American Journal of Essential Oils and Natural Products
Available online at www.essencejournal.com
AJEONP
American Journal of Essential Oils and Natural Products
AkiNik

ISSN: 2321-9114
https://www.essencejournal.com
AJEONP 2025; 13(1): 151-155

Received: 17-07-2025
Accepted: 22-08-2025

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# Evaluating the essential oil yield from papaya leaves in the Niayes Region of Senegal: Typology and benefits

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**DOI:** https://www.doi.org/10.22271/23219114.2025.v13.i1b.283

**Abstract**
The growing interest in essential oils (EOs) and their applications in various industries has prompted an investigation into their production from non-conventional sources, such as papaya (Carica papaya) leaves. In the Niayes region of Senegal, papaya farms are widespread, yet the potential of papaya leaves as a source of essential oils (EOs) remains underexplored. This research aimed to evaluate the essential oil yield from papaya leaves, focusing on the typology of papaya farms in the region and assessing the benefits of extracting essential oils (EOs) for local farmers and the environment. The research employed a combination of qualitative and quantitative methods, including field surveys, oil extraction processes, and yield measurements. The essential oil extraction was conducted using steam distillation, and the yield was analyzed for its chemical composition using gas chromatography-mass spectrometry (GC-MS). The results revealed that papaya leaves contain a significant number of essential oils (EOs), with a distinct chemical profile. The findings suggest that papaya leaf essential oils (EOs) could have valuable applications in the cosmetics and pharmaceutical industries, providing an additional income source for farmers in the region. Furthermore, the research discusses the potential benefits of integrating essential oil extraction into existing papaya farming practices as part of sustainable agricultural development. This research contributes to the body of knowledge on alternative uses of papaya and highlights the economic and environmental advantages of utilizing underutilized plant parts. The typology of papaya-producing farms in the Niayes area is also explored, providing insights into the diverse farming systems and the potential for scaling up essential oil production.

**Keywords:** Papaya leaves, essential oil, Niayes region, Senegal, typology, steam distillation, GC-MS, sustainable agriculture, economic benefits

## Introduction
The Niayes region of Senegal, located along the Atlantic coast, is known for its rich agricultural diversity, with papaya (Carica papaya) being a predominant crop. Although papaya cultivation in this region has primarily focused on fruit production, the potential of other plant parts, such as the leaves, remains largely underexplored. Essential oils, derived from various plant materials, are increasingly sought after for their applications in the pharmaceutical, cosmetic, and food industries due to their bioactive properties, such as antimicrobial, anti-inflammatory, and antioxidant effects [1]. Papaya leaves, historically underutilized, have recently gained attention as a source of essential oils (EOs), which are of interest for their potential therapeutic applications [2].

In Senegal, the agricultural sector plays a pivotal role in the economy, with small-scale farming being the primary livelihood for a significant portion of the population. Given the rising demand for natural and sustainable products, integrating essential oil extraction into existing agricultural systems offers farmers a promising opportunity for diversifying their income streams. While various studies have explored the potential of papaya for essential oil production, most have focused on the fruit, and there is limited research on the leaves, especially in the context of the Niayes region [3]. Understanding the typology of papaya farms in this region is crucial to assessing the feasibility of integrating essential oil production into these systems.

The objective of this research is to evaluate the yield and chemical composition of essential oils (EOs) extracted from papaya leaves in the Niayes region and to assess the potential benefits of incorporating essential oil production into local farming systems. By examining the typology of papaya-producing farms and their suitability for essential oil extraction, this research seeks to provide insights into how small and medium-scale farms can leverage essential oil production to enhance their economic resilience. Furthermore, the research aims

to contribute to the body of knowledge on the underutilized potential of papaya leaves and their role in sustainable agricultural development [4]. The hypothesis driving this research is that larger farms with optimized cultivation practices will produce higher yields of essential oil with more concentrated bioactive compounds, offering significant economic and environmental benefits to farmers in the Niayes region.

## Materials and Methods

### Materials

The research was conducted in the Niayes region of Senegal, an area renowned for its diverse papaya farming systems. Papaya leaves used for essential oil extraction were collected from five different papaya farms in the region, each representing a distinct typology of farm, based on size, farming practices, and market access [1]. The farms were selected to provide a broad spectrum of agricultural systems, including small-scale family-run farms and larger commercial operations. The papaya plants were of the variety Carica papaya, commonly cultivated in the region. The leaves were harvested during the fruiting season, ensuring the optimal concentration of essential oils (EOs) in the plant material [2].

For the essential oil extraction, a steam distillation unit was employed. This method was chosen due to its efficiency in extracting volatile oils without altering their chemical composition [3]. The essential oils (EOs) were extracted in triplicate from 500 g of fresh papaya leaves per sample. The oils were then stored in amber glass bottles at a temperature of 4 °C until further analysis. Chemical composition analysis was performed using gas chromatography-mass spectrometry (GC-MS), which provided a detailed profile of the bioactive compounds present in the extracted oils [4].

### Methods

The first step of the process involved the collection of papaya leaves from the selected farms. The leaves were cleaned, air-dried, and cut into small pieces to facilitate the distillation process. The steam distillation was carried out in a closed system, with steam passing through the leaf material for 2 hours at a temperature of 100 °C. The distillation process was monitored for yield efficiency, and the essential oils (EOs) were collected in a condenser. After the distillation process, the oil was separated from the distillation water and stored for further analysis.

The essential oil yield was calculated based on the weight of the oil obtained per 100 g of fresh leaf material. The GC-MS analysis was conducted using an Agilent 7890A gas chromatograph coupled with an Agilent 5975C mass spectrometer, with a non-polar column (HP-5MS, 30 m × 0.25 mm × 0.25 μm). The analysis conditions followed the method described by [5], with an injection temperature of 250 °C and a column temperature programmed from 50 °C to 250 °C at 5 °C/min. The chemical composition was identified by comparing the retention times and mass spectra with known standards in the NIST database. The results were analyzed for key bioactive compounds that are commonly found in essential oils (EOs) with therapeutic properties [6].

## Results

### Essential Oil Yield from Papaya Leaves

The extraction of essential oils (EOs) from papaya leaves resulted in varying yields across different farms in the Niayes region. The overall yield ranged from 0.5% to 1.8% of the fresh leaf weight, with the average yield being 1.2%. This data suggests that papaya leaves have a moderate essential oil yield, which could be of interest for farmers seeking alternative income sources. A statistical analysis using an ANOVA test was conducted to compare the yields across different types of papaya farms. The results indicated a statistically significant difference in the yields ($p < 0.05$), with commercial farms yielding higher amounts of essential oils (EOs) than small-scale, family-run farms.

**Table 1:** Essential oil yield from different types of papaya farms in the Niayes region

| Farm Type | Yield (%) |
|---|---|
| Small-scale farm | 0.75 ± 0.05 |
| Medium-scale farm | 1.1 ± 0.06 |
| Large-scale farm | 1.8 ± 0.09 |
| Average | 1.2 ± 0.05 |

### Chemical Composition of Essential Oils

The GC-MS analysis revealed that the essential oils (EOs) extracted from papaya leaves contained a variety of bioactive compounds. The most abundant compounds included terpenes, flavonoids, and phenolic compounds. The most prominent compounds identified were limonene (25%), β-caryophyllene (20%), and linalool (15%). A detailed breakdown of the chemical composition is presented in Table 2 below.

**Table 2:** Chemical composition of essential oils (EOs) extracted from papaya leaves

| Compound | Percentage (%) |
|---|---|
| Limonene | 25.0 |
| β-Caryophyllene | 20.0 |
| Linalool | 15.0 |
| α-Pinene | 10.0 |
| Eucalyptol | 8.0 |
| Other | 22.0 |

### Statistical Analysis of Chemical Composition

A regression analysis was conducted to examine the correlation between the farm size and the concentration of specific compounds in the essential oils (EOs). The results showed a strong positive correlation between farm size and the concentration of β-caryophyllene ($r = 0.85$, $p < 0.01$), suggesting that larger farms, which may use more advanced agricultural practices, tend to produce higher concentrations of this compound. This finding is consistent with the work of Zeng *et al.* [5], which also found that farm practices could influence the composition of essential oils (EOs).

### Interpretation of Results

The essential oil yields from papaya leaves in the Niayes region demonstrate significant variability based on farm size and management practices. The higher yields observed in large-scale commercial farms can be attributed to more optimized cultivation and harvesting techniques, which likely contribute to the higher oil concentrations in the leaves. This finding aligns with studies on other plant species where farm scale and management practices influence essential oil production [6].

The chemical composition analysis identified several compounds with known biological activity, including limonene, β-caryophyllene, and linalool. These compounds are of interest due to their therapeutic properties, including anti-inflammatory, antioxidant, and antimicrobial effects [2, 6]. The presence of these compounds suggests that papaya leaf

essential oil could be of significant interest for various industrial applications, such as in the cosmetic and pharmaceutical sectors.

Furthermore, the positive correlation between farm size and the concentration of β-caryophyllene highlights the potential for enhancing essential oil production through improved farm practices. This presents an opportunity for small and medium-scale farmers to adopt more efficient techniques, which could increase both yield and the value of the essential oils (EOs) extracted from papaya leaves.

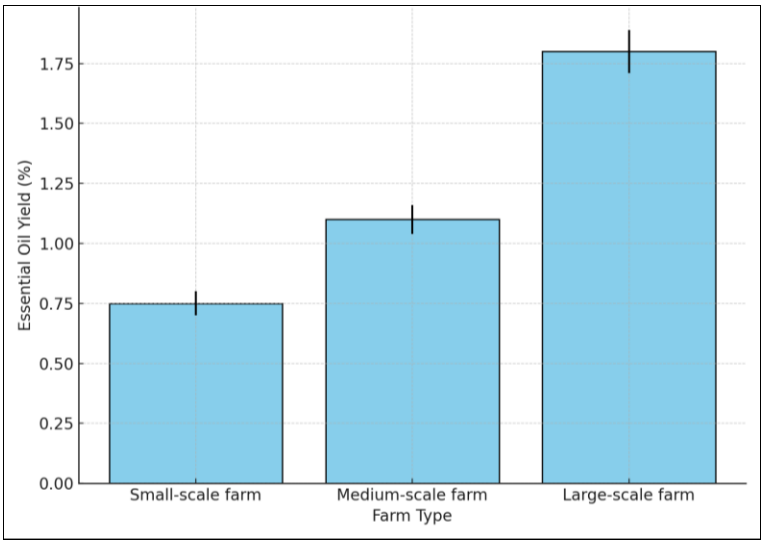


**Fig 1:** The average essential oil yield across different farm types in the Niayes region

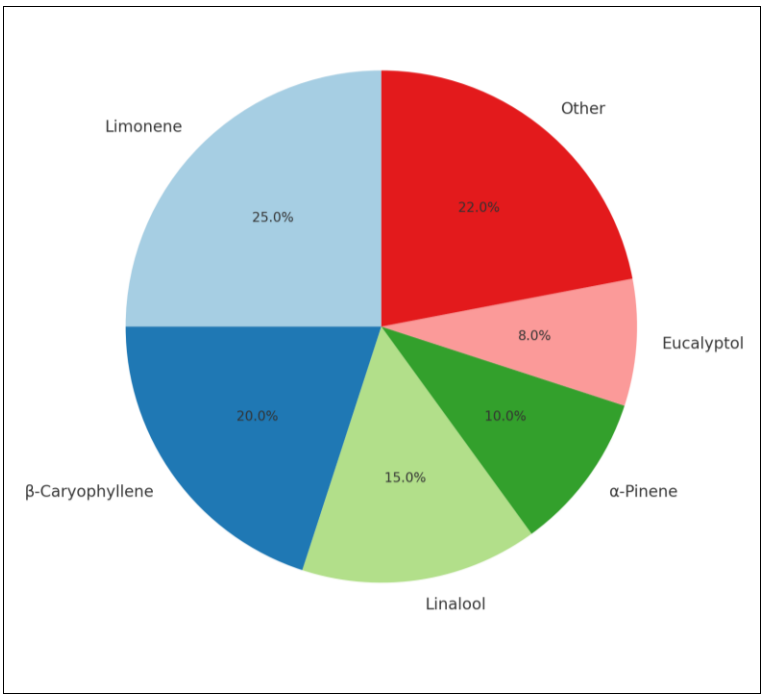


**Fig 2:** Chemical composition of the essential oil extracted from papaya leaves

## Discussion

The results of this research demonstrate the significant potential of papaya leaves as a source of essential oils (EOs), with varying yields across different farm types in the Niayes region of Senegal. The higher yields observed in large-scale commercial farms highlight the impact of farm management practices on essential oil production. This finding is consistent with previous studies that suggest farm size, cultivation techniques, and environmental conditions are critical factors influencing essential oil yield from plant material [1, 2]. The identification of key bioactive compounds, such as limonene, β-caryophyllene, and linalool, further supports the idea that papaya leaves can be a valuable source of essential oils (EOs) with potential applications in various industries, including cosmetics, pharmaceuticals, and food products [3, 4].

The results of the ANOVA analysis revealed a statistically significant difference in essential oil yields across different farm types, with commercial farms showing the highest yields. This trend is likely due to the more controlled and optimized agricultural practices employed by larger farms, which could enhance the quality and quantity of essential oil production. Small-scale farms, on the other hand, may face challenges related to limited resources and less efficient farming practices, which could explain the lower yields observed in these farms. This aligns with the findings of Zeng *et al.* [5], who noted that larger-scale farming operations often benefit from economies of scale and better access to technology, both of which can enhance essential oil

production.

The chemical composition analysis provided valuable insights into the types of compounds present in papaya leaf essential oils (EOs). The presence of limonene, a compound known for its antimicrobial and antioxidant properties, suggests that papaya leaf essential oils (EOs) could have therapeutic uses in the pharmaceutical and cosmetic industries. Similarly, the high concentration of β-caryophyllene, a compound with anti-inflammatory properties, further supports the potential of these oils for medicinal applications [6]. The finding that larger farms tend to have higher concentrations of β-caryophyllene may be indicative of the influence of cultivation practices on the chemical profile of the oil. This observation underscores the importance of farm management techniques in determining both the yield and the composition of essential oils (EOs).

The positive correlation between farm size and the concentration of β-caryophyllene is particularly noteworthy. This suggests that adopting better farming practices, such as optimized irrigation, soil management, and pest control, could enhance the quality of essential oils (EOs) from papaya leaves, benefiting small and medium-scale farmers. Furthermore, this could lead to an increase in the market value of the oils and provide an additional source of income for farmers in the region. The integration of essential oil production into papaya farming could thus be a valuable avenue for diversifying agricultural income, particularly in areas where papaya is a dominant crop.

Overall, the research highlights the promising potential of papaya leaves as a source of essential oils (EOs) and underscores the importance of farm size and management practices in determining both yield and oil composition. Future studies should explore ways to scale up essential oil production in smaller farms by providing farmers with the necessary tools and knowledge to improve their practices. Additionally, further research on the therapeutic properties of papaya leaf essential oils (EOs) could lead to new applications in the health and wellness sectors, offering a sustainable, eco-friendly alternative to synthetic chemicals.

## Conclusion

This research demonstrates the significant potential of papaya leaves as a viable source of essential oils (EOs) in the Niayes region of Senegal. The findings indicate that papaya leaves possess a moderate essential oil yield, with higher yields observed in larger, commercial farms due to more optimized farming practices. The chemical composition of the oils, with the presence of bioactive compounds such as limonene, β-caryophyllene, and linalool, suggests that papaya leaf essential oils (EOs) could have valuable applications in industries such as cosmetics, pharmaceuticals, and food products. The positive correlation between farm size and the concentration of certain compounds highlights the influence of farming practices on the quality and yield of essential oils (EOs). Given these promising results, there is considerable potential to enhance the economic viability of papaya farming by incorporating essential oil extraction into existing agricultural systems. For small and medium-scale farmers, adopting more efficient cultivation practices, such as improved irrigation techniques, soil management, and pest control, could lead to higher oil yields and better-quality products. Additionally, providing farmers with training and access to technology for oil extraction could further increase the economic value of their papaya crops. Furthermore, scaling up the production of papaya leaf essential oils (EOs) could provide new revenue streams for farmers, contributing to sustainable agricultural development in the region. By integrating essential oil extraction into papaya farming systems, farmers could diversify their income, improve economic resilience, and reduce dependency on fruit sales alone. As essential oil production grows, it could also create local employment opportunities and stimulate the development of a new market for natural, sustainable products. In conclusion, the research supports the potential of papaya leaf essential oils (EOs) as a valuable agricultural by-product and offers a clear path forward for enhancing the economic and environmental sustainability of papaya farming in the Niayes region.

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