Development and characterization of basil oil-encapsulated nanocarriers as antibacterial and antioxidant agents

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Abstract

Basil oil is widely used in food and medical industries due to its antibacterial and antioxidant properties. However, the use of pure basil oil is limited by its low stability and high volatility. The development of nanoencapsulation systems is to enhance its stability and control the release of active ingredients. This study aimed to develop and characterize basil oil-encapsulated nanocarriers and study their abilities to inhibit bacterial growth and scavenge free radicals. Four nanocarrier formulations containing 0%, 0.5%, 1%, and 2% of basil essential oil were prepared. The stability of the prepared nanoparticles was then tested and the developed nanocarriers were stable for 2 weeks. The nanocarrier containing 2% basil oil was then selected as the finest condition. Using dynamic light scattering (DLS) analysis, the 2% basil essential oil formulation exhibited a particle size of 128.8±2.75 nm, a polydispersity index (PI) of 0.213±0.05, and a zeta potential of -79.17±0.61 mV. The antibacterial assays, including disk diffusion and agar dilution methods, demonstrated that the developed nanocarriers were not able to inhibit the growth of *E. coli* and *S. aureus* when compared with pure basil oil and gentamicin. The antioxidant properties of the nanocarriers were studied using DPPH and ABTS assays. The 2% basil essential oil formulation did not show antioxidant activity, while 100% pure basil oil had antioxidant activity. The IC50 values obtained from the DPPH and ABTS assays were 11.64 ±0.03% and 1.26 ±0.05%, respectively. However, further studies on the optimal concentration of basil oil encapsulated in the nanocarriers are needed to enhance the efficacy when used as antibacterial and antioxidant agents. The findings of this research are anticipated to become an initial platform for the development of efficient nanocarrier systems for encapsulating and releasing active compounds, with applications in cosmetics, food, and medical industries, thereby enhancing the value and efficacy of natural product-based formulations.

Introduction

Basil oil, derived from *Ocimum basilicum*, has gained attention in the food and medical industries. Estragole and linalool are active components of *Ocimum basilicum* that contribute to both its antibacterial and antioxidant properties. Basil oil exhibits high antibacterial activity against Gram-positive bacteria due to estragole and linalool. Basil oils containing methyl chavicol and linalool exhibit strong radical scavenging activity. However, these bioactive compounds are sensitive to environmental conditions. To address this, Nanostructured Lipid Carriers (NLCs) which can encapsulate both hydrophilic and lipophilic drugs can be used to encapsulate water-insoluble active ingredients. They are highly biocompatible and improved stability, controlled release, and enhanced bioavailability of the active ingredients making them ideal for encapsulating basil oil.

Figure 1 Picture of *Ocimum basilicum*

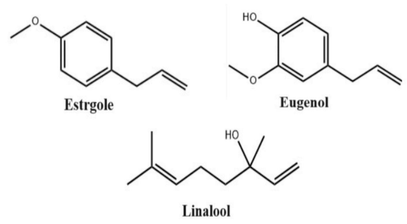
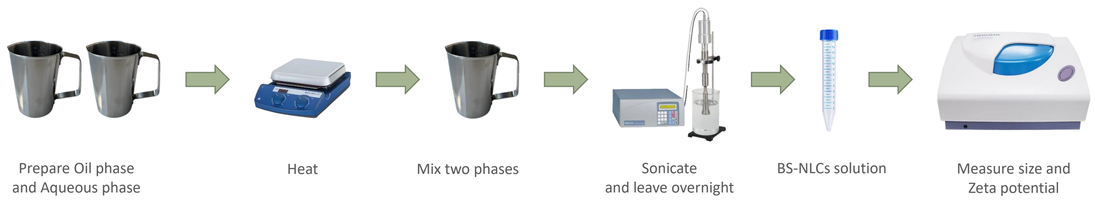


Figure 2 Chemical structures of the main biological active components of *Ocimum basilicum*

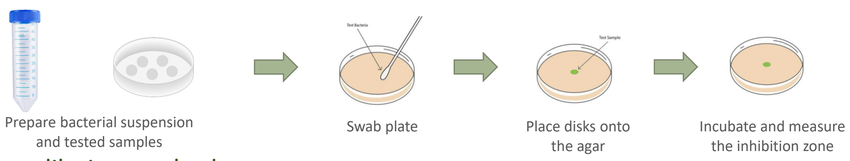
Methodology

Preparation and characterization of BS-NLCs

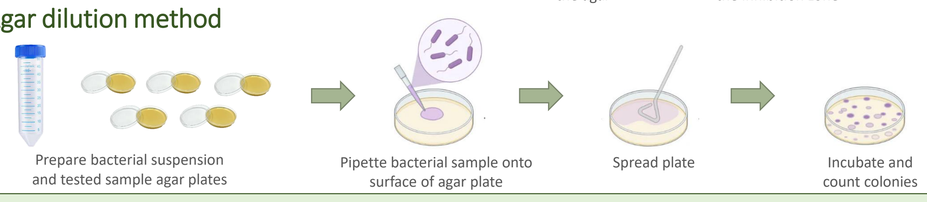


Antibacterial activity test

Disk diffusion method

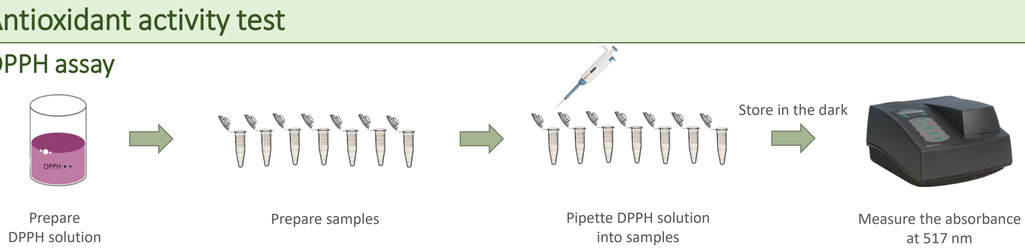


Agar dilution method

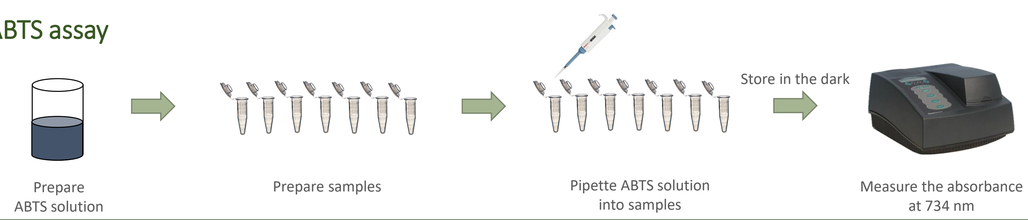


Antioxidant activity test

DPPH assay



ABTS assay



Results & Discussion

Preparation and Characterization of BS-NLCs

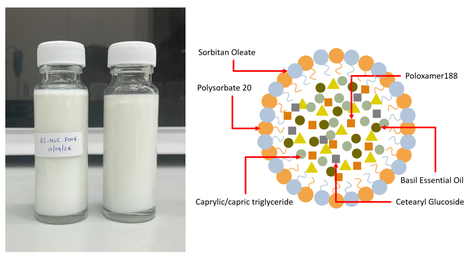


Figure 3 Structure of basil oil encapsulated nanostructured lipid carriers

Table 1 Particle size PI and zeta potential of BS-NLCs

Sample	Particle size (nm)	PI	Zeta potential (mV)
0% BS-NLCs	144.9 ±4.63	0.372 ±0.03	-58.97 ±0.87
0.5% BS-NLCs	143.6 ±2.33	0.253 ±0.02	-72.80 ±2.12
1% BS-NLCs	141.3 ±4.33	0.179 ±0.06	-76.90 ±1.45
2% BS-NLCs	128.8 ±2.75	0.213 ±0.05	-79.17 ±0.61

The particle sizes at different basil oil concentrations ranged from 120 to 140 nm, and the PI was approximately 0.1–0.3. These indicated a low degree of dispersion and high uniformity in particle distribution.

All formulations exhibited zeta potential values lower than -30 mV, indicating a high degree of stability.

Antibacterial Activity of 2% BS-NLCs

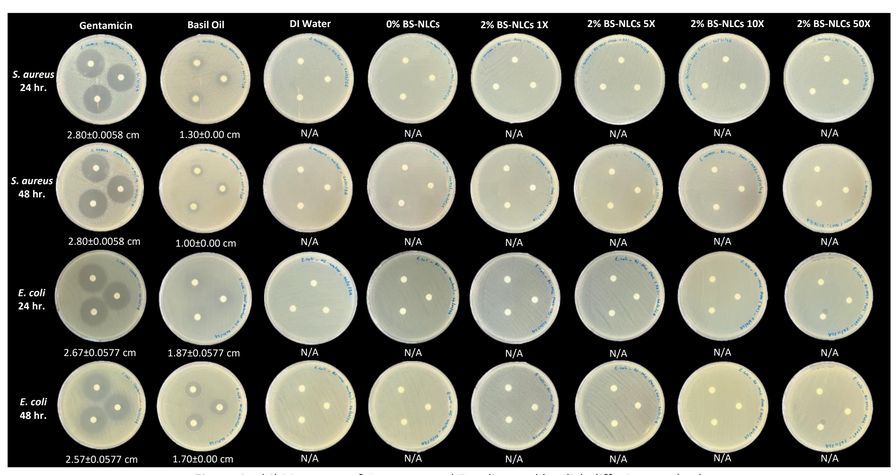


Figure 4 Inhibition zone of *S. aureus and E. coli* tested by disk diffusion method

The test sample exhibited no observable inhibition zone, in contrast to gentamycin and the basil oil, which demonstrated clear antimicrobial activity.

The 2% BS-NLCs exhibited no antibacterial activity due to the ineffective release of oil from the particle formulation. Additionally, insufficient concentration of active compound in basil oil encapsulated in NLCs possibly made the NLCs ineffective in inhibiting the growth of bacteria.

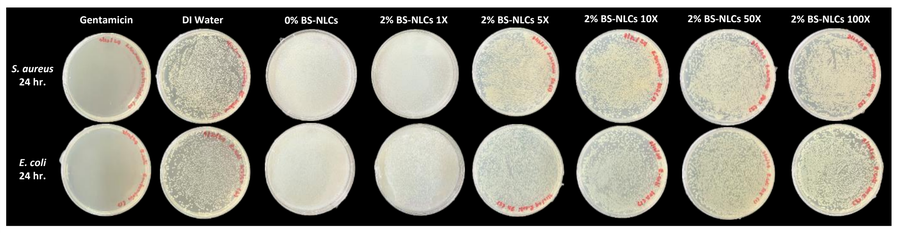


Figure 5 Colonies of *S. aureus* and *E. coli* at 24 hours tested by agar dilution method

The gentamicin plate exhibited a completely clear. In contrast, other plates showed visible bacterial colonies.

Antioxidant Activity of 2% BS-NLCs

Table 2 IC50 Values of Samples in DPPH and ABTS Assays

Sample	IC50	
	DPPH assay	ABTS assay
Trolox	24.15 ±2.54 µg/mL	18.38 ±0.36 µg/mL
Basil oil	11.64 ±0.03 %	1.26 ±0.05 %
0% BS-NLCs	N/A	N/A
2% BS-NLCs	N/A	N/A

In the DPPH assay, the pure basil oil exhibited antioxidant properties with an IC50 value of 11.64%. In contrast, the 2% BSEO formulation demonstrated minimal antioxidant activity, making its IC50 value indeterminable. Similarly, in the ABTS assay, pure BSEO showed an IC50 value of 1.26%, whereas the 2% BSEO formulation did not exhibit detectable antioxidant activity.

Conclusions

- The optimized 2% BS-NLCs formulation had the smallest particle size (128.8 nm), PI (0.213 ±0.05) and a stable zeta potential (-83.2 mV).
- The developed carriers did not inhibit the growth of *S. aureus* and *E. coli* when compared with gentamicin and pure basil oils.
- This formula did not exhibit antioxidant properties.

References

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