted from Conventional and Modified Conventional Hydrodistillation Methods from Vetiver Roots

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ABSTRACT
The conventional hydrodistillation method (CH) produces a lesser amount of the vetiver oils, as well as the absence of stirring in the round bottom flask, which may also cause burning. To overcome these problems, a method has been adapted using a modified conventional hydrodistillation (MCH) by using heating plate with a magnetic stirrer. The yield and composition of vetiver/khus oil with the modified method increased along with an increase in the amount and number of chemical molecules, as seen by GC-MS. The vetiver oil was extracted by MCH shows 58 molecules while 45 molecules from CH method can be observed in the oil gas chromatogram mass spectrometry. This method has better potential in the pharmaceutical industry, cosmetic and perfumery industries due to the ease of extraction and isolation.
Keywords: Vetiver, Modified Conventional Distillation, Yield, Chemical Composition

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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.

This research based on the developing a efficient method for the de-oilation from aroma crops. So here we have adapted conventional and modified conventional hydrodistillation method for the extraction of vetiver/khus essential oil from vetiver root for the comparing the chemical composition of vetiver oil obtained from both methods.

2. Extraction and Yield of Essential Oils

2.1 Hydrodistillation methods

Setup-I:

The Clevenger apparatus hydrodistillation (conventional) was carried out by following Vetiver grass roots (300 g) collected from Sitapur (UP) rural agriculture field and added to distilled water (3000 mL) in a round bottom flask. This flask was then kept in a heating mantle with an attached Clevenger (Fig. 1a). The mixture was allowed to boil at 100 °C, and then the temperature was reduced to 60 °C and kept for 6 h. The vetiver essential oil was collected in a separation flask. Finally, Kept separated essential oil was dehydrated (de-moistured) by anhydrous sodium sulphate for further studies.

Setup-II:

The modified conventional hydrodistillation method applied a magnetic stirrer with heating plate. Here, collected vetiver grass roots (300 g) added into distilled water (3000 mL) in a flat bottom flask containing a magnetic stir bar with attached Clevenger apparatus [21]. The mixture was allowed to boil at 100 °C with rotation set at 200 rpm. Later, the temperature was reduced to 60 °C and rotation was kept at 200 rpm for 6 h. Kept separated essential oil was dehydrated (de-moistured) by anhydrous sodium sulphate for further studies. The distillation yield of the obtained essential oil was calculated using following equation: (1);

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

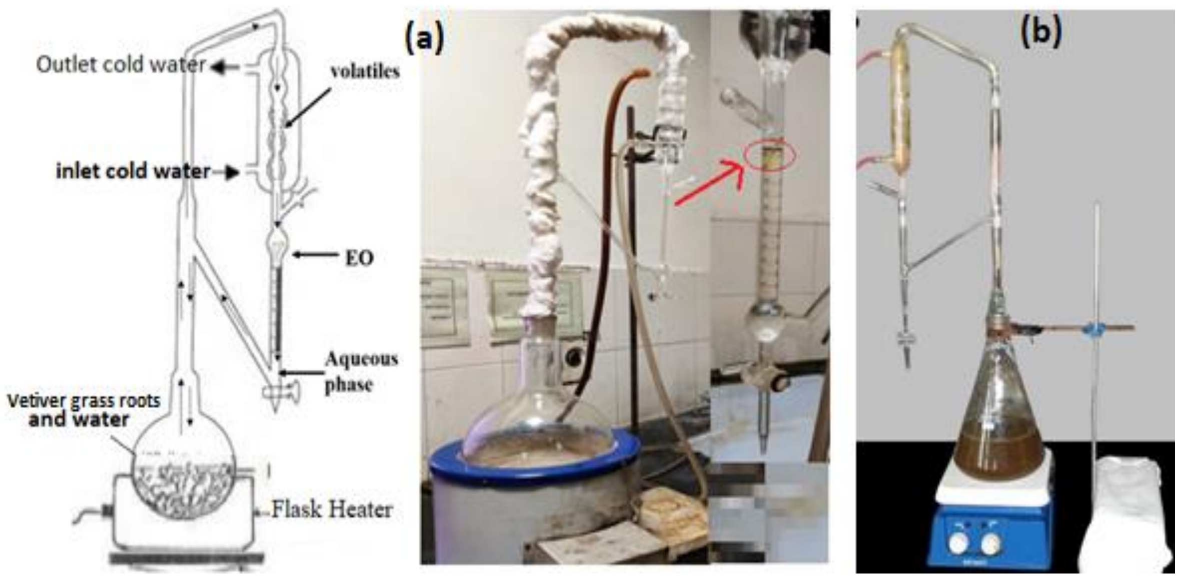

Figure-1. (a) Conventional hydrodistillation method **(b)** Modified conventional hydrodistillation method (MCH)

2.2 Yield of Essential Oil

The yield percentage was calculated as a volume of vetiver essential oil per 100 g of vetiver roots. Essential oils acquired from Vetiver roots by Clevenger apparatus hydrodistillation (conventional) and modified conventional hydrodistillation methods produced essential oil with colour golden-brown to amber-brown. It exudes a strong aroma that smells earthy, woody, and rich liquid with strong scent. The percentage yield in both distillation methods was found different as shown in table 1. It indicates that the amount of essential oil yield is influenced by the lack of stirring in the round bottom flask, which may also cause burning.

Table 1. Comparison of yield percentage in the vetiver essential oils extracted by modified conventional hydrodistillation (MCH) and conventional hydrodistillation (CH) from Vetiver Root

S. No.	Distillation method	Oil yield (% v/w)
1.	Conventional hydrodistillation	0.76
2.	Modified conventional hydrodistillation	0.83

3. Result and Discussion

3.1 Physio-chemical properties

It has been observed that physical and chemical values are almost similar. Gas Chromatogram-Mass Spectrosmetry (GC-MS) analysis supported by showing 58 molecues in vetiver oil of modified conventional hydrodistillation method and 45 molecules in conventional hydrodistillation method.

Table 2. Comparison of physicochemical properties of vetiver oils extracted by modified conventional hydrodistillation and conventional hydrodistillation.

S.N.	Physicochemical properties	Distillation Methods	
		Hydro-Distillation	Steam Distillation
1.	Relative density (at 27 °C	0.9989	0.9975
2.	Optical rotation	+40.00°	+39.20°
3.	Refractive index(at 27 °C	1.5170	1.5171
4.	Solubility in 80% alcohol (at 27 °C	2 vol. Soluble	2 vol. Soluble
5.	Acid value	15.51	15.18
6.	Ester value	13.98	13.11
7.	Ester number after acetylation	164.28	159.23

3.2 Chemical Composition of Essential Oil

Table 3 provides the essential oils' qualitative and semi-quantitative makeup. The constituents are arranged by class of compounds. The ratio of the peak areas of each individual chemical to the overall peak areas in GC-MS chromatograms was used to compute content (reported as%). Both the relative percent content and the presence of distinct compounds determine the composition of essential oils obtained by the two distillation processes. According to a Gas Chromatogram-Mass Spectroscopy (GC-MS) examination, 45 components were discovered using the standard hydrodistillation method, however 58 of the major and minor components in vetiver oil were only removed using vetiver oil obtained from modified conventional hydrodistillation.

Table 3. Comparison of number of chemical molecules and their amount in the vetiver essential oils extracted by modified conventional hydrodistillation (MCH) and conventional hydrodistillation (CH) from Vetiver Root

Vetiver Oil obtained from Modified Conventional Hydrodistillation			**Vetiver Oil obtained from Conventional Hydrodistillation**		
1.	Ylangene-Alpha	0.35%	1.	Himachalene-Alpha	0.34%
2.	Funebrene-Beta	0.25%	2.	Khusimene-Zazaene	0.55%
3.	Muurola-3,5-Diene-Cis	0.19%	3.	Amorphene-Alpha	1.49%
4.	Himachalene-Alpha	0.77%	4.	Eudesma-6,11-Diene-Cis	0.55%
5.	Khusimene	1.37%	5.	Cycloisolongifolene-Didehydro	1.25%
6.	Helifolen-12-Al D	0.33%	6.	Calamenene-Trans	0.59%
7.	Amorphene-Alpha	3.07%	7.	Calacorene-Alpha	0.51%
8.	Eudesma-6(11),4-Diene-Cis	0.78%	8.	Elemole Acetate	0.53%
9.	Cycloisolongifolene-Didehydro	1.65%	9.	Eudesma-6,11-Diene-Cis	2.18%
10.	Amorphene-Gamma	0.89%	10.	Isoledene	0.56%
11.	Amorphene-Delta	0.43%	11.	Vetivenene-Beta	0.55%
12.	Zonarene	1.17%	12.	Cadina-6(11),4-Diene-Trans	0.67%
13.	Zonarene	0.28%	13.	Khusimone	1.42%
14.	Calacorene-Alpha	0.97%	14.	Farnesene-(E)-Beta	0.52%
15.	Elemole Acetate	0.71%	15.	Muurolene-Gamma	5.58%
16.	Calamenene-Cis	0.56%	16.	Guaiene-Cis-Beta	0.91%
17.	Eudesma-6,11-Diene-Cis	3.65%	17.	Isoledene	0.82%
18.	Eudesm-7(11)-En-4-Ol	0.38%	18.	Cadina-1(6),4-Diene-Trans	0.61%
19.	Occidentalol	0.72%	19.	Vetivenol-Bicyclo	0.74%
20.	Vetivenene-Beta	0.34%	20.	Guaiene-Cis-Beta	1.16%
21.	Muurolene-Gamma	1.00%	21.	Cadina-1(6),4-Diene-Trans	5.22%
22.	Cedrene-Alpha	0.41%	22.	Amorphene-Gamma	1.67%
23.	Khusimone	2.25%	23.	Farnesene-(Z)-Beta	3.21%
24.	Funebrene-Beta	0.56%	24.	Atlantol-Beta	1.73%
25.	Epizonarene	7.44%	25.	Mayurone	2.09%
26.	Guaiene-Trans-Beta	0.95%	26.	Aromadendrene	2.20%
27.	Zonarene	0.98%	27.	Gurjuene-Alpha	1.44%
28.	Cadina-1(6),4-Diene-Trans	0.32%	28.	Khusimol	4.11%
29.	Cadinene-14-Hydroxy-Delta	0.40%	29.	Curcumene-Ar	1.76%
30.	Guaiene-Cis-Beta	1.33%	30.	Silphiperfol-4,7(14)-Diene	15.27%
31.	Cadina-1(6),4-Diene-Trans	6.48%	31.	Vetivenol-Bicyclo	0.71%
32.	Muurolene-Gamma	1.66%	32.	Atlantol-Beta	1.14%
33.	Isogeijerene C	3.01%	33.	Longifolene	0.53%
34.	Santalol Acetate (Z)-Alpha	0.83%	34.	Muurolene-Gamma	1.32%
35.	Acorenone B	0.36%	35.	Himachalene-Beta	0.68%
36.	Oplopenone-Beta	1.31%	36.	Vetivenene-Beta	0.68%
37.	Modheph-2-Ene	0.23%	37.	Coumarin-3-Methyl	2.30%
38.	Selinene-Delta	1.94%	38.	Vetivenene-Beta	0.70%
39.	Guaiene-Cis-Beta	0.73%	39.	Nootkatone	0.53%
40.	Khusimol	4.20%	40.	Helifolen-12-Al B	1.14%
41.	Curcumene-Ar	1.28%	41.	Vetivone-Beta	5.04%
42.	Khusimol	14.46%	42.	Vetivone-Beta	1.47%
			43.	Vetivone-Alpha	6.23%
			44.	Cycloisolongifol-5-Ol-Cis	3.94%
			45.	Vetivenene-Beta	3.75%

43.	Curcumen-15-Al-Gamma	0.52%	
44.	Occidentalol Acetate	0.47%	
45.	Caryophyllene-E	0.38%	
46.	Murrolene-Gamma	0.83%	
47.	Funebrene-Alpha	0.44%	
48.	Cycloisolongifol-5-Ol-Trans	8.43%	
49.	Silphiperfol-4,7(14)-Diene	1.60%	
50.	Vetivenene-Beta	0.46%	
51.	Nootkatone	0.41%	
52.	Longipinene-Alpha	1.10%	
53.	Vetivone-Beta	3.72%	
54.	Prenyl Limonene-Trans	1.52%	
55.	Vetivenene-Beta	0.33%	
56.	Vetivone-Alpha	4.63%	
57.	Calamenene-Trans	2.33%	
58.	Vetivenene-Beta	1.83%	

4. Conclusion

The results of this investigation showed that the modified conventional hydrodistillation (MCH) method is more effective than conventional hydrodistillation (CH) because it can give higher yields of 0.83% and 0.76%, respectively, and has faster extraction times. Only 45 of the major and minor components of vetiver oil were recovered using standard hydrodistillation, according to GC-MS analysis, while 58 components were extracted using a modified version of the typical hydrodistillation process. In summary, the modified traditional hydrodistillation process that combined a heated plate and magnetic stirrer produced a superior yield and composition in less time than the original method. Furthermore, this facilitates the isolation of a significant and physiologically active substance, making it appropriate for use in laboratories.

References

1. Bonlawar, J., Setia, A., Challa, R.R., Vallamkonda, B., Mehata, A.K., Vaishali, , Viswanadh, M.K., Muthu, M.S. (2024). Targeted Nanotheransotics: Integration of Preclinical MRI and CT in the Molecular Imaging and Therapy of Advanced Diseases. Nanotheranostics, 8(3), 401-426. https://doi.org/10.7150/ntno.95791.
2. Pasala, P. K., Rudrapal, M., Challa, R. R., Ahmad, S. F., Vallamkonda, B., & R., R. B. (2024). Anti-Parkinson potential of hesperetin nanoparticles: in vivo and in silico investigations. Natural Product Research, 1–10. https://doi.org/10.1080/14786419.2024.2344740
3. Suseela, M. N. L., Mehata, A. K., Vallamkonda, B., Gokul, P., Pradhan, A., Pandey, J., ... & Muthu, M. S. (2024). Comparative Evaluation of Liquid-Liquid Extraction and Nanosorbent Extraction for HPLC-PDA Analysis of Cabazitaxel from Rat Plasma. Journal of Pharmaceutical and Biomedical Analysis, 116149. https://doi.org/10.1016/j.jpba.2024.116149
4. Chakravarthy, P.S.A., Popli, P., Challa, R.R. et al. Bile salts: unlocking the potential as bio-surfactant for enhanced drug absorption. J Nanopart Res 26, 76 (2024). https://doi.org/10.1007/s11051-024-05985-6
5. Setia, A., Vallamkonda, B., Challa, R.R., Mehata, A.K., Badgujar, P., Muthu, M.S. (2024). Herbal Theranostics: Controlled, Targeted Delivery and Imaging of Herbal Molecules. Nanotheranostics, 8(3), 344-379. https://doi.org/10.7150/ntno.94987.

6. Dhamija P, Mehata AK, Tamang R, Bonlawar J, Vaishali, Malik AK, Setia A, Kumar S, Challa RR, Koch B, Muthu MS. Redox-Sensitive Poly(lactic-co-glycolic acid) Nanoparticles of Palbociclib: Development, Ultrasound/Photoacoustic Imaging, and Smart Breast Cancer Therapy. Mol Pharm. 2024 May 5. doi: 10.1021/acs.molpharmaceut.3c01086. Epub ahead of print. PMID: 38706253.
7. Eranti, Bhargav and Mohammed, Nawaz and Singh, Udit Narayan and Peraman, Ramalingam and Challa, Ranadheer Reddy and Vallamkonda, Bhaskar and Ahmad, Sheikh F. and DSNBK, Prasanth and Pasala, Praveen Kumar and Rudrapal, Mithun, A Central Composite Design-Based Targeted Quercetin Nanoliposomal Formulation: Optimization and Cytotoxic Studies on MCF-7 Breast Cancer Cell Lines. Available at SSRN: https://ssrn.com/abstract=4840349 or http://dx.doi.org/10.2139/ssrn.4840349
8. Setia A, Challa RR, Vallamkonda B, Satti P, Mehata AK, Priya V, Kumar S, Muthu MS. Nanomedicine And Nanotheranostics: Special Focus on Imaging of Anticancer Drugs Induced Cardiac Toxicity. Nanotheranostics 2024; 8(4):473-496. doi:10.7150/ntno.96846. https://www.ntno.org/v08p0473.htm
9. Mandal S, Vishvakarma P. Nanoemulgel: A Smarter Topical Lipidic Emulsion-based Nanocarrier. Indian J of Pharmaceutical Education and Research. 2023;57(3s):s481-s498.
10. Mandal S, Jaiswal DV, Shiva K. A review on marketed Carica papaya leaf extract (CPLE) supplements for the treatment of dengue fever with thrombocytopenia and its drawback. International Journal of Pharmaceutical Research. 2020 Jul;12(3).
11. Bhandari S, Chauhan B, Gupta N, et al. Translational Implications of Neuronal Dopamine D3 Receptors for Preclinical Research and Cns Disorders. *African J Biol Sci (South Africa)*. 2024;6(8):128-140. doi:10.33472/AFJBS.6.8.2024.128-140
12. Tripathi A, Gupta N, Chauhan B, et al. Investigation of the structural and functional properties of starch-g-poly (acrylic acid) hydrogels reinforced with cellulose nanofibers for cu2+ ion adsorption. *African J Biol Sci (South Africa)*. 2024;6(8): 144-153, doi:10.33472/AFJBS.6.8.2024.141-153
13. Sharma R, Kar NR, Ahmad M, et al. Exploring the molecular dynamics of ethyl alcohol: Development of a comprehensive model for understanding its behavior in various environments. Community Pract. 2024;21(05):1812-1826. doi:10.5281/zenodo.11399708
14. Mandal S, Kar NR, Jain AV, Yadav P. Natural Products As Sources of Drug Discovery: Exploration, Optimisation, and Translation Into Clinical Practice. African J Biol Sci (South Africa). 2024;6(9):2486-2504. doi:10.33472/AFJBS.6.9.2024.2486-2504
15. Kumar S, Mandal S, Priya N, et al. Modeling the synthesis and kinetics of Ferrous Sulfate production: Towards Sustainable Manufacturing Processes. African J Biol Sci (South Africa). 2024;6(9):2444-2458. doi:10.33472/AFJBS.6.9.2024.
16. Revadigar RV, Keshamma E, Ahmad M, et al. Antioxidant Potential of Pyrazolines Synthesized Via Green Chemistry Methods. African J Biol Sci (South Africa). 2024;6(10):112-125. doi:10.33472/AFJBS.6.10.2024.112-125
17. Sahoo S, Gupta S, Chakraborty S, et al. Designing, Synthesizing, and Assessing the Biological Activity of Innovative Thiazolidinedione Derivatives With Dual Functionality. African J Biol Sci (South Africa). 2024;6(10):97-111. doi:10.33472/AFJBS.6.10.2024.97-111

18. Mandal S, Bhumika K, Kumar M, Hak J, Vishvakarma P, Sharma UK. A Novel Approach on Micro Sponges Drug Delivery System: Method of Preparations, Application, and its Future Prospective. Indian J of Pharmaceutical Education and Research. 2024;58(1):45-63.
19. Mishra, N., Alagusundaram, M., Sinha, A., Jain, A. V., Kenia, H., Mandal, S., & Sharma, M. (2024). Analytical Method, Development and Validation for Evaluating Repaglinide Efficacy in Type Ii Diabetes Mellitus Management: a Pharmaceutical Perspective. Community Practitioner, 21(2), 29–37. https://doi.org/10.5281/zenodo.10642768
20. Singh, M., Aparna, T. N., Vasanthi, S., Mandal, S., Nemade, L. S., Bali, S., & Kar, N. R. (2024). Enhancement and Evaluation of Soursop (Annona Muricata L.) Leaf Extract in Nanoemulgel: a Comprehensive Study Investigating Its Optimized Formulation and Anti-Acne Potential Against Propionibacterium Acnes, Staphylococcus Aureus, and Staphylococcus Epidermidis Bacteria. Community Practitioner, 21(1), 102–115. https://doi.org/10.5281/zenodo.10570746
21. Khalilullah, H., Balan, P., Jain, A. V., & Mandal, S. (n.d.). Eupatorium Rebaudianum Bertoni (Stevia): Investigating Its Anti-Inflammatory Potential Via Cyclooxygenase and Lipooxygenase Enzyme Inhibition - A Comprehensive Molecular Docking And ADMET. Community Practitioner, 21(03), 118–128. https://doi.org/10.5281/zenodo.10811642