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Original Research Article

Impact of NaCl concentrations and drying on the essential oil yields and composition of *Murraya koenigii* (L.) Spreng leaf

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Abstract

The objective of this study was to investigate how varying concentrations of salt (NaCl) and different drying methods affect the yield and composition of essential oil extracted from the leaves of *Murraya koenigii* (L.) Spreng. The findings revealed that fresh samples yielded significantly more essential oil (0.24%) than both dried samples and those treated with different NaCl concentrations (5, 10, and 15% NaCl). Gas chromatography analysis identified 12 chemical constituents, with α-phellandrene and lavandulol being the primary ingredients. Medium proportions of β-phellandrene and β-caryophyllene were also detected, along with eight other chemicals. Among the samples, the oven-dried sample exhibited the highest concentration of α-phellandrene (44.205%), while the sample treated with 15% NaCl had the lowest concentration (33.064%). The difference in the α-phellandrene concentration between the fresh and oven-dried samples was significant (8.011%). The lavandulol concentration was highest in the 15% NaCl sample (27.905%) and lowest in the oven-dried sample (23.577%), with no notable variation observed among the dried, NaCl-treated, and fresh samples. β-Phellandrene was highest in the 5% NaCl sample (9.216%) and lowest in the fresh sample (6.77%). No significant variations were observed in the concentration of β-caryophyllene across all the samples. The elevated β-phellandrene content in *M. koenigii* essential oils by a particular treatment suggests potential market competitiveness and enhances the commercial viability of these oils.

Keywords: *Murraya koenigii*, Drying, Salt media, Essential oil, Gas chromatography.

Introduction

Curry leaf (*Murraya koenigii* (L.) Spreng., syn. *Bergera koenigii* L., *Chalcas koenigii* (L.) Kurz., Family: Rutaceae; 2n = 18) is an aromatic, pubescent, deciduous shrub or small tree reaching heights of up to 6 m. This small tree is widespread in various tropical and subtropical regions, spanning from Sri Lanka and India to the southern Ryukyu Islands and extending from China and Malaysia to Australia. It also thrives in the Pacific region, from the Mariana Islands to Vanuatu and New Caledonia (Smith, 1985). In India, it can grow up to 1650 m in altitude and exists in both wild and cultivated forms. Often cultivated in home gardens in South India, it is renowned for its fragrant leaves (Joseph and Peter, 1985). The leaves possess a distinctive taste characterized by spices, bitterness, acridity, coolness, and mild acidity. Even after drying, the aromatic leaves maintain their original color and flavor, making them marketable in both fresh and dry forms (Ramalakshmi, Rao and Sulochanamma, 2000). In indigenous medicine, the leaves, bark, and roots serve various purposes, such as tonics, stomachics, anthelmintics, analgesics, stimulants, appetizers, and carminatives. They are used to treat a range of ailments, including piles, influenza, fever, itching, dropsy, bronchial asthma, eruptions, animal bites, dysentery, diarrhea, body aches, fresh cuts, kidney pains, and vomiting (Kumar *et al*., 1999; Rana *et al*., 2004). Additionally, reports suggest that curry leaves are beneficial for diabetes management (Grover *et al*., 2002) and have antibacterial, antifungal, antioxidant, and pesticidal properties (Deshmukh *et al*., 1986; Pathak *et al*., 1997). Essential oils can be extracted from various parts of plants, including leaves, stalks, flowers, fruits, and seeds, through steam or hydrodistillation methods (Mallavarapu *et al*., 2000; Walde *et al*., 2005; Walde *et al*., 2006).

Fresh leaves, dry leaf powder, and essential oils are widely used for flavoring various culinary delights, such as soups, curries, chutneys, sausages, fish and meat dishes, pickles, buttermilk, egg preparations, curry

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powder blends, seasonings, ready-to-eat meals, and other contemporary food preparations (Verghese, 1989). The essential oil also has applications in aromatherapy, as well as in the soap and cosmetics industries. Many countries export dried leaf powder, essential oils, and food items that incorporate leaf powder and essential oils. In addition to the essential oils, other parts of the tree are known to contain biologically active alkaloids such as carbazole and indole (Kumar *et al*., 1999). The chemical compositions of leaf essential oils have been documented in various regions, including India (Mallavarapu *et al*., 2000), Bangladesh (Chowdhury *et al*., 2008), Malaysia (Wong and Tie, 1993), Nigeria (Onayade and Adebajo, 2000), and Sri Lanka (MacLeod and Pieris, 1982).

The aim of this study was to investigate how different drying methods and salt solutions at varying concentrations affect the yield and chemical composition of essential oils extracted from *M. koenigii* leaves, offering valuable insights into potential applications. Ultimately, the results contribute to the production of enhanced essential oils suitable for diverse commercial purposes, thereby enhancing the value of *M. koenigii* essential oils in both the food and pharmaceutical industries.

Materials and Methods

Plant material collection

Leaves of *M. koenigii* plants (aged 4 years) were harvested from Husnabad, Siddipet, TS, in May 2023. Dr. Venkat Ramana, an Assistant Professor in the Department of Botany at Nizam College, Osmania University, Hyderabad, India, conducted the identification process. A voucher specimen (CIMAP-MK/23) was subsequently archived at the CSIR-CIMAP Research Center in Hyderabad.

Sample preparation

The freshly harvested leaf sample of *M. koenigii* was partitioned into equal segments. Each segment underwent hydrodistillation using NaCl solutions of different concentrations (5, 10, and 15%). Additionally, another segment of the leaf material was subjected to drying, both in the shade at ambient temperatures and in a hot air oven, until complete dryness was achieved.

Extraction of essential oil

The essential oils were extracted through hydrodistillation using a Clevenger-type apparatus. A total of 250 g of *M. koenigii* leaves were placed in a 2 L RB flask filled with 1 L of distilled water, and then hydrodistillation was carried out for approximately 3 hours. The obtained oil samples were stored in airtight containers at temperatures between 0 and 5°C until analysis. Before gas chromatography (GC) analysis, the oil samples were dehydrated using anhydrous sodium sulfate.

Gas chromatography parameters

The essential oils were analyzed on a Varian CP-3800 model gas chromatograph with a Galaxy software system equipped with a flame ionization detector (FID) and an electronic integrator. The separation of the compounds was achieved by employing a Varian CP–Sil 5CB capillary column (ID: 50 m × 0.25 mm; film thickness 0.25 μm). Nitrogen was used as the carrier gas at a constant flow rate of 0.4 mL/min. The column temperature was increased from 60°C (held for 2 minutes) to 220°C (held for 6 minutes) and then increased to 245°C (held for 0 minutes) at a rate of 5°C/min. The injector and detector temperatures were set at 250 and 300°C, respectively. The samples (0.2 μL) were injected at a 20:100:20 split ratio. Retention indices were generated with a standard solution of *n*-alkanes (C_6–C_{19}). The composition was reported as a relative percentage of the total peak area without FID response factor correction.

Chemical compound identification

The identification of components was performed based on their retention indices (RIs), which were determined with reference to a homologous series of *n*-alkanes (C_9–C_{24}, Polyscience Corp., Niles, IL, USA) under identical experimental conditions) in both polar and nonpolar columns *via* coinjection with standards (Natural Remedies, India). The relative amounts of components were calculated based on computer-calculated GC peak areas without correction for flame ionization detection response factors.

Results and Discussion

Effect of shade dry and sodium chloride salt concentration on essential oil yield

The aim of this study was to assess oil yield and composition by extracting essential oils from *M. koenigii* leaves using two distinct drying methods (oven and shade) and different NaCl concentrations (5, 10, and 15%). Notably, fresh leaf samples exhibited significantly greater oil recovery (0.24%) than those subjected to distillation with salt and drying processes (Figure 1). The essential

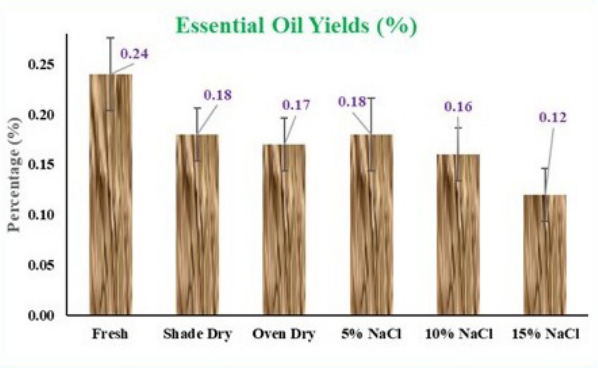

Figure 1: Essential oil yields in *M. koenigii* samples

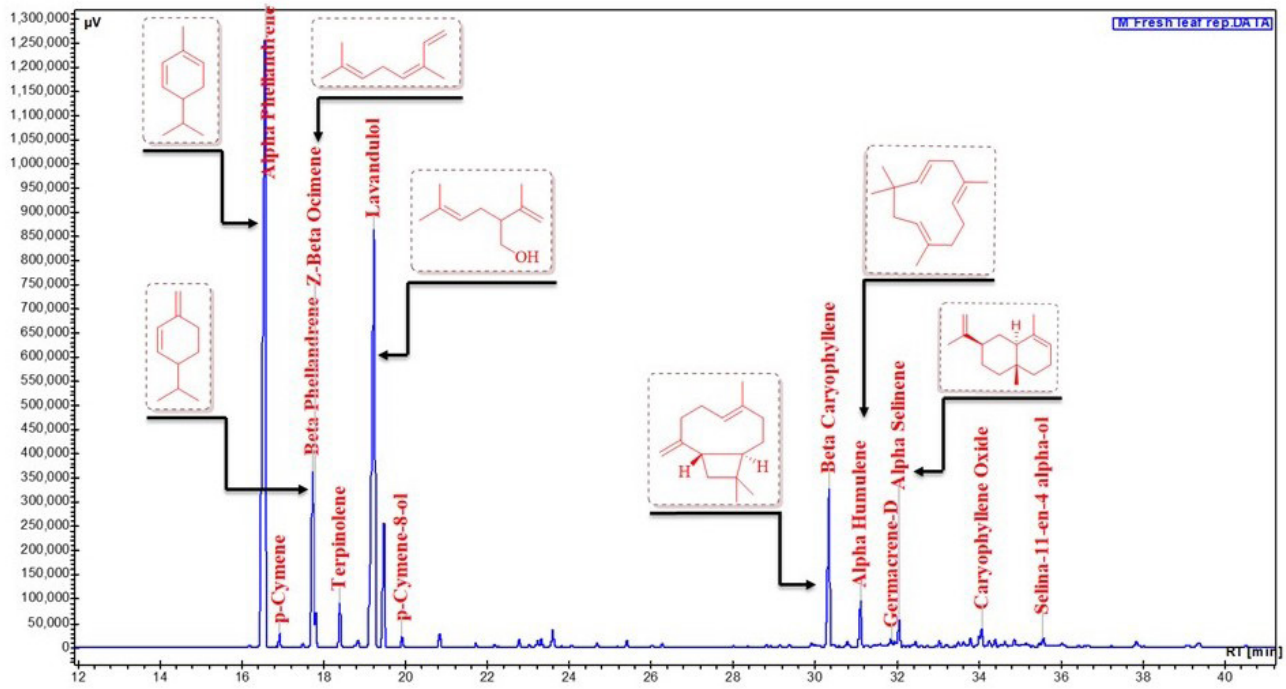

Figure 2: GC of *M. koenigii* essential oil

Table 1: GC analysis results of *M. koenigii* leaf essential oils

Constituents	*Chemical composition (%)*					
	Fresh	*Shade dry*	*Oven dry*	*5% NaCl*	*10% NaCl*	*15% NaCl*
α- Phellandrene	36.194 (± 1.132)	43.528 (± 1.963)	44.205 (± 1.257)	41.751 (± 2.032)	35.452 (± 1.721)	33.064 (± 1.352)
p-Cymene	0.481 (± 0.099)	0.509 (± 0.018)	0.412 (± 0.019)	0.624 (± 0.018)	0.543 (± 0.011)	0.544 (± 0.013)
β-Phellandrene	6.770 (± 0.167)	7.606 (± 0.152)	7.090 (± 0.197)	9.216 (± 0.110)	8.770 (± 0.495)	8.544 (± 0.111)
Terpinolene	1.588 (± 0.338)	2.477 (± 0.124)	2.506 (± 0.167)	2.244 (± 0.112)	2.698 (± 0.179)	2.147 (± 0.132)
Lavandulol	25.849 (± 0.295)	23.663 (± 0.312)	23.577 (± 1.012)	24.844 (± 0.956)	27.905 (± 1.003)	25.256 (± 1.219)
p-Cymene-8-ol	0.363 (± 0.027)	0.375 (± 0.018)	0.356 (± 0.038)	0.421 (± 0.021)	0.469 (± 0.013)	0.461 (± 0.026)
β- Caryophyllene	6.873 (± 0.105)	6.786 (± 0.197)	6.346 (± 0.155)	4.458 (± 0.106)	4.590 (± 0.157)	6.756 (± 0.195)
α- Humulene	1.677 (± 0.017)	1.505 (± 0.096)	1.373 (± 0.106)	0.907 (± 0.122)	0.937 (± 0.123)	1.418 (± 0.197)
Germacrene-D	0.431 (± 0.020)	0.392 (± 0.018)	0.359 (± 0.014)	0.225 (± 0.018)	0.255 (± 0.018)	0.421 (± 0.020)
α- Selinene	1.101 (± 0.097)	0.927 (± 0.030)	0.827 (± 0.017)	0.627 (± 0.010)	0.708 (± 0.106)	1.200 (± 0.090)
Caryophyllene oxide	0.681 (± 0.011)	0.657 (± 0.027)	0.597 (± 0.101)	0.218 (± 0.012)	0.383 (± 0.080)	0.453 (± 0.014)
Selina-11-en-4 alpha-ol	0.415 (± 0.016)	0.257 (± 0.029)	0.248 (± 0.032)	0.159 (± 0.015)	0.230 (± 0.091)	0.394 (± 0.024)
Total	82.423	88.582	87.896	85.694	82.940	80.658

Table 2: Correlation data of *M. koenigii* leaf essential oils

	α- Phellandrene	p-Cymene	β-Phellandrene	Terpinolene	Lavandulol	p-Cymene-8-ol	β- Caryophyllene	α- Humulene	Germacrene-D	α- Selinene	Caryophyllene Oxide	Selina-11-en-4 alpha-ol
α- Phellandrene	1											
p-Cymene	-0.263	1										
β-Phellandrene	-0.245	**0.879**	1									
Terpinolene	0.350	0.022	0.402	1								
Lavandulol	-0.745	0.339	0.375	0.005	1							
p-Cymene-8-ol	-0.670	**0.662**	**0.840**	0.316	**0.671**	1						
β- Caryophyllene	-0.030	-0.633	-0.760	-0.454	-0.487	-0.526	1					
α- Humulene	-0.033	-0.641	-0.845	-0.585	-0.408	-0.620	**0.971**	1				
Germacrene-D	-0.204	-0.584	-0.723	-0.531	-0.336	-0.420	**0.984**	**0.966**	1			
α- Selinene	-0.510	-0.327	-0.463	-0.600	-0.111	-0.099	**0.863**	**0.828**	**0.931**	1		
Caryophyllene Oxide	0.148	-0.820	-0.936	-0.298	-0.346	-0.703	**0.861**	**0.906**	**0.829**	**0.593**	1	
Selina-11-en-4 alpha-ol	-0.631	-0.353	-0.511	-0.702	0.112	-0.089	**0.764**	**0.787**	**0.866**	**0.951**	**0.583**	1

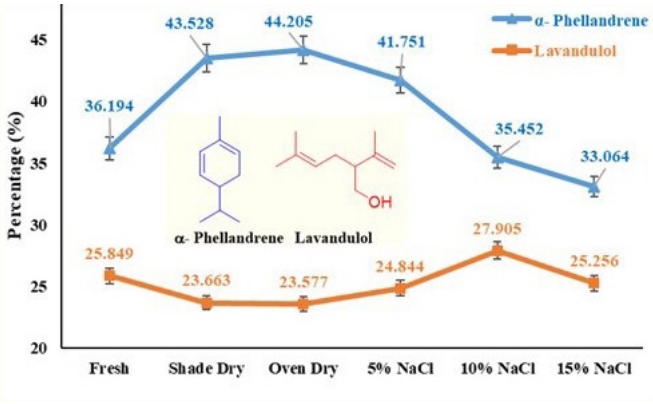

Figure 3: Variations of α-phellandrene and lavandulol content in EOs samples analysed

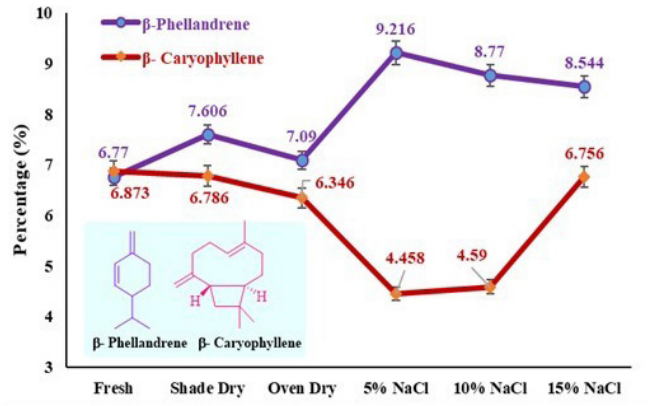

Figure 4: Variation of β-phellandrene and β-caryophyllene content in EOs samples analysed

oil content may decrease during leaf drying, and the presence of saltwater could hinder the extraction of essential oils during the hydrodistillation of the samples.

Effects of shade dry and sodium chloride salt concentration on chemical composition

The essential oils (EOs) were analyzed using gas chromatography with a flame ionization detector (FID). This analysis revealed 12 chemical constituents with a total content ranging from 80.658 to 88.582% (Table 1 & Figure 2).

The EOs derived from fresh, dried (shade and oven), and varying sodium chloride concentration (5, 10, and 15%) samples exhibited intriguing alterations in their chemical compositions. Notably, the major chemical constituent α-phellandrene increased in the dried samples, particularly in the oven-dried sample (44.205%), in contrast to the fresh samples (36.194%). In comparison, the 15% NaCl sample exhibited the lowest concentration (33.064%). There was a significant difference (8.011%) in the α-phellandrene concentration between the fresh and oven-dried samples. The increase in the β-phellandrene (from 6.77–9.216%) content within *M. koenigii* essential oils has the potential to meet market expectations and enhance the commercial viability of these oils.

In contrast, lavandulol, another major constituent, exhibited a slight decrease in the dry samples (shade 23.663% and oven 23.577%) compared to the fresh sample (25.849%) (Figure 3, Table 1). However, in the NaCl samples, the amount of lavandulol slightly increased at 10% NaCl (27.905%). These findings suggest that the shade-drying technique may not be optimal for maximizing the lavandulol content in leaf essential oils from this plant.

Increasing the concentrations of α-phellandrene and lavandulol in essential oils, which are commonly utilized in flavoring, functional food ingredients, and traditional medicine, could benefit both farmers and consumers. This study indicates that the shade-dry approach yields higher percentages of α-phellandrene in enhanced essential oils, making it particularly advantageous from a consumer perspective.

The medium-concentration components β-phellandrene and β-caryophyllene were significantly influenced by both the drying technique and the NaCl hydrodistillation media. Dried samples (shade: 7.606%; oven: 07.09%) and NaCl-treated samples (5:9.216%; 10:8.770%; 15:8.544%) exhibited higher levels of β-phellandrene than did fresh samples (6.77%) (Figure 4, Table 1). Particularly noteworthy was the increase in the β-phellandrene concentration up to 2.446% in the 5% NaCl medium. Conversely, the content of another medium characteristic component, β-caryophyllene, was lower in all shade- and NaCl-treated samples than in the fresh ones (6.873%). This reduction in the β-caryophyllene content was attributed to a negative correlation with the increased concentration of β-phellandrene.

Correlations

In our correlation study, we examined the individual chemical constituents of essential oils extracted using various hydrolysis and drying methods and observed correlations among them (Table 2). This investigation sheds light on the intricate relationships between these components within the essential oil composition. The primary constituent, α-phellandrene, exhibited positive correlations with terpinolene (0.350) and caryophyllene oxide (0.148) but showed significant negative correlations with lavandulol (-0.745), p-cymene-8-ol (-0.670), α-selinene (-0.510), and selina-11-en-4 alpha-ol (-0.631). Similarly, lavandulol, another major constituent, was significantly positively correlated with p-cymene-8-ol (0.671), β-phellandrene (0.375), p-cymene (0.339), and selina-11-en-4 alpha-ol (0.112). Furthermore, one of the minor constituents, β-phellandrene, exhibited significant positive correlations with p-cymene (0.879) and p-cymene-8-ol (0.840), while another minor constituent, β-caryophyllene, showed significant positive correlations with α-humulene (0.971), germacrene-D (0.984), α-selinene (0.863), caryophyllene oxide (0.861), and selina-11-en-4 alpha-ol (0.764). This intricate network of correlations underscores the complexity of essential oil composition and the interactions among its diverse chemical elements.

Conclusion

Our study highlights the significant impacts of varying NaCl concentrations and different drying techniques on both the quantity and quality of active components in essential oils extracted from *M. koenigii* leaves. Interestingly, the fresh leaf samples exhibited notably greater oil recovery (0.24%) than the samples distilled with salt and the dried samples. However, concerning quality, the concentration of α-phellandrene in the essential oils was notably influenced by the hot air oven drying process, with a significant difference (8.011%) between the fresh and oven-dried samples. This enriched content of β-phellandrene in *M. koenigii* essential oils holds promise for meeting market expectations and enhancing their commercial potential. Moreover, the β-phellandrene concentration increased (2.44%) in the 5% NaCl distillate media. For farmers aiming for optimal economic returns, the hot air oven drying technique is recommended for obtaining α-phellandrene-enriched essential oil from *M. koenigii*.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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