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A Research on Nanoemulsion of Ginger Grass Oil (Cymbopogon Martini).

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ABSTRACT: Ginger grass oil, derived from Cymbopogon martinii, is known for its therapeutic properties, including antimicrobial, antioxidant, and anti-inflammatory effects. However, its application is often limited due to poor solubility, volatility, and bioavailability. Nanoemulsion technology offers a promising approach to enhance the stability and efficacy of ginger grass oil by reducing droplet size and improving dispersion in aqueous systems.

This study focuses on the formulation and characterization of ginger grass oil nanoemulsions using high-energy emulsification techniques and biocompatible surfactants. The nanoemulsions were evaluated for particle size, polydispersity index (PDI), zeta potential, and stability under various storage conditions. Preliminary results indicate that optimized formulations exhibit enhanced solubility, prolonged stability, and improved bioavailability, making them suitable for pharmaceutical and cosmetic applications. The findings suggest that nanoemulsions of ginger grass oil could serve as an effective delivery system for therapeutic and industrial purposes.

Nanoemulsions are advanced delivery systems that enhance the stability and bioavailability of essential oils. Ginger grass oil, known for its antimicrobial and antioxidant properties, can benefit from nanoemulsion formulations to improve its therapeutic efficacy. These formulations exhibit improved droplet size distribution, stability, and enhanced biological activity, including antiproliferative effects in cancer models.

Nanoemulsions of ginger grass oil are formulated using surfactants like Tween 80 and ethanol as cosurfactants, employing techniques such as high-pressure homogenization and phase inversion composition. These methods help achieve stable formulations with improved droplet size distribution and enhanced biological activity.

KEYWORDS: Antimicrobial, Antioxidant, Anti-inflammatory, Nanoemulsion, zeta potential.

I. INTRODUCTION

Ginger grass oil is an fundamental oil , Fundamental oils are normal compounds containing a blend of nonvolatile and unstable compounds delivered by fragrant plants.

The advancement of ginger grass oil nanoemulsions is established in broader headways in nanotechnology and emulsion science. Whereas a unmistakable, disconnected "history" is restricted, the application of nanoemulsion methods to basic oils like ginger grass oil has advanced essentially. Early investigate centered on moving forward basic oil solidness and bioavailability. Strategies like high-pressure homogenization and microfluidization got to be imperative for making steady nano-sized beads. Thinks about have investigated improving ginger oil's restorative impacts through nanoemulsions, with applications in pharmaceuticals, makeup, and nourishment. Continuous investigate points to optimize definitions and grow their applications, leveraging nanotechnology to maximize ginger grass oil's potential.

Ginger is a broadly developed nourishment and therapeutic trim in numerous parts of the world. It is among the most broadly utilized flavors all inclusive . It was to begin with developed in Ethiopia in the 1200s and proceeds to be developed in spite of challenges of moo quality, decreased financial yield and destitute taking care of by ranchers and venders .In spite of the fact that with comparable wellbeing benefits as new ginger, ginger fundamental oil is said to be the most strong portion

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of ginger . The fundamental oil of ginger is the yellowish or green coloured unstable oil extricated from ginger rhizomes, which is around 1–3% of a rhizome. It may be gotten from new ginger rhizome, dried rhizomes or ginger peel, with oil from the new ginger detailed to be of superior scent than that from dried ginger . .As it is known with flavors, ginger oil is for the most part respected as secure [GRAS]. It is known as the oil of strengthening since it gives the client a feeling of self-assurance and courage Ginger grass oil nanoemulsions upgrade the oil's application by making little beads, boosting steadiness and retention. .This innovation progresses conveyance in pharmaceuticals, makeup, nourishment, and agribusiness. Nanoemulsions increment water dissolvability and ensure the oil's properties, permitting for controlled discharge and more prominent effectiveness.

Ginger grass oil nanoemulsions speak to a combination of conventional botanical benefits with cutting-edge nanotechnology. These nanoemulsions are made by scattering ginger grass oil into another fluid, shaping fantastically little beads, regularly extending from 20 to 200 nanometers. This handle altogether increments the oil's surface zone, driving to improved solvency, steadiness, and bioavailability.

Nanoemulsions have one of a kind characteristics due to their nanometric measure, which incorporate expanded contact surface range and expanded physicochemical solidness. Meat frameworks have a complex chemical composition that can associated with the compounds show in EO and decrease their bioactivity. The fundamental oil nanoemulsified is a preservation elective to immaculate oil, with the capacity to progress the interaction with particular targets in meat and apply antimicrobial and antioxidant movement. This paper summarizes the basic characteristics of nanoemulsions and presents the primary propels in the application of basic oil nanoemulsified in meat and meat items for preservation.

The oil itself, inferred from the Cymbopogon martini plant, has important antimicrobial, anti-inflammatory, and antioxidant properties. In any case, its hydrophobic nature limits its coordinate utilize in numerous applications. Nanoemulsification overcomes these confinements by typifying the oil inside a steady, water-miscible system.

This innovation permits for made strides conveyance of ginger grass oil in different segments, counting pharmaceuticals, where it can improve sedate conveyance; makeup, for moved forward skin infiltration; nourishment, as a common additive; and farming, as a biopesticide. Present day methods like high-pressure homogenization and microfluidization are fundamental for accomplishing the required nano-scale bead measure, guaranteeing the nanoemulsion's soundness and adequacy. Progressing inquire about centers on optimizing definitions and investigating unused applications, maximizing the potential of ginger grass oil.

The guideline strategy for extraction of ginger grass oil is steam distillation.

This strategy depends on the rule that the fundamental oil in the plant fabric will vaporize when warmed with steam .The vaporized oil and steam are at that point cooled and condensed, permitting the oil to be isolated from the water.

ginger grass oil

Methods of preparation
1] High energy approaches
a) High-pressure homogenization
b) Ultrasonication
c) Microfluidization

2] Low energy method
a) Phase inversion emulsification method
b) spontaneous emulsification method
c) Membrane Emulsification process

Ginger grass oil
Botanical Title - Cymbopogon Martinii (sofia).
Family – Zingiberaceae
Genus – Cymbopogon
Species – Martini
Common Title -gingergrass, Rusa grass, Palmarosa
Part Utilized – Grass
Colour of oil- pale yellow in colour with new citrus odour

Chemical composition of ginger grass oil
The chemical composition of ginger grass oil primarily includes monoterpenes and

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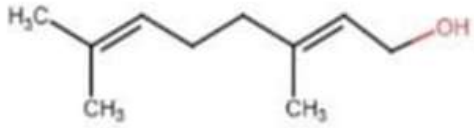
sesquiterpenes. Key constituents are geraniol, linalool, citronellol, and borneol. These compounds contribute to its characteristic aroma and therapeutic properties.

Ginger grass oil is rich in bioactive compounds that define its aroma, therapeutic potential, and industrial applications. The composition consists primarily of monoterpenes and sesquiterpenes, which contribute to its medicinal properties.

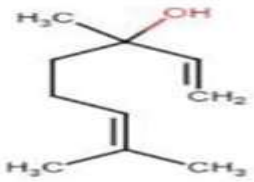
1. Major Constituents

i. Geraniol – A dominant component responsible for its sweet, floral scent. Known for its antimicrobial and antioxidant properties, geraniol is widely used in aromatherapy and skincare formulations. Geraniol is the backbone of ginger grass oil's aroma and therapeutic value. Its antimicrobial properties make it particularly useful in skincare products, helping to combat bacteria and fungi, while its antioxidant effects contribute to cell protection and anti-aging benefits.



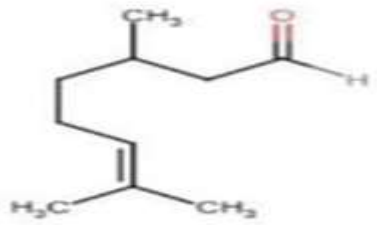
Geraniol

ii. Linalool –A terpene alcohol with a floral, lavender like scent, it posses calming, anti-anxiety and anti-inflammatory properties.



Linalool

iii. Citronellol – Offers mosquito-repelling properties, contributing to ginger grass oil's use in natural insect repellents. It also possesses antiseptic qualities.



Citronellol

iv. Borneol – Recognized for its analgesic and circulatory-stimulating effects, borneol is an important compound in traditional medicine.

2.Supporting and Minor Constituents

i. Farnesol – Provides additional antimicrobial benefits and contributes to the oil's smooth fragrance profile.
ii. β-Caryophyllene – A sesquiterpene with anti-inflammatory and pain-relieving properties.
iii. Elemol and Eugenol – Known for their antioxidant capabilities and role in fragrance stability.

The chemical composition of ginger grass oil consists mainly of geraniol (approximately 70-80%), with other significant constituents including neral, geranyl acetate, β-caryophyllene, and farnesol. These compounds contribute to the characteristic aroma and therapeutic properties of the oil.

Ginger grass oil possesses a fresh, slightly earthy, and citrus-like fragrance. It is commonly used in the fragrance industry as a middle note in perfumes, soaps, and cosmetics due to its unique scent profile. Its aroma is also utilized in aromatherapy to promote relaxation and balance emotions.

In addition to its aromatic properties, ginger grass oil has various therapeutic benefits. It is known for its analgesic, antispasmodic, anti-inflammatory, and antibacterial properties. This makes it suitable for alleviating muscle and joint pain, reducing muscle spasms, relieving inflammation, and combating bacterial infections.

Preformulation studies

Preformulation studies are a set of experiments that focus on understanding the physicochemical properties of a drug candidate and excipients that could affect the drug performance and the development of a dosage form . Preformulation studies can accurately predict the difficulties that will be encountered when

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combining the active pharmaceutical ingredient (API) with suitable excipients that will deliver a therapeutic agent to a patient in a safe, predictable and efficient manner . To design and evaluate the final dosage form, knowledge of physicochemical properties can be used to improve drug solubility, dissolution, permeability, and stability, as well as to choose suitable excipients and processing conditions.

Nanoemulsions are thermodynamically stable colloidal dispersion systems made up of two immiscible liquids combined with emulsifying agents (surfactants and co-surfactants) to produce a single phase. There has been a significant amount of research conducted on nanoemulsions as modes of drug delivery . Nanoemulsions have globule diameters typically in the range of 20–600 nm though some scientific literature has proposed an upper limit for particle size in the range of 300–1,000 nm . These systems appear optically clear and exhibit improved stability against droplet flocculation and coalescence. In addition, nanoemulsions demonstrate the potential for efficient oral, parenteral, ophthalmic, and topical systemic distribution of active compounds, such as food ingredients and lipophilic drugs.

1)Drug-excipient compatibility studies

Drug-excipient compatibility studies in nanoemulsions are crucial for ensuring the stability and effectiveness of the final formulation. These studies aim to identify potential interactions between the drug and excipients, which could lead to instability, reduced drug solubility, or altered drug release. Techniques like FTIR spectroscopy and DSC are used to assess compatibility. Nanoemulsions have been described as excellent carriers for lipophilic bioactive compounds with enhanced properties compared to conventional emulsions. Typically, nanoemulsions are defined as oil-in-water emulsions with a very small droplet size (r < 100 nm).

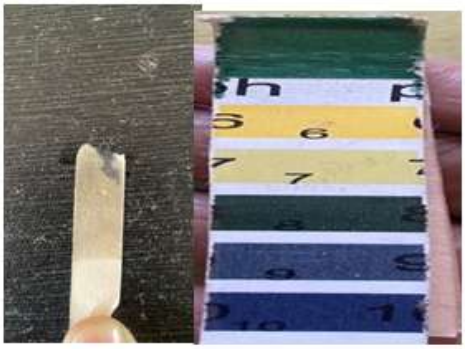
2)Density of ginger grass oil

The density of gingergrass essential oil, specifically Cymbopogon martinii var. sofia, typically falls within a range of 0.895 to 0.953 g/cm³ at 25°C.

Density of oil

3)PH of ginger grass oil

The PH of ginger grass oil is 7 i.e neutral . the ginger grass oil is neutral in nature.



PH of oil

4)Solubility study of ginger grass oil

Two important factors in the entire development process are drug solubility and bioavailability. Drug solubility is an important parameter for both oral and intravenous administration. Measurement of drug solubility in various solvents is one of the key elements of compound characterization during the whole discovery and development process.

A) Ethanol – highly soluble
B) Hexane - highly soluble
C) Diethyl ether – moderately soluble
D) Propylene glycol – moderate to highly soluble
E) Vegetable oil (olive oil and coconut oil) – highly soluble

5)Viscosity of oil

viscosity is one of an oil's most important physical properties. The Ostwald viscometer, with its simple design and operation, offers a reliable method for this measurement.

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6)Refractive index:

The refractive index of a material is one of the most important optical parameters. In this review article we have discussed different methods and techniques for the measurement of refractive indices of various materials. We have considered the literature of the past two decades from 1980 to 2001 and have shown how the techniques have been developed and improved for the measurement of refractive indices.

It is generally in the range of 1.4760 to 1.4940 at 20°C.

Materials and preparation

Sr No	Ingredients	Catogery	Uses
1	Ginger grass oil	Essential oil	Anti-oxidant
2	Tween 80	Surfactant	creation of stable, small droplets
3	saline water	solvent	To form stable o/w emulsion
4	methyl paraben	preservative	Prevent form contamination

Preparation:

Essential oil and tween 80 were mixed by magnetic stirrer for 30 min at 500 rpm and then the mixed oil phase (tween 80 and ginger grass essential oil) was added slowly to the aqueous phase while mixing by magnetic stirrer for 30 min at 700 rpm (25°C ± 3°C). Then, the produced premixed emulsions were transferred to the water bath ultrasonic with 100 w powers and 40 kHz frequency for 15 min (30°C ± 5°C). The ratio of surfactant-to-oil was fixed for all of the nano emulsions (1:1), while the aqueous phase content was varied (50, 70, 80, and 90%).

It is well known that CEOs have antioxidant capabilities due to their chemical composition. Their high terpene (limonene, linalool, b-pinene) content gives them antioxidant potential. Naringenin is a citrus flavanone (preponderantly found in grapefruits) which possesses antioxidant activity, having the capacity to chelate metals, scavenge oxygen free radicals and prevent oxidation of low-density lipoproteins. Carotenoids are natural pigments that exhibit important antioxidant activities, bringing benefits such as: blocking the action of free radicals on cells, preventing cancer and aging.

The use of NEs as functional systems is a good opportunity.

Evaluation parameters of Nanoemulsion

1.Determination of PH : weighed 10 ml of nano emulsion is transferred into beaker and measured it by using the digital PH met3er .the PH of the formulation is 4.5 – 5

PH of Nanoemulsion

2.particle size;To observe the particle size, the dynamic light diffusion (DLS)
Instrument [horiba scientific instrument]

3.Determination of viscosity:

Procedure:

a) Clean and dry the Ostwald viscometer thoroughly.
b) Introduce a known volume of the liquid whose viscosity you want to measure into the wider arm of the viscometer. Use a pipette to ensure accuracy, filling it up to the mark above the upper bulb.
c) Suction the liquid carefully using a rubber bulb attached to the narrower arm until the liquid level rises above the upper etched mark in the upper bulb.
d) Remove the suction and allow the liquid to flow down under gravity.
e) Start a stopwatch as the meniscus of the liquid passes the upper etched mark.
f) Stop the stopwatch when the meniscus passes the lower etched mark.
g) Record the flow time in seconds.
h) Repeat the measurement at least three times to get an average flow time for the unknown liquid.

Repeat the entire procedure using a reference liquid (usually distilled water) with a known viscosity.

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Viscosity of Nanoemulsion

4.Density of nanoemulsion

a) To determine nanoemulsion density using a density bottle,
b) first weigh the clean, dry bottle with its stopper (m_1).
c) Then, carefully fill the bottle with the nanoemulsion, ensuring no air bubbles, and weigh it again (m_2).
d) The density (\rho) is calculated by dividing this mass by the calibrated volume (V) of the density bottle: \rho = (m_2 - m_1) / V.

Density of Nanoemulsion

5.Partical size of nano emulsion

The particle size of nano emulsion should be in standard range of 10-200nm.

6.Zita potential of nano emulsion

Zita potential of nano emulsion ranging from -12.33 ± 1.01 mV to -39.33 ± 0.96 mV.

7.Antimicrobial activity:

Nano emulsion of Ginger Grass oil shows strong antimicrobial activity, especially against gram-positive bacteria and fungi, due to enhanced bioavailability.

Microbial test

ADVANTAGES OF NANOEMULSION OF GINGER GRASS OIL

1) Enhanced Solubility:

Ginger grass oil, like many essential oils, is hydrophobic (water-repelling). Nanoemulsions increase its water solubility, allowing for easier incorporation into water-based products.

2) Improved Stability:

Nanoemulsions protect the oil from degradation caused by factors like oxidation and light, extending its shelf life.

3) Increased Bioavailability:

The small droplet size of nanoemulsions increases the surface area of the oil, leading to better absorption and enhanced delivery of its active compounds.

4) Controlled Release:

Nanoemulsions can facilitate controlled release of the oil, allowing for sustained and targeted delivery.

5) Enhanced Penetration:

The nanoscale size of the droplets allows for better penetration into skin or other tissues, increasing the oil's effectiveness in topical applications.

6) Improved Product Formulation:

Nanoemulsions allows for the creation of more visually appealing, and texturally pleasing products.

7) Increased Antimicrobial Effects:

By increasing the bioavailability, the antimicrobial effects of the ginger grass oil can be increased.

DISADVANTAGES OF NANOEMULSION OF GINGER GRASS OIL

1) Stability Issues

Nanoemulsions can be prone to **phase separation** over time, especially if the surfactant concentration is not optimized.

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2) High Energy Requirement

The preparation process often requires **ultrasonication or high-pressure homogenization**, which can be costly and energy-intensive.

3) Limited Shelf Life

Due to their **small droplet size**, nanoemulsions may degrade faster than conventional emulsions, affecting their efficacy.

4) Potential Toxicity

Some surfactants and co-surfactants used in nanoemulsion formulations may pose **toxicity risks**, particularly in pharmaceutical applications.

5) Encapsulation Challenges

Hydrophobic compounds may not always be efficiently encapsulated, leading to **reduced therapeutic effectiveness**.

Result:

1) PH Determination : "The pH of the nano emulsion formulated with Ginger Grass oil was found to be in the range of 5 indicating a mildly acidic nature suitable for topical applications."

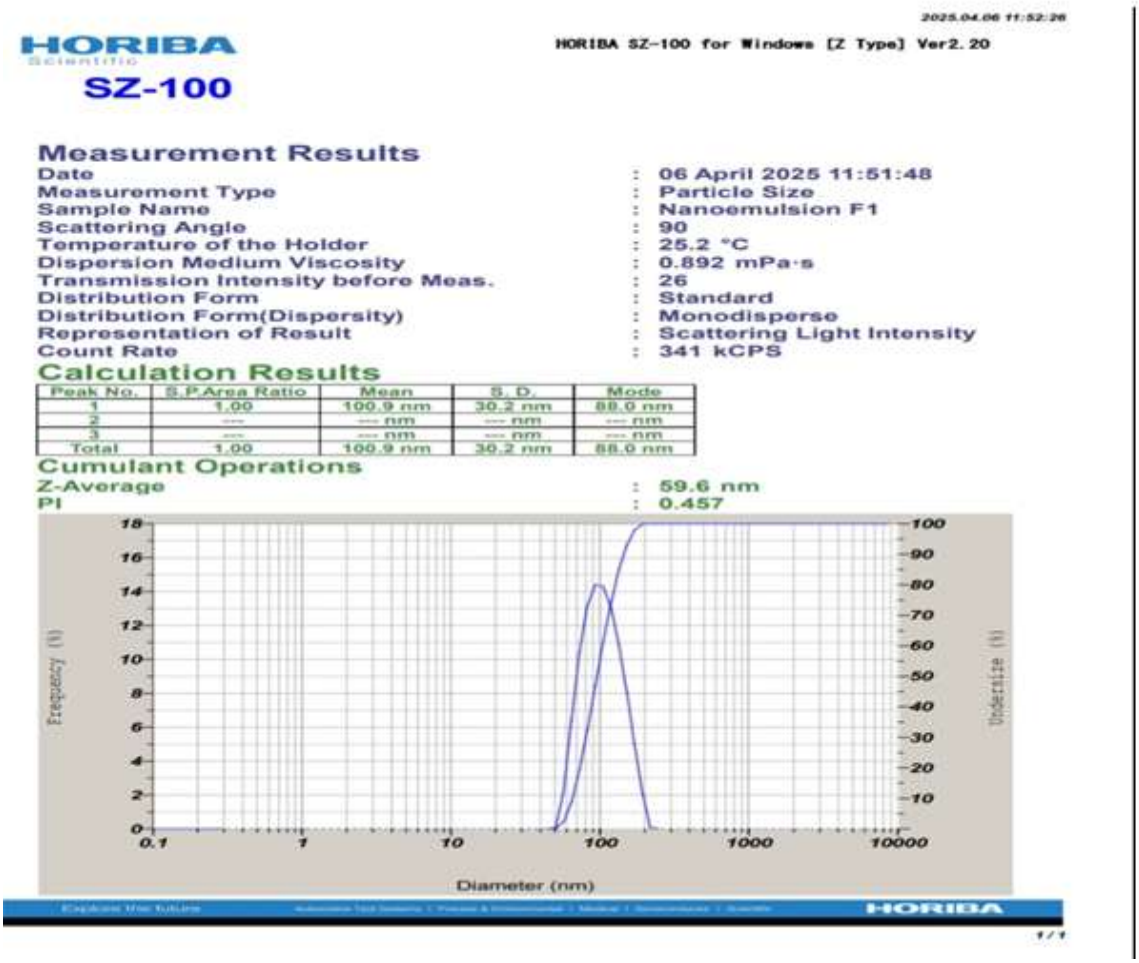
2) Viscosity Determination :"The viscosity of the nano emulsion formulated with Ginger Grass oil was found to be in the range of 0.61 indicating a low-viscosity system suitable for nano emulsion.

3) Density of nano emulsion : The density of the nanoemulsion of Ginger Grass oil was found to range between 0.89 to 0.95 g/mL, indicating a stable and homogenous formulation suitable for antimicrobial evaluation**.**

4) Partical size : The particle size of nano emulsion is in standard. range of 10-200nm.

The results are as following :

a)



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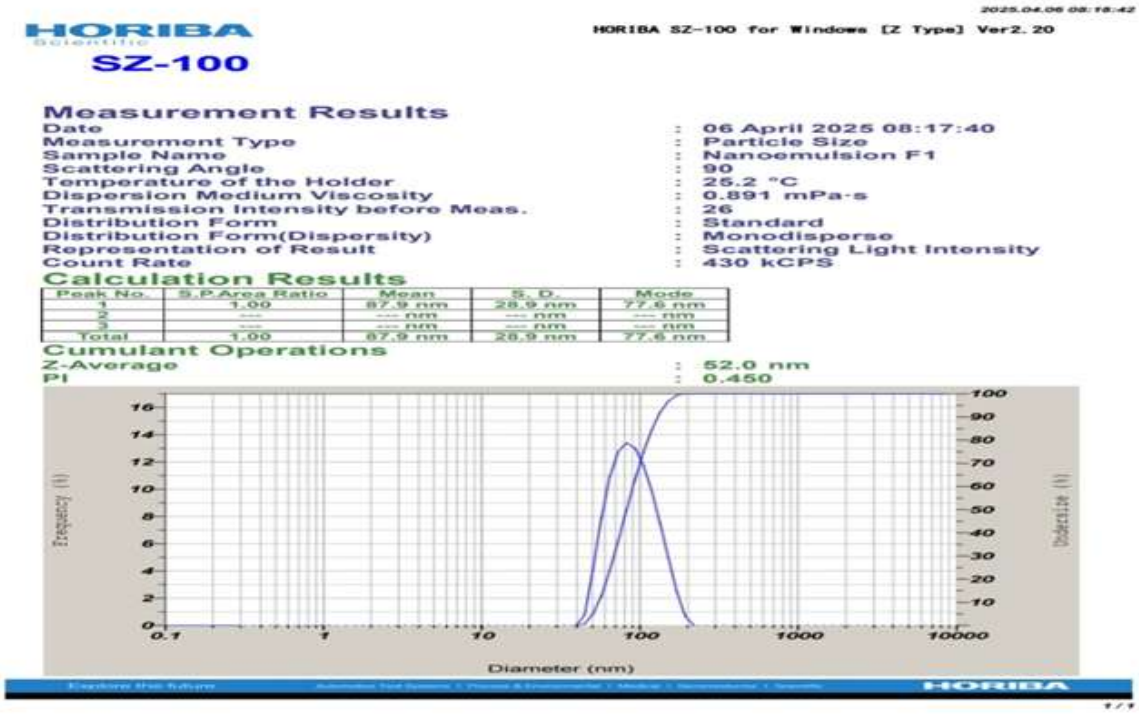
b)



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HORIBA Scientific
SZ-100

Measurement Results

Date	:	06 April 2025 08:17:40
Measurement Type	:	Particle Size
Sample Name	:	Nanoemulsion F1
Scattering Angle	:	90
Temperature of the Holder	:	25.2 °C
Dispersion Medium Viscosity	:	0.891 mPa·s
Transmission Intensity before Meas.	:	26
Distribution Form	:	Standard
Distribution Form(Dispersity)	:	Monodisperse
Representation of Result	:	Scattering Light Intensity
Count Rate	:	430 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	87.9 nm	28.9 nm	77.6 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	87.9 nm	28.9 nm	77.6 nm

Cumulant Operations

Z-Average	:	52.0 nm
PI	:	0.450

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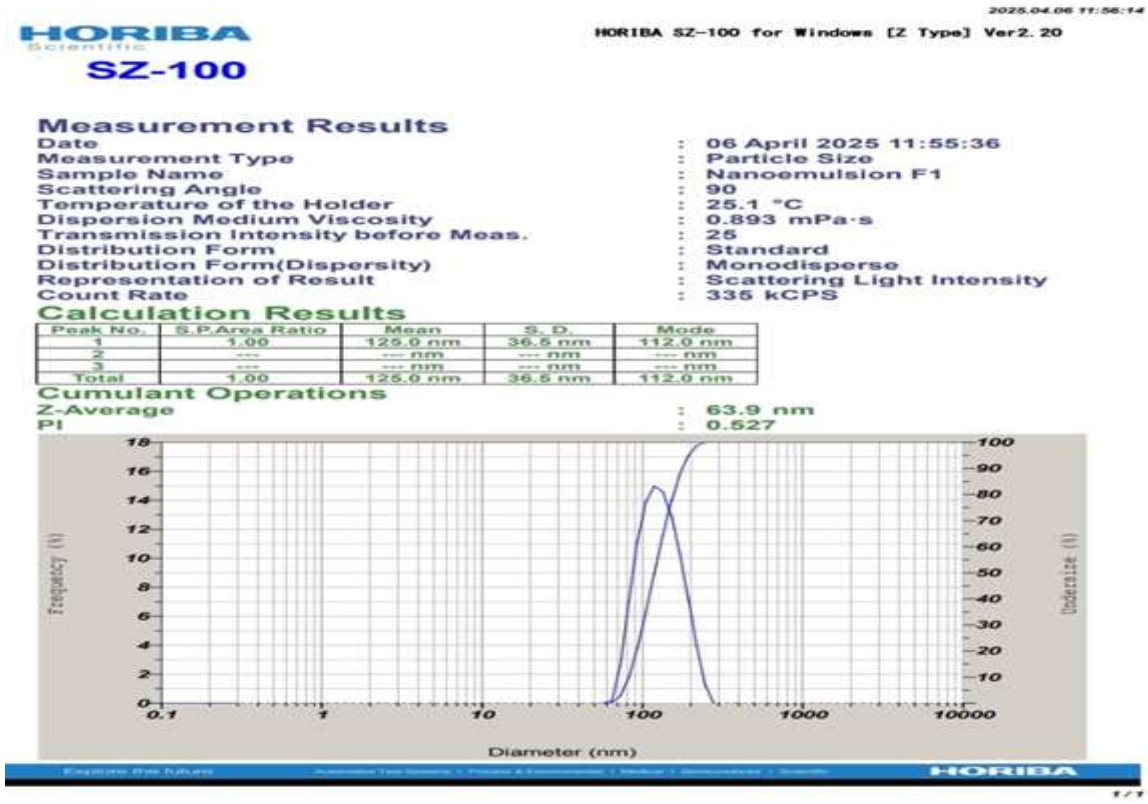
c)



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HORIBA SZ-100 for Windows [Z Type] Ver2.20

HORIBA Scientific
SZ-100

Measurement Results

Date	:	06 April 2025 11:55:36
Measurement Type	:	Particle Size
Sample Name	:	Nanoemulsion F1
Scattering Angle	:	90
Temperature of the Holder	:	25.1 °C
Dispersion Medium Viscosity	:	0.893 mPa·s
Transmission Intensity before Meas.	:	25
Distribution Form	:	Standard
Distribution Form(Dispersity)	:	Monodisperse
Representation of Result	:	Scattering Light Intensity
Count Rate	:	335 kCPS

Calculation Results

Peak No.	S.P.Area Ratio	Mean	S. D.	Mode
1	1.00	125.0 nm	36.5 nm	112.0 nm
2	---	--- nm	--- nm	--- nm
3	---	--- nm	--- nm	--- nm
Total	1.00	125.0 nm	36.5 nm	112.0 nm

Cumulant Operations

Z-Average	:	63.9 nm
PI	:	0.527

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5) Zeta potential of nano emulsion : The zeta potential of nano emulsion is within a standard range of -12.33 ± 1.01 mV to -39.33 ± 0.96 mV.

The results are as following :

a)

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HORIBA Scientific

SZ-100

HORIBA SZ-100 for Windows [Z Type] Ver2.20

Measurement Results

Measurement Results

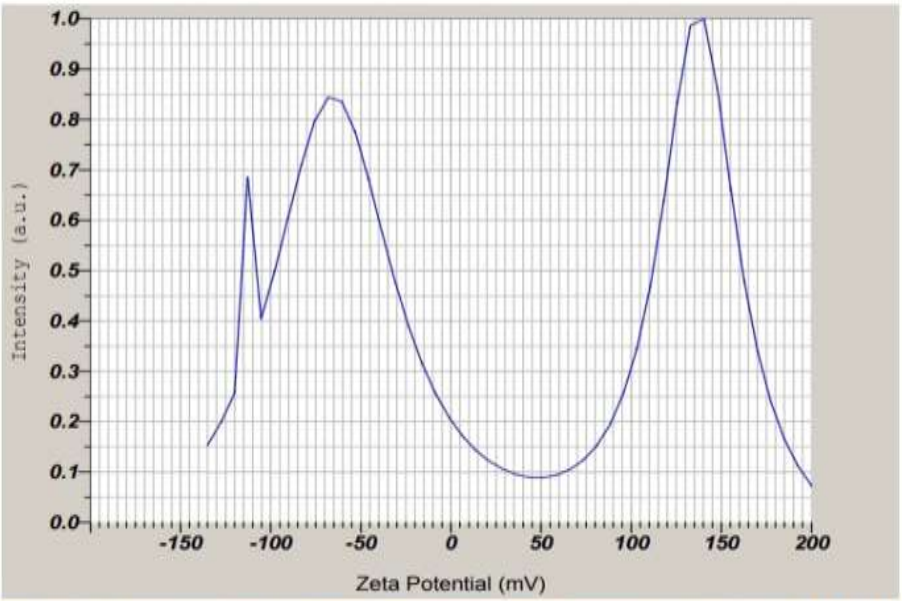
Date	:	06 April 2025 12:28:51
Measurement Type	:	Zeta Potential
Sample Name	:	Nanoemulsion F2
Temperature of the Holder	:	25.1 °C
Dispersion Medium Viscosity	:	0.893 mPa·s
Conductivity	:	0.307 mS/cm
Electrode Voltage	:	3.4 V

Calculation Results

Peak No.	Zeta Potential	Electrophoretic Mobility
1	137.3 mV	0.001065 cm2/Vs
2	-65.6 mV	-0.000509 cm2/Vs
3	-112.2 mV	-0.000870 cm2/Vs

Zeta Potential (Mean) : -57.0 mV

Electrophoretic Mobility Mean : -0.000442 cm^2/Vs



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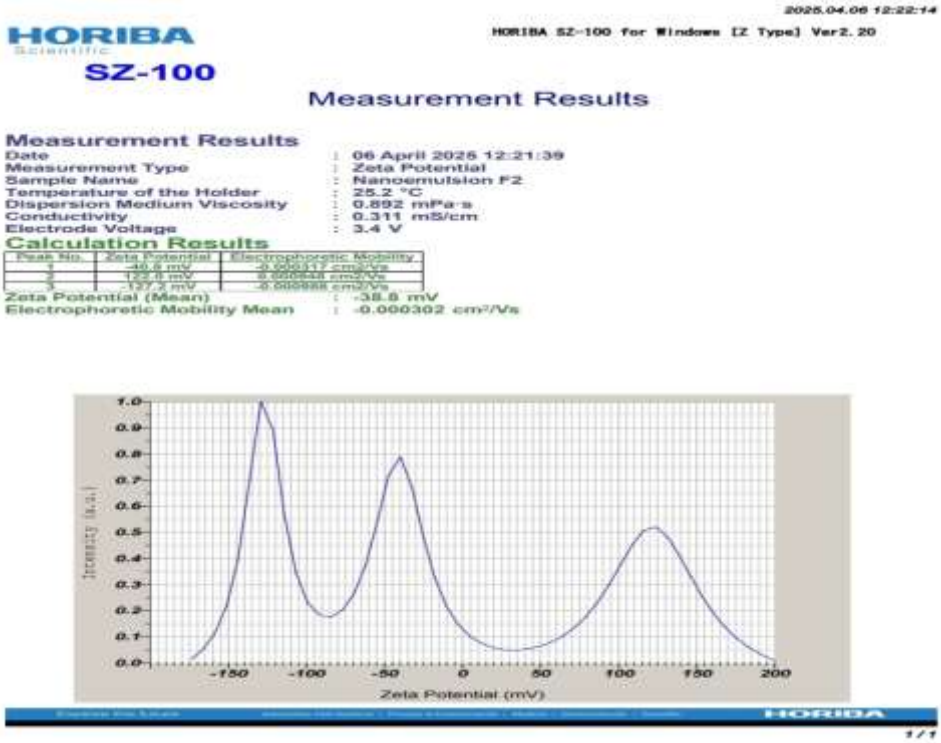

c)

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6) **Antimicrobial activity**: Nano emulsion of Ginger Grass oil shows strong antimicrobial activity, especially against gram-positive bacteria and fungi, due to enhanced bioavailability.

The zone of inhibition for sample in well 1 was observed as 530mm^2

The zone of inhibition for sample in well 2 was observed as 177mm^2

On the base of above observation it is proved that the nanoemulsion of ginger grass oil has antimicrobial activity

II. CONCLUSION:

The development of a nano emulsion system for Ginger Grass oil has proven to be a promising approach for enhancing the stability, solubility, and bioavailability of this essential oil. Ginger Grass oil, known for its therapeutic properties including antimicrobial, anti-inflammatory, and antioxidant effects, often faces challenges related to volatility, poor water solubility, and degradation upon exposure to environmental factors. Through nano emulsion technology, these limitations were effectively addressed.

The prepared nano emulsion displayed favorable physicochemical characteristics such as small droplet size (typically below 200 nm), low polydispersity index (PDI), and high zeta potential, indicating good dispersion and long-term physical stability. These characteristics are crucial for ensuring consistent delivery and effectiveness of the active components. The transparent and stable nature of the nano emulsion also suggests its suitability for various formulations, particularly in cosmetic and pharmaceutical applications.

Moreover, preliminary studies showed that the nano emulsion significantly improved the biological activity of Ginger Grass oil due to enhanced penetration and absorption, thereby potentially increasing its therapeutic efficacy. The small droplet size facilitates better interaction with biological membranes, which is essential for effective topical or systemic delivery.

The nano emulsion of Ginger Grass oil can be further transformed into a topical patch to enable controlled and sustained release, enhancing localized antimicrobial activity. This approach offers a convenient, effective, and targeted delivery system, potentially improving treatment outcomes for skin infections and reducing the need for frequent application or systemic therapy.

In conclusion, nano emulsification is a viable and efficient method for delivering Ginger Grass oil in a stable and functional form. This approach opens new avenues for incorporating this essential oil into health care and cosmetic products with improved performance and shelf-life. However, further investigations including in vivo testing, toxicity analysis, and scalability assessments are recommended to fully validate its safety and efficacy for commercial use. With continued research, Ginger Grass oil nano emulsions could become a valuable component in modern natural product-based therapeutics.

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